Lecture 2
Anatomy of the spinal cord pt 1

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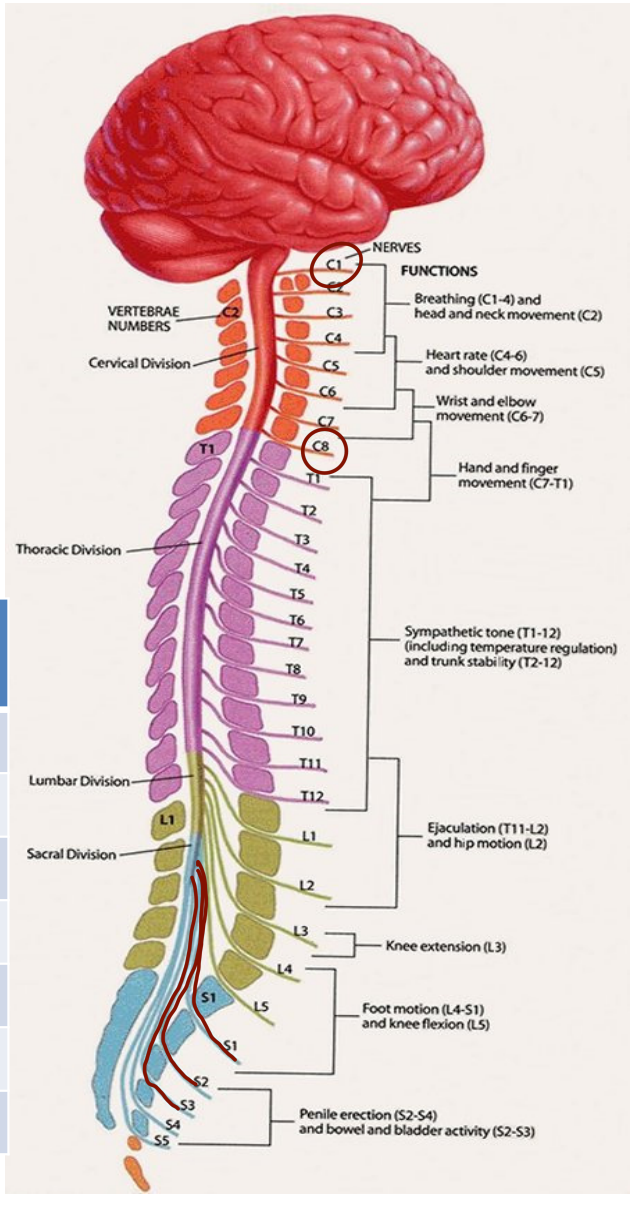
Spinal cord segment

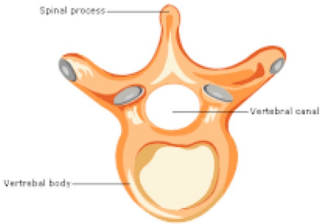
- The segments of the spinal cord are not in line with the corresponded vertebrae and the difference increases as we go downward.
- The roots increase in length as you go downward.
- Every spinal nerve emerges from the spinal column through the intervertebral foramen under its corresponding vertebra
- first 7 cervical nerves pass above their corresponding vertebrae

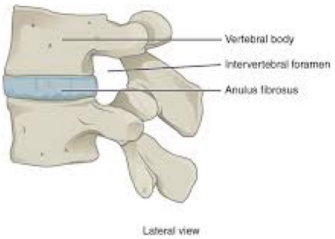
Spinous process	spinal cord segment
C7	C8
T3	T5
T9	T12
T10	L1-2
T11	L3-4
T12	L5
L1	S1-end



* The spinal cord has 31 segments and each segment gives the rise of one spinal nerve on each side so there are 31 pair of spinal nerves.
* The spinal cord occupies the upper two third of the vertebral canal because the bone growth during development will bypass the growth of the spinal cord (ends at the level of L_1/L_2)meaning that the lower spinal nerves have long route ,So as we go down the spinal segment doesn't line with the corresponding vertebrae (the spinal segment of the spinal nerve s_3 is located above the s_3 vertebrae)
* the spinal cord is located at the vertebral canal
* the spinal nerves leave the spinal cord through the intervertebral foramen which is located under the corresponding foramen Spinal segment T_2 gives the right and left spinal nerves T_2 that leave the spinal cord via the intervertebral foramen below T_2
* this rule is applied to all spinal nerves except the cervical nerves

C_1 leaves above C_1
C_2 leaves above C_2
C_8 leaves below C_8 (ABOVE T_1) because we only have 7 cervical vertebras but we have 8 cervical segments and 8 cervical nerves

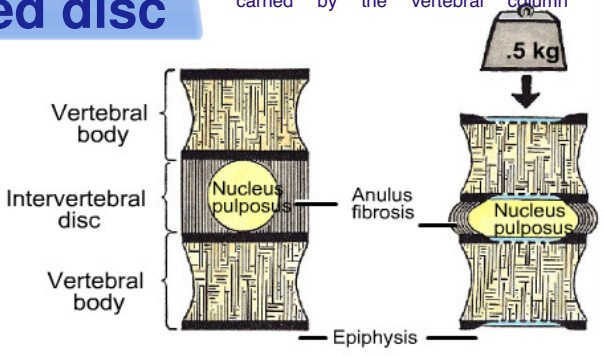




Lateral view

Herniated Disc/ ruptured disc/ slipped disc

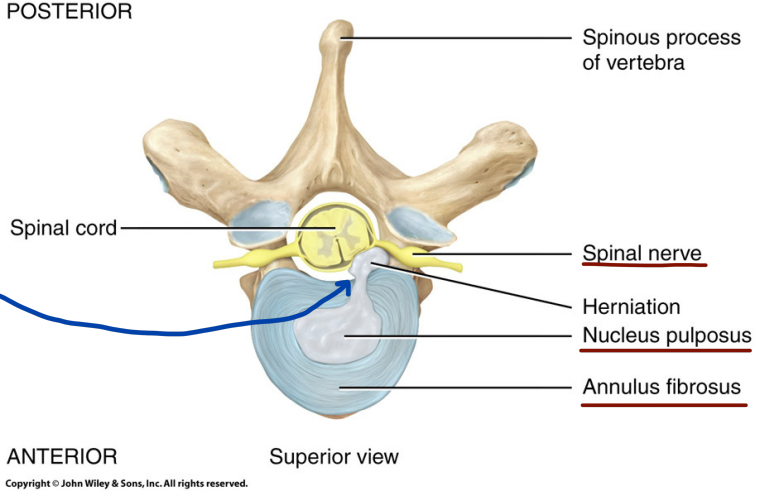
* 70% of body weight is carried by the vertebral column



protrusion (leakage) of the gelatinous nucleus pulposus through the anulus fibrosus of IV disc

Posterolateral direction:

Thinner annulus fibrosus



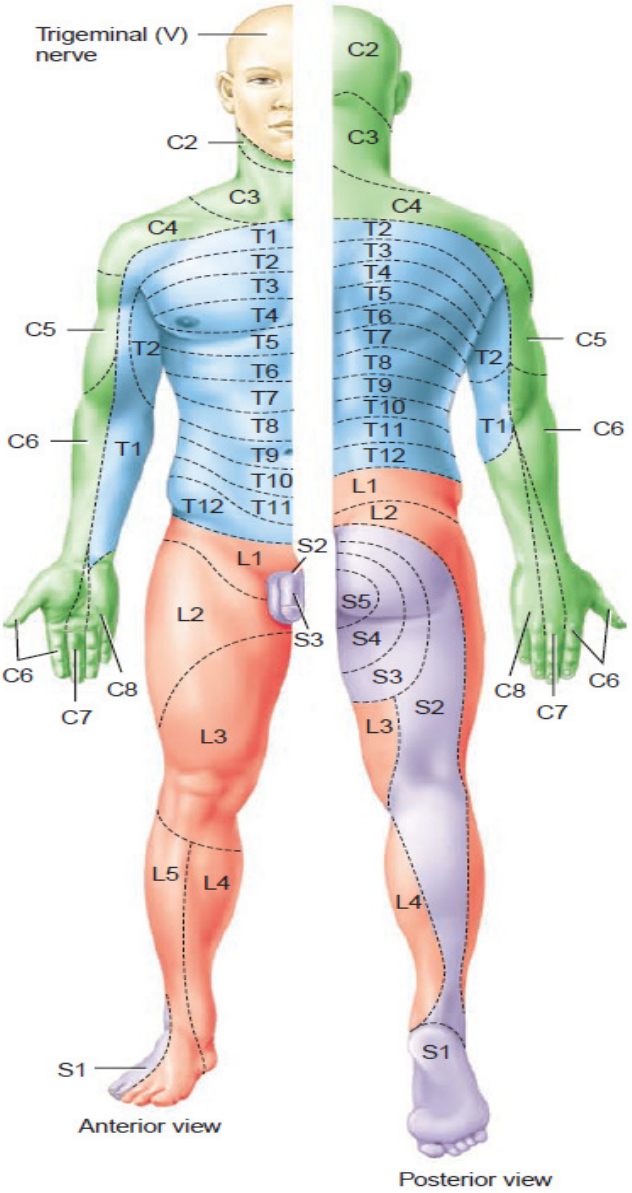
95% in L4/L5 or L5/S1

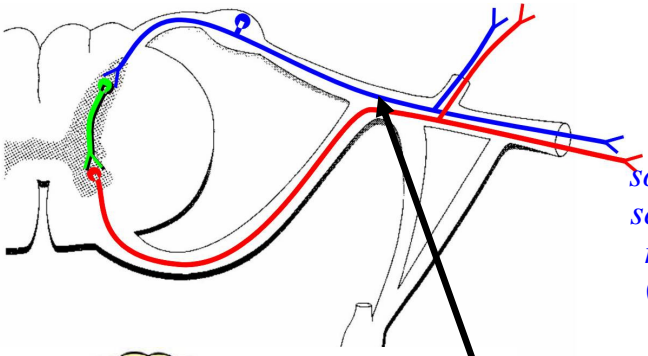
Between each two vertebras there is intervertebral disc that consist of outer annulus fibrosis and inner nucleus pulposus.

* the weakest part of the annulus fibrous is the posterior lateral part so any over pressure on the intervertebral disc leads to the herniation of the posterior lateral part.
* the herniation will exert pressure on the spinal nerve..... 95% of the herniation occurs either between L_4/L_5 OR L_5/S_1

Note how the spinal nerves leave through the vertebral foramen

* each spinal nerve have dorsal and ventral root then they meet together to form one mixed spinal nerve





somatic sensory nerve (GSA)

somatic motor nerve (GSE)

spinal nerve

skin (dermatome)

muscle (myotome)

Each nerve (a collection of processes at the PNS) have a root value
So always ask your self (from which roots this nerve originate from?) and by knowing the roots you will know the segments.

Dermatome

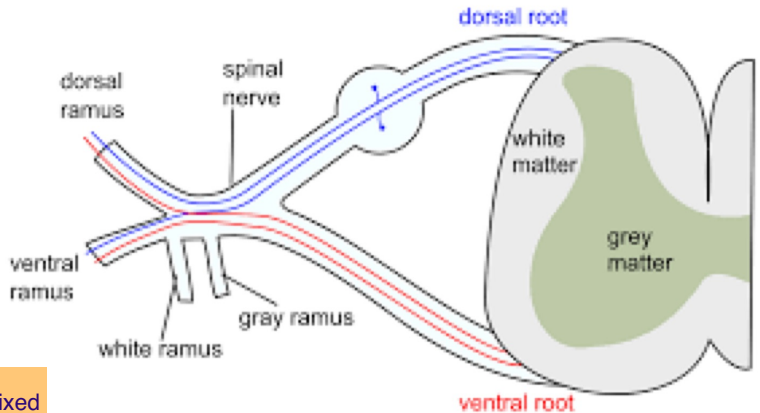
a single area of the skin that is supplied by the sensory fibers of a single spinal nerve

Myotome

a group of muscles supplied by the motor fibers of a single spinal nerve

To understand the symptoms of the herniated disc

When a disc herniate it will compress a specific root according to the location of the herniated disc , by compressing that root the motor and sensory function and the reflex action related to that nerve will be affected because each nerve has anterior (ventral) motor root and posterior (dorsal) sensory root



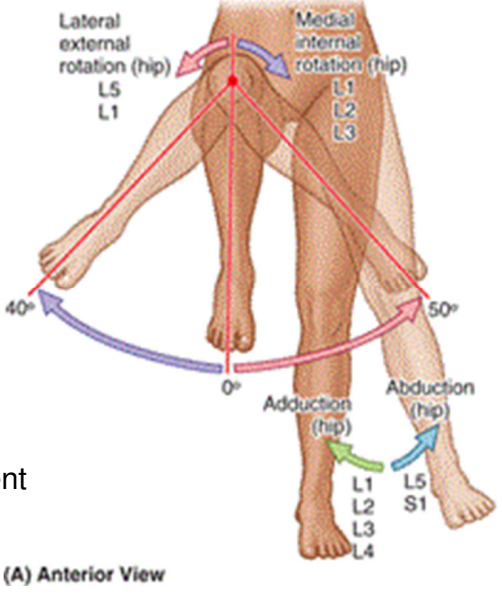
The spinal nerve is a mixed nerve

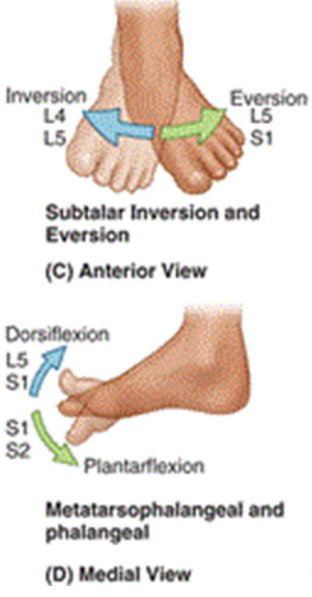
Common lumbar disc problems

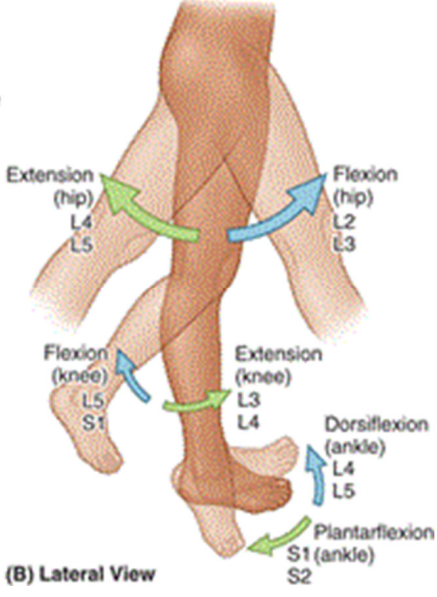
Disc	Root	Percentage	Motor weakness	Sensory changes	Reflex affected
L3-L4	L4	3-10%	Knee extension (Quadriceps femoris	Anteriomedial leg (saphenous)	Knee jerk
L4-L5	L5	40-45%	Big toe dorsifelxion (EHL) and TA	Big toe , anteriolateral leg (Common P)	Hamstring jerk
L5-S1	S1	45-50%	Foot planter flextion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

Important myotomes of lower limb

- **Test L5**: by asking the patient to stand on his heels
- **Test S1**: by asking the patient to stand on his tiptoes

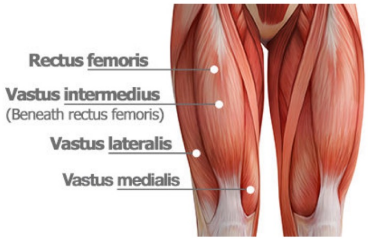






Disc	Root	Percentage	Motor weakness	Sensory changes	Reflex affected
L3-L4	L4	3-10%	Knee extension (Quadriceps femoris	Anteriomedial leg (saphenous)	Knee jerk

By tapping the hummer On the patellar tendon that normally result in knee extention



* The quadriceps femoris at the anterior compartment of the thigh is innervated by the femoral nerve
* If the disc between the L_3 /L_4 herniate ,the L_4 root mainly is the affected root

And as we said every root have sensory fibers and motor fibers , a sensory changes related to specific dermatome and a motor function related to specific myotome will be affected

(Motor function is knee extension)

(Sensory function of anteriomedial leg)

L4-L5	L5	40-45%	Big toe dorsifelxion (EHL) and TA	Big toe , anteriolateral leg (Common P)	Hamstring jerk

extensor hallucis longus at the anterior compartment of the leg responsible for the big toe extension (dorsiflexion)

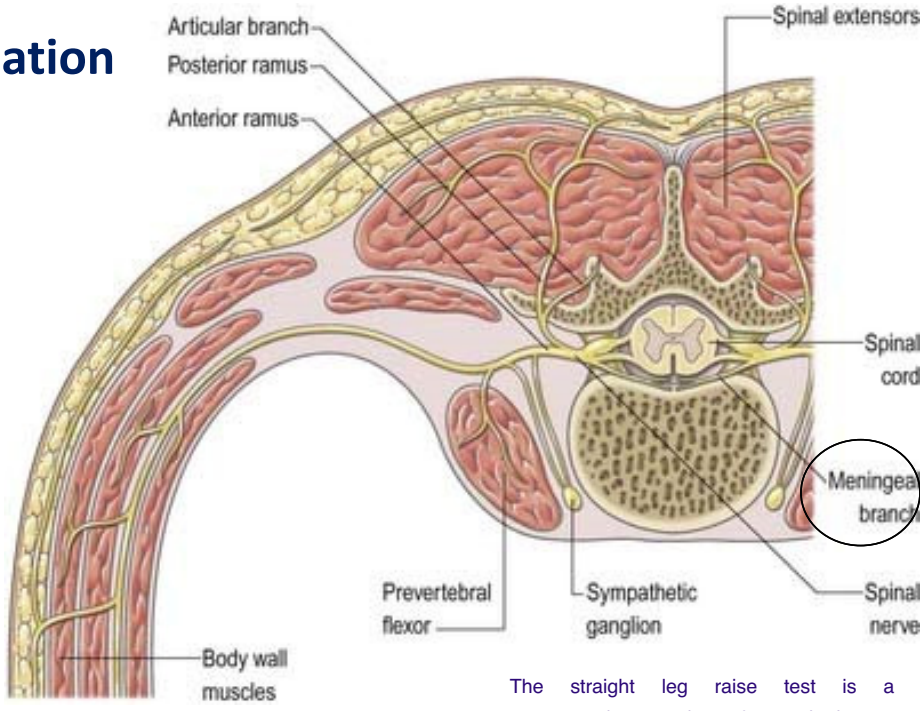
L5-S1	S1	45-50%	Foot planter flextion (Gastrocnemius)	Lateral border of foot (sural)	Ankle jerk

Asking the patient to stand on his tiptoes ..... you are testing the integrity of the planter flexion .... so you are testing the S_1 root

Asking the patient to stand on his ankle ...yo are testing the integrity of the dorsiflexion.... so you are testing the L_5 root

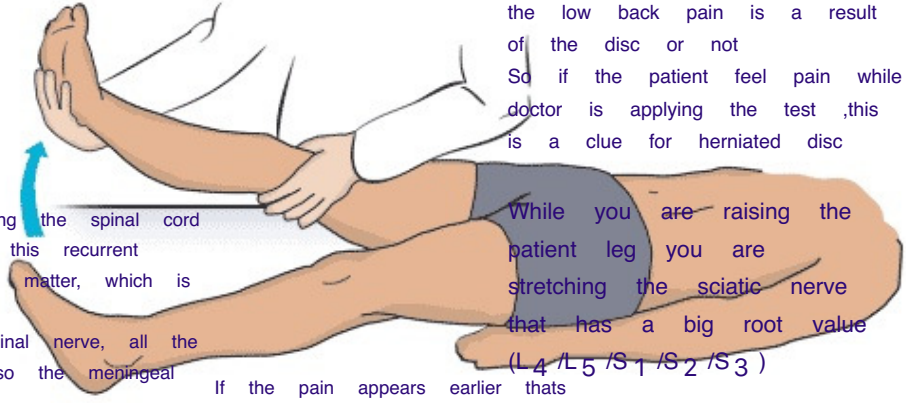
Major symptoms of disc herniation

- **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)**



the spinal nerve gives a recurrent branch after leaving the spinal cord called meningeal branch or the recurrent branch and this recurrent branch is responsible for the innervation of the Dura matter, which is the outermost layer of the spinal cord
So as the herniated disc apply pressure on the spinal nerve, all the branches of the spinal nerve will be affected too, so the meningeal branch is one of the branches that will be affected

The straight leg raise test is a test used to determine whether the low back pain is a result of the disc or not
So if the patient feel pain while doctor is applying the test ,this is a clue for herniated disc

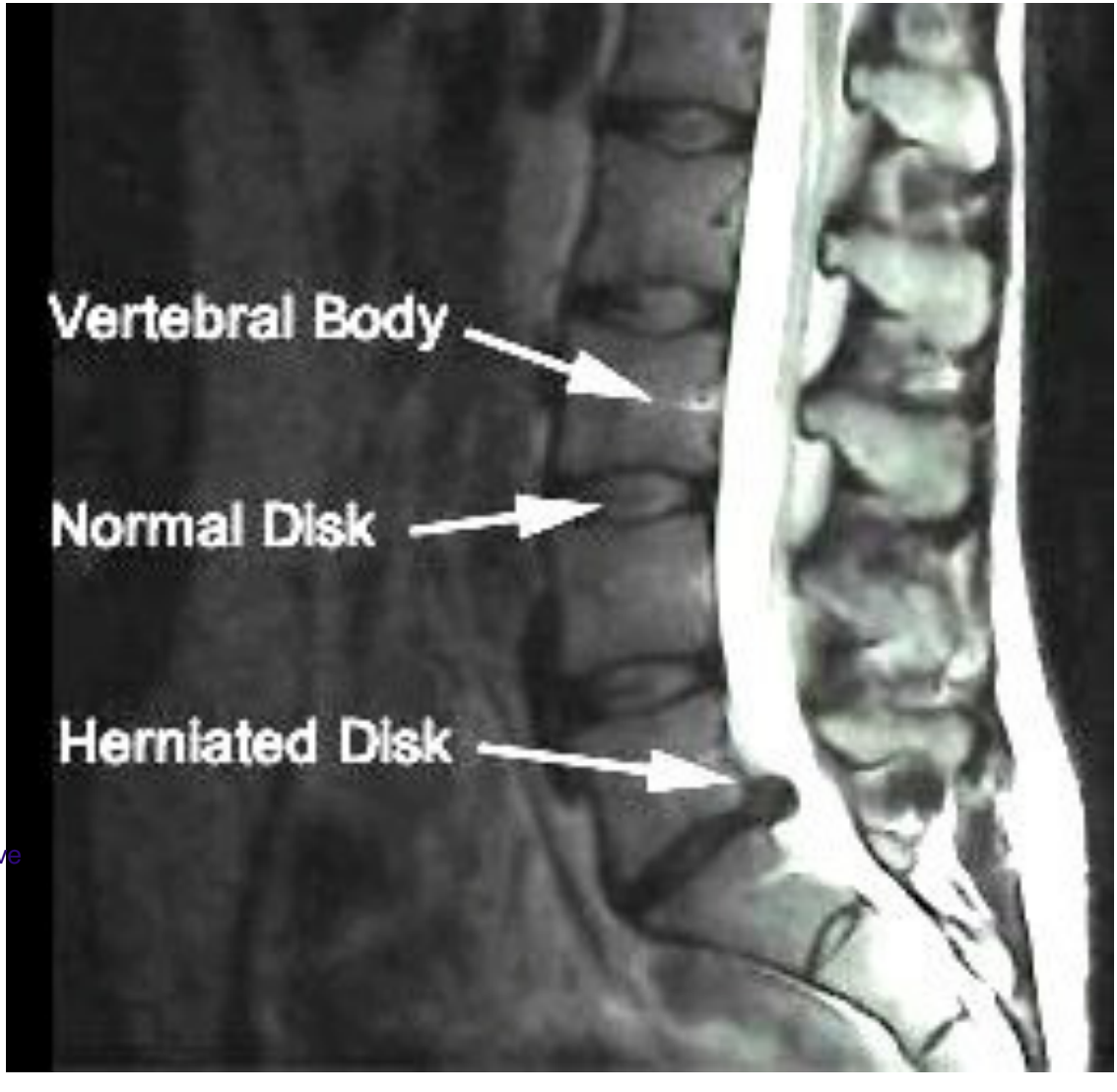


While you are raising the patient leg you are stretching the sciatic nerve that has a big root value ($L_4/L_5/S_1/S_2/S_3$)

If the pain appears earlier thats mean the type of disc that this patient has is worser

- MRI is commonly used to aid in making the diagnosis of a herniated disc

So you patient comes with the previous symptoms and low back pain and when applying SLR test the pain appears ,do MRI to give a definitive diagnosis



Cross Section of Spinal Cord

The inner gray matter is divided into horns

And the outer white matter is divided into columns(funiculus)

- Anterior median fissure:

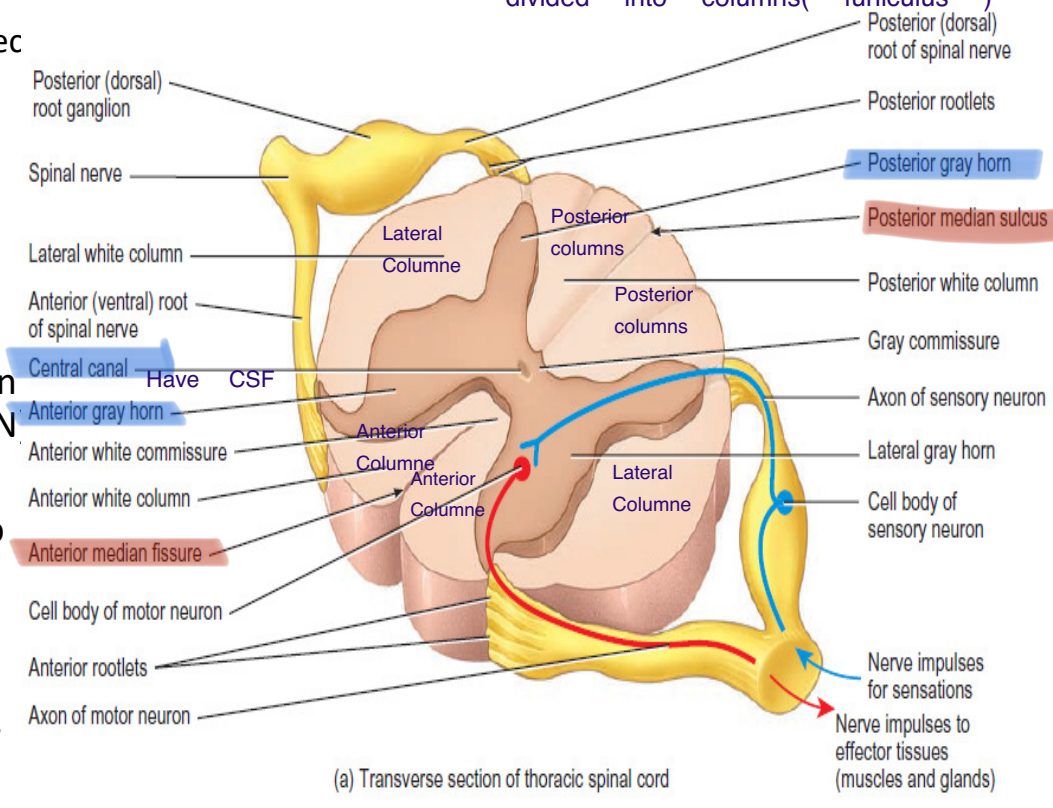
wide groove on the Anterior aspec

- posterior median sulcus:

Narrow groove on the posterior aspect

- Gray matter: neuron cell bodies, dendrites, axons
  - Divided into *horns*
  - **Posterior** (dorsal) horn (cell body of sensory N
  - **Anterior** (ventral) horn (cell body of motor N to skeletal M)
  - **Lateral** horn (cell body of motor N to cardiac M, smooth M, glands)

* The lateral horn of the gray matter doesn't appear in all segment



(a) Transverse section of thoracic spinal cord

Cross Section of Spinal Cord

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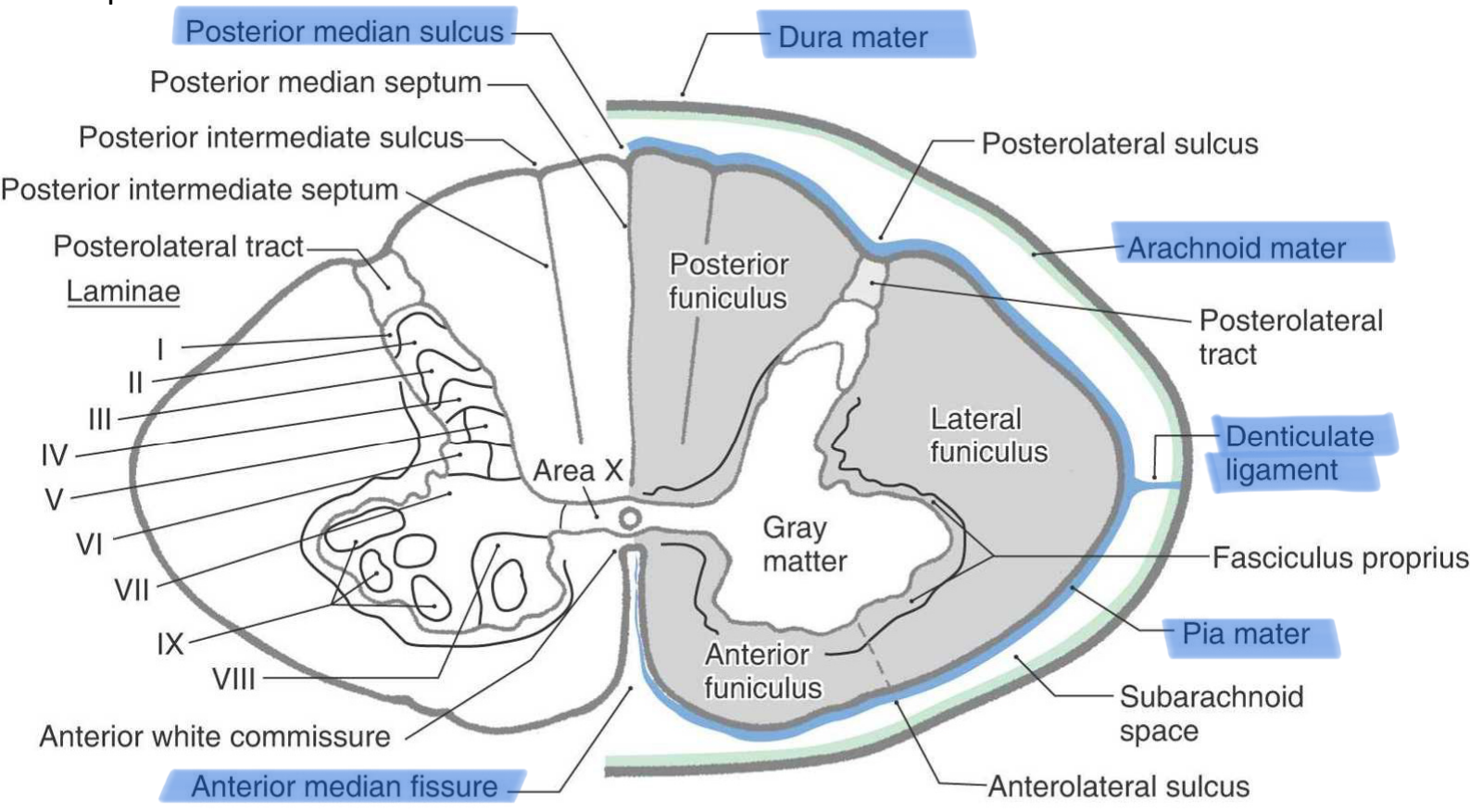


The gray matter is divided into 10 laminas

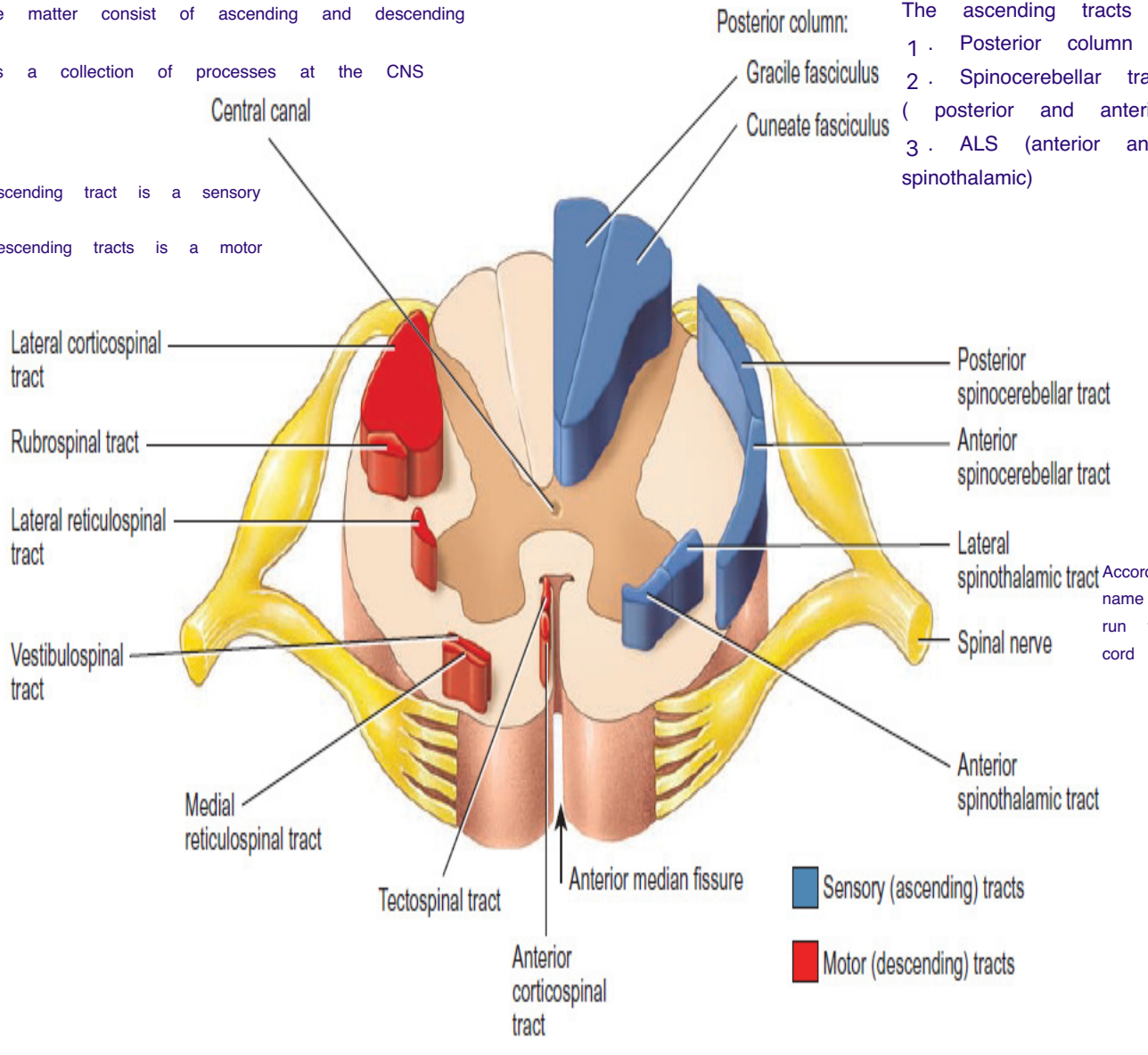
The white matter consist of ascending and descending tracts

* tract is a collection of processes at the CNS

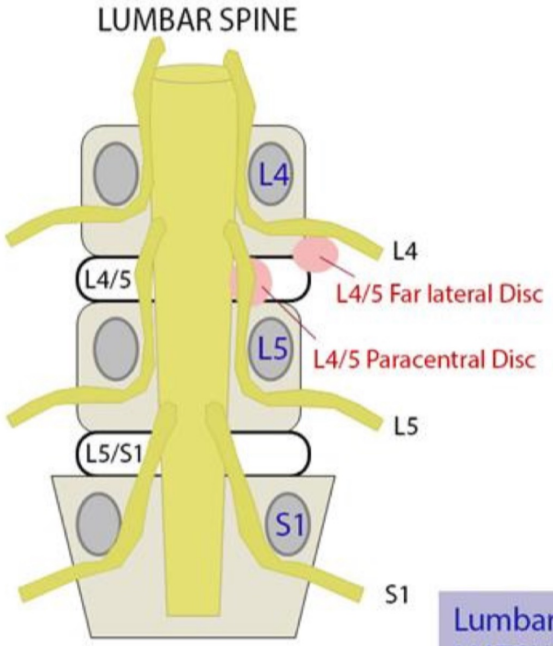
* The ascending tract is a sensory tract
* The descending tracts is a motor tract

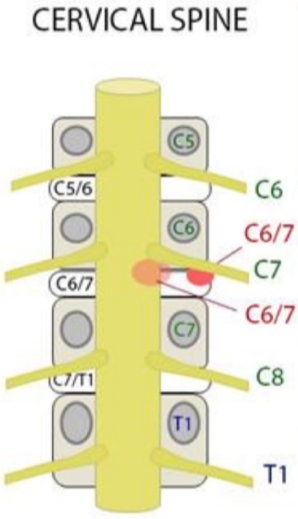
The ascending tracts are:

1. Posterior column
2. Spinocerebellar tract (posterior and anterior)
3. ALS (anterior and lateral spinothalamic)



According to its name , the tract run from the spina cord to the thalam





Both discs affect same nerve root in cervical spine, different than lumbar spine

C8 and above Pedicle / Nerve Root MISMATCH

"Extra C8 Nerve Root (without C8 pedicle) allows transition from MISMATCH to MATCH

T1 and below Pedicle / Nerve Root MATCH

Lumbar Spine Pedicle/nerve Root MATCH

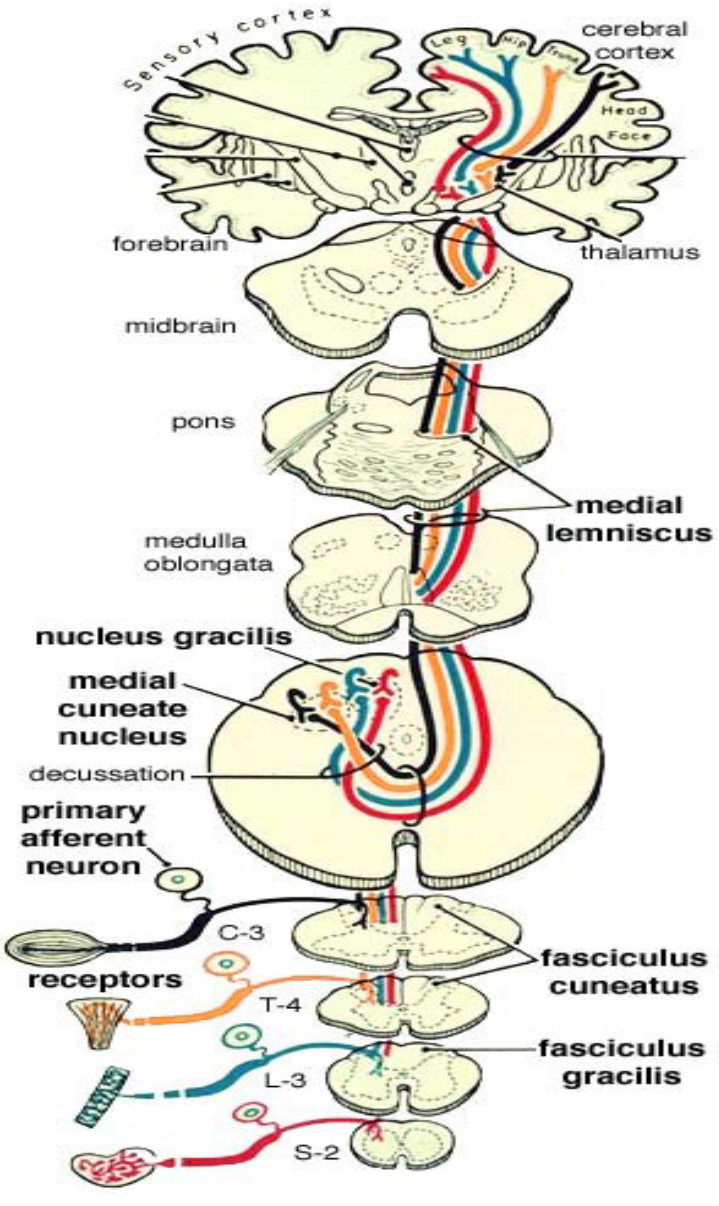
Posterior White Column-Medial Lemniscal Pathway

- Modality: Discriminative Touch Sensation (include Vibration) and Conscious Proprioception
- Receptor: Most receptors except free nerve endings
- Ist Neuron: Dorsal Root Ganglion
- 2nd Neuron: Dorsal Column Nuclei (Nucleus Gracilis and Cuneatus)

---Internal Arcuate Fiber - Lemniscal Decussation

---Medial Lemniscus

- 3rd Neuron: Thalamus (VPL) Internal Capsule ----- Corona Radiata
- Termination: Primary Somesthetic Area (S I)



Modality: is the type of sensation in which each type of tact respond to.

* in case of posterior white column , the modalities are discriminative touch and conscious proprioception (muscle joint sense or sense of position)

(More explanation of the proprioception):

The skeletal muscles (effectors) consist of spindle fibers , theses spindle fibers have sensory receptors that are responsible for continuous backing of data to the cerebral cortex to be aware for your body position without looking

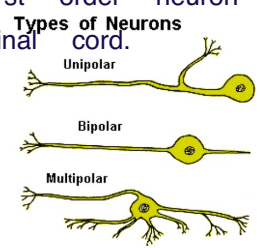
* also you must know the type of receptors that receive that type of modality

* the perception of any modality occurs when the signal reaches the cerebral cortex

(To understand the first,second,and third order neuron look for this example :)

to trace how the signal will be transmitted from achilles tendon , there are three types of neuron :

1) first order neuron is the neuron whose peripheral processes are located at the achilles tendon and the cell body is located at the dorsal root ganglia (a collection of cell bodies outside the CNS) (they are pseudo-unipolar ganglia in which one process that emerge from the cell body will divide later into central and peripheral processes) the peripheral process goes to receptors and the central process enter the spinal cord and run in the posterior white column (no synapsing of the first order neuron at the dorsal root ganglia and no decussation at the level of the spinal cord.



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