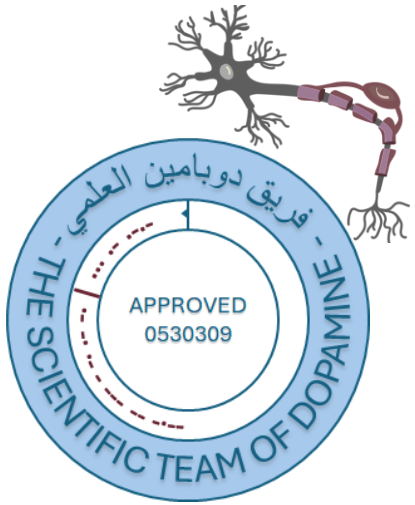


بسم الله الرحمن الرحيم

DOPAMINE SCIENTIFIC TEAM

Spinal Cord (Pt.1)

MID | Lecture 2

﴿إِنِّي تَوَكَّلْتُ عَلَى اللَّهِ رَبِّي وَرَبِّكُمْ ۚ مَا مِن دَابَّةٍ إِلَّا هُوَ آخِذٌ بِنَاصِيَتِهَا ۚ إِنَّ رَبِّي عَلَىٰ صِرَاطٍ مُّسْتَقِيمٍ﴾

Written by: Ehab Alarakza
Ahmad Abu Aisha

Reviewed by: Almothana Khalil

ANATOMY

رحلة اليقين مع سورة يس

بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

إِنَّكَ لَمِنَ ٱلۡمُرۡسَلِينَ ﴿٣﴾ عَلَىٰ صِرَٰطٖ مُّسۡتَقِيمٖ ﴿٤﴾ تَنزِيلَ ٱلۡعَزِيزِ ٱلرَّحِيمِ ﴿٥﴾

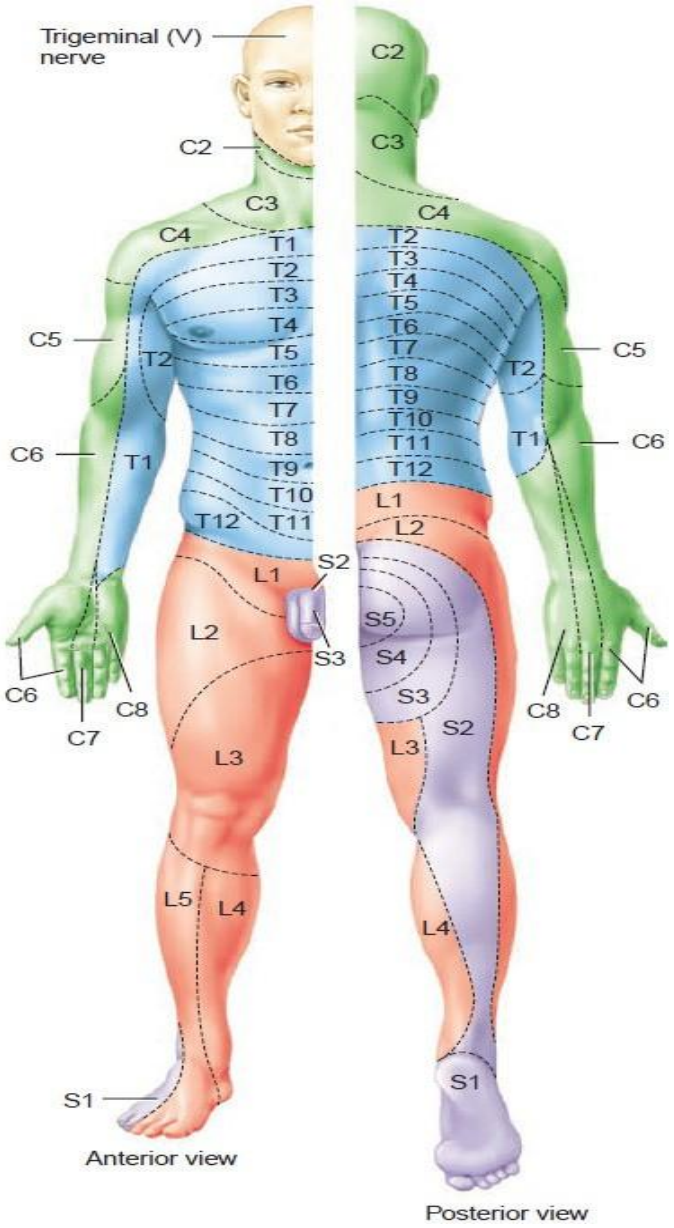
{إِنَّكَ لَمِنَ الْمُرْسَلِينَ} هذا المقسم عليه، وهو رسالة محمد صلى الله عليه وسلم، وإنك من جملة المرسلين، فلست ببدع من الرسل، وأيضا فجئت بما جاء به الرسل من الأصول الدينية، وأيضا فمن تأمل أحوال المرسلين وأوصافهم، وعرف الفرق بينهم وبين غيرهم، عرف أنك من خيار المرسلين، بما فيك من الصفات الكاملة، والأخلاق الفاضلة. ولا يخفى ما بين المقسم به، وهو القرآن الحكيم، وبين المقسم عليه، [وهو] رسالة الرسول محمد صلى الله عليه وسلم، من الاتصال، وأنه لو لم يكن لرسالته دليل ولا شاهد إلا هذا القرآن الحكيم، لكفى به دليلا وشاهدا على رسالة محمد صلى الله عليه وسلم، بل القرآن العظيم أقوى الأدلة المتصلة المستمرة على رسالة الرسول، فأدلة القرآن كلها أدلة لرسالة محمد صلى الله عليه وسلم.

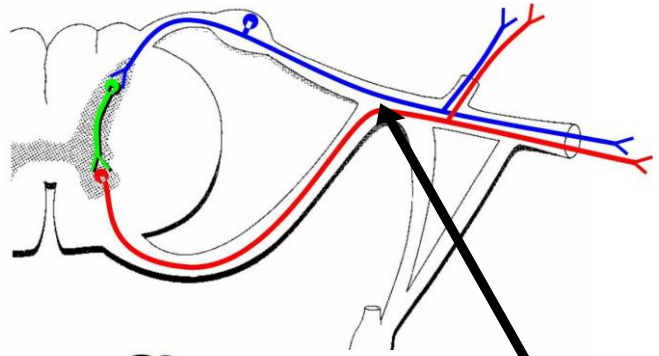
ثم أخبر بأعظم أوصاف الرسول صلى الله عليه وسلم، الدالة على رسالته، وهو أنه {عَلَى صِرَاطٍ مُسْتَقِيمٍ} معتدل، موصل إلى الله وإلى دار كرامته، وذلك الصراط المستقيم، مشتمل على أعمال، وهي الأعمال الصالحة، المصلحة للقلب والبدن، والدنيا والآخرة، والأخلاق الفاضلة، المزكّية للنفس، المطهّرة للقلب، المثمّرة للأجر، فهذا الصراط المستقيم، الذي هو وصف الرسول صلى الله عليه وسلم، ووصف دينه الذي جاء به، فتأمل جلالة هذا القرآن الكريم، كيف جمع بين القسم بأشرف الأقسام، على أجل مقسم عليه، وخبر الله وحده كاف، ولكنه تعالى أقام من الأدلة الواضحة والبراهين الساطعة في هذا الموضع على صحة ما أقسم عليه، من رسالة رسوله ما نبهنا عليه، وأشرنا إشارة لطيفة لسلوك طريقه.

وهذا الصراط المستقيم {تَنْزِيلَ الْعَزِيزِ الرَّحِيمِ} فهو الذي أنزل به كتابه، وأنزله طريقا لعباده، موصلا لهم إليه، فحماه بعزته عن التغيير والتبديل، ورحم به عباده رحمة اتصلت بهم، حتى أوصلتهم إلى دار رحمته، ولهذا ختم الآية بهذين الاسمين الكريمين: العزيز. الرحيم.

Dermatomes and Myotomes

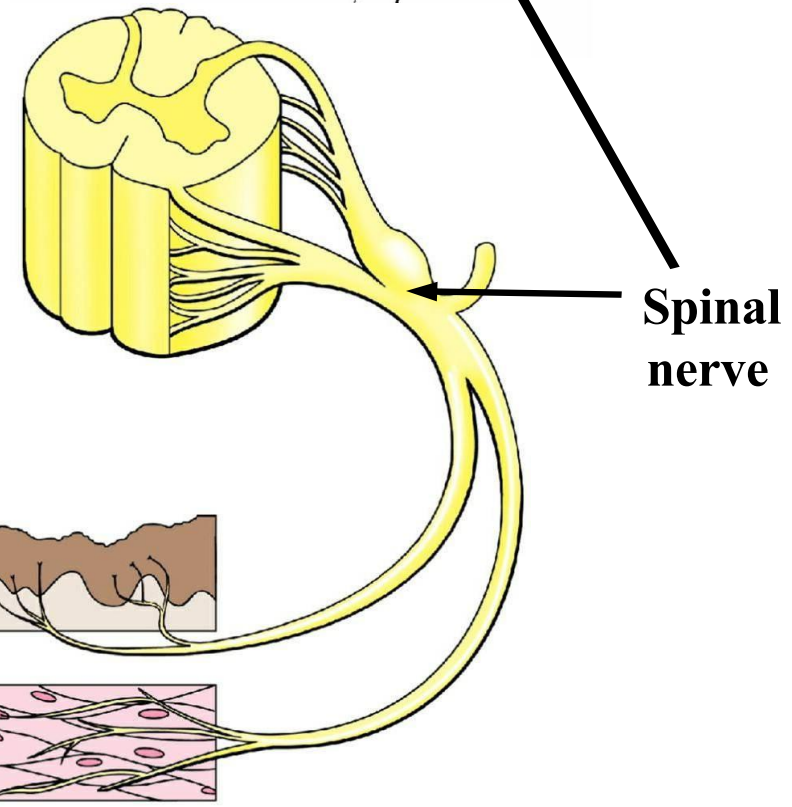
See next slide





*somatic **sensory** nerve (GSA)*

*somatic **motor** nerve (GSE)*



Spinal nerve

skin (dermatome)

muscle (myotome)

Dermatomes and Myotomes – Explained

- The motor and sensory innervation of the limbs follows a hierarchical anatomical organization that begins centrally and progresses peripherally. Motor commands originate in descending tracts within the spinal cord. At each spinal level, these signals exit through the anterior (ventral) root, while sensory fibers enter through the posterior (dorsal) root. The two roots unite to form a spinal nerve (spinal root), which then usually contributes to a plexus.

- In the upper limb, the most important plexus is the Brachial plexus (C5–T1), where roots reorganize into trunks, divisions, cords, and finally terminal peripheral nerves such as the Radial nerve, Median nerve, and Ulnar nerve. A peripheral nerve injury, such as radial nerve palsy, produces deficits limited to that specific nerve distribution (for example, wrist drop).

- We study roots because each peripheral nerve contains fibers from several spinal roots and each root contributes to multiple peripheral nerves. Therefore, a lesion at the root level (for example, from a disc herniation) produces radiculopathy — pain in a dermatome, weakness in a myotome, and altered reflexes — whereas a lesion of a named nerve produces a focal nerve palsy that does not follow a pure dermatomal pattern.

- A dermatome is the skin area supplied mainly by one spinal root (e.g., T4 → nipple line), and a myotome is the muscle group supplied mainly by one root (e.g., C6 → wrist extension and elbow flexion). Clinically, many different root injuries can occur depending on level; we will cover the common root injuries and their characteristic findings on the next slide.

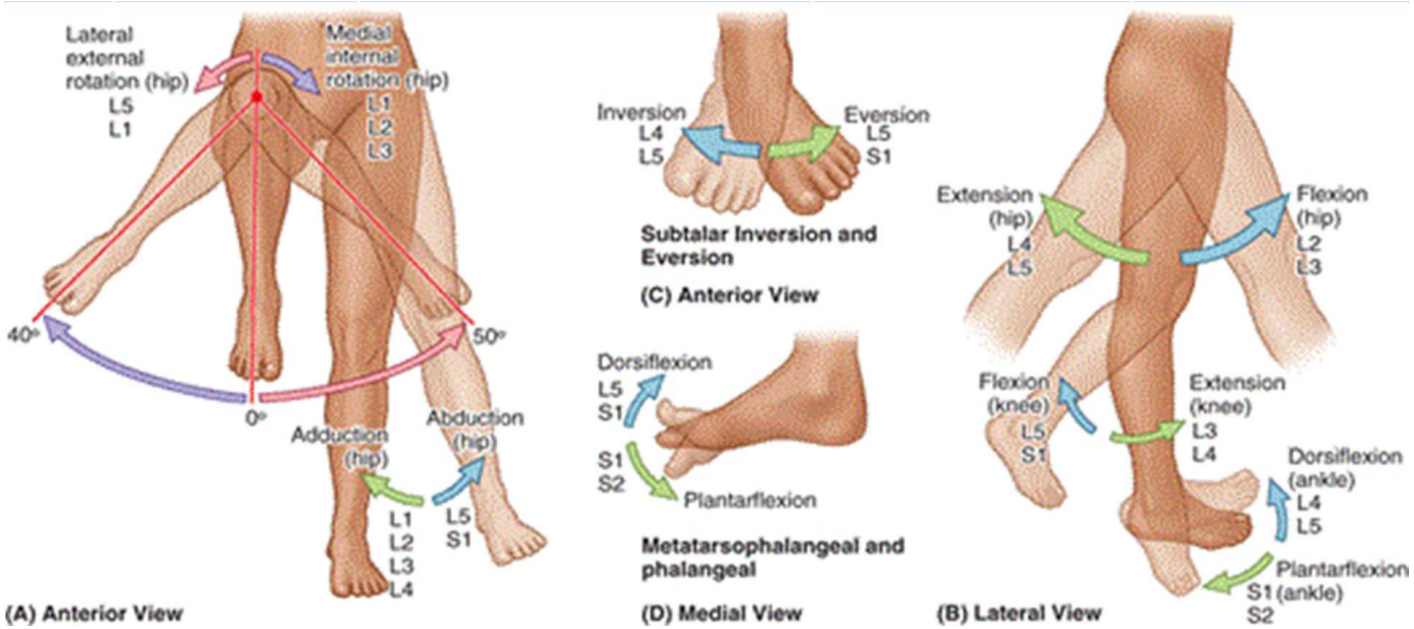
Common lumber disc problems (memorize) Further explanation on the next slide

Disc	Root	Percentage	Motor weakness	Sensory changes	Reflex affected
L3-L4	L4	3-10%	Knee extension (Quadriceps femoris)	Anteriomedial leg (saphenous N.)	Knee jerk
L4-L5	L5	40-45%	Big toe dorsifelxion (EHL) and TA	Big toe , anteriolateral leg (Common P. N.)	Hamstring jerk
L5-S1	S1	45-50%	Foot planter flextion (Gastrocnemius)	Lateral border of foot (sural N.)	Ankle jerk

- **Test L5**: by asking the patient to stand on his heels, this represent **dorsiflexion**
- **Test S1**: by asking the patient to stand on his tiptoes, this represent **planter flexion**

Important myotomes of lower limb

- Just as dermatomes map sensory distribution on the body, the myotome image represents how each spinal segment controls a specific movement in the lower limb.



Further explanation of the table

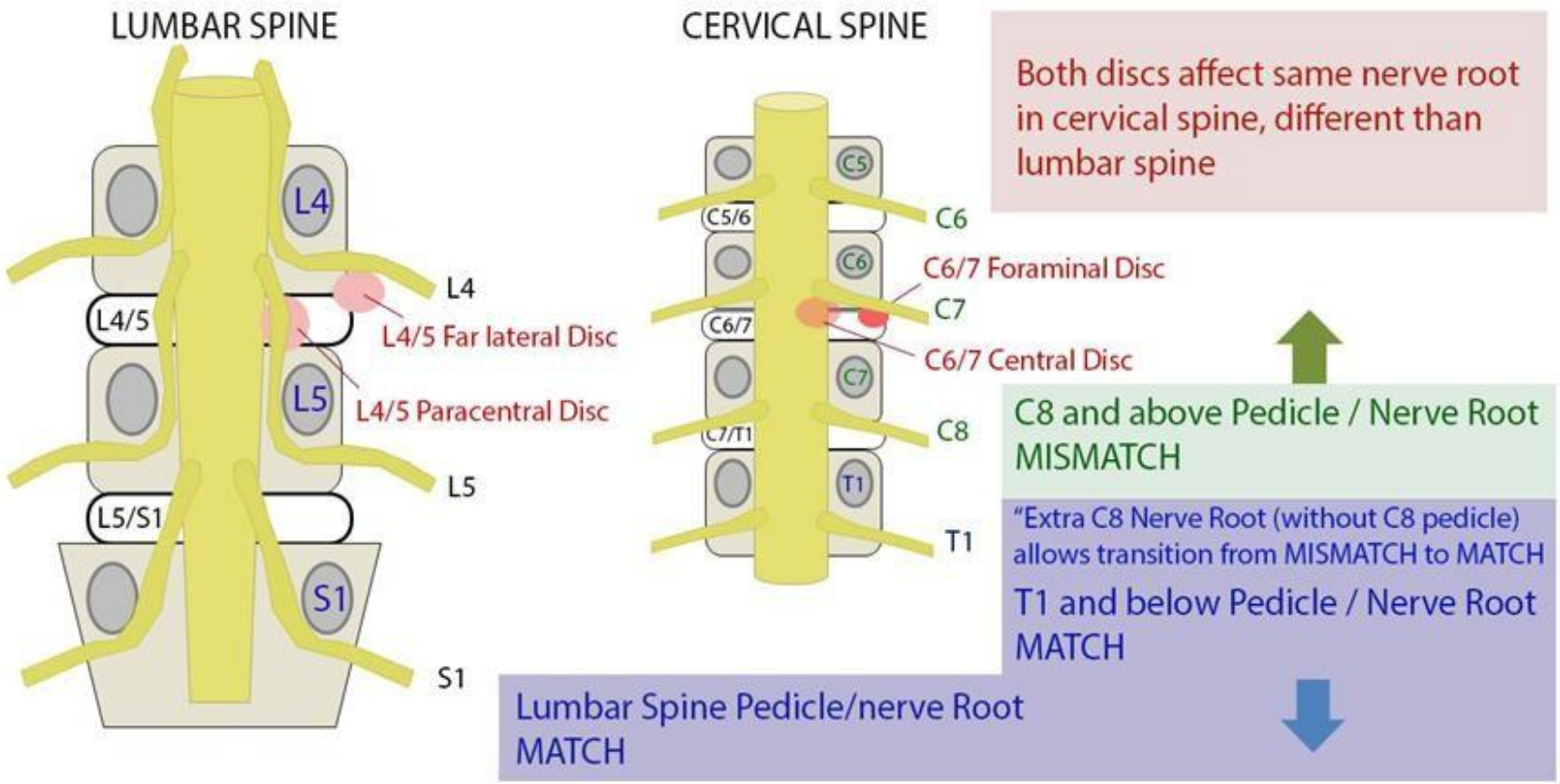
- An L3–L4 disc commonly affects the **L4 root**. Clinically, this mainly weakens knee extension (quadriceps femoris), which is carried through the femoral nerve (L2–L4). Sensory loss appears over the anteromedial leg (via the saphenous branch of the femoral nerve). The reflex affected is the knee jerk (patellar reflex), tested by tapping the patellar tendon; if L4 is injured, knee extension is reduced or absent.

- The more common L4–L5 disc usually compresses the **L5 root**. The key motor deficit is weakness of big toe dorsiflexion (extensor hallucis longus) and ankle dorsiflexion (tibialis anterior). These muscles receive fibers from L5 (mainly through branches of the sciatic nerve via the common fibular/peroneal division). Sensory changes occur over the anterolateral leg and dorsum of the foot. The reflex that may be reduced is the hamstring reflex.

- The L5–S1 disc commonly compresses the **S1 root**, producing weakness in plantar flexion (gastrocnemius). Sensory loss appears along the lateral border of the foot, and the reflex affected is the ankle jerk (Achilles reflex), tested by tapping the Achilles tendon.

Remember that:

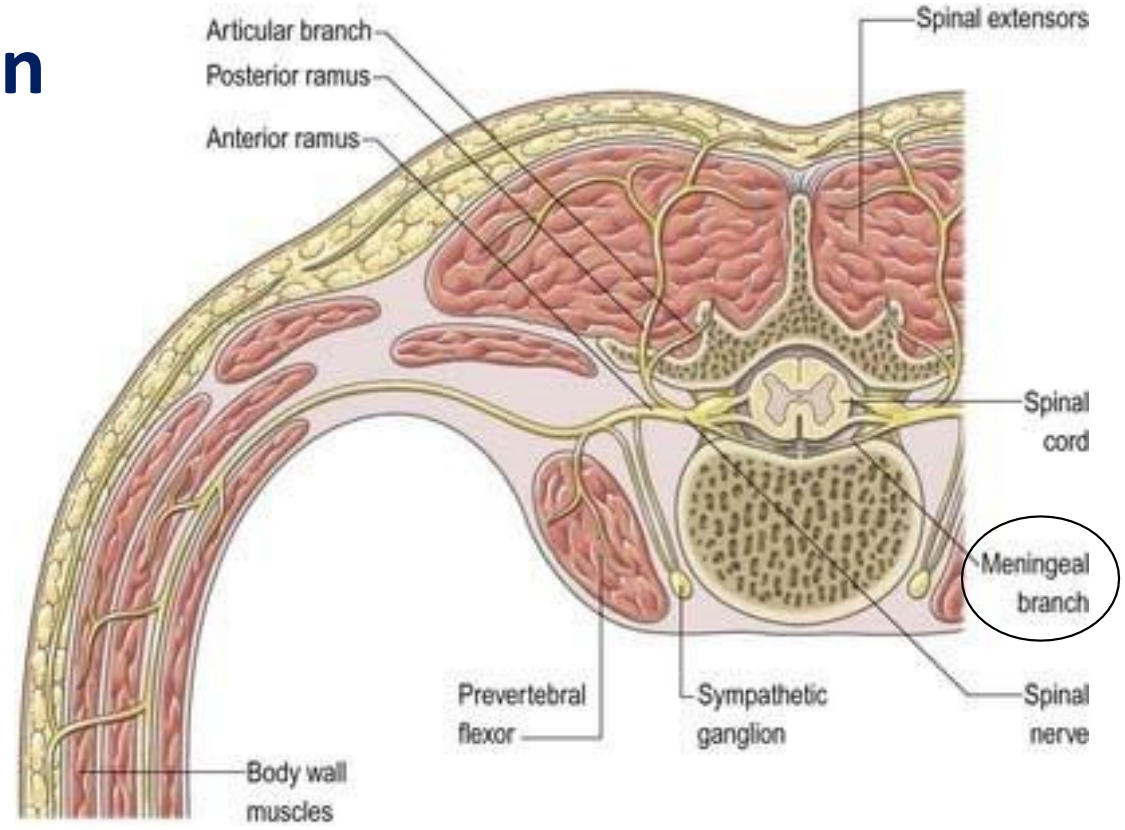
- ✓ **Multiple discs** usually is involved, so more than one root can be affected at the same time.
- ✓ **Sensory symptoms** are usually more common and appear earlier than motor weakness; marked muscle weakness suggests more severe compression.
- ✓ **Sensory <u>changes</u>** in root compression are variable and may range from radicular pain to numbness and paresthesia (abnormal sensations such as tingling or pins and needles)



- As we mentioned in the previous slide, in the lumbar spine the most commonly affected nerve root is the one **below the disc level**, because lumbar roots descend before exiting; therefore, a typical **paracentral disc herniation** compresses the traversing (inferior) root – for example, L3–L4 affects L4, L4–L5 affects L5, and L5–S1 affects S1. However, clinically this is not always straightforward. The pattern becomes more complicated because not all herniations are paracentral; a **far lateral (foraminal) disc** can instead compress the exiting nerve root at the same level, producing a different neurological picture. So, while the "root below" rule is the common pattern in lumbar disc disease, the exact presentation depends on the location of the herniation. In contrast, in the cervical spine, the affected root usually corresponds to the disc level.

Major symptoms of disc herniation

- **Low back pain**: radiating to the gluteal region, the back of the thigh and back of the leg
- spinal nerve gives a meningeal branch bring sensation from the dura matter
- Dura matter is sensitive to stretch
- Pain is diffused due to overlapping dermatomes
- **Straight Leg Raise Test (SLR)**



Further explanation on the next slide

Further explanation

- In disc herniation, we must first remember the anatomy of the spinal nerve. The anterior (ventral) and posterior (dorsal) roots unite to form the spinal nerve, which exits the vertebral canal through the intervertebral foramen. Immediately after exiting, it gives a small recurrent branch called the meningeal branch (recurrent meningeal nerve) before dividing into anterior and posterior rami.

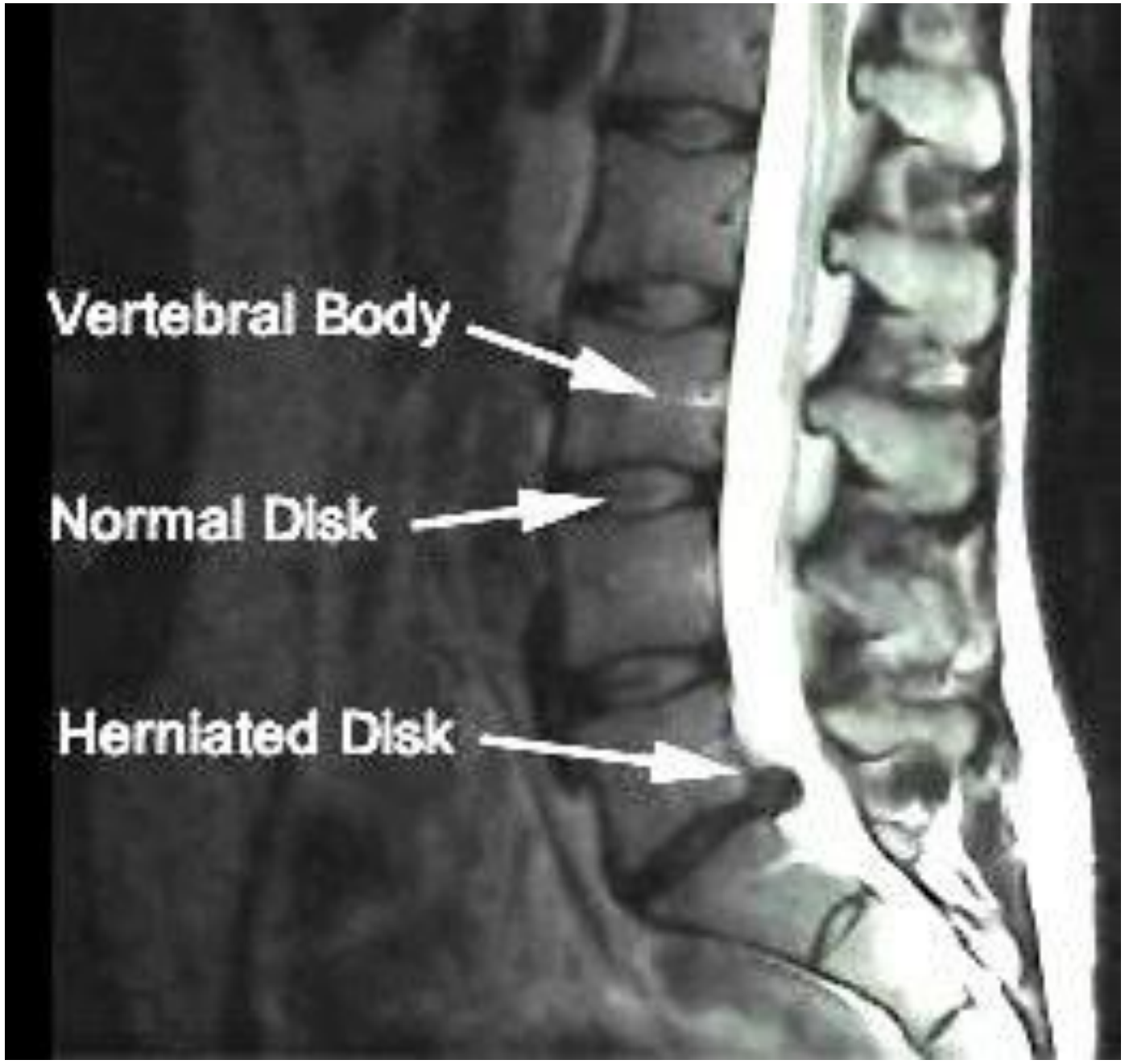
- This meningeal branch re-enters the vertebral canal and supplies the meninges, especially the dura mater, which is sensitive to stretch. In disc herniation, irritation or compression of this branch – in addition to nerve root compression – contributes to the low back pain.

- **The Straight Leg Raise (SLR)** test is used to assess lumbar nerve root irritation. The patient lies supine, and the examiner raises the straight leg. This maneuver stretches the sciatic nerve (L4–S3 roots) and indirectly stretches the affected nerve roots and dura. In a normal person, this does not cause significant pain. However, in a patient with disc herniation, stretching increases tension on the already compressed or inflamed nerve root and meninges, reproducing radicular pain.

- Clinically, pain occurring at a lower angle of elevation suggests more severe nerve root irritation, whereas pain at a higher angle suggests milder involvement.

- Management is usually conservative at first, and surgery is reserved for cases with significant motor (suggestive of severe damage) weakness, progressive neurological deficit, or severe persistent symptoms.

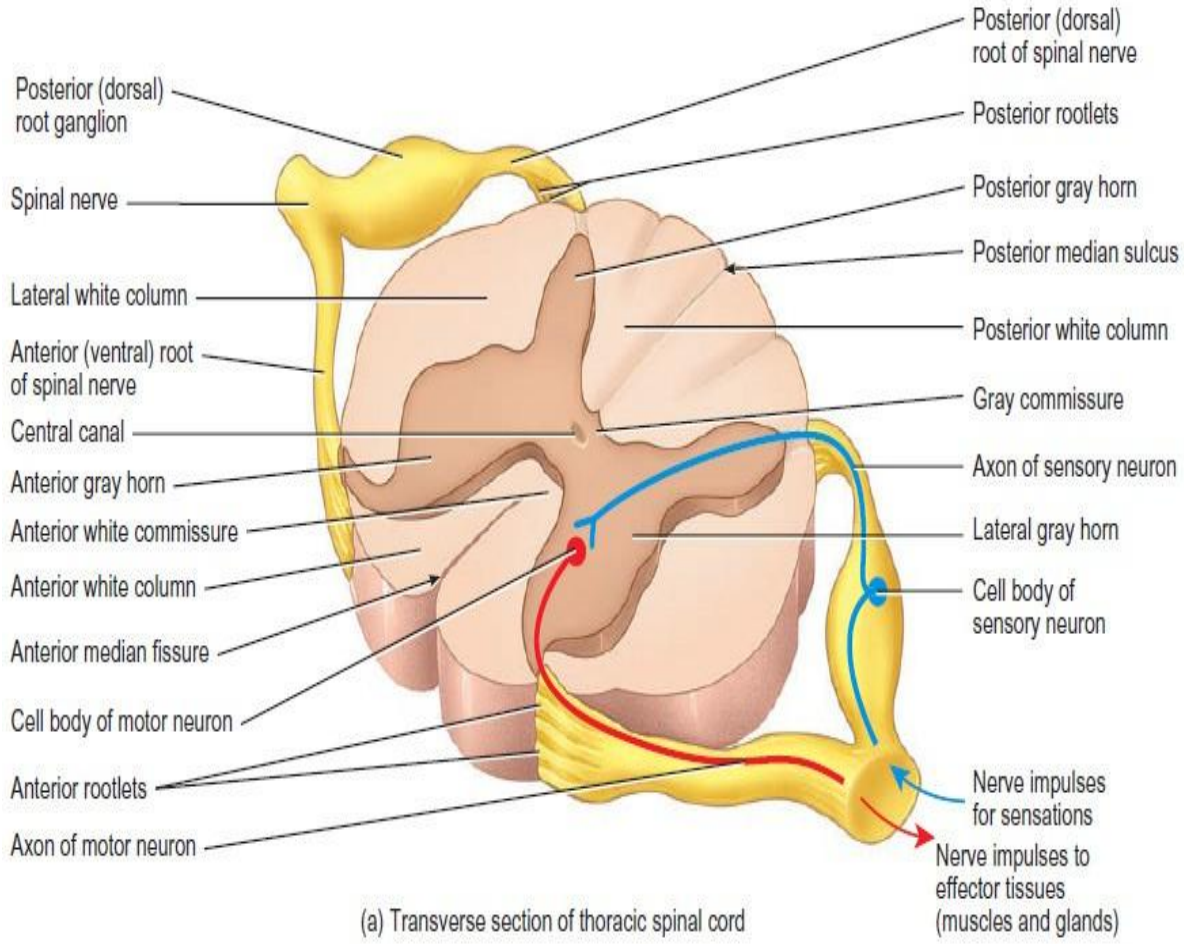
- Nowadays, **MRI** is commonly used to aid in making the diagnosis of a herniated disc.



Cross Section of Spinal Cord

- The spinal cord is flattened slightly anteriorly and posteriorly, with a length ranging from 42 to 45 cm in adults.

- CSF circulation:
  The CSF circulates in brain ventricles, with the 4th ventricle (cavity of the hindbrain) being continuous with the central canal of the spinal cord and **opening to subarachnoid space** where CSF also circulates.



CSF: cerebrospinal fluid

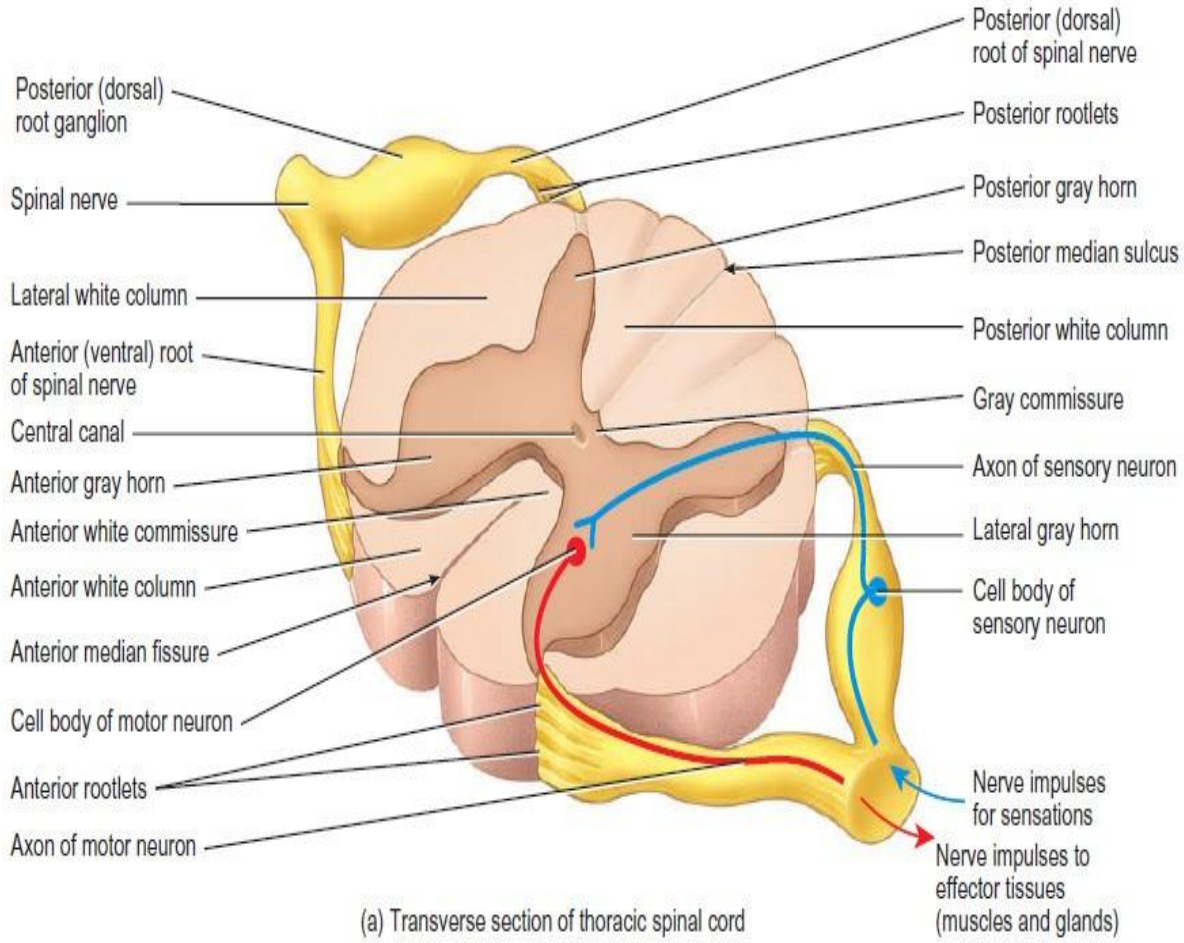
Cross Section of Spinal Cord

- Anterior median **fissure**:
  wide groove on the Anterior aspect

- Posterior median sulcus:
  Narrow groove on the posterior aspect

- Gray matter: is **H-** or **butterfly-shaped** and contains neuron **cell bodies**, dendrites, axons.

  Divided into ***horns*** (it may be named gray column):
  - **Posterior** (dorsal) horn (cell body of **sensory N**)
  - **Anterior** (ventral) horn (cell body of **motor N** to skeletal M)
  - **Lateral** horn (if present)
    (cell body of motor N to cardiac M, smooth M, glands) i.e., **Autonomic ganglia**



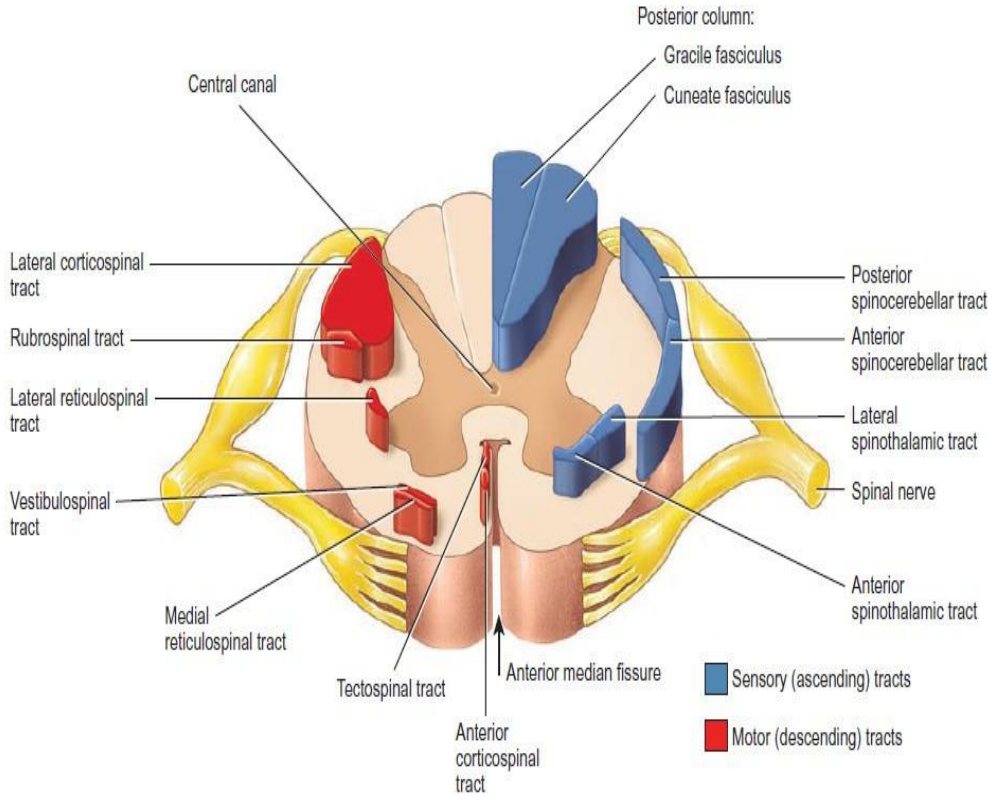
(a) Transverse section of thoracic spinal cord

Cross Section of Spinal Cord

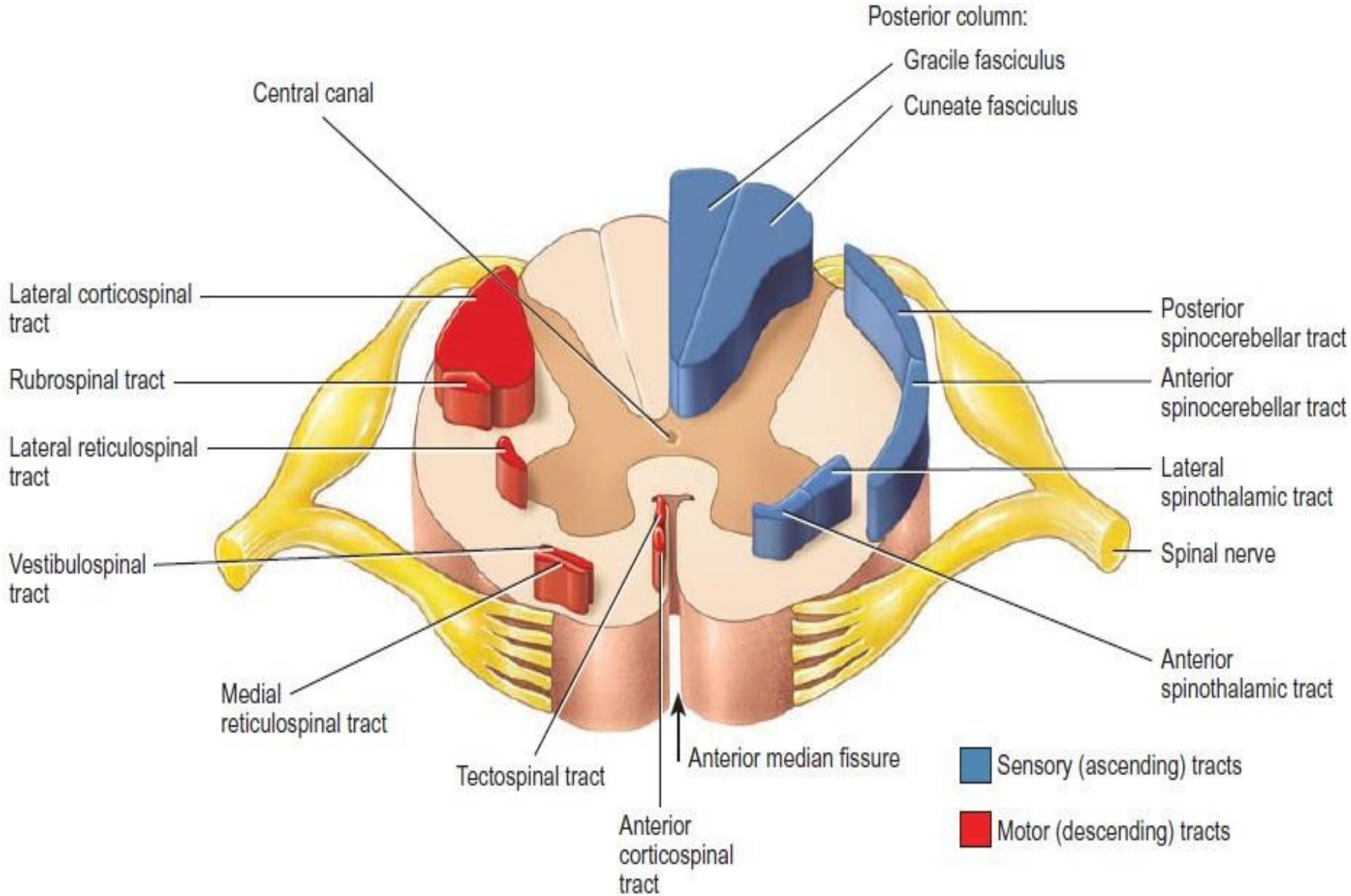
- White matter: formed by neuronal processes, i.e., **tracts** (neuronal processes in the CNS)

- Divided functionally into:
  - Ascending tracts (sensory tracts)
    Their names start with the term (spino-), followed by the name of an area in the brain
  - Descending tracts (motor tracts)
    Their names start with name of an area in the brain and ends with the term (-spinal)

- Divided Anatomically into columns (funiculi):
  - Posterior
  - Anterior
  - Lateral

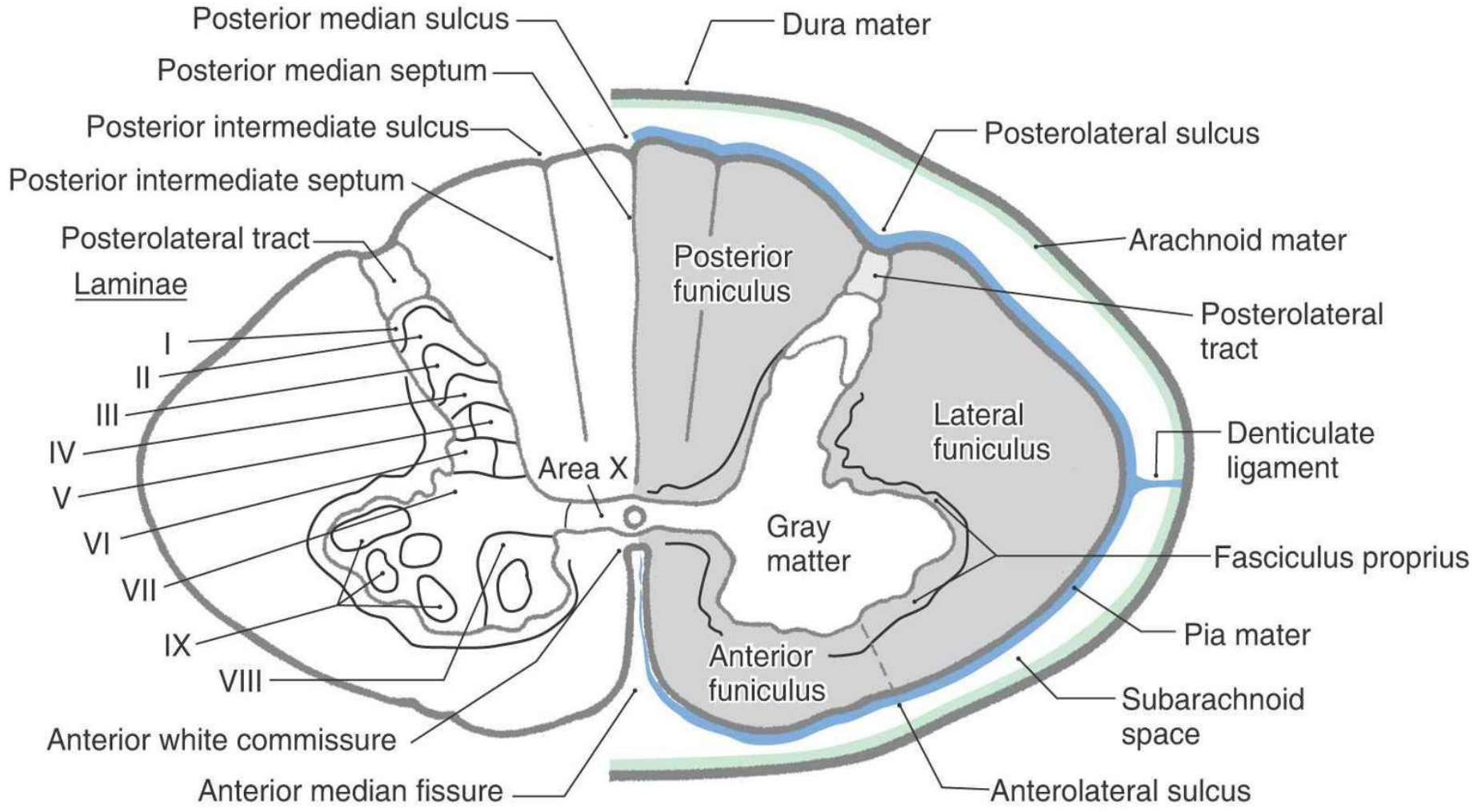


Appreciate the naming (first and second part); the specific tracts will be explained in the upcoming lectures.



Cross Section of Spinal Cord

The 10 Rexed laminae will be explained in order in the upcoming lectures.



Some notes about studying tracts (Tractology)

Tracts are sensory systems that have:

- **Modality:** the type of sensation they transmit

- **Neuron orders:**

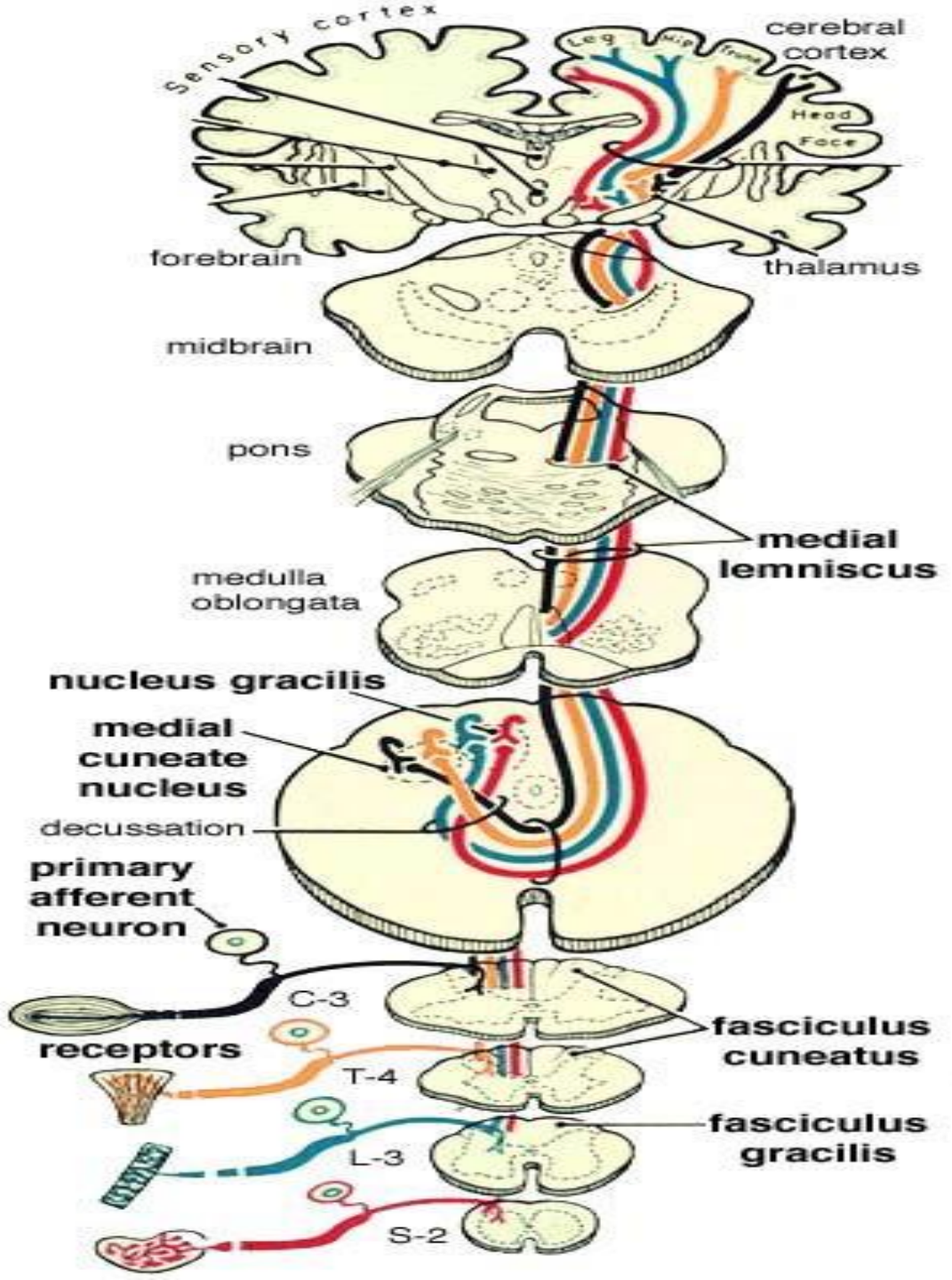
1. **First-Order Neuron:** primary sensory neuron. It collects information from the peripheral receptor and carries it into the spinal cord (or brain stem).
2. **Second-Order Neuron:** the "crossing" neuron. In almost all sensory pathways, it is the one that decussates; however, the location of decussation depends on the specific tract.
3. **Third-Order Neuron:** acts as the final relay, typically carrying the signal from the thalamus through the internal capsule.

- **Termination site:** The final destination. **The sensation is considered conscious only if the termination is in the cortex.**

The first tract:

Posterior (Dorsal) White Column-Medial

Lemniscal Pathway (DCML)

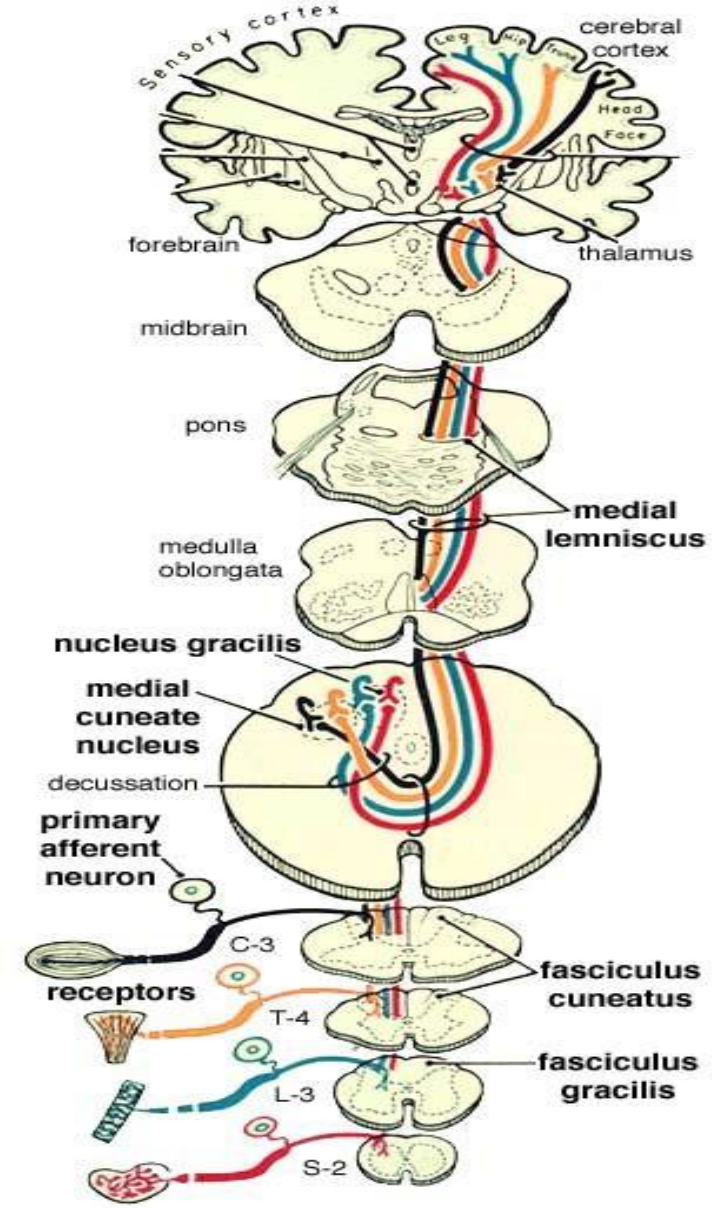


Posterior (Dorsal) White Column-Medial Lemniscal Pathway (DCML) [1]

Modality:
(1) Discriminative Touch Sensation (include Vibration)
(2) Conscious Proprioception i.e., sense of position or muscle-joint sense. This is responsible for the realization of position even in situations where the person is blinded.

Receptor: Most receptors except free nerve endings, specifically the are Golgi tendon apparatus and muscle spindle.

Conscious proprioception helps CNS plan movement from A→B and fine muscle control like controlling the spectrum of grip strengths.



Posterior (Dorsal) White Column-Medial Lemniscal Pathway (DCML) [2]

1st Neuron: a pseudo-unipolar neuron that has its body in Dorsal Root ganglia

2nd Neuron: starts at Dorsal Column Nuclei (Nucleus Gracilis and Cuneatus)

→ Internal Arcuate Fiber - Lemniscal **Decussation** (in lower medulla)

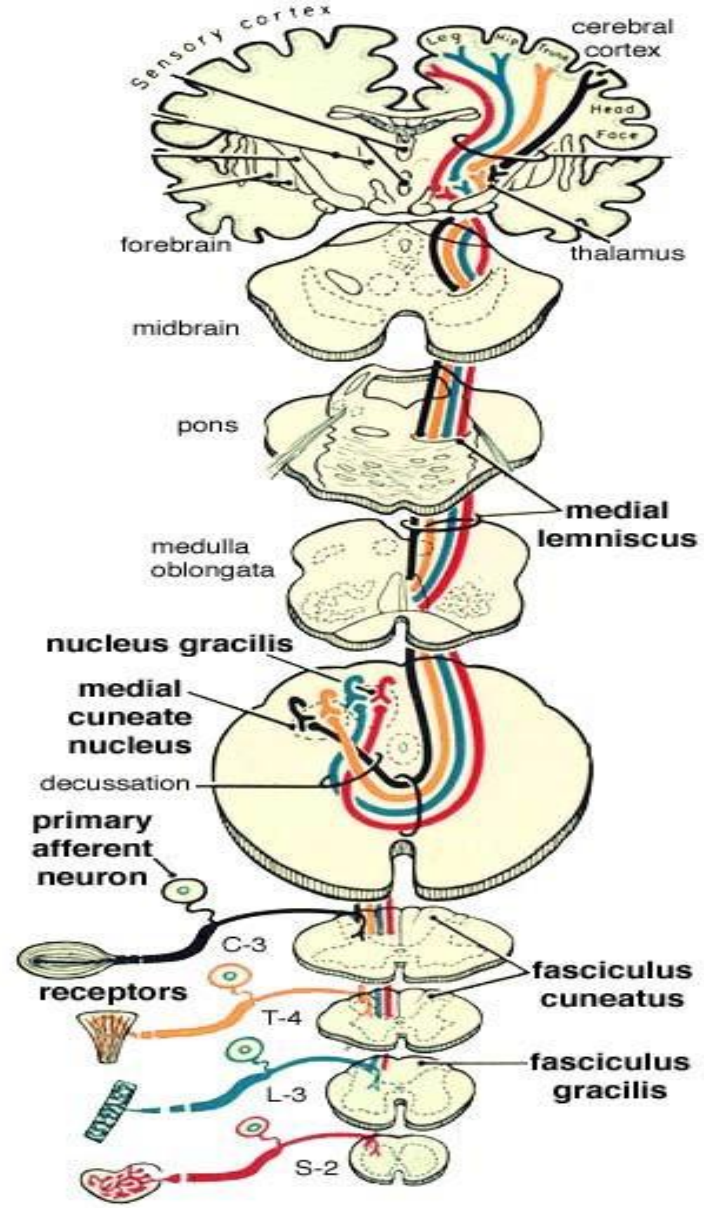
→ Medial Lemniscus

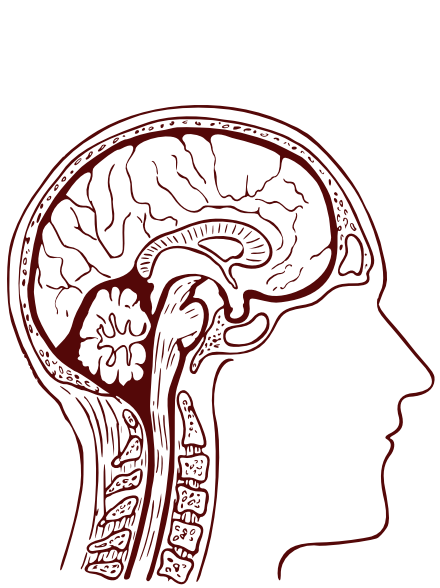
3rd Neuron: starts at Thalamus (VPL)

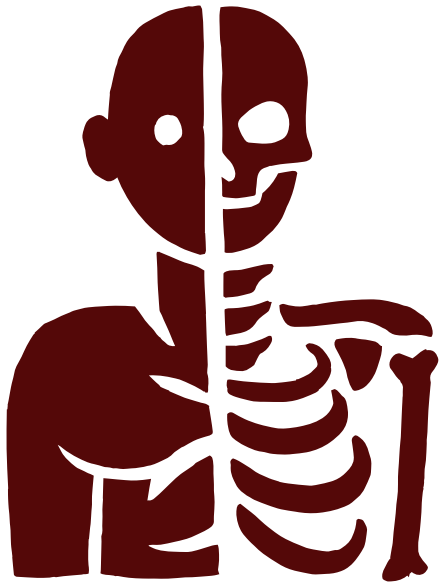
→ Internal Capsule

→ Corona Radiata

DCML Termination: Primary Somesthetic Area (SI), as it is conscious sensation







ANATOMY QUIZ LECTURE 2

External Resources

رسالة من الفريق العلمي

اللهم إن عمر عطية في ذمتك وحبل جوارك، فقِه من فتنة القبر وعذاب النار،
أنت أهل الوفاء والحق، فاغفر له وارحمه إنك أنت الغفور الرحيم.

يُنصح به وبشدّة !!

الحمدلله الذي بلّغنا رمضان، اللهم أعنّا على صيامه وقيامه، واجعلنا فيه من المقبولين،
واغفر لنا ذنوبنا، واعتق رقابنا من النار، اللهم اجعلنا من الفائزين برحمتك ومغفرتك
ورضوانك في هذا الشهر المبارك.

For any feedback, scan the code or click on it.

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1			
V1 → V2			