

Brain

ترتيب embryology, developmental

•Forebrain:

(Prosencephalon)

• Cerebrum:

(Telencephalon) >

(Telen=outer"بعيد")

• Diencephalon > (Dien=مركزي)

• Thalamus

• Hypothalamus

• Epithalamus

• Subthalamus

• Midbrain:

(Mesencephalon)

• Hindbrain:

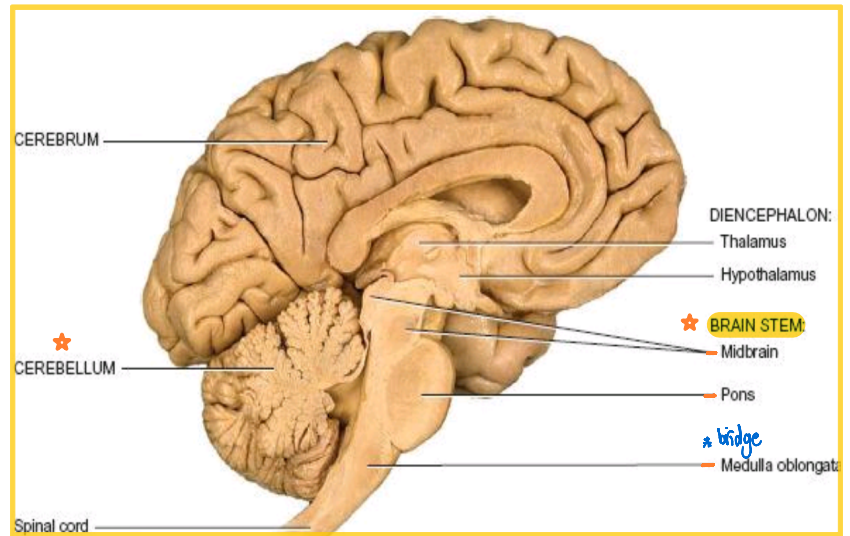
(Rhombencephalon)

• Pons

• Medulla oblongata

• Cerebellum

Mid sagittal section



Peripheral Nervous System

_Responsible for communication between the CNS and the rest of the body.

_Can be divided into:

•Sensory Division

ΔAfferent division الأاخر

-Conducts impulses from receptors to the CNS

-Informs the CNS of the state of the body interior and exterior

-Sensory nerve fibers can be **somatic** (from skin, skeletal muscles or joints) or **visceral** (from organs within the body cavity) (viscera of the abdomen+thorax)

•Motor Division

ΔEfferent division

-Conducts impulses from CNS to effectors (muscles/glands)

-Motor nerve fibers

(voluntary)

Somatic nervous system

1) Sensory neurons: (somatic sensory neurons)

• convey information to the CNS from sensory receptors in the skin, skeletal muscles, and joints, and from the receptors for the special senses. → taste, vision, olfaction

2) Motor neurons: (somatic motor neurons)

-VOLUNTARY

-conduct impulses from the CNS to skeletal muscles

(involuntary)

Autonomic nervous system

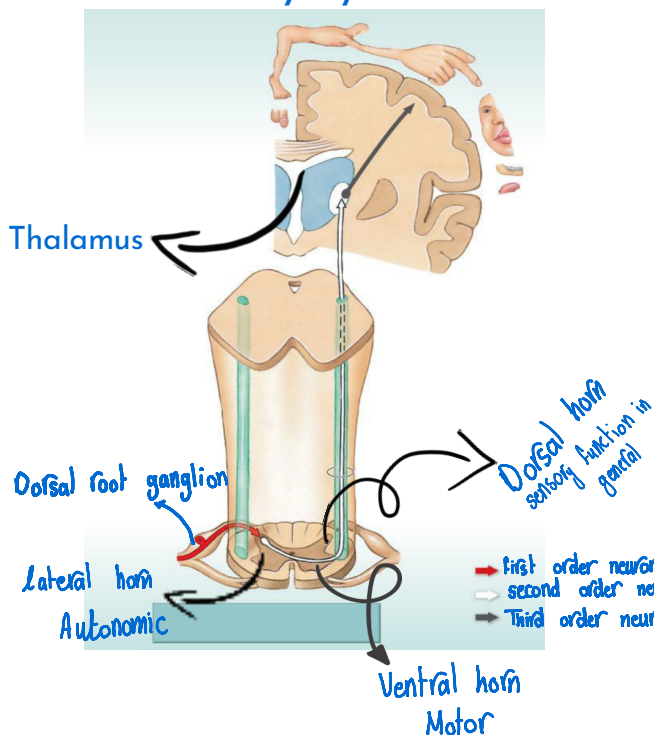
1) Sensory neurons:Autonomic (visceral) sensory neurons convey information to the CNS from autonomic sensory receptors, located primarily in the visceral organs (smooth muscle organs in the thorax, abdomen,and pelvis)

2) Motor neurons:Autonomic motor neurons

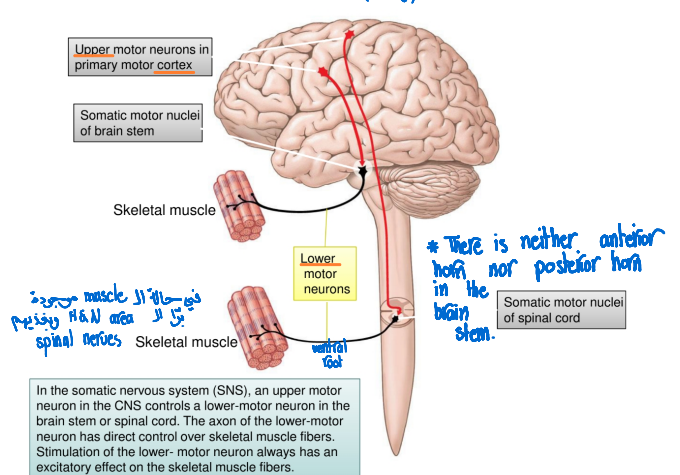
-INVOLUNTARY (generally)

-Conducts impulses from the CNS to smooth muscle, cardiac muscle, and glands.

sensory system

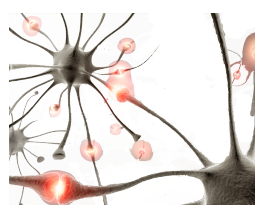


motor system (from cortex to effector) somatic (CNS)

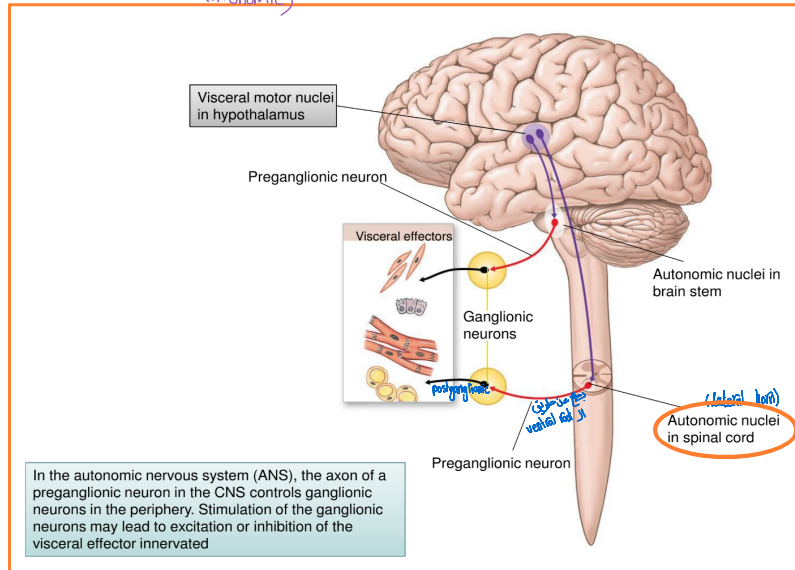


* notice how the signal came from one side and along its course, it went to the opposite side, this is called decussation (axons crossing the midline to opposite)

* why did we need more than one neuron? this provides a chance for neuro modulation, regulation of these pathways

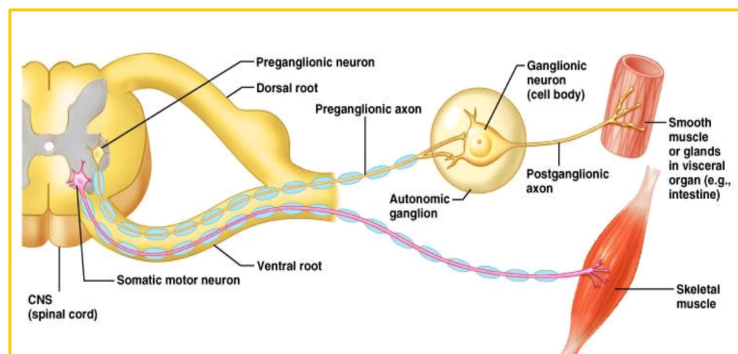


Autonomic

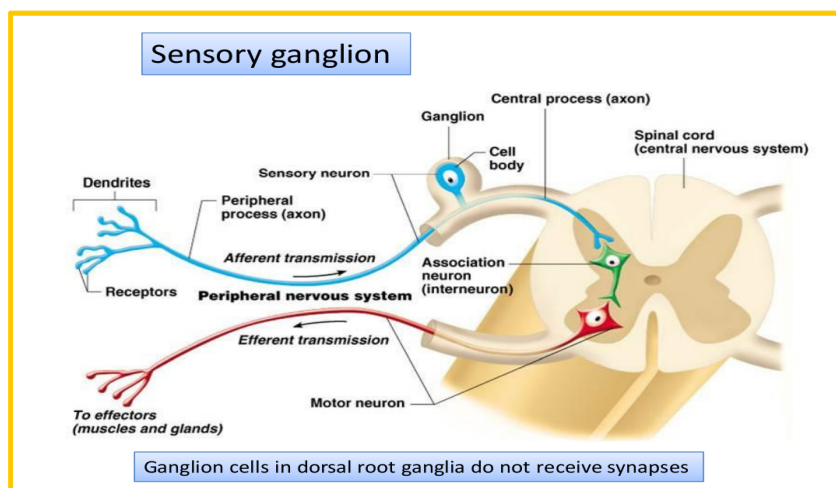


- Axon of 1st (preganglionic) neuron leaves CNS to synapse with the 2nd (ganglionic) neuron.
- Axon of 2nd (postganglionic) neuron extends to the organ it serves.

Diagram contrasts somatic (lower) and autonomic:



Note: the autonomic ganglion is **motor**.



External anatomy of Spinal Cord

- Runs through the vertebral canal
- Extends from foramen magnum to second (between L1&L2) lumbar vertebra

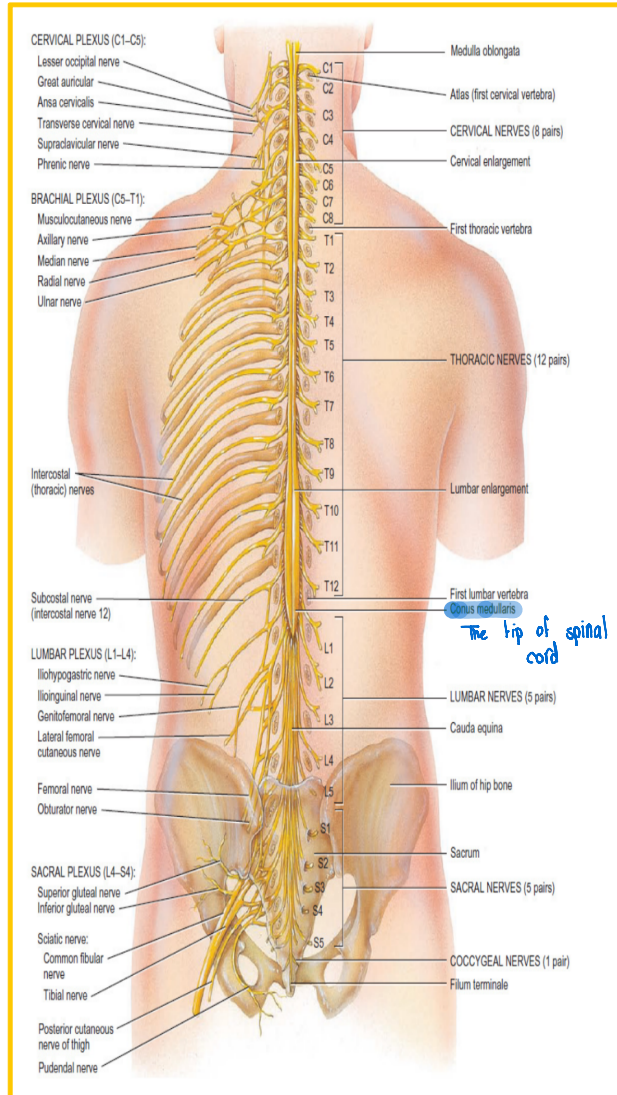
•Regions

- Cervical (8)
- Thoracic (12)
- Lumbar (5)
- Sacral (5)
- Coccygeal (1)
- Gives rise to (31) pairs of spinal nerves

-All are mixed nerves (all of them have ventral "motor" root and dorsal "sensory" root)

•Not uniform in diameter

- Cervical enlargement: supplies upper limbs
- Lumbar enlargement: supplies lower limbs



•Flattened slightly anteriorly and posteriorly

•length of the adult spinal cord ranges from 42 to 45 cm

•Conus medullaris - tapered inferior end (conical structure)

- Ends between L1 and L2

•Cauda equina - origin of spinal nerves extending inferiorly from conus medullaris.

* التركيز على Conus medullaris و Cauda equina

* 2/3 of vertebral canal are occupied by the spinal cord

* why the spinal cord fills 2/3 of canal ?

embryologically: at first, it is filling the whole length of the canal, but eventually bony growth will override the spinal cord growth leaving a space between them

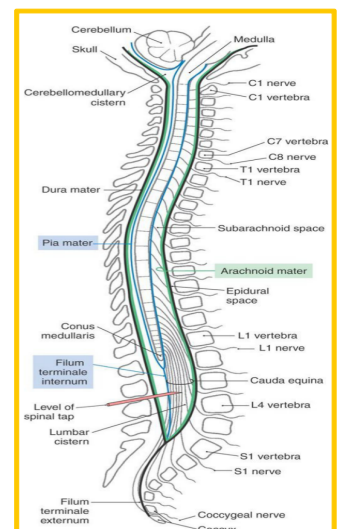
Meninges

Connective tissue membranes

•Dura mater: (represented by black in the adjacent picture)

- Outermost layer; continuous with epineurium of the spinal nerves
- Dense irregular connective tissue
- from the level of the foramen magnum to S2

① dura mater
② arachnoid
③ pia mater } meninges

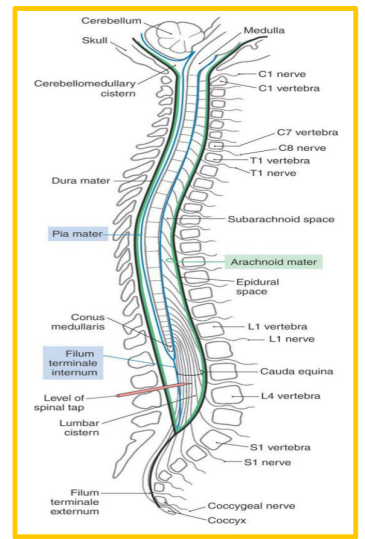


-Closed caudal end is anchored to the coccyx by the filum terminale externum

• **Arachnoid mater:** (represented by green in the adjacent picture)

-Thin web arrangement of delicate collagen and some elastic fibers.

-Adheres to the inner surface of the dura mater



* Both filum terminale (directly) & internum (indirectly) anchors the spinal cord to the coccyx providing stability and protection within the canal

• **Pia mater:** (represented by blue in the previous picture)

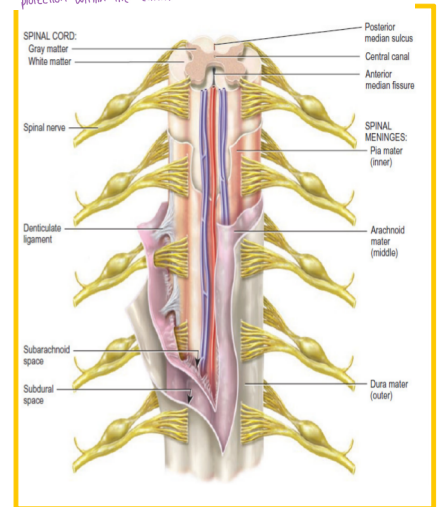
-Bound tightly to surface

-Thin transparent connective tissue layer that adheres to the surface of the spinal cord and brain

-Forms the filum terminale

-anchors spinal cord to coccyx

-Forms the denticulate ligaments that attach the spinal cord to the arachnoid mater and inner surface of the dura mater



(Function: stability of the spinal cord within the canal)

Spaces:

_ **Epidural (extradural):** space between the dura mater and the wall of the vertebral canal.

• Anesthetics injected here (epidural anesthesia)

• Fat-fill → epidural space is filled with fat

- **Subdural space:** serous fluid (between dural and arachnoid)

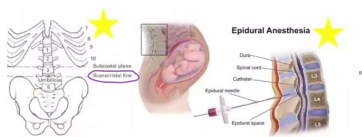
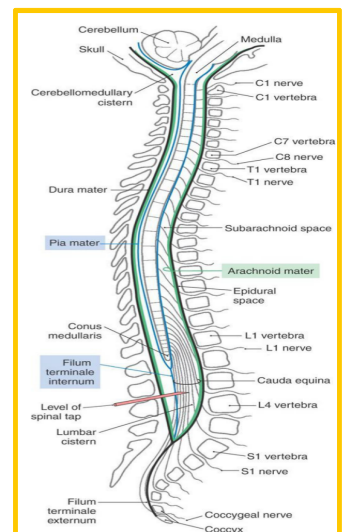
- **Subarachnoid:** between pia and arachnoid

• Filled with CSF (cerebrospinal fluid)

• Lumbar puncture → to take a sample of CSF, it is diagnostic (indicate infection, changes in CSF pressure)

• supracristal line

• L3-L4 (the best location to take a sample of the CSF)



Spinal cord segment

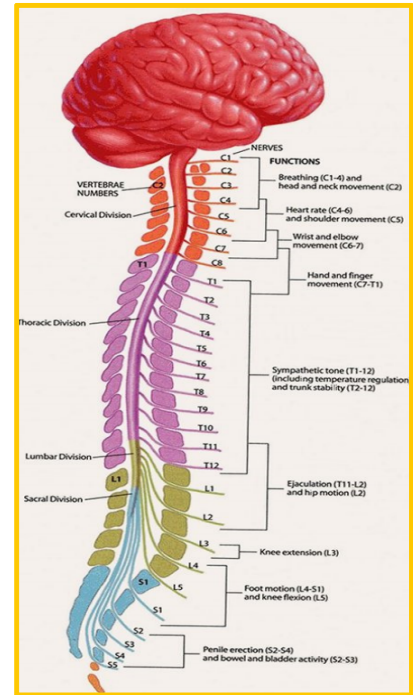
→ the place where a spinal nerve emerges from

- 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

*we have 8 cervical nerves but 7 cervical vertebrae

← من هنا

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



Herniated (something come out of its natural position) Disc/ ruptured disc/ slipped disc

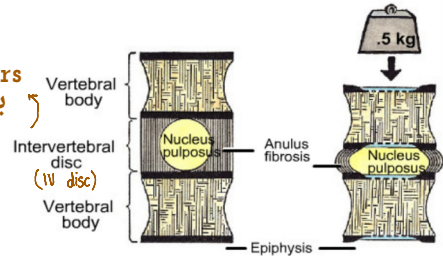
ضغط disc/ slipped يتحرك disc

slides content
lecture notes

protrusion (leakage) of the gelatinous nucleus

pulposus through the annulus fibrosus of IV disc

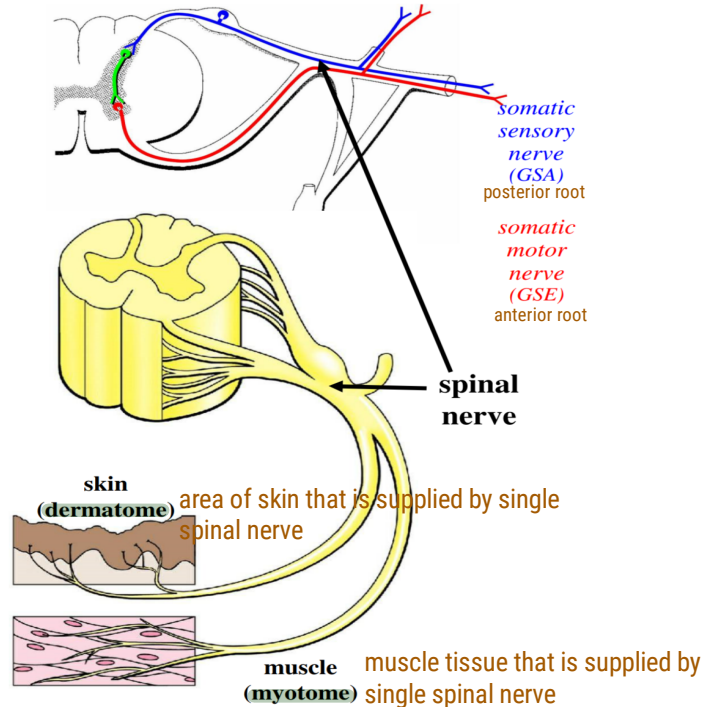
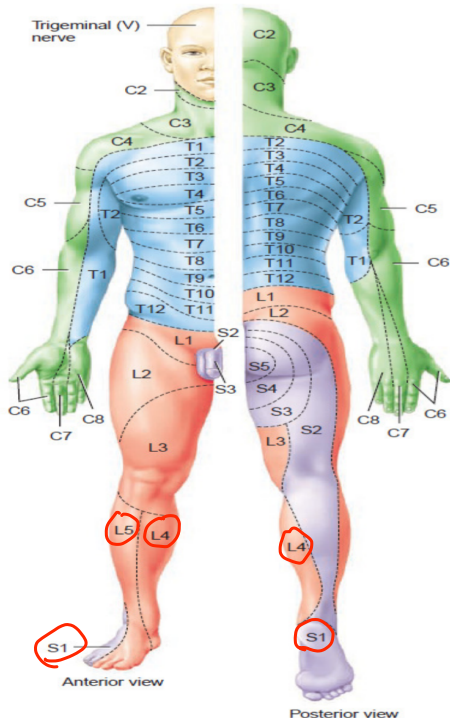
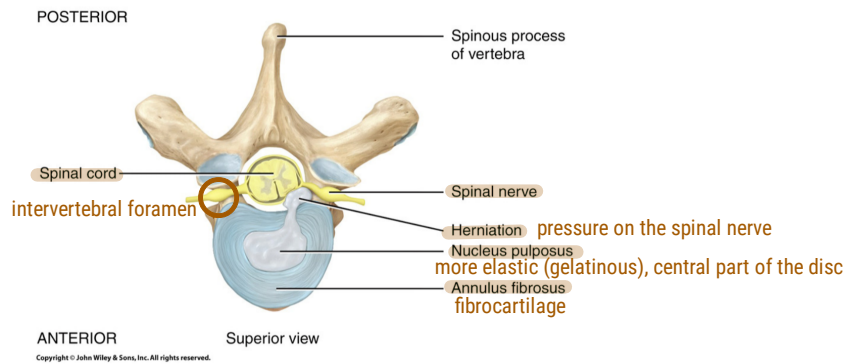
fibrocartilage > reinforced by collagen fibers
بذلك تتحمل قوة الضغط ويتحمل ضغط عالي من الجسم
(about 70% of the body weight)



Posterolateral direction: (weakest point)

Thinner annulus fibrosus

95% in L4/L5 or L5/S1



when asking about the sensory innervation of the lateral aspect of the forearm
The answer could be the lateral cutaneous nerve of forearm (a branch from the musculocutaneous nerve)

OR C6 because the musculocutaneous nerve is a branch from the lateral cord (brachial plexus) that is formed by the anterior division of the upper and middle trunk (C5+C6)

Common lumbar disc problems

Disc	Root	Percentage	Motor weakness	Sensory changes	Reflex affected
L3-L4	L4	3-10%	Knee extension (Quadriceps femoris) <i>femoral nerve</i>	Anteromedial leg (<i>saphenous</i>)	Knee jerk
L4-L5	L5	40-45%	Big toe dorsiflexion (EHL) and TA	Big toe , anteriolateral leg (<i>Common P</i>) <i>posterior compartment of the thigh</i>	Hamstring jerk
L5-S1	S1	45-50%	Foot planter flexion (Gastrocnemius)	Lateral border of foot (<i>sural</i>)	Ankle jerk

Important myotomes of lower limb

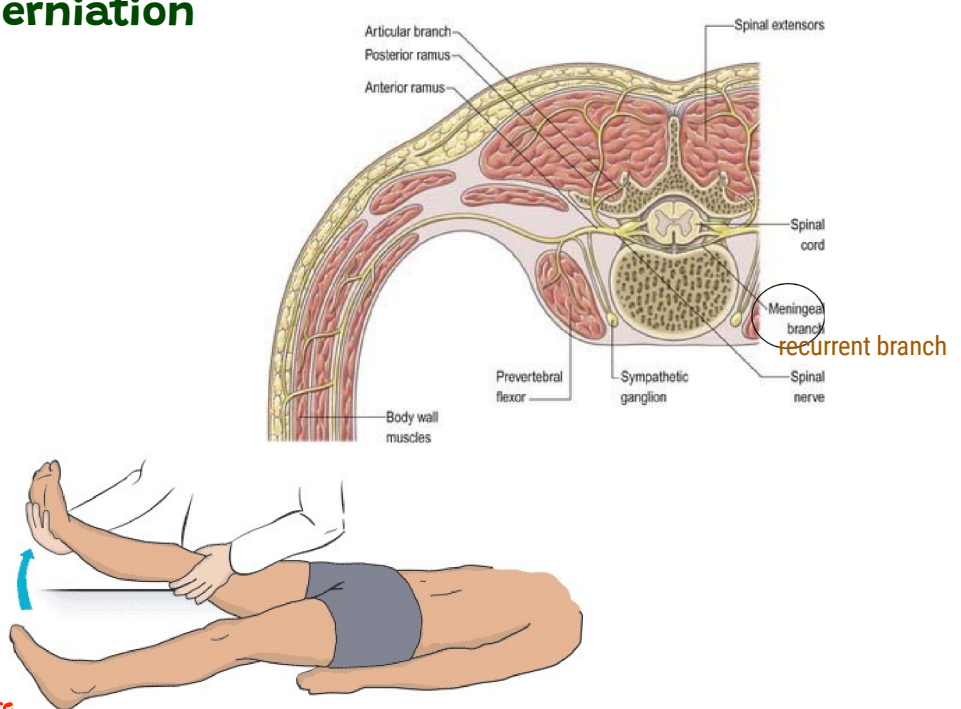
- Test L5: by asking the patient to stand on his heels
- Test S1: by asking the patient to stand on his tiptoes

Major symptoms of disc herniation

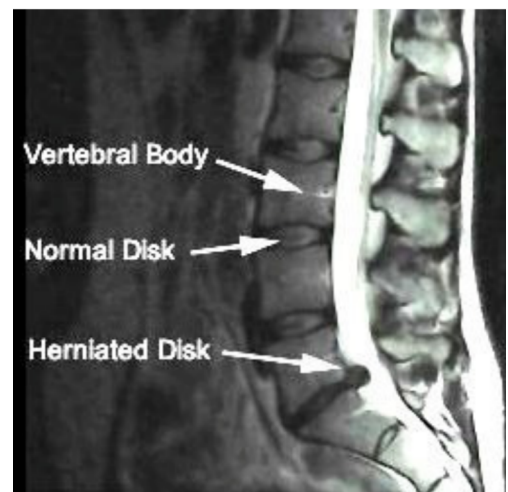
- Low back pain: radiating to the gluteal region, the back of the thigh and back of the leg
- spinal nerve gives a meningeal branch bring sensation from the dura matter
- Dura matter is sensitive to stretch
- Pain is diffused due to overlapping dermatomes
- **Straight Leg Raise Test (SLR)**

raising the leg that way will tight the sciatic nerve

** when you feel pain at a lower angle it's more serious than at a higher angle.*

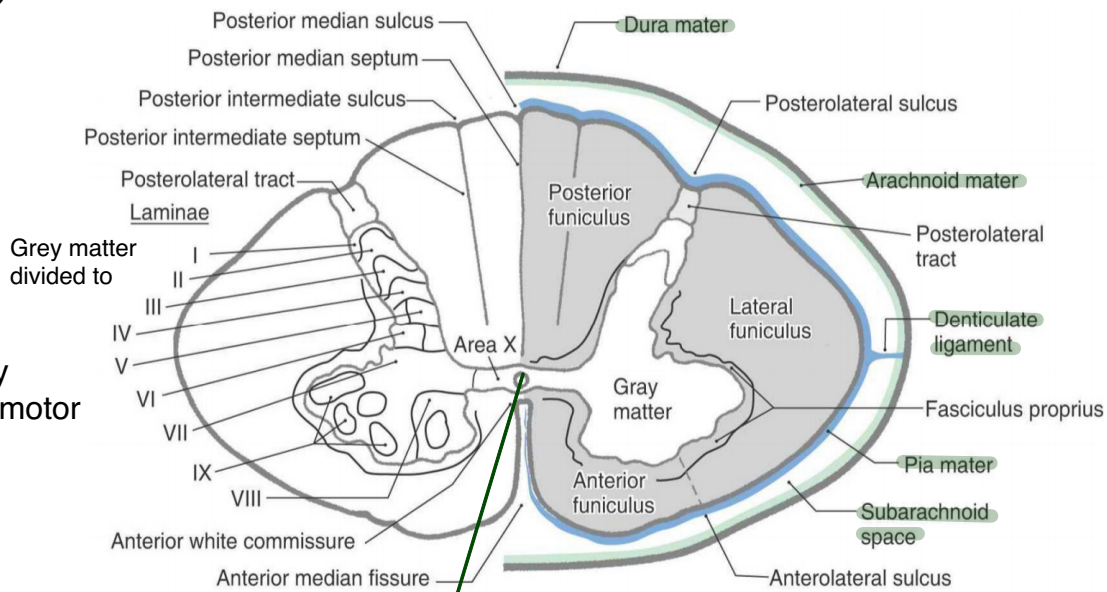
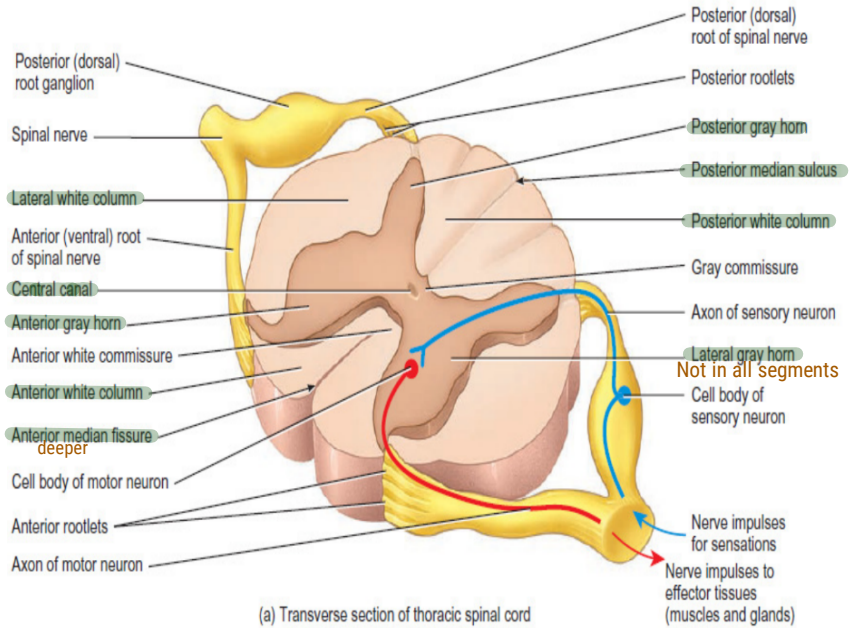


MRI is commonly used to aid in making the diagnosis of a herniated disc



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: 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** (Doesn't present always) (cell body of motor N to cardiac M, smooth M, glands)



1-6: sensory
7: sensory+motor
8+9: motor

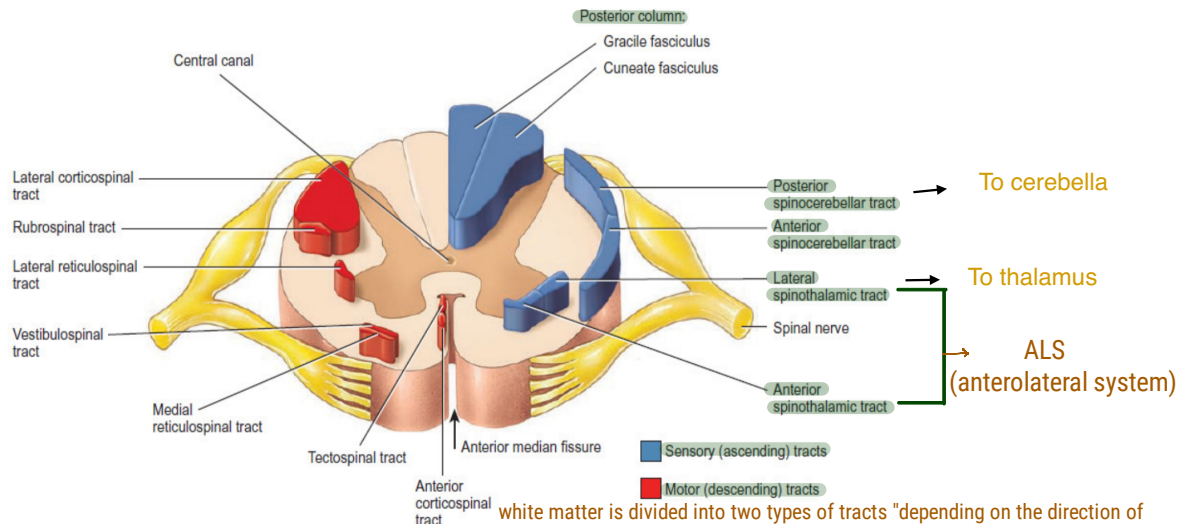
central canal
بمر فيها CSF

white matter consists of axons that transfer signals either to the thalamus or from the brain to nuclei where they synapse.

تذكري :

white matter has processes and no cell bodies.

gray matter has cell bodies



white matter is divided into two types of tracts "depending on the direction of the signals"
-ascending (sensory)
-descending (motor)

Posterior White Column-Medial Lemniscal Pathway

(High velocity, well advanced)

• Modality (type of sensation): Discriminative (localized) Touch Sensation (include Vibration) and **Conscious** (aware of->go to cortex) (unconscious Proprioception reach the cerebellum) Proprioception (muscle-joint sense||sense of position)

• Receptor: Most receptors **except free nerve endings**

→ Pure sensory or motor

• 1st Neuron: Dorsal Root Ganglion

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

---Internal Arcuate Fiber - Lemniscal Decussation (sensation from the right go to the left and vice versa)

---Medial Lemniscus

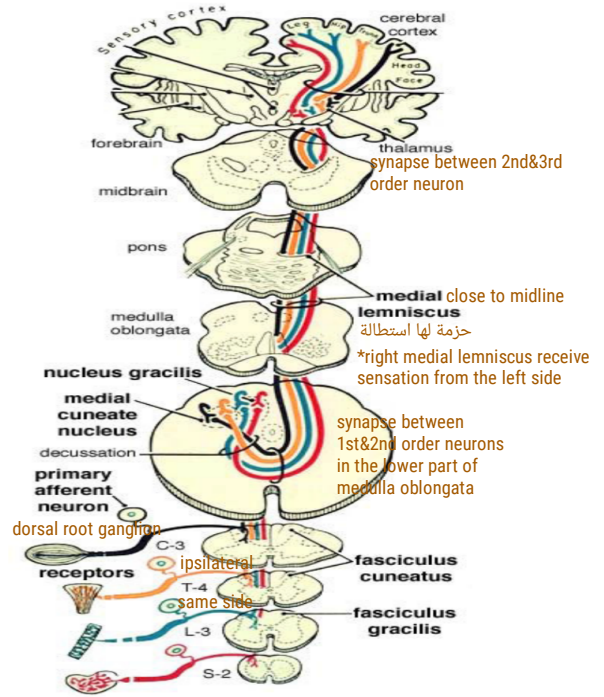
• 3rd Neuron: Thalamus (VPL) (ventroposterolateral nucleus of thalamus)

Internal Capsule fibers from thalamus to cortex تجمعوا في منطقة ضيقة

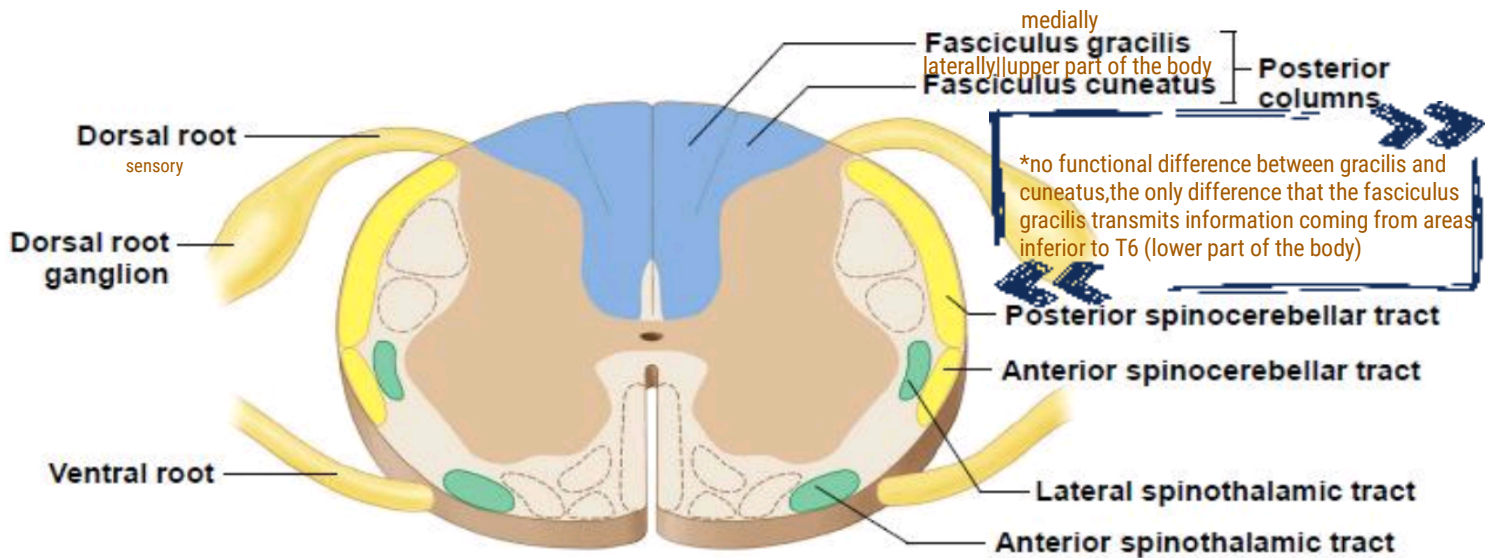
---- Corona Radiata the same fibers بس تفرقوا

• Termination: Primary Somesthetic Area (S I)

↳ Sensory place in VPI



Posterior White Column-Medial Lemniscal Pathway



Discriminative touch, vibratory sense, and conscious muscle-joint sense

• **Posterior Column tract consists of:**

• **Fasciculus gracilis**

• Transmits information coming from areas inferior to T6

• **Fasciculus cuneatus**

• Transmits information coming from areas superior to T6

First-Order Neuron:

It is a pseudo-unipolar neuron, with:

Peripheral process: Receives sensory input from skin, joints, and muscles.

Cell body: Located in the dorsal root ganglion (DRG).

Central process: Enters the spinal cord and ascends ipsilaterally (on the same side) in the posterior column.

Pathway Division:

Upper body (above T6) → Fasciculus Cuneatus (lateral part of posterior column).

Lower body (below T6) → Fasciculus Gracilis (medial part of posterior column).

Synapse in the Medulla

The first-order neuron terminates in the Gracile or Cuneate nucleus in the lower part of the medulla.

Here, it synapses with the second-order neuron, which will cross (decussate) to the contralateral side and ascend via the medial lemniscus to the VPL of the thalamus.

- The first-order neuron stays ipsilateral.
- The second-order neuron crosses the midline in the medulla.
- The third-order neuron from the VPL projects to the somatosensory cortex.

Second-Order Neuron:

- Location: Cell bodies in the nucleus gracilis (lower body) and nucleus cuneatus (upper body) of the medulla.

- Decussation (Crossing Midline):

Axons cross the midline at the medulla.

This crossing is called the lemniscal decussation and occurs via internal arcuate fibers.

Left-side sensory input → crosses to the right medial lemniscus.

Right-side sensory input → crosses to the left medial lemniscus.

- Medial Lemniscus:

After crossing, the axons ascend to the thalamus via the medial lemniscus.

They synapse in the VPL (ventral posterolateral nucleus) of the thalamus.

Third-Order Neuron:

- Location: Cell body in the VPL nucleus of the thalamus.

- Pathway:

The third-order neuron projects from the VPL to the primary somatosensory cortex (postcentral gyrus, parietal lobe).

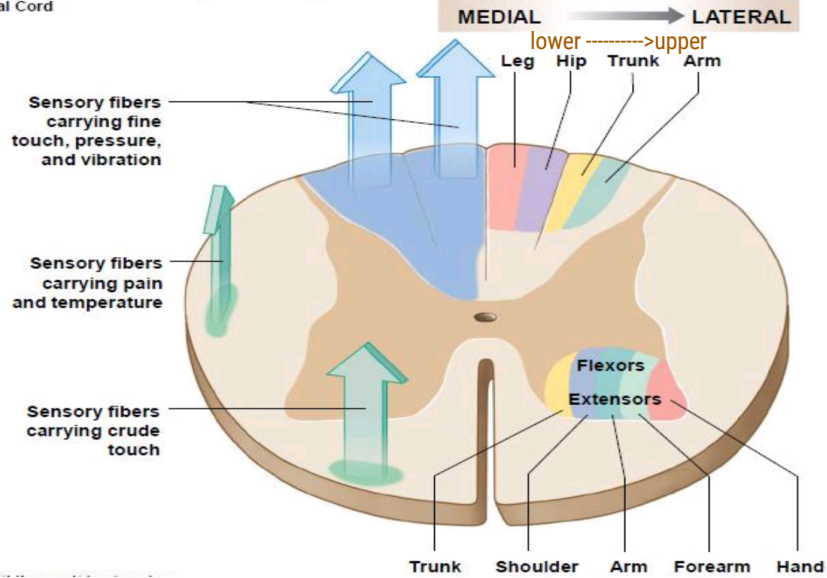
It travels through the internal capsule and then via the corona radiata to the cortex.

- Function:

The sensory information is processed in the primary somatosensory cortex.

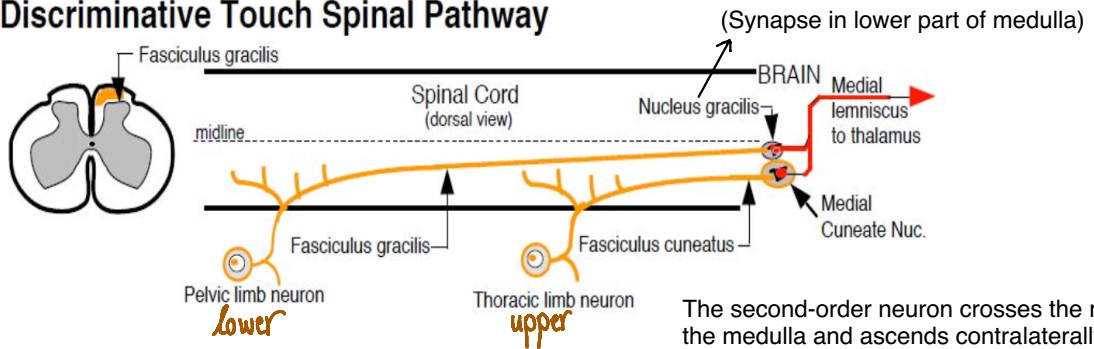
Localization of sensations follows the homunculus (sensory map).

Figure 15.1 Anatomical Principles for the Organization of the Sensory Tracts and Lower-Motor Neurons in the Spinal Cord



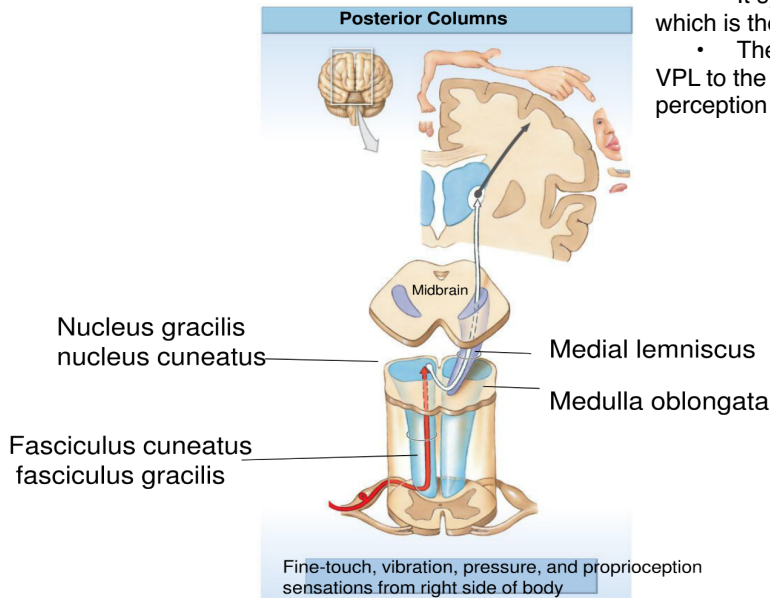
Ipsilateral in the spinal cord

Discriminative Touch Spinal Pathway



The second-order neuron crosses the midline in the medulla and ascends contralaterally.

- It synapses in the VPL of the thalamus, which is the main relay for body sensation.
- The (third-order) neuron projects from the VPL to the somatosensory cortex for conscious perception of sensation.



ELECTROPHYSIOLOGIC CLASSIFICATION OF PERIPHERAL NERVES	CLASSIFICATION OF AFFERENT FIBERS ONLY (CLASS/GROUP)	FIBER DIAMETER (μm)	CONDUCTION VELOCITY (m/s)	RECEPTOR SUPPLIED
Sensory Fiber Type				
Aα	Ia and Ib	13-20 the biggest	80-120 the fastest	Primary muscle spindles, Golgi tendon organ
Aβ	II	6-12	35-75	Secondary muscle spindles, skin mechanoreceptors
Aδ	III	1-5	5-30 fast pain	Skin mechanoreceptors, thermal receptors, and nociceptors
C	IV	0.2-1.5	0.5-2 slow pain	Skin mechanoreceptors, thermal receptors, and nociceptors
Motor Fiber Type				
Aα	N/A	12-20	72-120	Extrafusal skeletal muscle fibers
Aγ	N/A	2-8	12-48	Intrafusal muscle fibers
B	N/A	1-3	6-18	Preganglionic autonomic fibers
C	N/A	0.2-2	0.5-2	Postganglionic autonomic fibers

sensory system

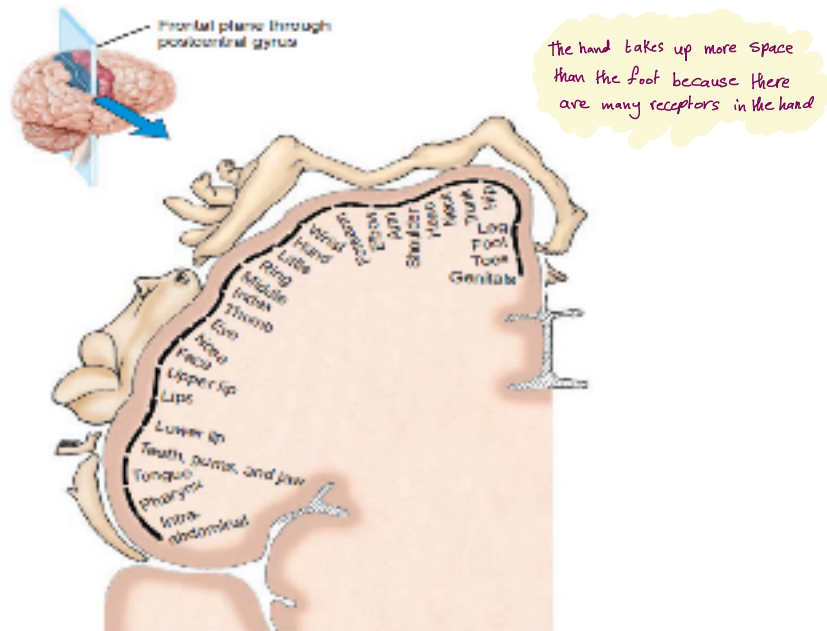
There are 4 lobes in the cortex

-frontal lobe

-parietal lobe → homunculus (sensory system)

-temporal lobe

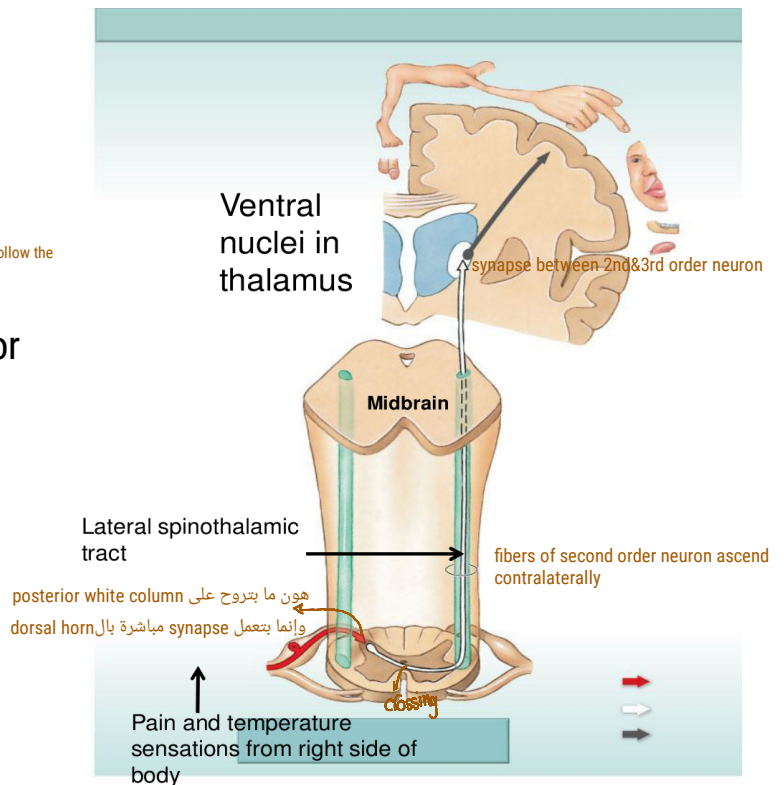
-occipital lobe



lateral spinothalamic tract

- Modality: pain and temperature
 - Receptors: free nerve endings
 - 1st Neuron: Dorsal root ganglia
 - 2nd Neuron: the posterior gray column (substantia gelatinosa site of synapse between 1st&2nd) lamina 1&2 (follow the next slide)
- The axons of 2nd order neurons cross obliquely to the opposite side in the anterior gray and white commissures, ascending in the contralateral white column as the lateral spinothalamic tract
- 3rd Neuron: Thalamus (VPL)
- Internal Capsule ----- Corona Radiata
- Termination: Primary Somesthetic Area (S I) and Widespread Cortical Region

Widespread Cortical Region means activation of areas other than the cortex



Rexed laminae

- **Lamina 1** relay information related to pain and temperature
- **Lamina 2:** relay information related to pain and temperature (pain modulation)
- **Lamina 3 and 4:** nucleus proprius; these laminae have many interneurons

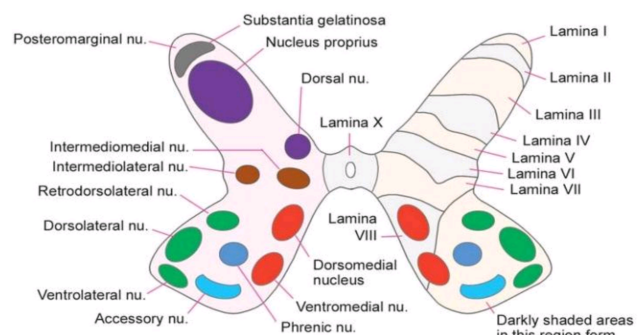
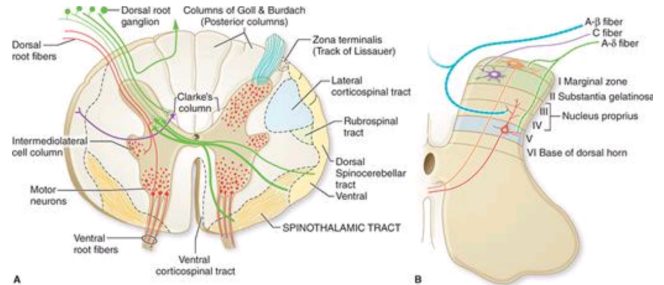


Fig. 5.2. Subdivisions of the grey matter of the spinal cord. The left half of the figure shows the cell groups usually described. The right half shows the newer concept of laminae.

- **Lamina 5:** relay information related to pain and temperature
- **Lamina 6:** presents only at the cervical and lumbar enlargements and receives proprioception
- **Lamina 7:** Intermedio-lateral nucleus, contains preganglionic fibers of sympathetic (T1 -L2). **Intermedio-medial nucleus**, all over the spinal cord, receive visceral pain. **Dorsal nucleus of Clark's** presents at (C8 – L2 or T1-L4), relay center for **unconscious proprioception**

lateral spinothalamic tract

- Lamina 1+ 5: the spinothalamic tract ascend which transmit pain (fast pain), temperature and touch. (A delta fibers)
- Lamina 1+ 2: the spinothalamic tract ascend (C fibers).



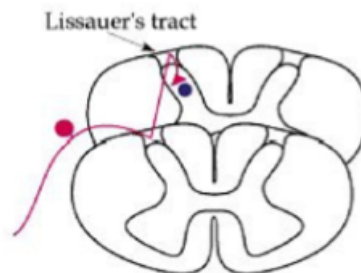
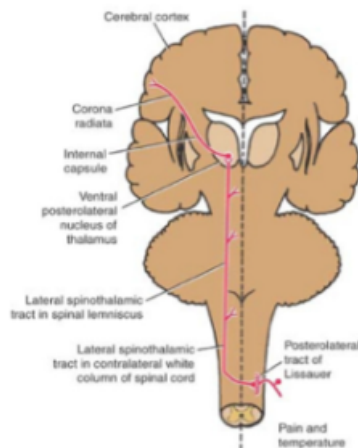
Posterolateral tract of Lissauer (Lissauer tract)

- located between the posterior white column and the lateral white column

Slides content
lecture notes

There is a first order neuron that enters a certain segment (T1 for example) This neuron doesn't have to synapse in that segment, rather it can ascend to C7 or C8 and synapse there.

هذا المسار المتكون من بداية دخول ال neuron لل segment (T1 في هذا المثال) إلى مكان ال synapse (في segment أخرى ممكن (C7 في هذا المثال) يسمى ب Lissauer tract



Other Terminations of the Lateral Spinothalamic Tract

- **Reticular formation:** (present in the core of brain stem)
(majority of the slow pain fibers) individual becomes aware of the pain حتى أثناء النوم، إذا كان الألم قوي

Functions:

- regulation of sleep-wake cycle

- switch the cortex between ON/OFF

- **Cingulate gyrus:** in the fissure that separates left and right

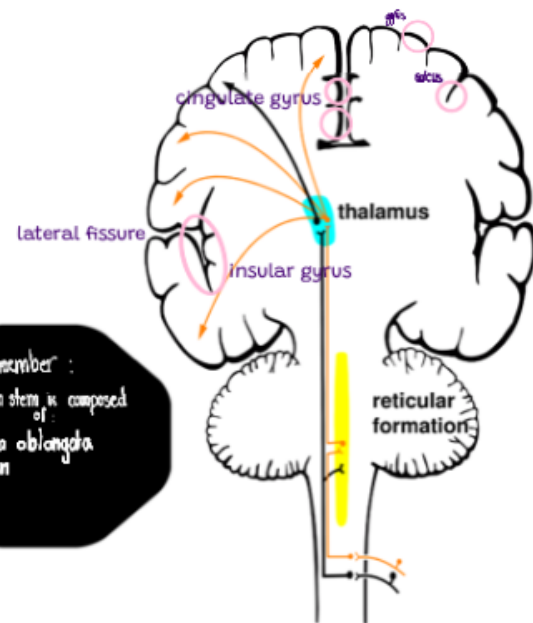
hemispheres/hidden cortex

interpretation of the emotional aspect of pain

- **Insular gyrus:**

concerned with the interpretation of pain stimuli from the internal organs of the body and brings about an autonomic response

Remember:
The brain stem is composed of:
- Medulla oblongata
- Midbrain
- pons



Anterior spinothalamic tract

- Modality: crude touch and pressure

- Receptors: free nerve endings

- 1st Neuron: Dorsal root ganglia

- 2nd Neuron:

the posterior gray

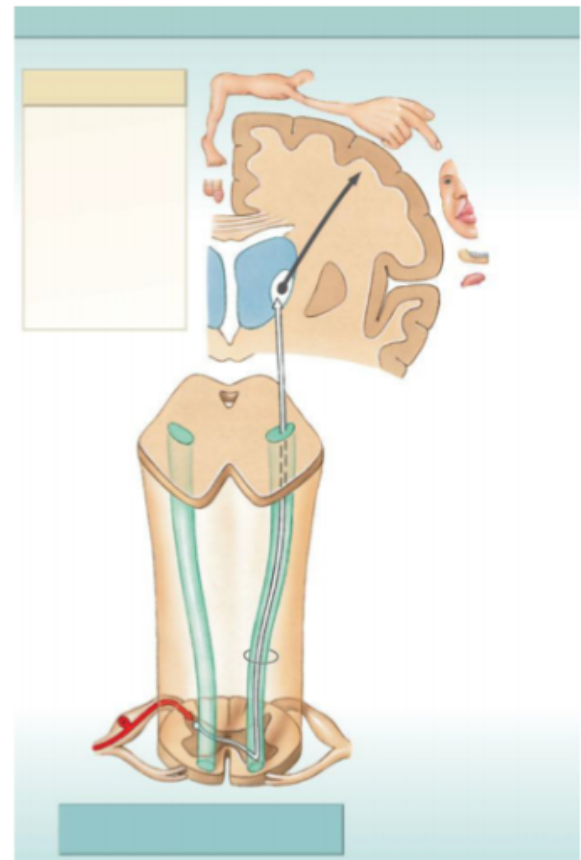
column (nucleus proprius lamina 3&4)

The axons of 2nd order neurons cross obliquely to the opposite side in the anterior gray and white commissures, ascending in the contralateral white column as the Anterior spinothalamic tract

- 3rd Neuron: Thalamus (VPL)

Internal Capsule ----- Corona Radiata

- Termination: Primary Somesthetic Area (S I)





NEUROANATOMY

SUMMARY
FOR

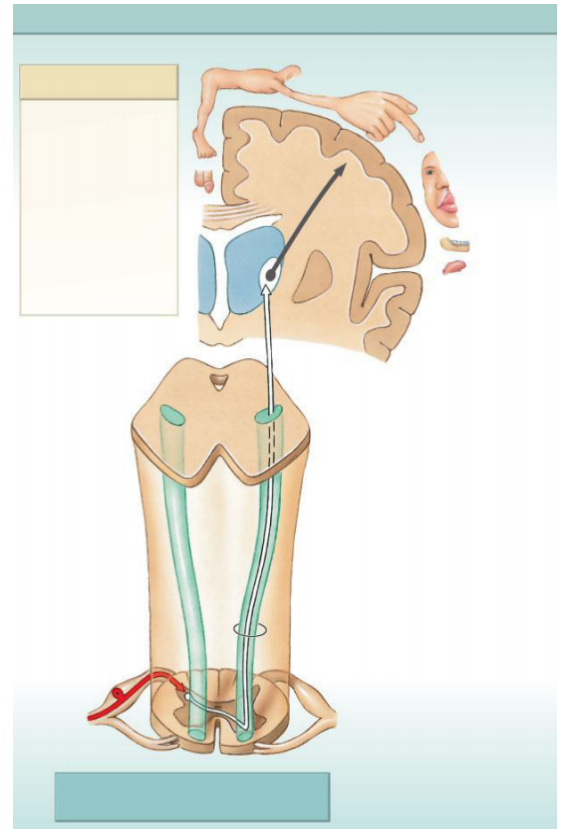
WEEK 3

BY : HEMMEH ASNAN



Anterior spinothalamic tract

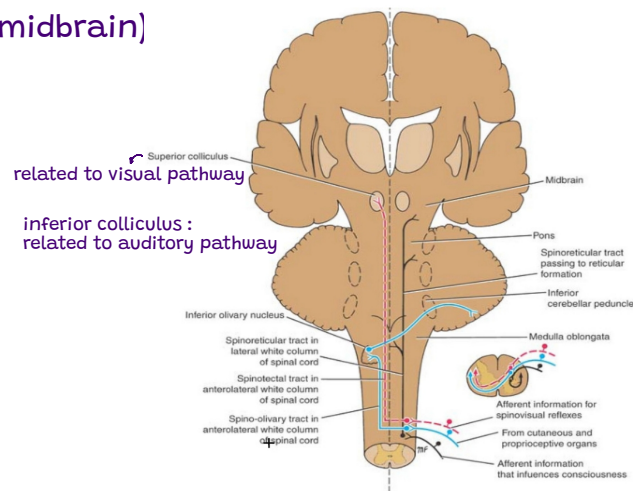
- Modality: crude touch and pressure
- Receptors: free nerve endings
- 1st Neuron: Dorsal root ganglia
- 2nd Neuron: the posterior gray column (nucleus proprius lamina 3&4)
- The axons of 2nd order neurons cross obliquely to the opposite side in the anterior gray and white commissures, ascending in the contralateral white column as the Anterior spinothalamic tract
- 3rd Neuron: Thalamus (VPL) Internal Capsule ----- Corona Radiata
- Termination: Primary Somesthetic Area (S I)



Spinotectal Tract

related to the tectum (posterior aspect of midbrain) consists of 4 colliculi

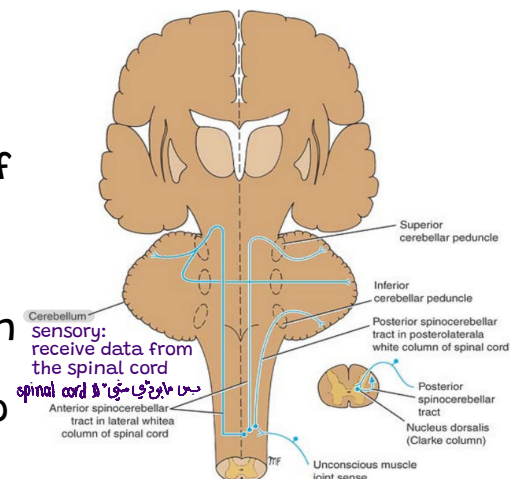
- ascend in the anterolateral white column lying close to the lateral spinothalamic tract
- Terminate: superior colliculus
- Provides afferent information for spino\visual reflexes



In Medulla: ant spinothalamic tract + spinotectal + lateral spinothalamic = spinal lemniscus

Posterior spinocerebellar ascending tract

- Modality: muscle and joint sensation (unconscious part, neuromuscular coordination) (Does not reach the cortex as the conscious)
- 1st order neuron axons terminate at the base of post gray column (nucleus dorsalis or **Clarke's nucleus (lamina 7)**)
- the axons of 2nd order neurons enter posterolateral part of the lateral white matter on the **same side** (ipsilateral)
- ascend as the posterior spinocerebellar tract to medulla oblongata
- Terminates in cerebellar cortex (through inferior cerebellar peduncle)



white matter

• note: axons of lower lumbar and sacral spinal nerves ascend in the posterior white column until they reach L3 or L4 segments where they synapse with nucleus dorsalis (No lamina 7 "No clarks nucleus")

Rexed laminae

- **Lamina 1** relay information related to pain and temperature
- **Lamina 2:** relay information related to pain and temperature (**pain modulation**)
- **Lamina 3 and 4:** nucleus proprius; these laminae have many interneurons
- **Lamina 5:** relay information related to pain and temperature
- **Lamina 6:** presents only at the cervical and lumbar enlargements and receives proprioception
- **Lamina 7: Intermedio-lateral nucleus**, contains preganglionic fibers of sympathetic (T1 -L2). **Intermedio-medial nucleus**, all over the spinal cord, receive visceral pain. **Dorsal nucleus of Clark's** presents at (C8 - L2 or T1-L4), relay center for **unconscious proprioception**

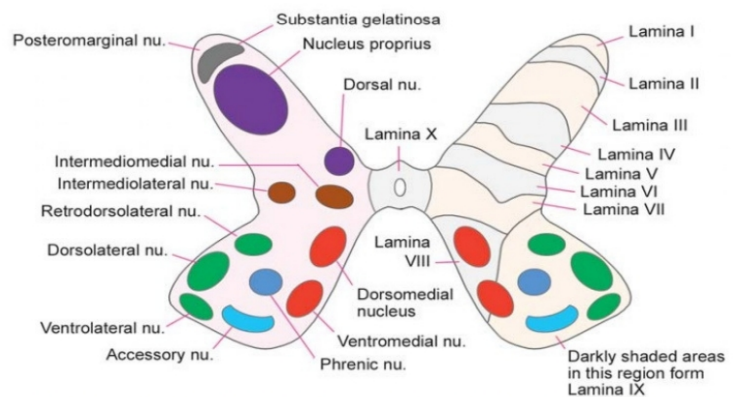
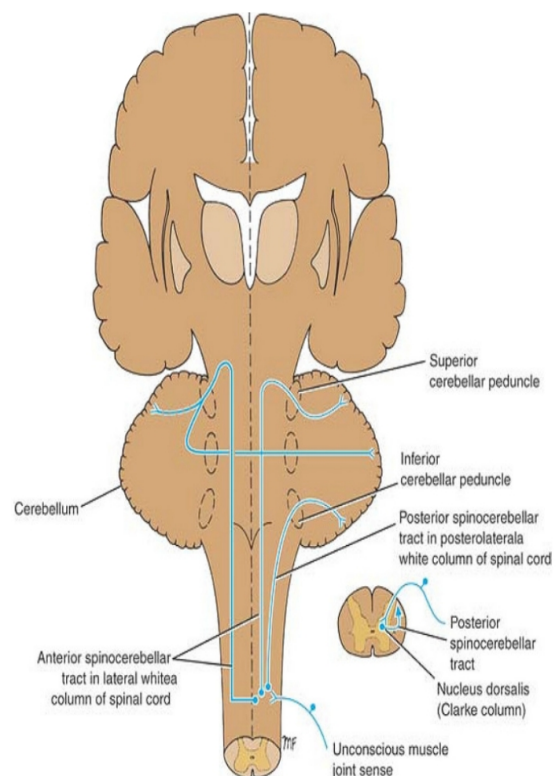


Fig. 5.2. Subdivisions of the grey matter of the spinal cord. The left half of the figure shows the cell groups usually described. The right half shows the newer concept of laminae.

Anterior spinocerebellar tract

- muscle and joint sensation
- 1st order neuron axons terminate at the base of post gray column (nucleus dorsalis)
- the majority of axons of 2nd order neurons cross to opposite side and ascend as anterior spinocerebellar tract in the contralateral white column
- the minority of axons ascend as anterior spinocerebellar tract in the lateral white column of the same side
- ascend as anterior spinocerebellar tract to medulla oblongata and pons
- Terminates in cerebellar cortex (through superior cerebellar peduncle)

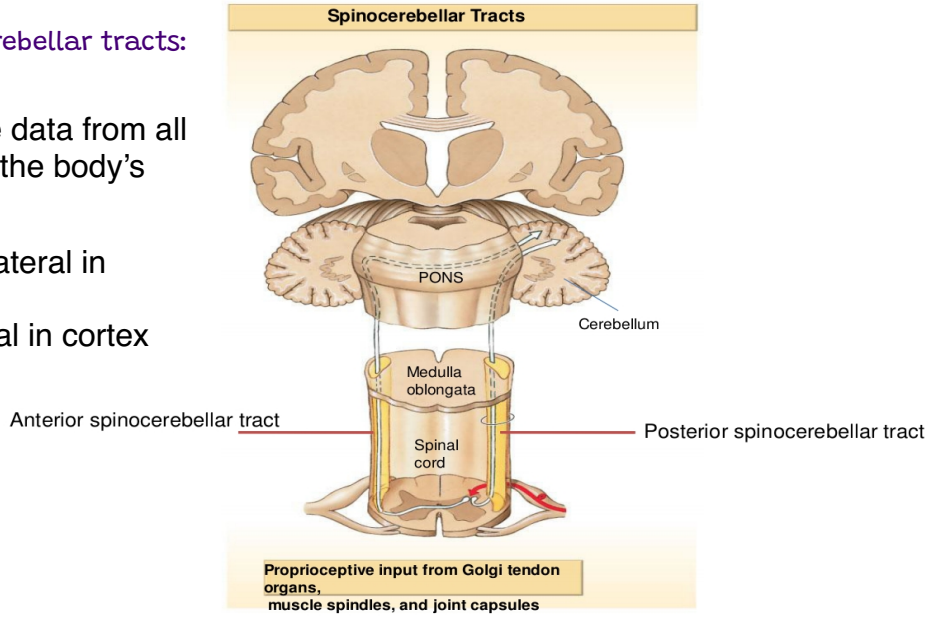
Δthe fibers that **crossed over** in spinal cord **cross back** within cerebellum (double crossing) (eventually they will reach the same side cerebellum.)



Summary for spinocerebellar tracts:

Cerebellum receive data from all the body, to record the body's position

The signal stay ipsilateral in cerebellum and stay contralateral in cortex



Motor tracts

×There are two major descandin tracts

-Pyramidal tracts

(Corticospinal) :

Conscious control of skeletal muscles

-Extrapyramidal:

Subconscious regulation of balance, muscle tone, eye, hand, and upper limb position:

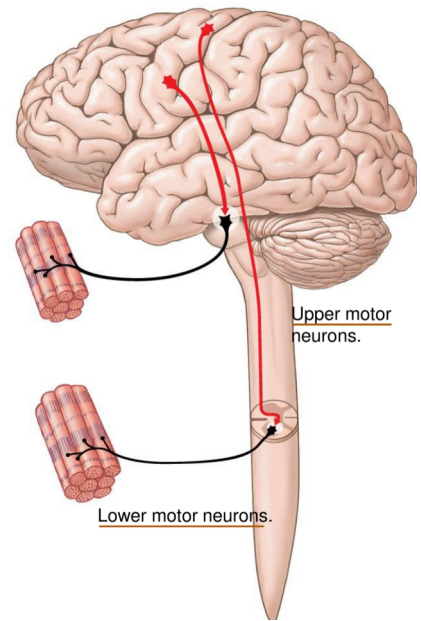
•**Vestibulo/spinal tracts**

vestibular nuclei related to the vestibule of the inner ear (The organ of balance)

•**Reticulospinal tracts**

•**Rubrospinal tracts**

•**Tectospinal tracts**



Extrapyramidal tracts arise in the brainstem, but are under the influence of the cerebral cortex

Rexed laminae Anterior horn (lamina 8,9) motor system

•**Lamina 8** : motor interneurons, Commissural nucleus

•**Lamina 9**: ventral horn, LMN, divided into nuclei:

-**Ventromedial**: all segements (extensors of vertebral coloumn)

-**Dorsomedial**: (T1-L2) intercostals and abdominal muscles

-**Ventrolateral**: C5-C8 (arm) L2-S2 (thigh)

-**Dorsolateral**: C5-C8 (Forearm), L3-S3 (Leg)

-**Reterodorsolateral**: C8-T1 (Hand), S1-S2 (foot)

-**Central**: Phrenic nerve (C3-C5)

•**Lamina X**: Surrounds the central canal – the grey commissure

هذا الملايد ليس المحظ
وانما لهم المنطق الموجود فيه ومعرفة
Lamina 8 و 9 → Anterior horn

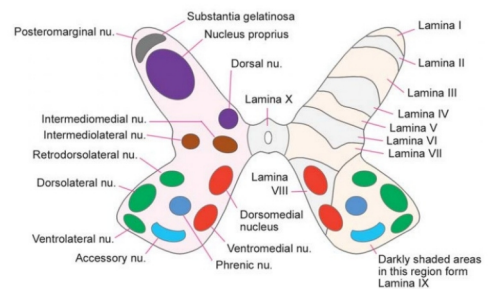


Fig. 5.2. Subdivisions of the grey matter of the spinal cord. The left half of the figure shows the cell groups usually described. The right half shows the newer concept of laminae.

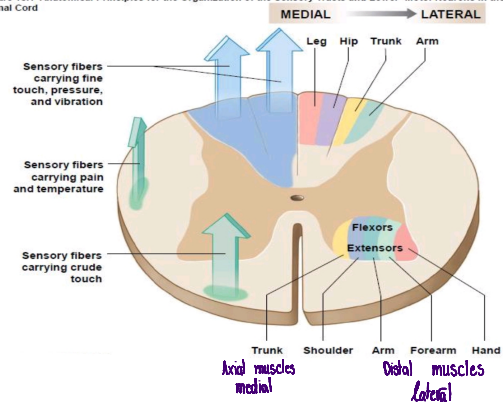
*Motor neurons of anterior horn

-Medial group: (All segments) (Axial muscles)

-Lateral group: only enlargements (Distal muscles)

axial skeletal (medial) → medial side .
 extremist group (Lateral) → Lateral side .

Figure 15.1 Anatomical Principles for the Organization of the Sensory Tracts and Lower-Motor Neurons in the Spinal Cord



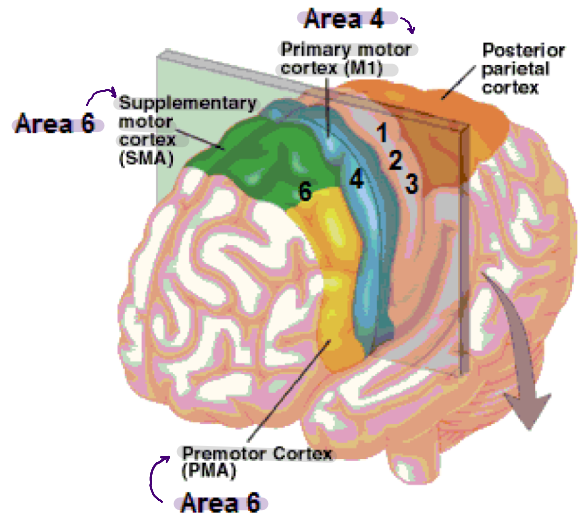
Motor tracts

•Both pyramidal tracts and extrapyramidal both starts from cortex: Mainly from the frontal lobe

- Area 4 Lesion in area 4 results in paralysis
- Area 6 lesion in area 6 results in losing coordination
- Area 3, 1, 2 sensory cortex from which motor fibers descends.

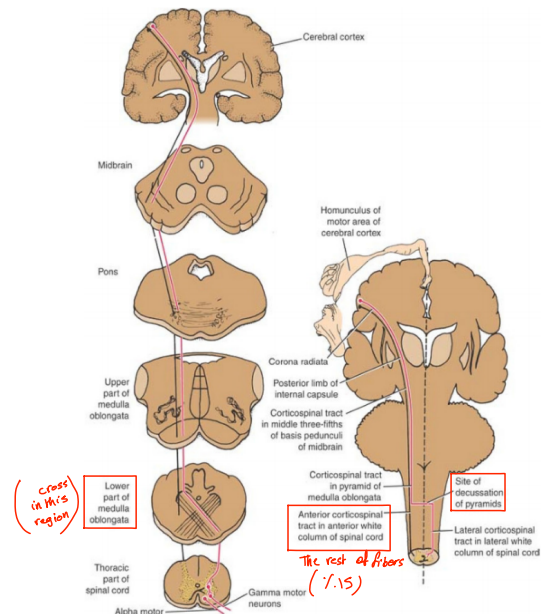
*Pyramidal: mainly from area 4
 *Extrapyramidal: mainly from area 6
 •area 6

-Premotor area: uses external cues (أبعد عن الـmidline)
 -Supplementary motor area: uses internal cues (أقرب للـmidline) (for memory)



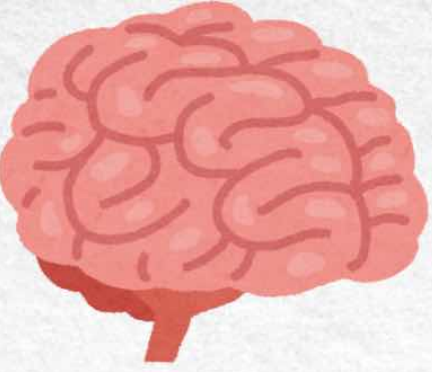
Lateral corticospinal tract

*The upper motor neurons of these tracts originate in the precentral gyrus of the cerebral cortex
 *In midbrain: middle three-fifths of the basis pedunculi of the midbrain
 *In medulla oblongata: pyramids
 *Most of the fibers (85 percent) cross over (decussate) to the opposite side in the pyramidal decussation, where they continue to descend in the lateral funiculus of the spinal cord as the lateral corticospinal tract (LCST).



LCST → in the Lateral horn supply the Lateral area (extremist) . function → (skilled movement)
 ACST → in the anterior horn supply the medial area (axial) . function → (balance + posture)





NEUROANATOMY

SUMMARY
FOR

WEEK 4

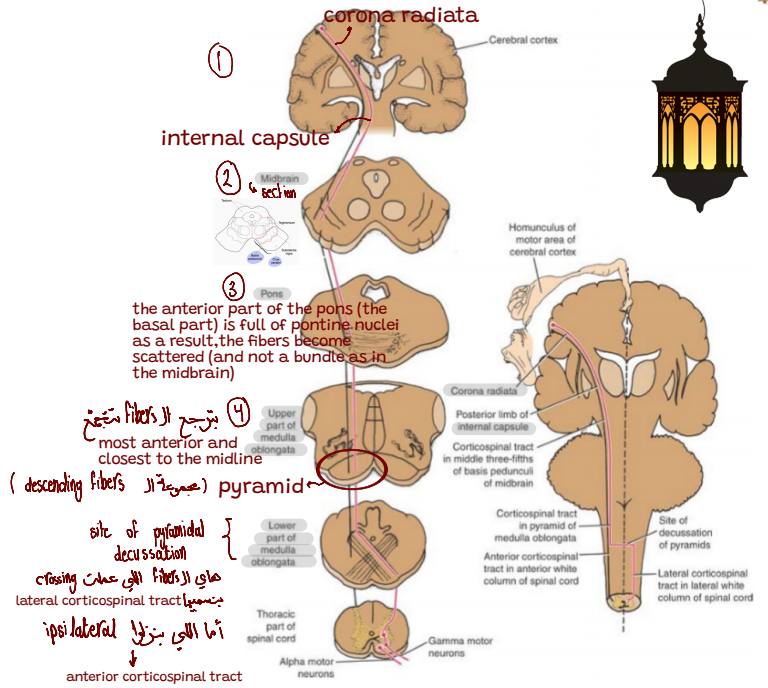
BY : HEMMEH ASNAN



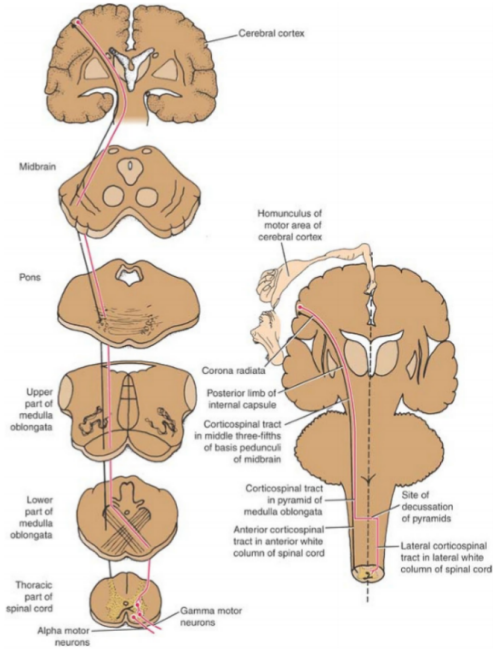
Lateral corticospinal tract

- The upper motor neurons of these tracts originate in the precentral gyrus of the cerebral cortex
- In midbrain: middle three-fifths of the **basis pedunculi of the midbrain**
- In medulla oblongata: pyramids
- Most of the fibers (85percent) cross over (decussate) to the opposite side in the pyramidal decussation, where they continue to descend in the **lateral funiculus** of the spinal cord as the **lateral corticospinal tract (LCST)**.

primary motor cortex in the frontal lobe



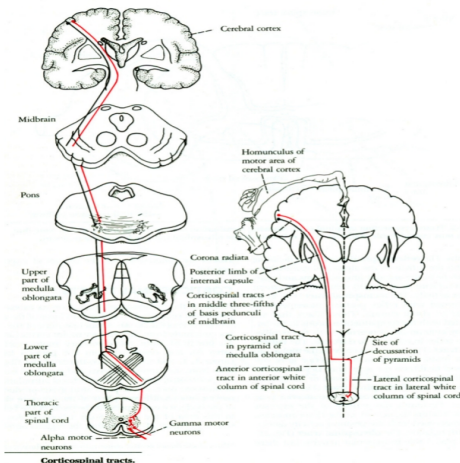
- The tract descends all the way of spinal cord with fibers continually leaving it in order to synapse on interneurons in the anterior gray horn. (Some even synapse directly on alpha and gamma motor neurons)
- Those corticospinal fibers which do not decussate in the medulla continue descending on the same (ipsilateral) side of the cord and become the anterior corticospinal tract (ACST). *But in the end you will make a cross for the*



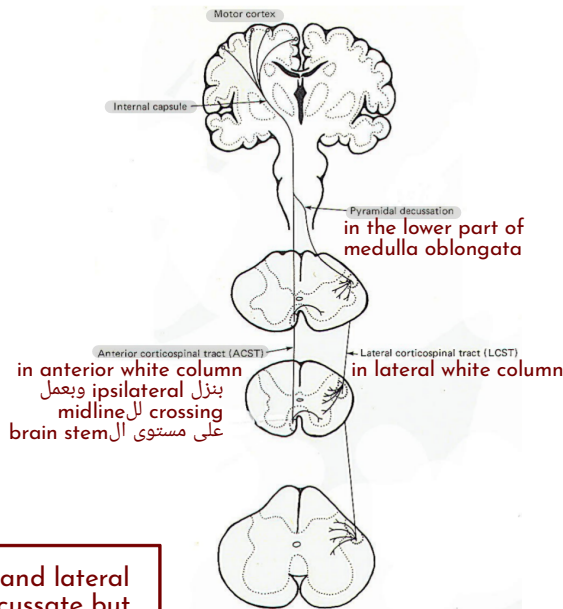
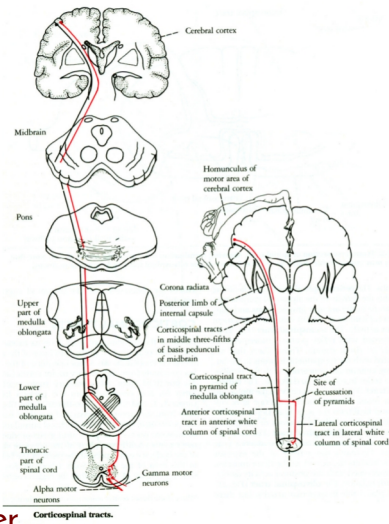
corticospinal tract for fine skilled movements

(by lateral (distal) muscles)
مثل حركة المارغول المشد والي تعبر متعقبة جدا

lateral muscles (muscles of skilled movement) is controlled by lateral corticospinal tract



- Lateral corticospinal tract descends the full length of the spinal cord
- LCST fibers synapse with alpha and gamma nuclei of the
 - Cervical region (55%) (great effect on the upper limb) *the hand has the most skilled movements*
 - Thoracic 20%
 - Lumbar and Sacral 25%
- The lateral corticospinal tract synapses **mainly by interneurons** in laminae IV, V, VI, VII, VIII
- **Exception:** 3% originate from the fifth layer of area 4 (giant cells of Betz) synapse directly. (Accurate movements) *the upper motor neuron synapses the lower directly*



The anterior and lateral tracts will decussate but at different locations.

The anterior corticospinal tract acts on the proximal muscles of upper limb (shoulder muscle) of the ipsilateral and contralateral sides

Fibers leave the tract at various levels to cross over in the anterior white commissure to synapse on interneurons in the anterior gray horn.

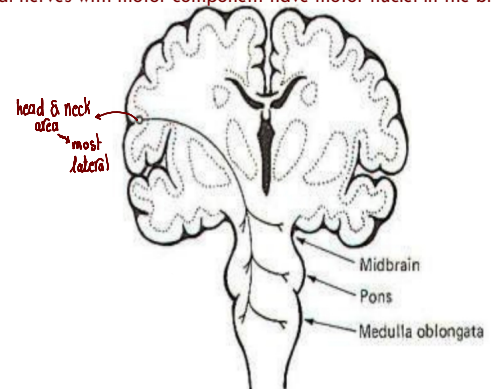
A part of the medial motor system (Affect the AXIAL muscles)

keep in mind that both the medial and lateral systems work together in a complementary manner

The Corticobulbar Tract (fibers)

- This tract is composed of fibers originating in the precentral gyrus of the lower quarter of the motor cortex.
- The descending fibers terminate in the motor nuclei of cranial nerves III and IV in the midbrain; V, VI, and VII in the pons; and IX, X, XI, and XII in the medulla.
- The corticobulbar fibers from one side of the brain project to the motor nuclei on both sides of the brainstem (bilateral input) *(No decussation)*

cranial nerves with motor component have motor nuclei in the brain stem



The corticobulbar input is bilateral **Except** :
 1-Part of 7th (which supplies LOWER facial muscles) *Motor nucleus of facial*
 2-Part of 12th (which supplies genioglossus muscle)

The Subconscious Motor Tracts

- Consists of four tracts involved in monitoring the subconscious motor control
 - (Vestibulo)spinal tracts
 - (Tecto)spinal tracts
 - (Reticulo)spinal tracts
 - (Rubro)spinal tracts
- ~> Most of them are structures that exist in the brain stem

Extrapyramidal tracts arise in the brainstem, but are under the influence of the cerebral cortex

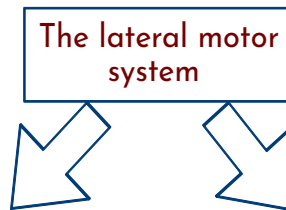
↓ polysynaptic

These motor pathways are complex and multisynaptic, and regulate:

- Axial muscles that maintain balance and posture
- Muscles controlling coarse movements of the proximal portions of limbs
- Head, neck, and eye movement

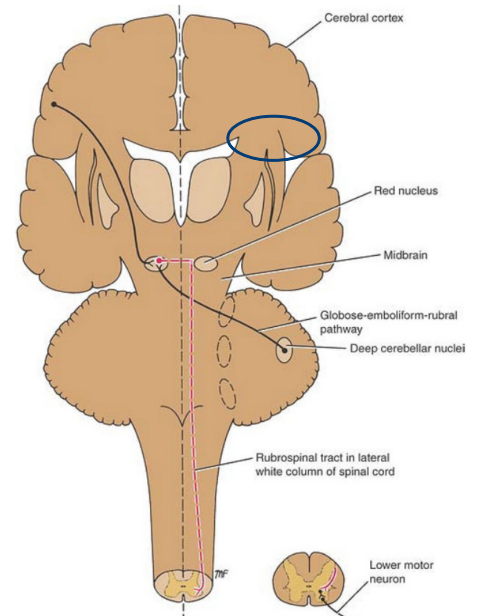
Rubrospinal tract The only extrapyramidal tract that is a part of the lateral motor system

- **Red nucleus**
 - In the midbrain at the level of superior colliculus
 - Receives afferent fibers from cerebral cortex and the cerebellum
- **Crossed** (at the level of the nucleus)
- Lateral white column
- **Function:** facilitate the activity of flexors and inhibit the activity of extensors



Rubrospinal tract
(extrapyramidal)

lateral corticospinal tract
(pyramidal)



Rubrospinal tract

- rubrospinal tract is very close to the lateral corticospinal tract in the spinal cord. They form the lateral motor system
- synapses with alpha and gamma through interneurons
- Excitatory to flexors and inhibitory to extensors
- supply the **distal flexors** muscles mainly with little effect on the proximal muscles (facilitate the activity of flexor muscles)

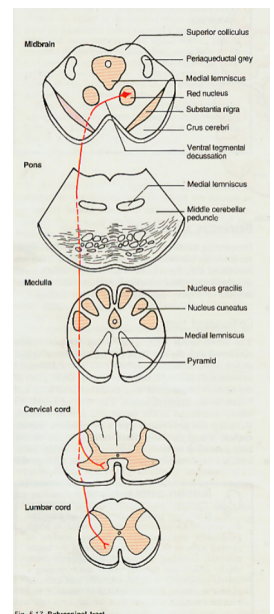
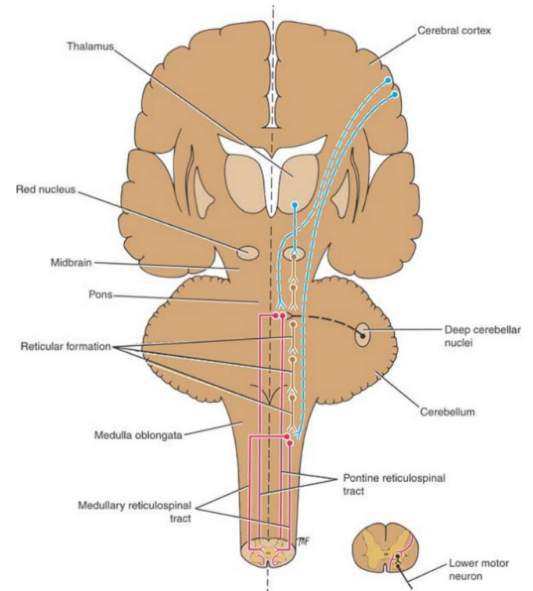


Fig. 5.17 Rubrospinal tract.

Pontine reticulospinal tract

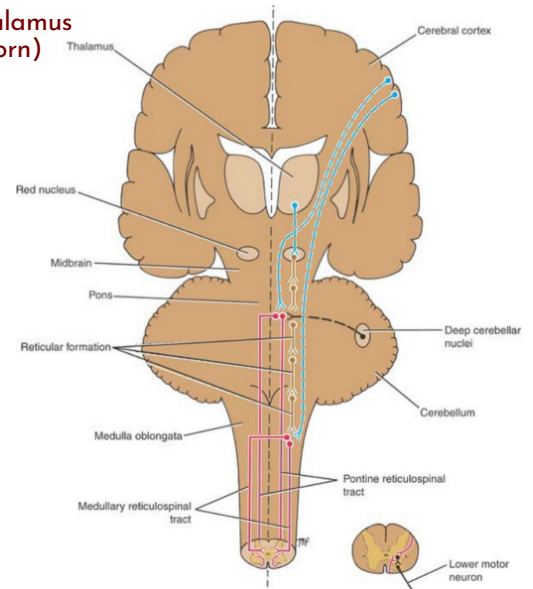
- From pons:
- axons of RF neurons descend uncrossed into the spinal cord
- Anterior white column
- medial reticulospinal tract (MRST)
- tonically active *دائماً شغال*
- normally under inhibition from cortex
- Function:
- activate the axial and proximal limb extensors
- antigravity muscles (help you to stand up)*



Medullary reticulospinal tracts

Somatic motor activity + fibers from the hypothalamus (Autonomic) >> (have an effect on the lateral horn)

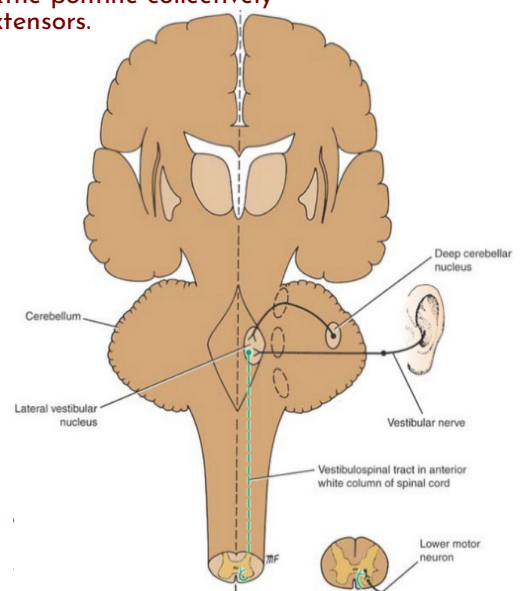
- From medulla
- axons of RF neurons descend crossed and uncrossed into the spinal cord
- Lateral white column *The anatomical position (it is NOT a part of the lateral motor system)*
- Lateral reticulospinal tract (LRST)
- NOT tonically active
- normally under stimulation
- Function:
- Inhibit the axial and proximal limb extensors



Vestibulospinal Tract

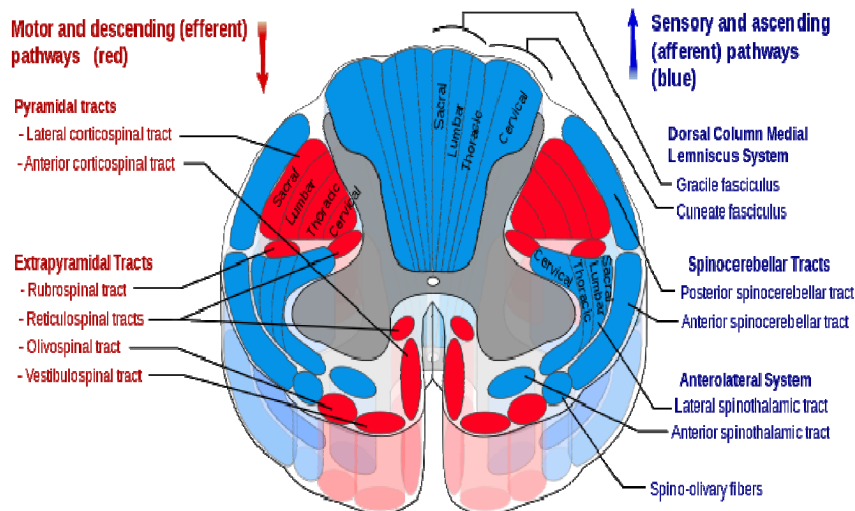
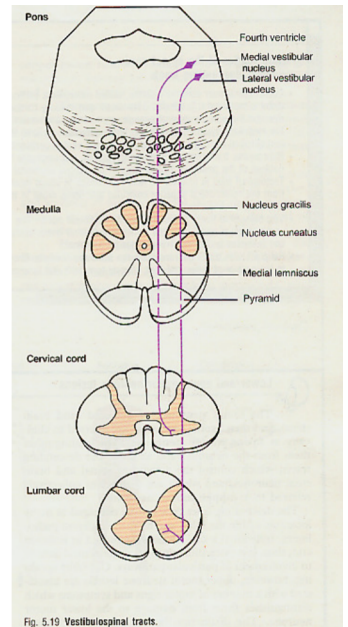
The vestibulospinal tract & the pontine collectively enhance the activity of extensors. medullary ال مكنى

- **Vestibular nuclei**
- in the pons and medulla beneath the floor of 4th ventricle
- Receives afferent fibers from the inner ear through the vestibular nerve and from the cerebellum
- **Uncrossed**
- Anterior white column
- **Function:** *same as the pontine* facilitate the activity of extensor muscles and inhibit the activity of flexor muscles in association with the maintenance of balance



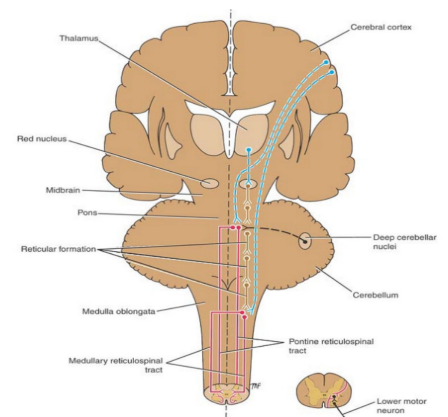
Vestibulospinal Tract

- nerve cells in vestibular nucleus (in the pons and medulla oblongata)
- received afferents from inner ear and cerebellum
- axons descend uncrossed
- through medulla and through the length of spinal cord
- synapse with neuron in the anterior gray column of the spinal cord (**balance by facilitate the activity of the extensor muscles**)



Reticulospinal tracts

- Has also descending autonomic fibers providing a pathway by which the hypothalamus can control the sympathetic and sacral parasympathetic outflow.
- Most of these fibers are derived from the lateral reticulospinal tract

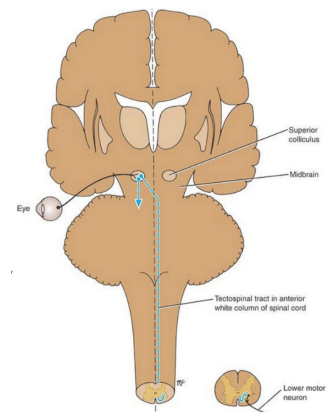


Tectospinal tract

- nerve cells in superior colliculus of the midbrain
- **Crossed**
- The tract descends in the anterior white column close to Anterior median fissure

- Majority of fibers terminate in the anterior gray column of upper cervical segments of spinal cord
(responsible for reflex movement of head & neck in response to visual stimuli)

Afferent limb -> vision
efferent -> movement of the head and neck area



The motor pathways are classified into

✓ **Medial Motor system:** axial & proximal muscles. Medial Motor system include:

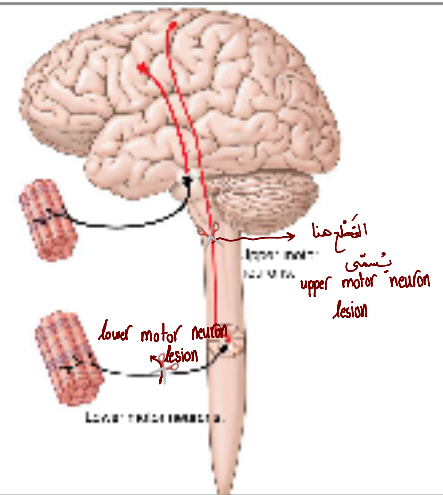
- Anterior corticospinal tract.
- Extrapyramidal pathway in general

✓ **Lateral Motor system:** distal muscles mainly, lateral Motor system include

- lateral corticospinal tract
- Rubrospinal tract distal muscles mainly (and proximal).

هل تختلف نتيجة قطع ال upper motor neuron عن قطع ال lower motor neuron ؟

Yes, because there are reflexes on the level of the spinal cord that sustain the muscle tone



COMPARISON BETWEEN UMN AND LMN

Features	Upper motor neuron lesions(UMN)	Lower motor neuron lesion(LMN)
	UMN starts from motor cortex to the cranial nerve nuclei in brain and anterior horn cells in spinal cord	LMN is the motor pathway from anterior horn cell(or Cranial nerve nucleus)via peripheral nerve to the motor end plate
Bulk of muscles	No wasting	Wasting of the affected muscles (atrophy)
Tone of muscles	Tone increases (Hypertonia)	Tone decreases (Hypotonia)
Power of muscles	Paralysis affects movements of group of muscles Spastic/ clasp knife صلابة	Individual muscles is paralyzed Flaccid (flaccid paralysis) رخوة
Reflexes	Exaggerated. (Hyperreflexia)	diminished or absent. (Hyporeflexia)
Fasciculation	Absent	Present
Babinski sign	Present	Absent
clasp-knife reaction	Present	Absent
Clonus clasp knife reaction مستند ال راسم ال على مستوى القدم	Present	Absent

hypertonia and hyperreflexia, is the result of an increase in gamma motor neurons activity

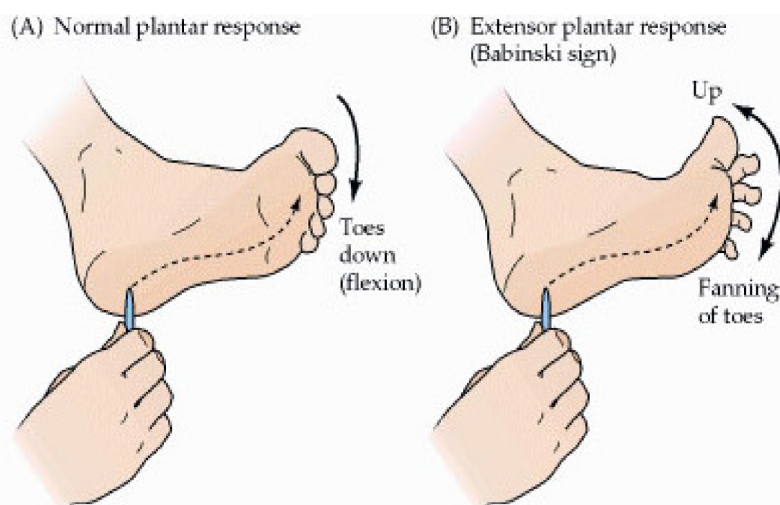
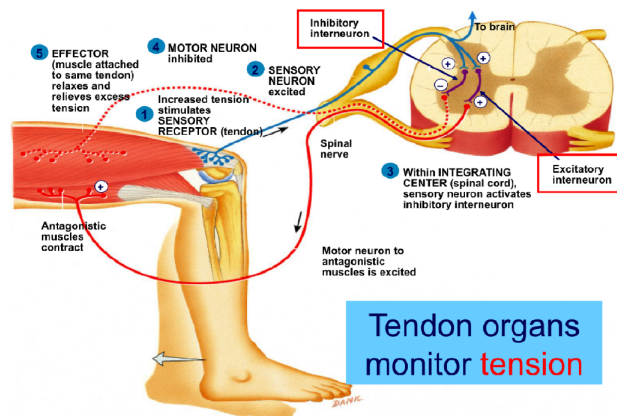
Clasp knife reaction

- Overactivity of the pointine excitatory system (spasticity)
- Initial resistance: Exaggerated stretch reflex
- Sudden release: After applying pressure, the tension in the muscle will increase and will be enough to activate the Golgi tendon organs which will cause the relaxation



Tendon reflex

- ✓ Polysynaptic reflex arc
- ✓ law of reciprocal innervation



When the corticospinal tracts are nonfunctional, the influence of the other descending tracts on the toes becomes apparent, and a kind of withdrawal reflex takes place in response to stimulation of the sole, with the great toe being dorsally flexed and the other toes fanning out.

يُعتقد إنه إله علاقة بالpyramidal tract لذلك لو عملنا هذا الاختبار على طفل عمره أقل من سنة

he will show extensor plantar response as the pyramidal tract hasn't completely developed

Clinical significance of lamination of the ascending tracts

- Any external pressure exerted on the spinal cord in the region of the spinothalamic tracts will first experience a loss of pain and temperature sensations in the sacral dermatome of the body
- If pressure increases the other higher segmental dermatomes will be affected

○ Remember that in the spinothalamic tracts the cervical to sacral segments are located medial to lateral

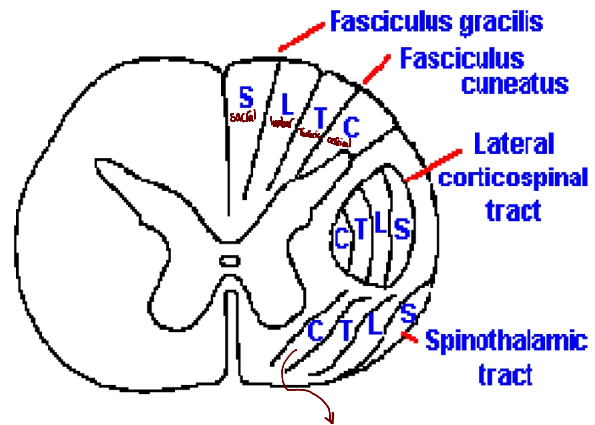
• **Intramedullary tumor:** affect the cervical fibers (Medial)

• **Extramedullary tumor** would affect lower limb fibers (lateral).

– **Sacral sparing:**

Occur at intramedullary tumor

لأنه ال sacral بعيد جداً



لو صار عندي intramedullary tumor أكثر شيء رح يتأثر في ال spinothalamic tract هو ال cervical (لأنه أقرب شيء)

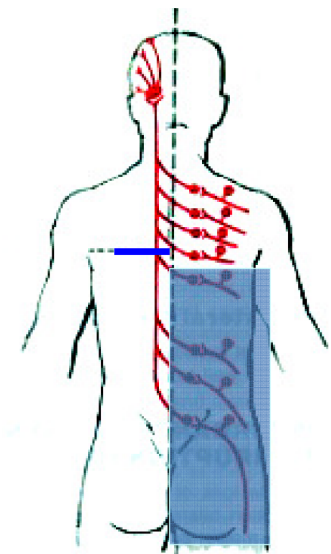
Clinical application

destruction of LSTT

- loss of
 - pain and thermal sensation
 - on the contralateral side
 - below the level of the lesion

patient will not recognize hot and cold

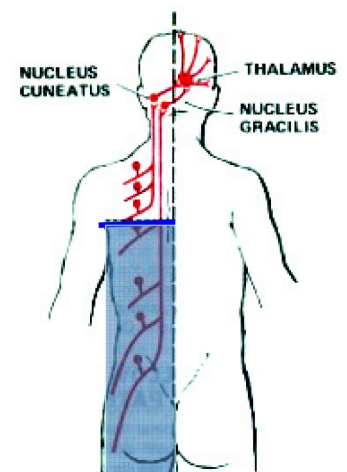
in the posterior column system, if a cut occur at the right side the loss of sensation will occur also at the right side ((ipsilateral)) whereas, in the lateral spinothalamic tract if a cut occur at the right side, the loss of sensation will occur at the left side ((contralateral))



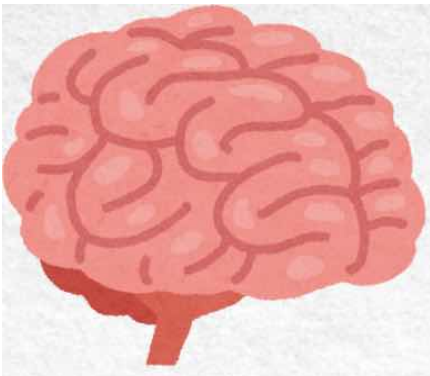
LATERAL SPINOTHALAMIC TRACT

destruction of fasciculus gracilia and cuneatus

- loss of muscle joint sense, position sense, vibration sense and tactile discrimination
- on the same side
- below the level of the lesion (extremely rare to have a lesion of the spinal cord to be localized as to affect one sensory tract only)



DORSAL COLUMNS



NEUROANATOMY

SUMMARY
FOR

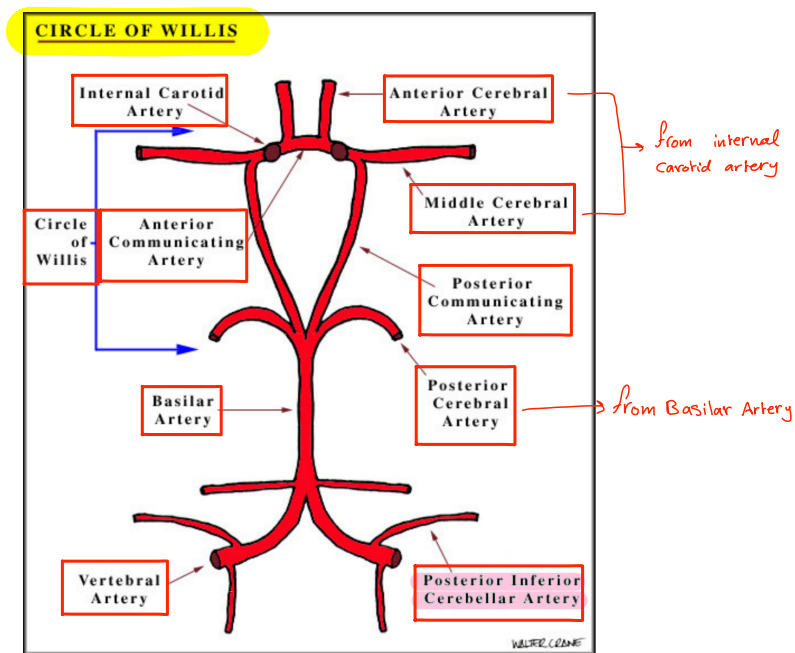
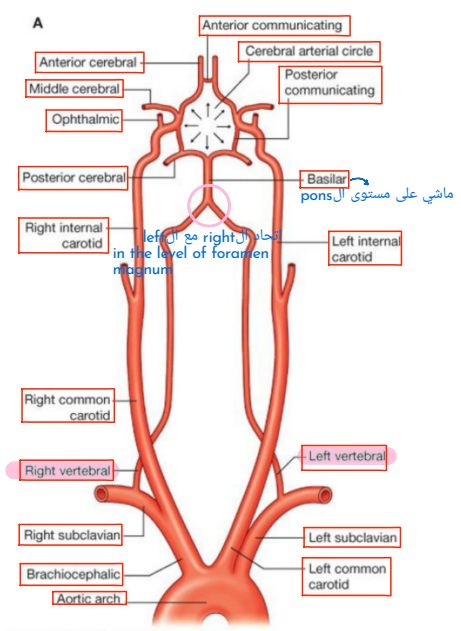
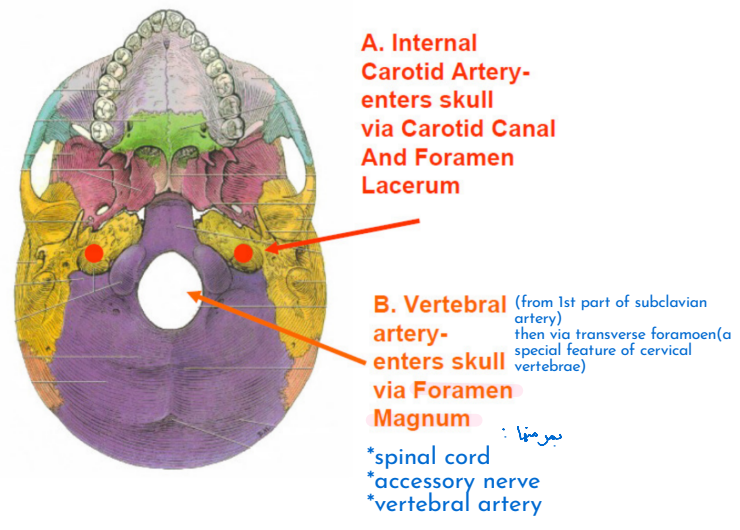
WEEK 5

BY : HEMMEH ASNAN



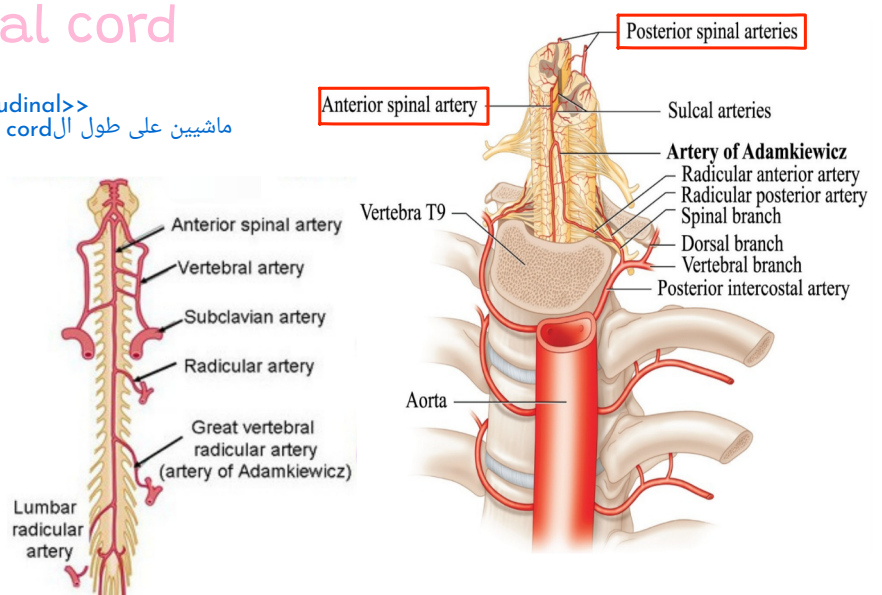
Arterial Blood Supply

- Brain is supplied by pairs of internal carotid artery and vertebral artery.
- The four arteries lie within the subarachnoid space
- Their branches anastomose on the inferior surface of the brain to form the circle of Willis



Blood supply of spinal cord

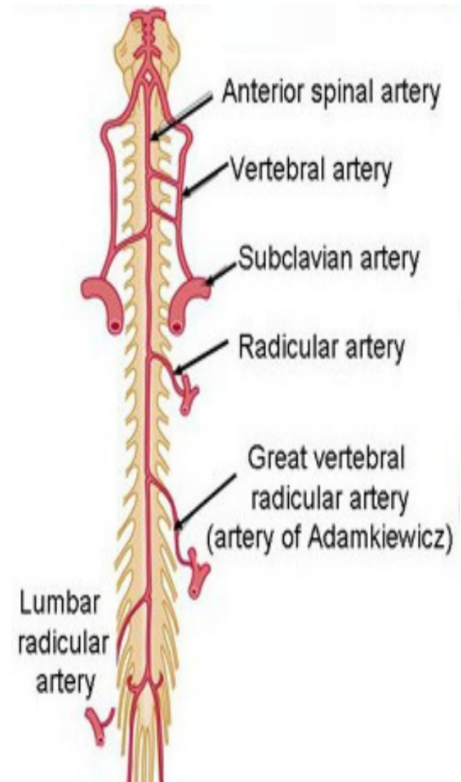
- **Longitudinal arteries:** longitudinal spinal cord
 - **One anterior spinal artery:** arise from the vertebral arteries (in anterior median fissure)
 - **Two posterior spinal arteries:** arise from the posterior inferior cerebellar artery (in the posterolateral sulcus)



Blood supply of spinal cord

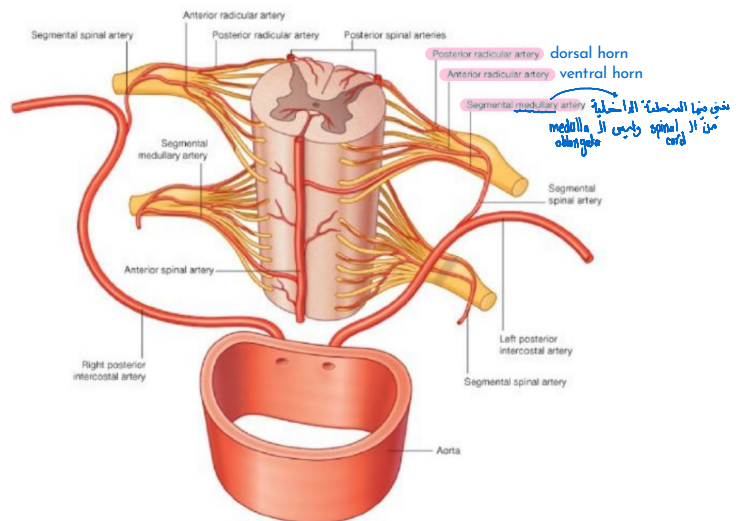
segmental > enters to the spinal cord transversely

- **segmental spinal arteries**, arise from:
 - Vertebral arteries
 - Deep cervical arteries in the neck
 - Posterior intercostal arteries in the thorax
 - lumbar arteries in the abdomen
- Branches : جذري، (root)
 - **Anterior radicular arteries**
 - **Posterior radicular arteries**
 - **Segmental medullary arteries**
- **Artery of Adamkiewicz**
 - usually on the left side,
 - reinforces the arterial supply to the lower portion of the spinal cord
 - From Left posterior intercostal artery at the level of the 9th to 12th intercostal artery, which branches from the aorta, and supplies the lower two thirds of the spinal cord
 - Anastomose with anterior spinal artery



Blood supply of spinal cord

- **segmental spinal arteries**, arise from:
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 - Deep cervical arteries in the neck
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- Branches :
 - **Anterior radicular arteries**
 - **Posterior radicular arteries**
 - **Segmental medullary arteries**

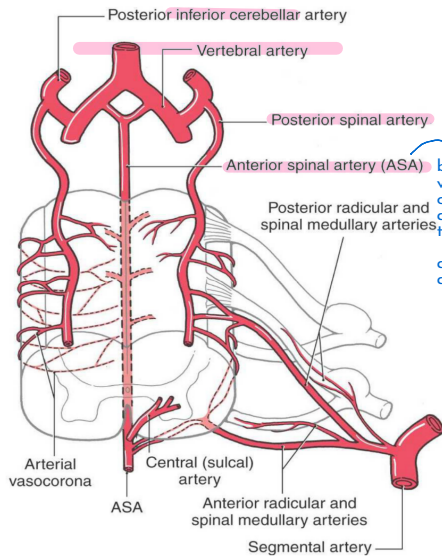


• Artery of Adamkiewicz

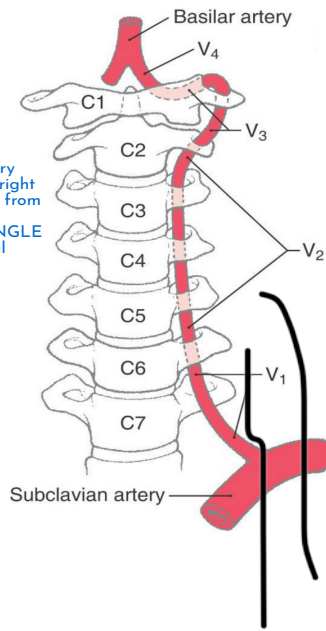
Supply the lower part of the spinal cord which cant be supplied by longitudinal arteries (supply the upper part)



Blood supply of spinal cord



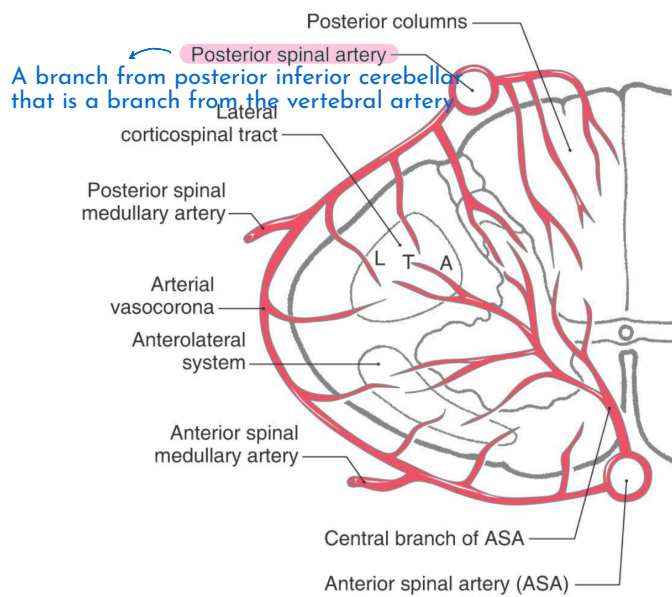
branch from vertebral artery one from the right and the other from the left unite to form a SINGLE anterior spinal artery



There are 2 vertebral arteries
1 anterior spinal artery
2 posterior spinal arteries

Blood supply of spinal cord

- Terminal branches of the spinal medullary arteries join to form **arterial vasocorona**. *A branch that goes inside*
- **The posterior spinal arteries and arterial vasocorona:** The **posterior white** columns and peripheral parts of the lateral and anterior funiculi
- **The anterior spinal artery:** Most of the **gray matter** and the adjacent parts of the white matter *وكذلك جزء من الـ posterior*



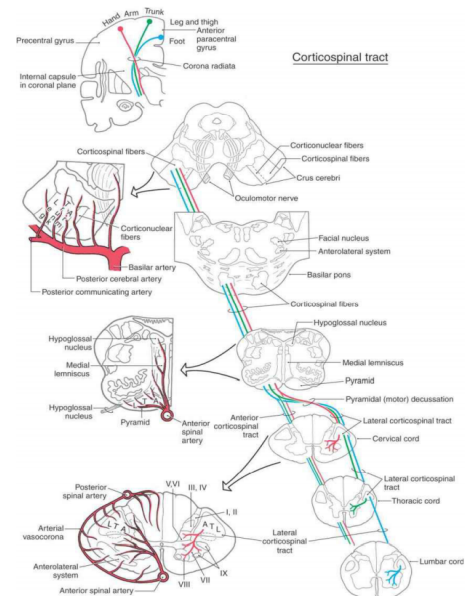
A branch from posterior inferior cerebellar that is a branch from the vertebral artery

Central Cord Syndrome

- may result from hyperextension of the neck
- Occludes blood supply to the cord via the anterior spinal artery
- **bilateral weakness of the extremities** (more so of the upper than of the lower)
- pain and thermal sensation loss (as it reaches the dorsal horn (lamina I, II, V), and bladder dysfunction **Lateral horn (autonomic)**)



single تـ anterior spinal artery



- Compromise of blood flow in the **posterior spinal artery** results in:
 - **Ipsilateral** (A problem in the right side will be accompanied with a loss of sensation in the right side)
 - reduction or loss of discriminative, positional, and vibratory tactile sensations at and below the segmental level of the injury**

