ANATOMY

SHEET NO. 2

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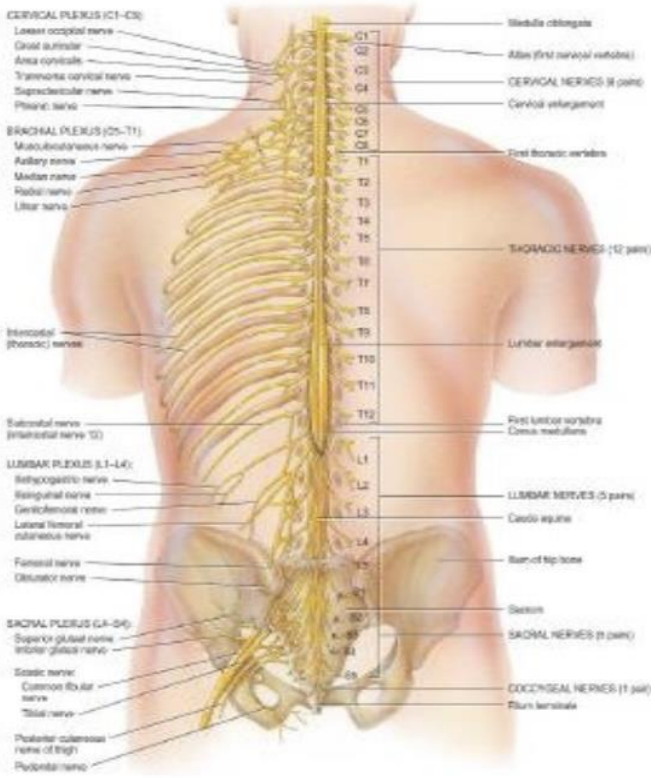
External anatomy of Spinal Cord



- **Spinal cord** is located within vertebral canal. ,Descends from foramen magnum(from occipital bone) to the intervertebral disc L1/L2.
- Slightly flattened anteriorly and posteriorly.
- Length of the adult spinal cord ranges from 42 to 45 cm.

- Not uniform in diameter: we have 2 enlargements that give rise to plexuses to supply the upper and lower limbs.

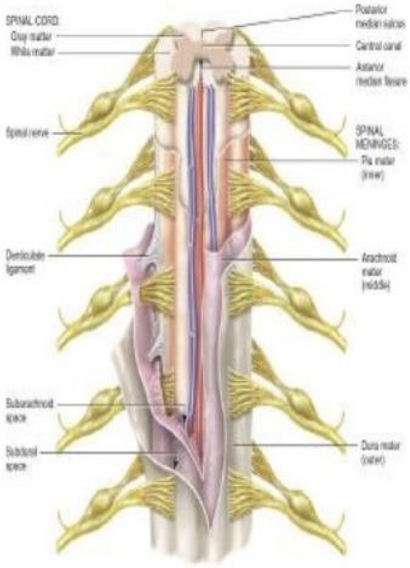
1) Cervical enlargement: supplies upper limbs ->The brachial plexus (C5-C8 & T1).
2) Lumbar enlargement: supplies lower limbs ->The lumbosacral plexus.

- Spinal cord is divided into 31 segments/regions (where the nerves leave): Cervical (8), Thoracic (12), Lumbar (5), Sacral (5), Coccygeal (1)
  Give rise to (31) pairs of spinal nerves (All are mixed)

Note: The number of segments = the number of nerves BUT not the vertebrae; we have 8 cervical spinal segments but 7 cervical vertebrae (in other words, the The segment not necessarily corresponding to that location vertebra, Because the growth of bone bypass the growth of spinal cord so the spinal cord will occupy 2/3 of the canal)

- The lower 1/3 contains the lower spinal nerves(horsetail appearance) which is called Cauda Equina, this is why they have longer roots (origin of spinal nerves extending inferiorly from conus medullaris).

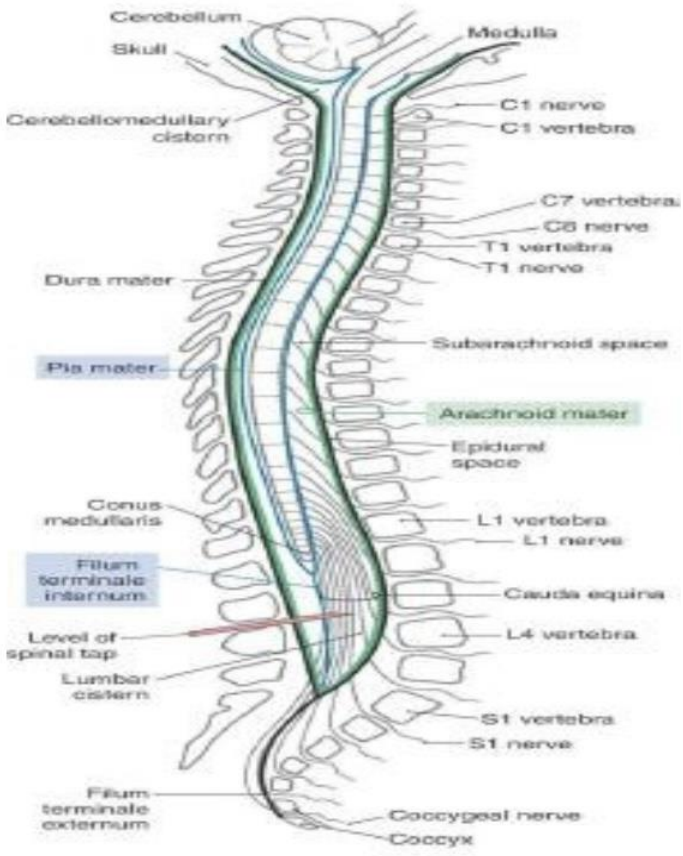
-The average person is born with 33 individual bones (the vertebrae). By the time a person becomesan adult most have only 24 vertebrae because some vertebrae at the bottom end of the spine fuse together during normal growth and development.



- The spinal cord forming a tapered inferior end (conical structure) called Conus Medullaris

Meninges (السحايا)

The connective tissues that covers the spinal cord



1) Dura mater: (الجافية)

- Outermost layer, lines the bony canal /closest to the bone.
- continuous with epineurium of the spinal nerves.
- Dense irregular connective tissue
- Extends from the level of the foramen magnum to the level of S2, Forming the Filum Terminale Externum (the closed end of the Dura mater caudally, it is a connective tissue that anchors the Dura mater to the coccyx bone)

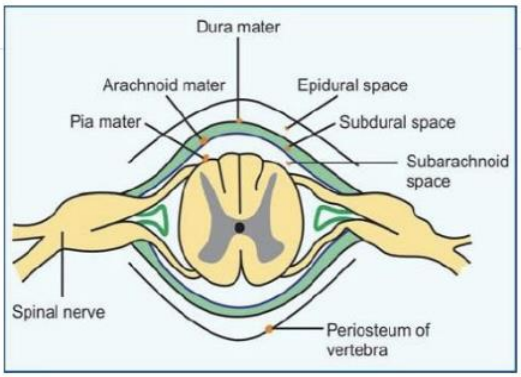
2) Arachnoid mater: (العنكبوتية)

- Attached to the inner aspect of the dura matter ,so what is no true space between them.
- Thin web-like arrangement of delicate collagen and some elastic fibers.
- Ends at the level of S2.

3) Pia mater:

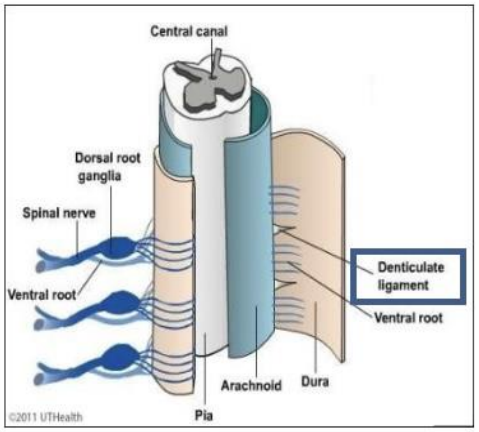
-The innermost layer

- Thin transparent connective tissue layer that adheres (Bound tightly) to the surface of the spinal cord and brain.
- Since it is firmly attached to the spinal cord, thus, both end at the level of L1-L2
- It forms the Filum Terminale Internum (connective tissue at the caudal end of the pia mater, anchors spinal cord to coccyx bone.)



- both Filum Terminale Externum (directly &Internum (indirectly) anchor the spinal cord to the coccyx providing stability and protection within the canal.

-Forms that in the denticulate ligament(مسنن)which extends from the pia mater and attach the spinal cord to the arachnoid mater and inner aspect of the Dura mater, it also helps in providing stability.



Spaces

❖ epidural/ subarachnoid/ subdural

1) Epidural space: extradural (outside the dura)

-space between the dura mater and the wall of the vertebral canal.

-fat-filled

- Epidural anesthesia -> commonly used for labor pain.
(آلآم المخاض و الديسك)

2) Subdural space: contains serous fluid (between the dura and arachnoid), not a true space

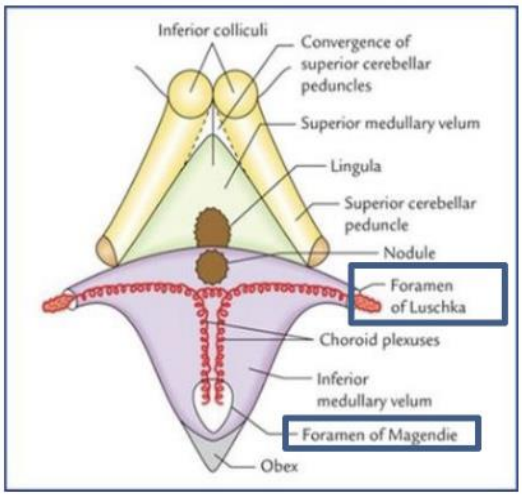
3) Subarachnoid space: between pia and arachnoid

- A true space and the most important one.Major blood vessels supplying the CNS pass through this space.

- It also has physiologic functions related to temperature,protection…etc.

-filled with CSF.

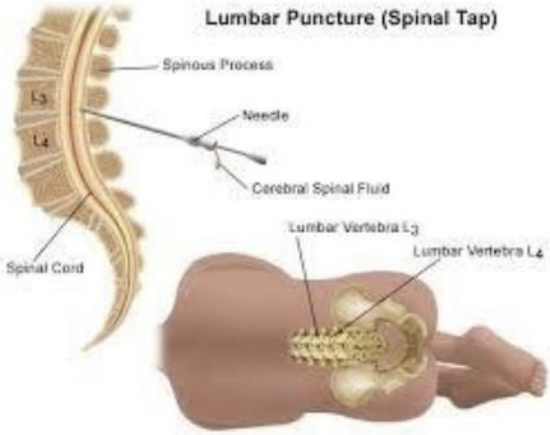
-The CSF circulates through the brain ventricles, centralcanal of the spinal cord, subarachnoid space.



- From the 4th ventricle, the CSF passes into the subarachnoid space through 4 openings: 1)the central canal of the spinal cord, 2+3) two lateral apertures (foramina of Luschka) and 4) single median aperture (foramen of Magendie).

- A sample of the CSF can be taken using a **lumbar puncture (**spinal tap). It is diagnostic (indicates infection, bleeding ,changes in CSF pressure).

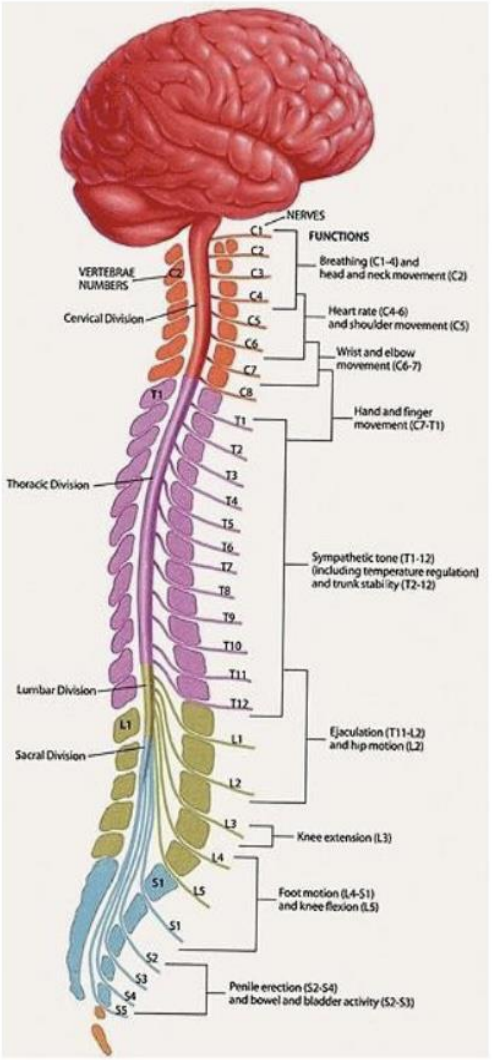
A lumbar puncture is safer anywhere between L2-S2 (nospinal cord) but the needle is usually inserted between L3-L4 at the level of the anatomical plane (supracristal line) because The space is wider and there is no spinal cord.



Spinal cord segment

A Segment is the place where a spinal nerve emerges from, and since we have 31 pairs of spinal nerves, there must be 31spinal segments.

-General rule: the spinal nerve will emerge under the corresponding Vertebra through the intervertebral foramen; T7 nerve emerges under the T7 vertebra, Except for the cervical nerves which emerge above the corresponding vertebra (C8 nerve emerges between C7 and T1 vertebrae.)



we mentioned that the spinal cord occupies only two thirds of the spinal canal; ending with theconus medullaris at the level of L1-L2. How come we have spinal nerves below this level?

The segments of the spinal cord <u>are not in line with the corresponding vertebrae</u> and the difference increases as we go downward, so the nerve roots increase in length as you godownward.

Look at the picture and notice the following:

To further clarify our point, this table shows the vertebrae and the segment in line witheach one:

Spinous process	Spinal cord segment
C7	C8
T3	T5
T9	T12
T10	L1-2
T11	L3-4
T12	L5
L1	S1-end

You may wonder: Why the spinal cord only fills two thirds of the canal?

Embryology answers: At first, it is actually filling the whole length of the canal, but eventually bony growth will override the spinal cord growth leaving a space between them.

AT The level of cervical vertebra we see some harmony but as we go down the roots increase in length and the difference increases(The difference between the spinal cord segments and the corresponding spinous processes)

Study this case: (this is extra you can skip it if you like)

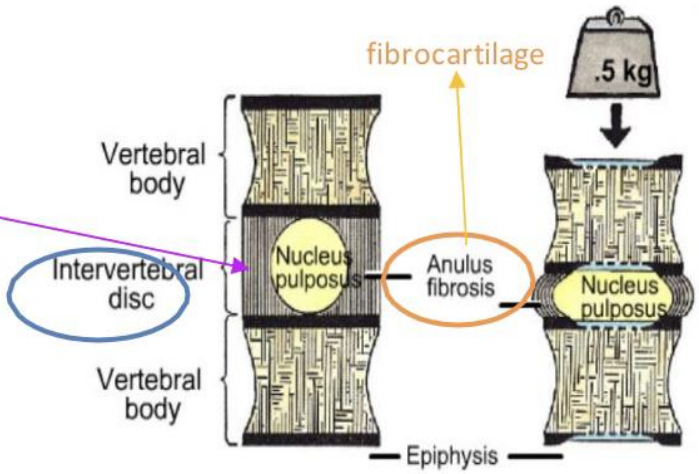
A 30-year-old female presented complaining of two months' worth of progressive low back pain and severe, radiating pain in the right lower extremity (sciatica). At the time of presentation, she reportedassociated numbness and weakness in her right lower extremity, particularly in her calf muscle. Her ability to ambulate and perform usual activities was severely impaired.

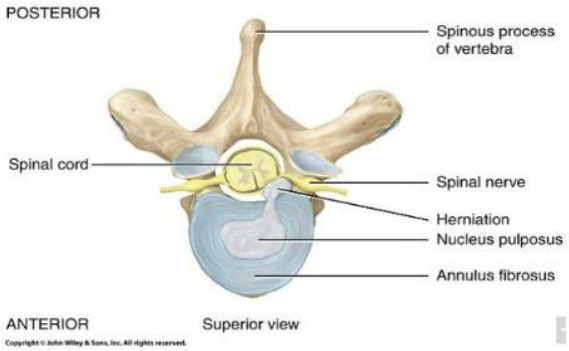
On examination, she was found to have reduced range of motion of her lumbar spine, positive sciatic nerve stretch testing, and measurable weakness in her calf muscle on the right side. Her gaitwas impaired, and she walked with a limp.

Herniated Disc/ ruptured disc/slipped disc

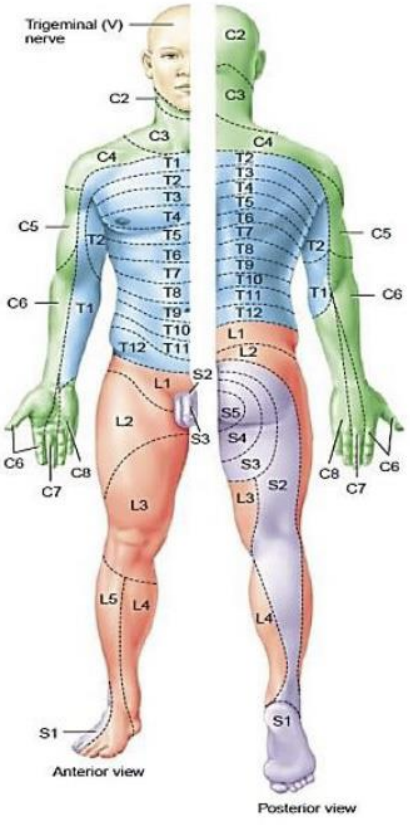
A herniated disc is a protrusion (leakage) of the gelatinous nucleus pulposus through the anulus fibrosus of an IV disc, usually as a result of heavy weight pressuring these discs.

If you look at the picture below, you'll see the hernia leaking in a **posterolateral direction**, which makes sense because it's where the annulus fibrosus is thinnest and weakest.





95% of herniated discs are the ones between L4/L5 or L5/S1.



Symptoms start when the herniated disc compresses the spinal nerve. But in order to understand the symptoms, we need to stop by the principle of dermatomes and myotomes:

A dermatome is an area of skin that is mainly supplied by a single spinal nerve.

A myotome is the group of muscles that a single spinal nerve innervates, for example,The biceps innervated By Musculocutaneous nerve or C6.

So, when a nerve is compressed by a herniated disc, we'll see weakness in the myotome and abnormal sensation in the dermatome supplied by this nerve, because every spinal

nerve has a sensory and a motor part. See the figure above for the distribution of dermatomes and their corresponding nerves.

Common lumbar disc problems

Disc	Root	Percentage	Motor weakness	Sensory changes	Reflex affected
L3-L4	L4	3-10%	Knee extension (Quadriceps femoris)	Anteromedial leg (saphenous)	Knee jerk
L4-L5	L5	40-45%	Big toe dorsiflexion (EHL) and (TA)	Big toe, Anterolateral leg (CPN)	Hamstring jerk
L5-S1	S1	45-50%	Foot planter flexion (Gastrocnemius)	Lateral border of foot (sural)	Ankle jerk (Achilles tendon)

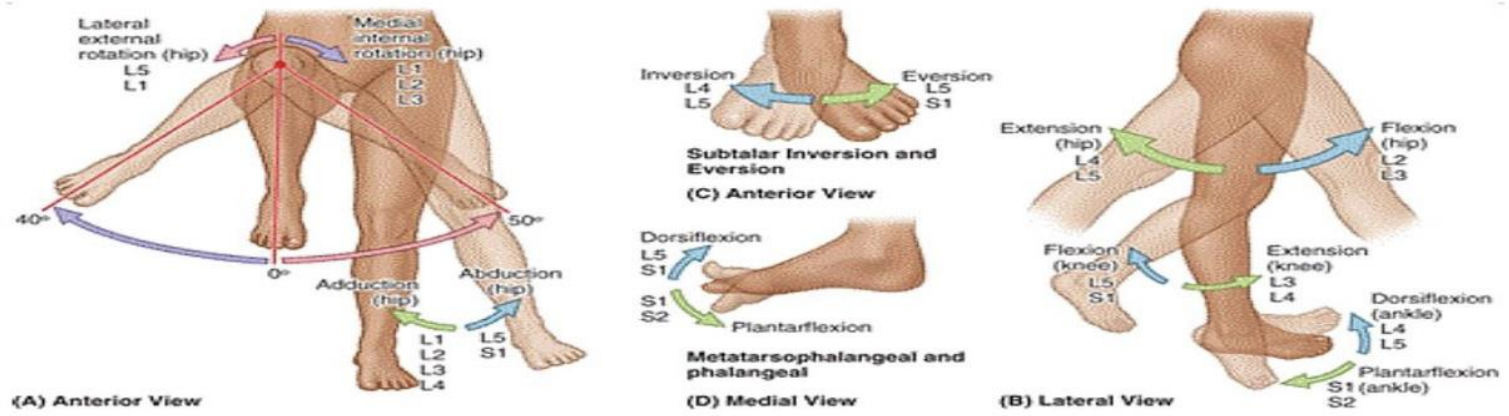
-EHL: external hallucis longus, TA: tibialis anterior, CPN: common peroneal nerve

-The doctor mentioned to Memorise the most commonly affected

Notes on this table:

- Motor weakness refers to the muscle actions affected. Shown between parentheses are the names of the muscles.
- Please be aware that the root value here is not the same concept as the nerve innervating the muscle. e.g. quadriceps femoris is innervated by the femoral nerve (L2, L3, and L4), however, an injury to the L4 spinal nerve will affect the quadriceps. And the same aspect applies to the sensory changes.
- Sensory changes refer to skin areas affected, and the nerves are shown between parentheses.
- Reflex affected is a test used to indicate the location of the injury.
- This table is very important, make sure you don't skip any part of it.

his picture shows the actions that you can test to help you figure out what nerve root is jured.

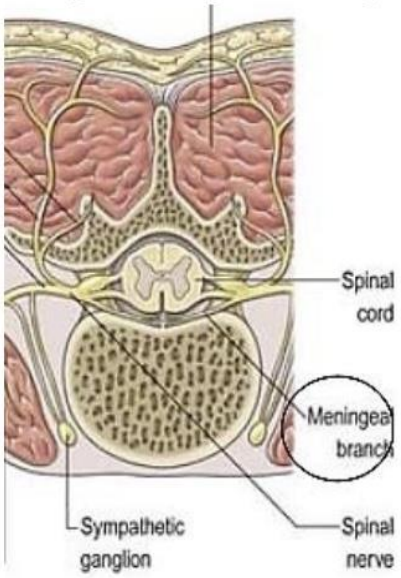


Test L5: by asking the patient to stand on his heels (dorsiflexion).

Test S1: by asking the patient to stand on his tiptoes (plantar flexion).

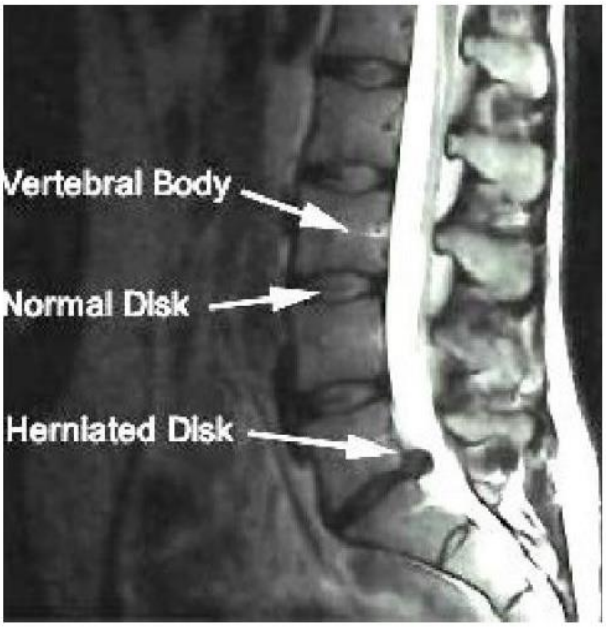
Major symptoms of Disc herniation

The symptoms we discussed earlier are surely important, however, patients often only present with one major symptom which is **low back pain,** radiating to the gluteal region, the back of the thigh and back of the leg.



As you can see in this picture, spinal nerves give a meningeal branch (recurrent) that brings sensation from the dura matter, which is sensitive to stretch. When a herniated disc compresses the nerve, it'll compress the meningeal branch as well, causing diffused pain or numbness due to overlapping dermatomes.

Straight Leg Raise Test (SLR): Flexing the hip joint while extending the knee causes pulling of the sciatic nerve (L4-S3) and pressure on the nerve root. This test is commonly used to check for disc herniation.



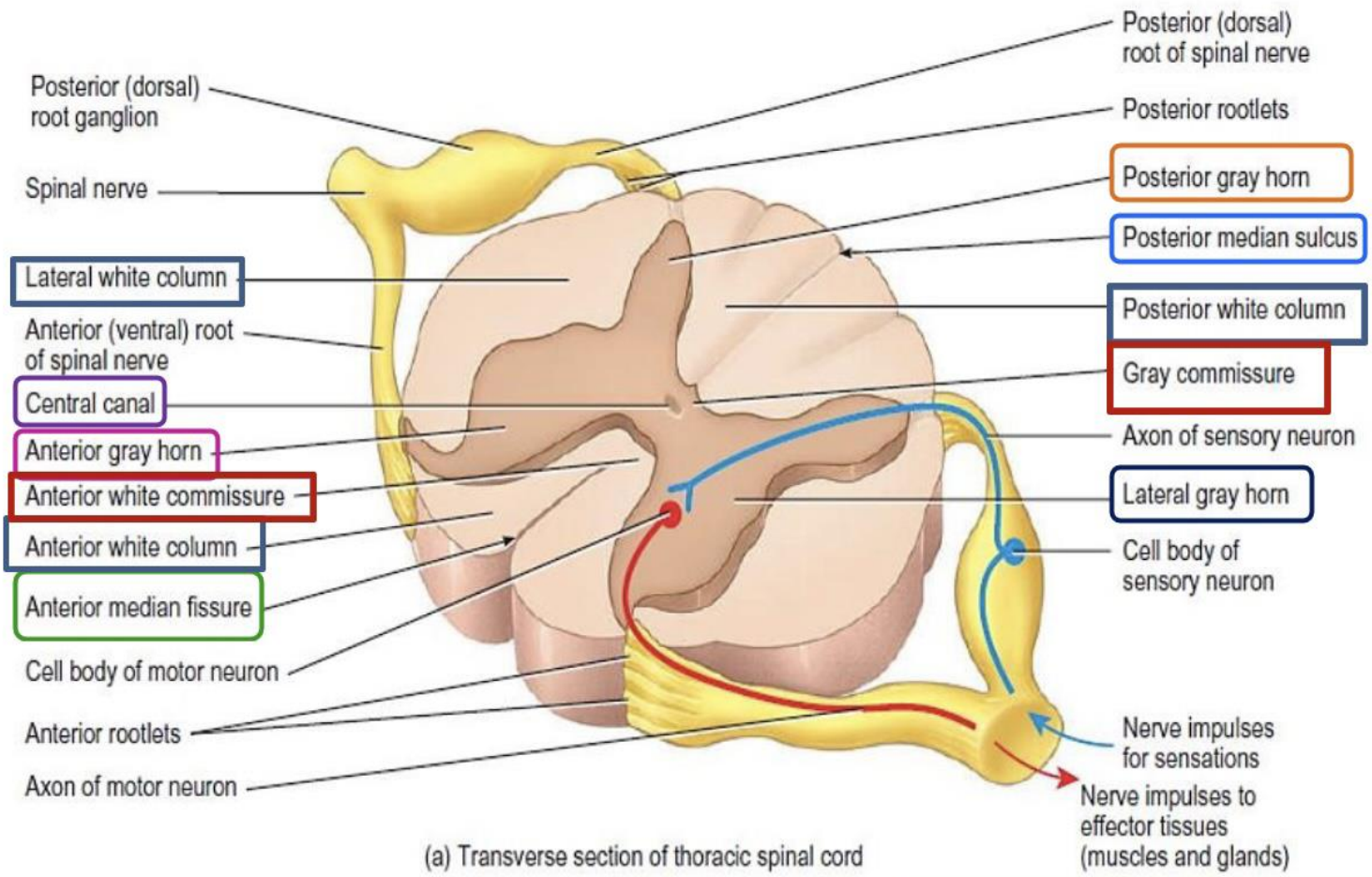
While all the maneuvers and tests above may help you diagnose disc hernia, nothing's as brilliant as a beautiful MRI to confirm the diagnosis of a herniated disc.

Now, you can go back to our case earlier and apply the symptoms of the patient to what we've discussed sofar. For diagnosis, treatment and more information: https://www.stiebermd.com/case-studies/lumbar- herniated-disc/

Cross-section of spinal cord

The spinal cord is divided into white matter and gray matter, and the white matter is further divided to columns/funicului; lateral, posterior, and anterior, while the gray matter is dividedinto horns.

1. White matter: neuronal dendrites and axons
   a. Anterior median fissure: a wide groove on the anterior aspect (deeper than the sulcus).
   b. Posterior median sulcus: a narrow groove on the posterior aspect.



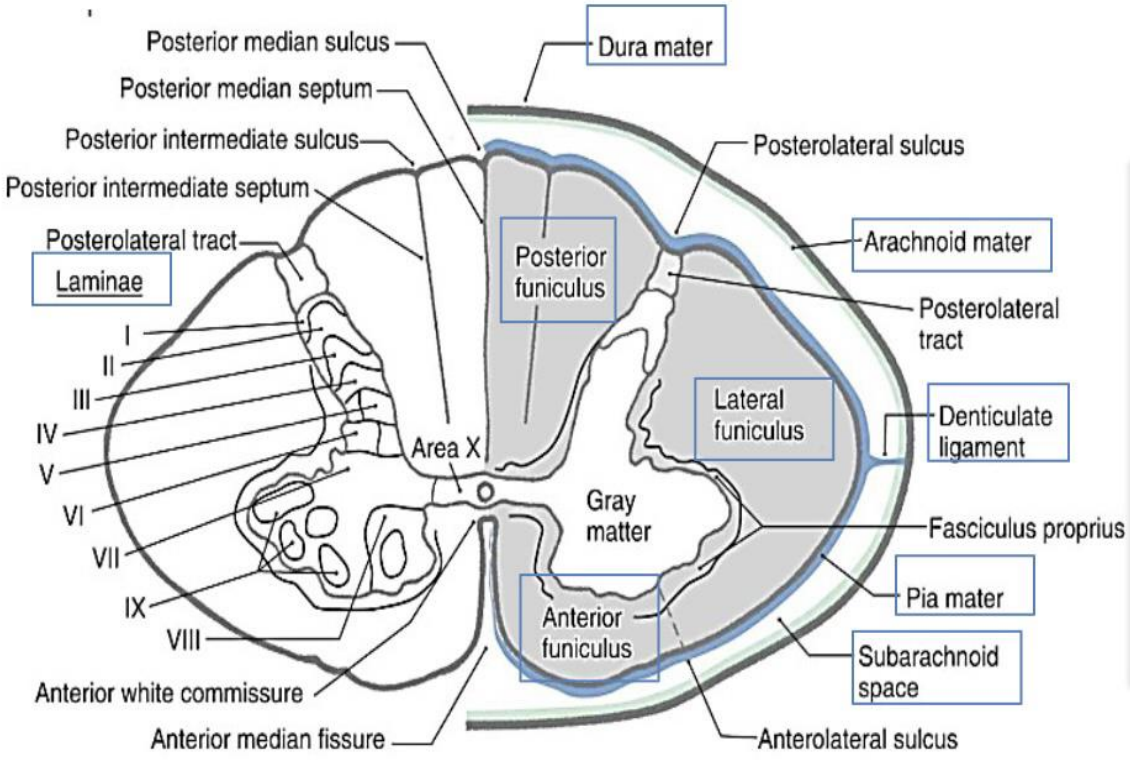
(a) Transverse section of thoracic spinal cord

Don't confuse this with the dorsal root ganglia that has the cell bodies of sensory neurons

2. Gray matter (neuronal cell bodies, dendrites, axons):

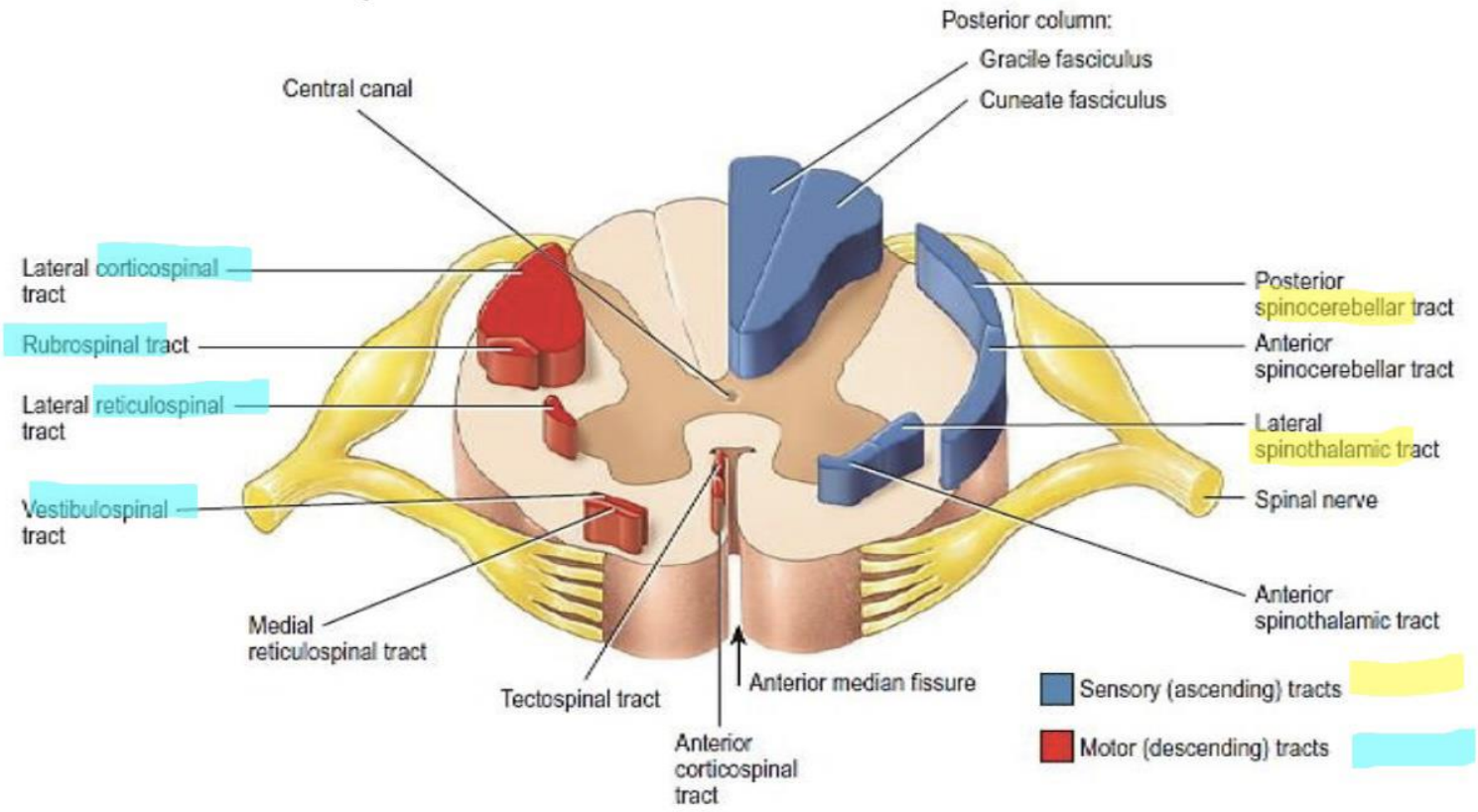
a. Posterior (dorsal) horn; collection of neuronal cell bodies of the sensory system.
b. Anterior (ventral) horn; collection of motor neuronal cell bodies of skeletal muscles.
c. Lateral horn (autonomic); collection of preganglionic motor cell bodies (to cardiac muscles, smooth muscles, and glands). However, this horn doesn't exist in all segments (thoracic segments ,L1-L2, Sacral segments)

In the center of the gray horn, there is a central canal that contains the CSF and is linked to the 4th ventricle in the brain.



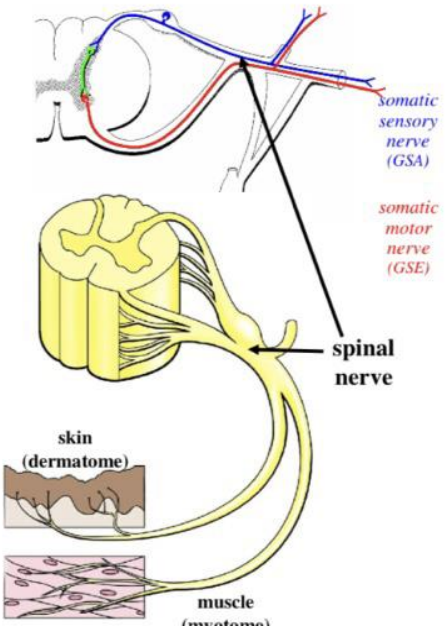
In this picture, please notice the meninges layers, the columns (faniculi) of the white matter, and the laminae of the gray matter. And please don't confuse the white matter and gray matter depending on this graph's colors.

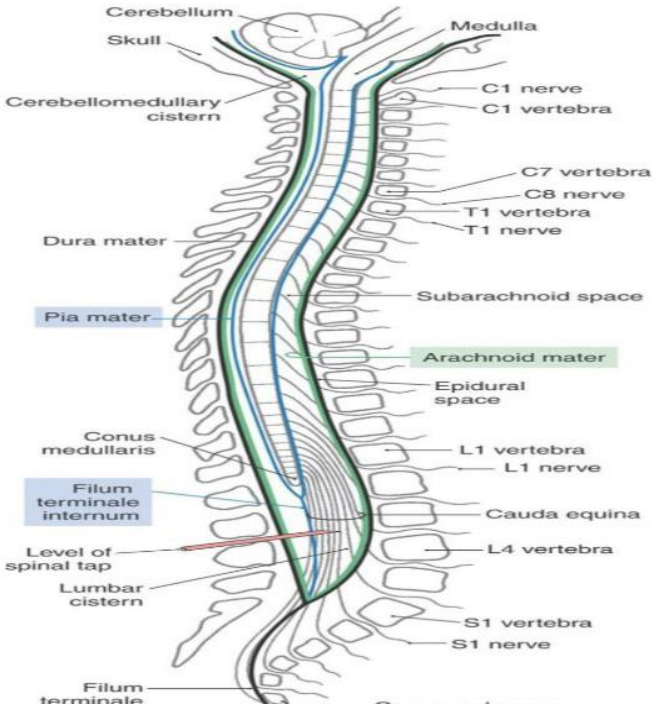
- Lamina VI Forms the base of the dorsal horn
- Lamina VIII & IX have motor function(have the cell budies of lower motor neurones)
- Lamina X surrounding the central canal which is called gray commissure
- Commissure: connects the right side to the left side



The white matter, consists of the axons and processes of the neurons, and in the CNS we call them tracts. These tracts in the spinal cord are divided according to the direction of the signal into ascending (sensory) tract and descending (motor) It makes senseas the sensory signal needs to ascend to the brain and motor signal will descend from the brain. And not just that, the ascending and descending tracts are also subdivided.

*Pictures I couldn't add with the texts:





يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ وَاللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ