Central Nervous System

Lecture 4: Descending Tracts

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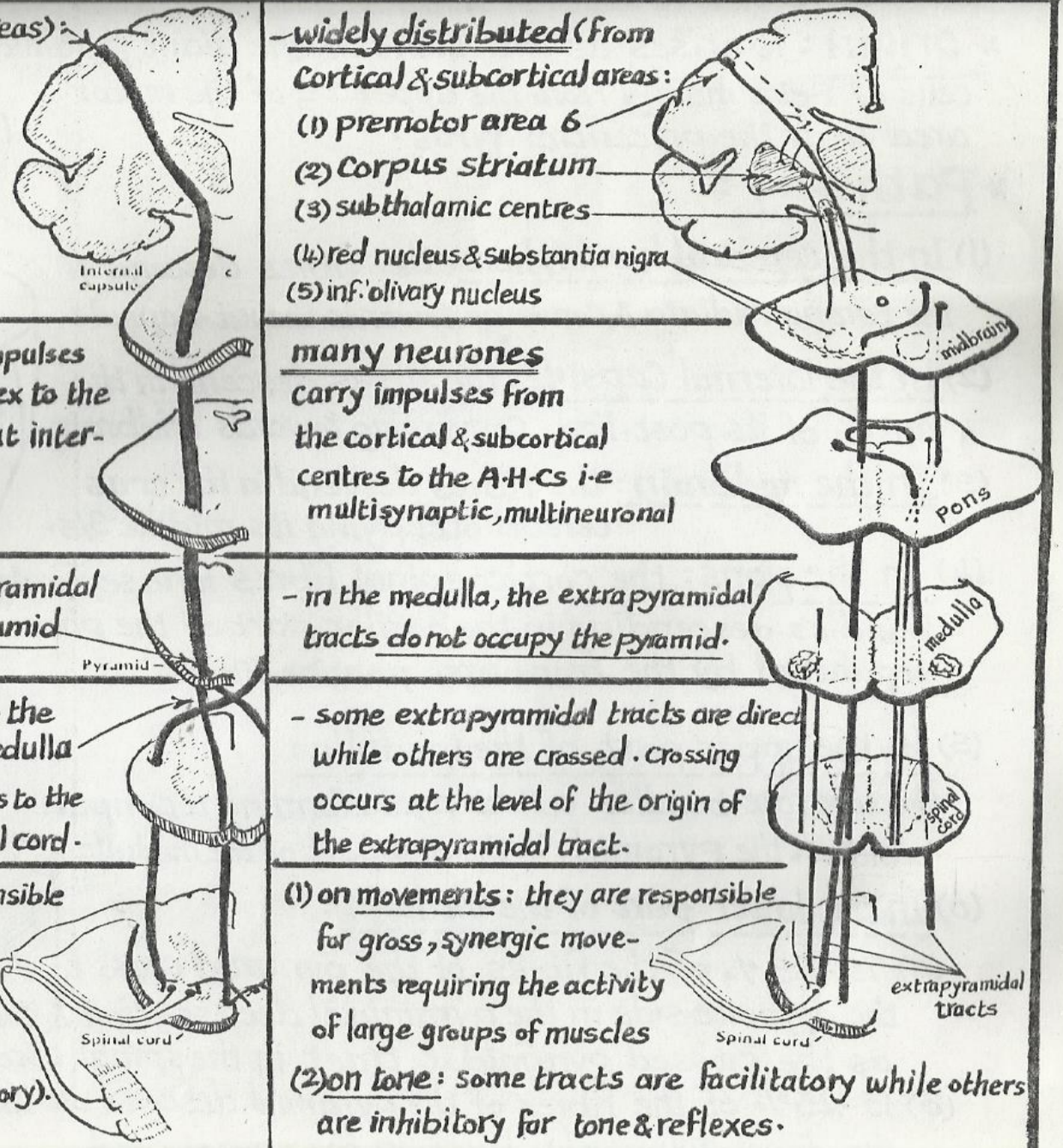
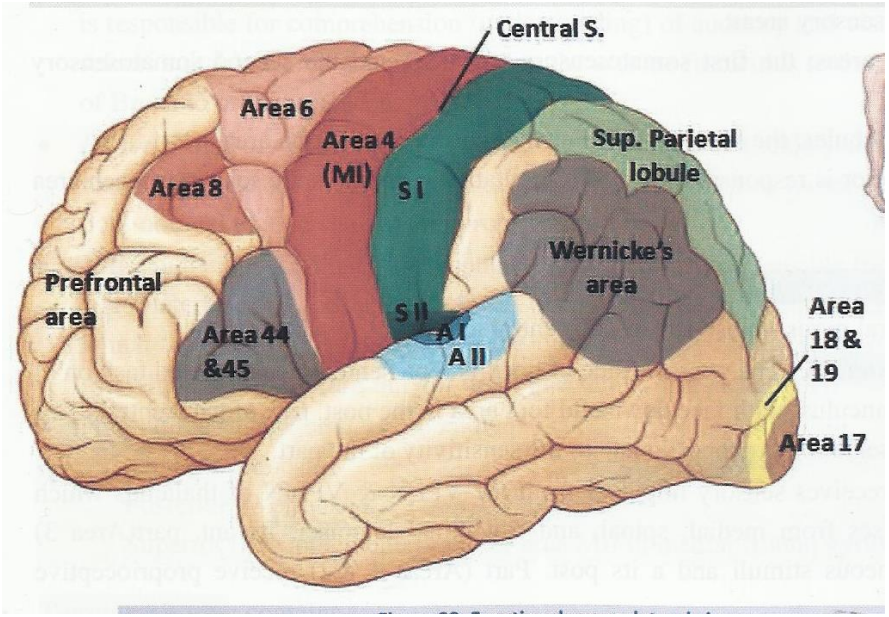
	Pyramidal tract	Extrapyramidal tracts
origin	localized (cortical areas): motor area 4 & premotor area 8	widely distributed (from cortical & subcortical areas): (1) premotor area 6 (2) Corpus striatum (3) subthalamic centres (4) red nucleus & substantia nigra (5) inf. olivary nucleus
Course	one neurone carries impulses from the cerebral cortex to the ant. horn cells without interruption	many neurones carry impulses from the cortical & subcortical centres to the A·H·Cs i.e multisynaptic, multineuronal
site in the medulla:	in the medulla, the pyramidal tract occupies the pyramid	- in the medulla, the extrapyramidal tracts do not occupy the pyramid.
Crossing of fibres:	- 80% of fibres cross to the opposite side in the medulla - the remaining fibres cross to the opposite side in the spinal cord.	- some extrapyramidal tracts are direct while others are crossed. Crossing occurs at the level of the origin of the extrapyramidal tract.
Function:	(1) on movement: responsible for fine, isolated, precise & specific movements (2) on tone: it increases tone & reflexes (facilitatory).	(1) on movements: they are responsible for gross, synergic movements requiring the activity of large groups of muscles (2) on tone: some tracts are facilitatory while others are inhibitory for tone & reflexes.

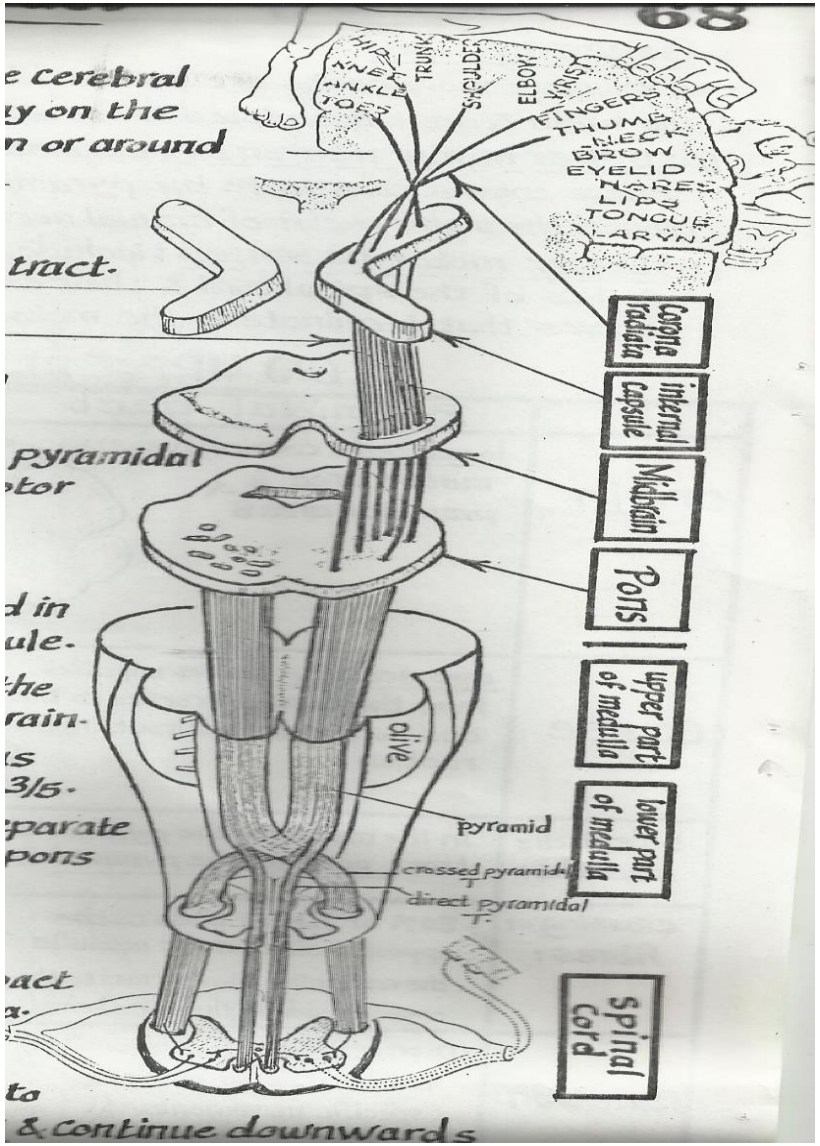


Descending Tracts of Spinal Cord

I. Pyramidal Tract

* **Origin: From neurons in cerebral cortex.**
* **The majority of fibers arise from the motor area 4 and the premotor area 6.**

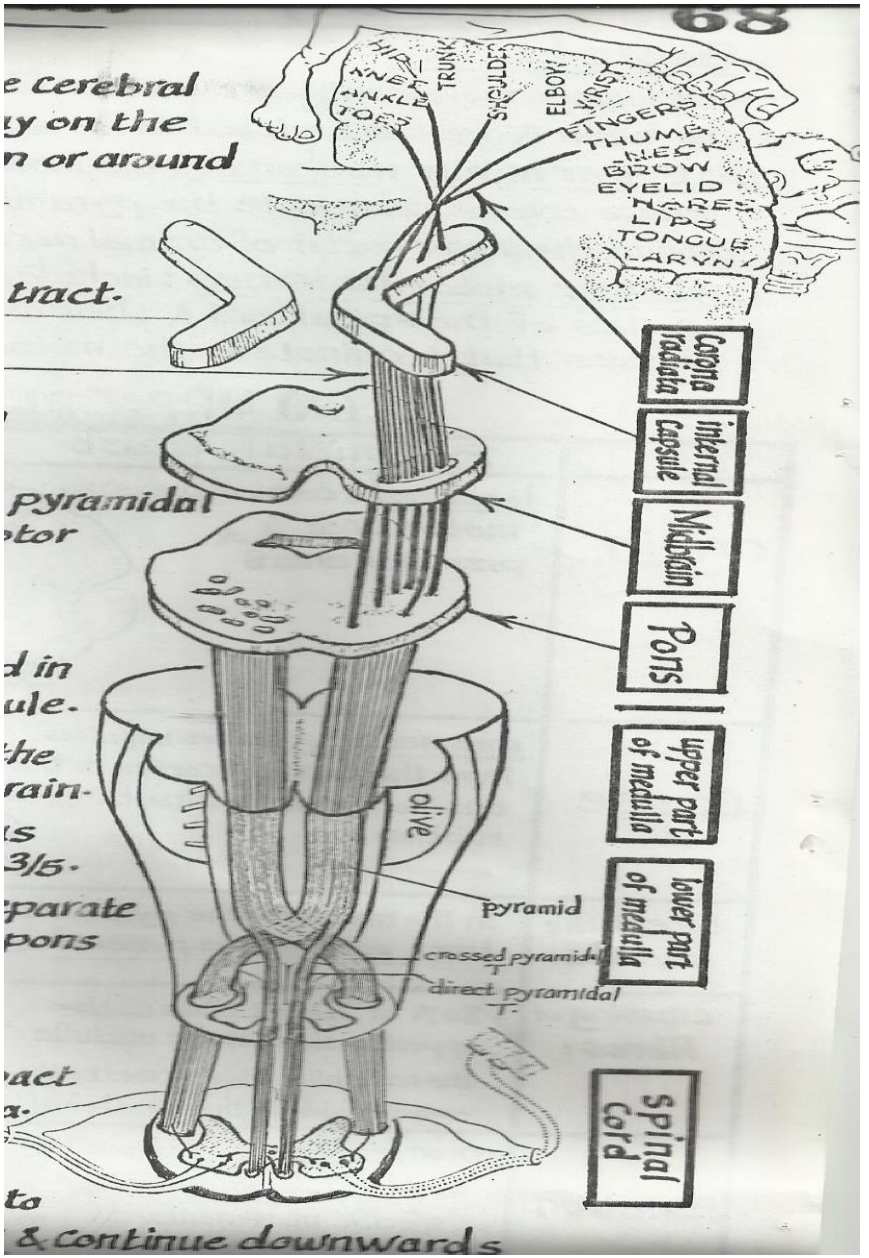




Pyramidal Tract (contd)

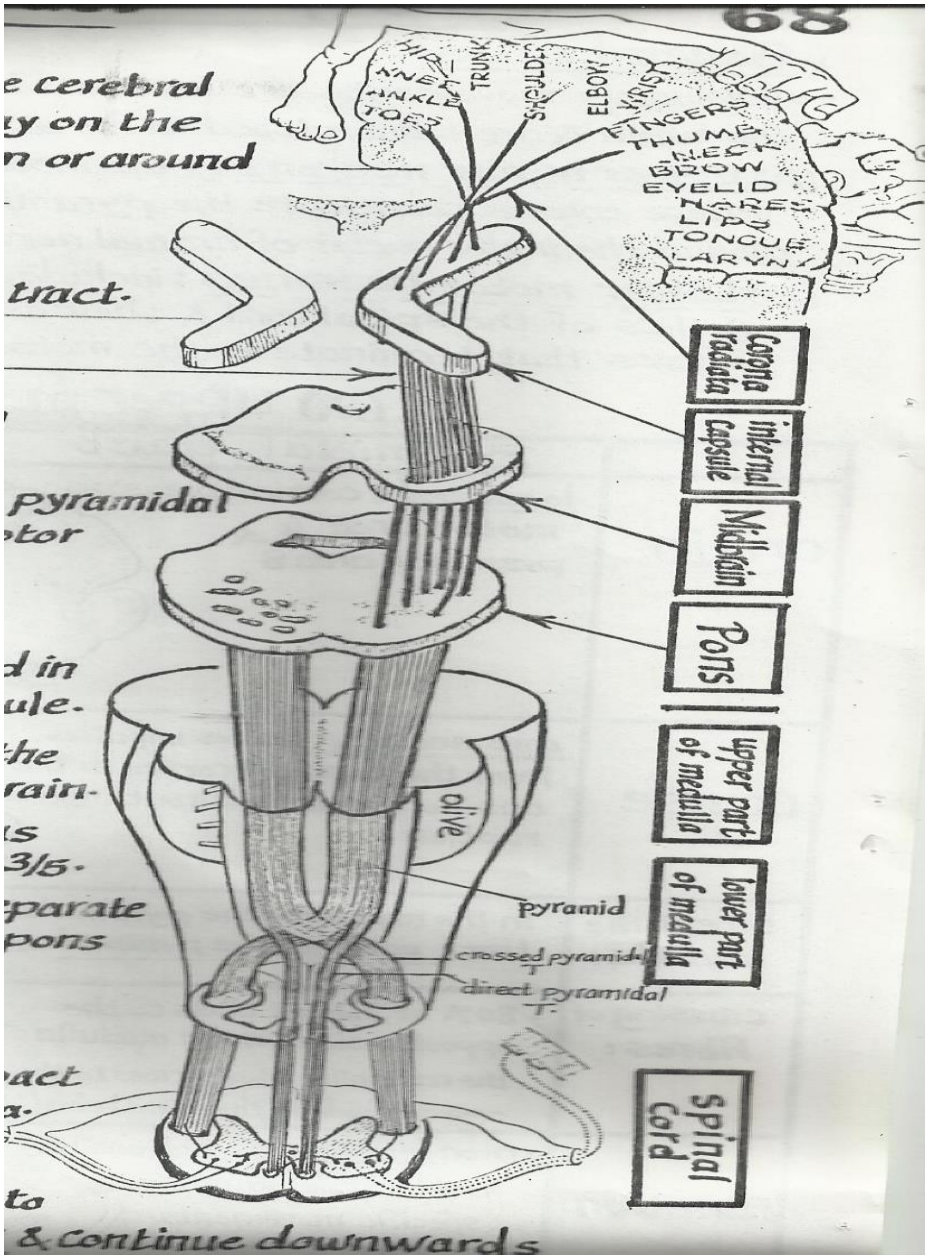
** Course:

* Axons of neurons in the cerebral cortex descend & converge in the corona radiata.
* They pass in the anterior 2/3 of posterior limb of internal capsule.
* They descend in the middle 3/5 of the crus cerebri (basis pedunculi of midbrain).
* They descend as scattered bundles in the basis pontis separated by the transverse pontine fibers.
* Fibers collect and form the pyramid of the medulla oblongata.



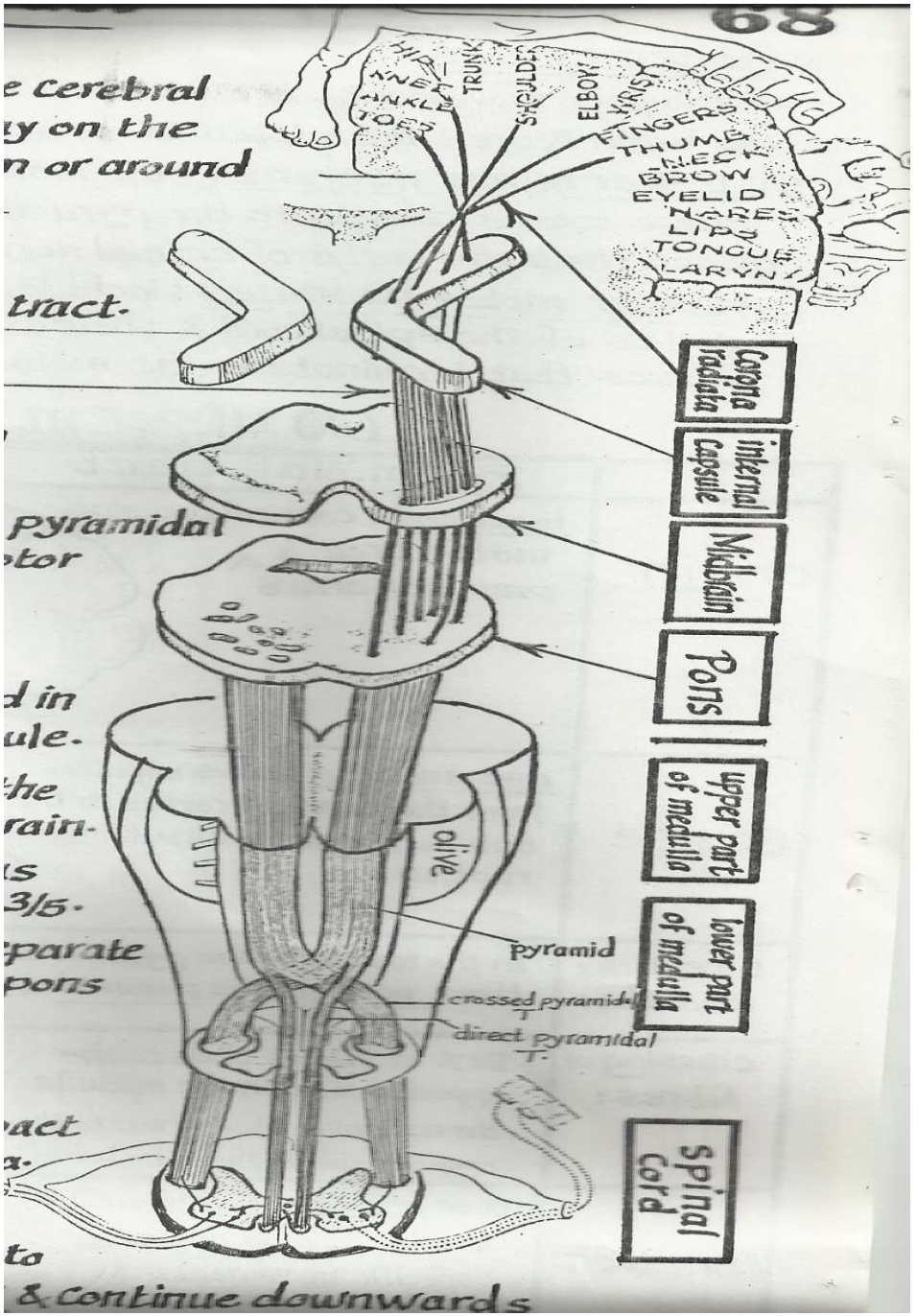
Pyramidal Tract (contd)

* 80% of fibers cross in the lowermost part of the medulla forming the motor decussation → then descend in the spinal cord as the lateral corticospinal tract which lies in the lateral white column.
* The uncrossed fibers descend in the spinal cord as the anterior corticospinal tract. The uncrossed corticospinal fibers usually cross at a lower level (in the spinal cord).



** **Lamination:**

* **In the cerebral cortex:** the body is represented upside down with the face area lowermost and foot area on the medial surface of the cerebral hemisphere.
* **In the internal capsule:** fibers for face muscles are in the genu, upper limb area lie most anterior & lower limb area most posterior in the posterior limb of internal capsule.
* **In the midbrain & spinal cord: (lateral corticospinal tract):** cervical fibers are medial while sacral fibers are lateral.



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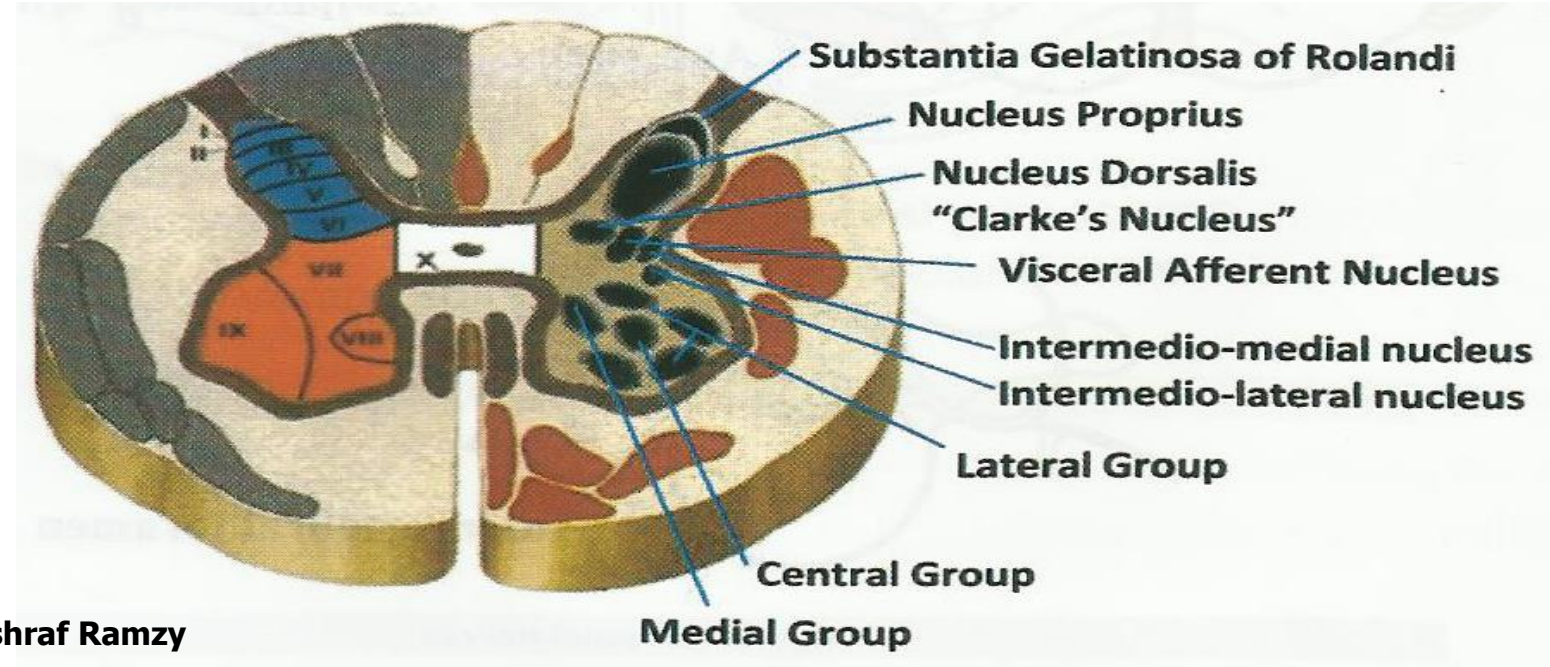
** Termination:

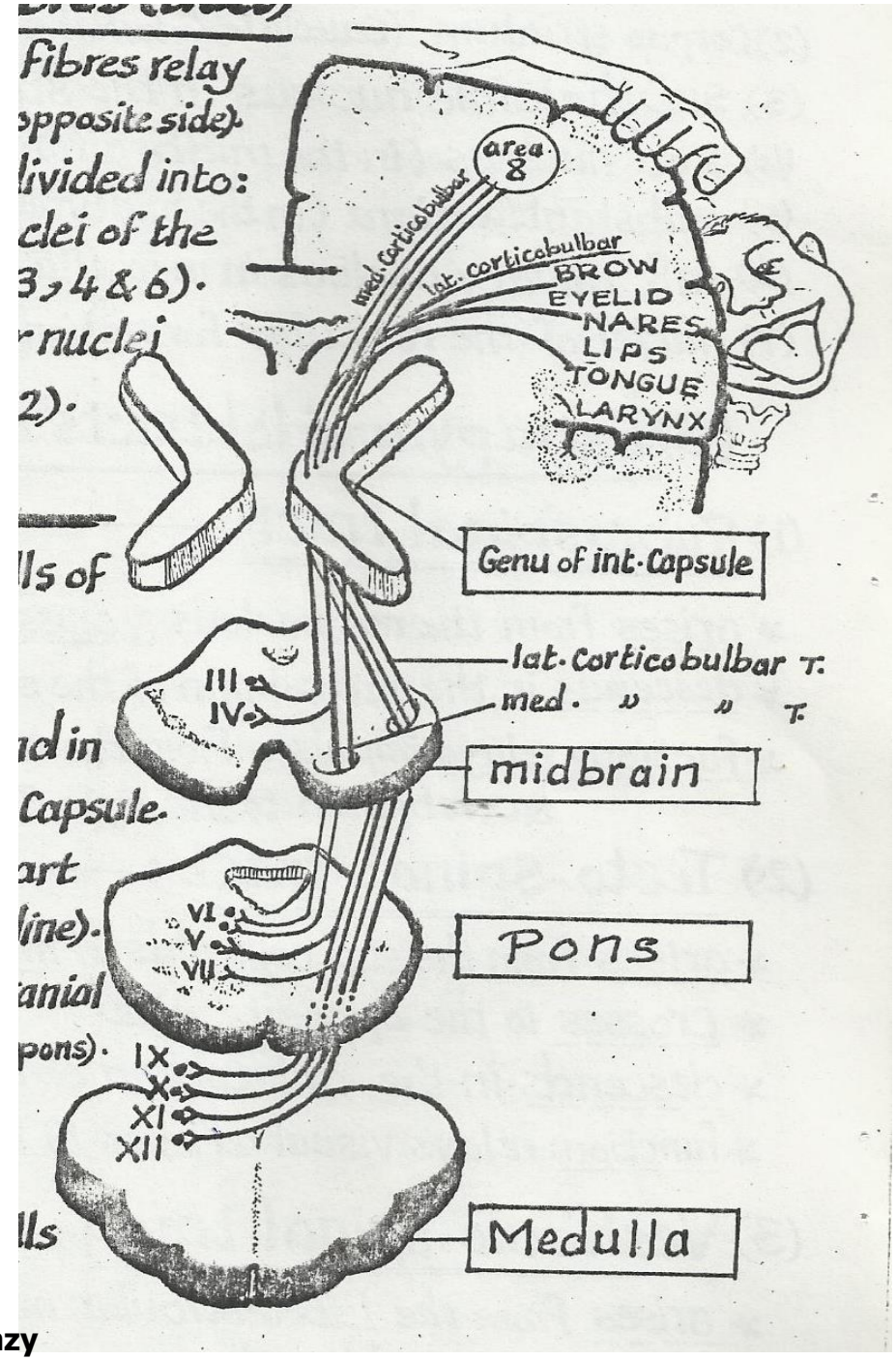
1. In spinal cord:

* The crossed fibers (80%) end on the lateral group of anterior horn cells (AHCs) which supply the limbs.
* The uncrossed fibers (20%) end on the medial group of AHCs of both sides (supplying the trunk). Only 2% end on the spinal accessory nucleus of the same side (supplying the sternomastoid).



2. In brain stem: Some pyramidal tract fibers do not reach the spinal cord but end on motor nuclei of cranial nerves that lie in the brain stem. These fibers form the corticonuclear tract (corticobulbar tract) which controls muscles of the head.

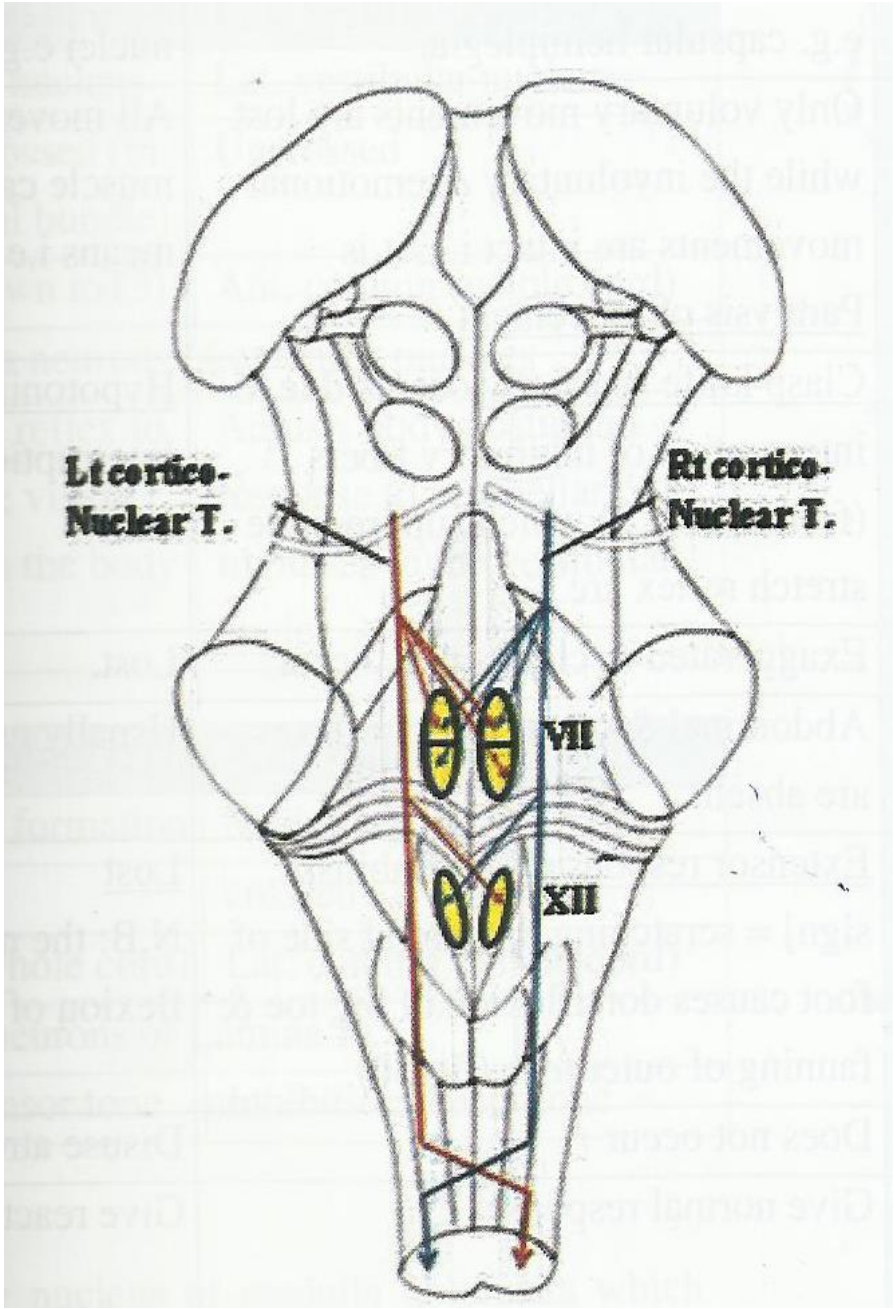
* **Fibers of the corticonuclear tract** → descend in the corona radiata, genu of internal capsule, to reach the brain stem to terminate mainly on contralateral motor nuclei present in brain stem and on ipsilateral nuclei as well.



* **Two exceptions for this double control are:**

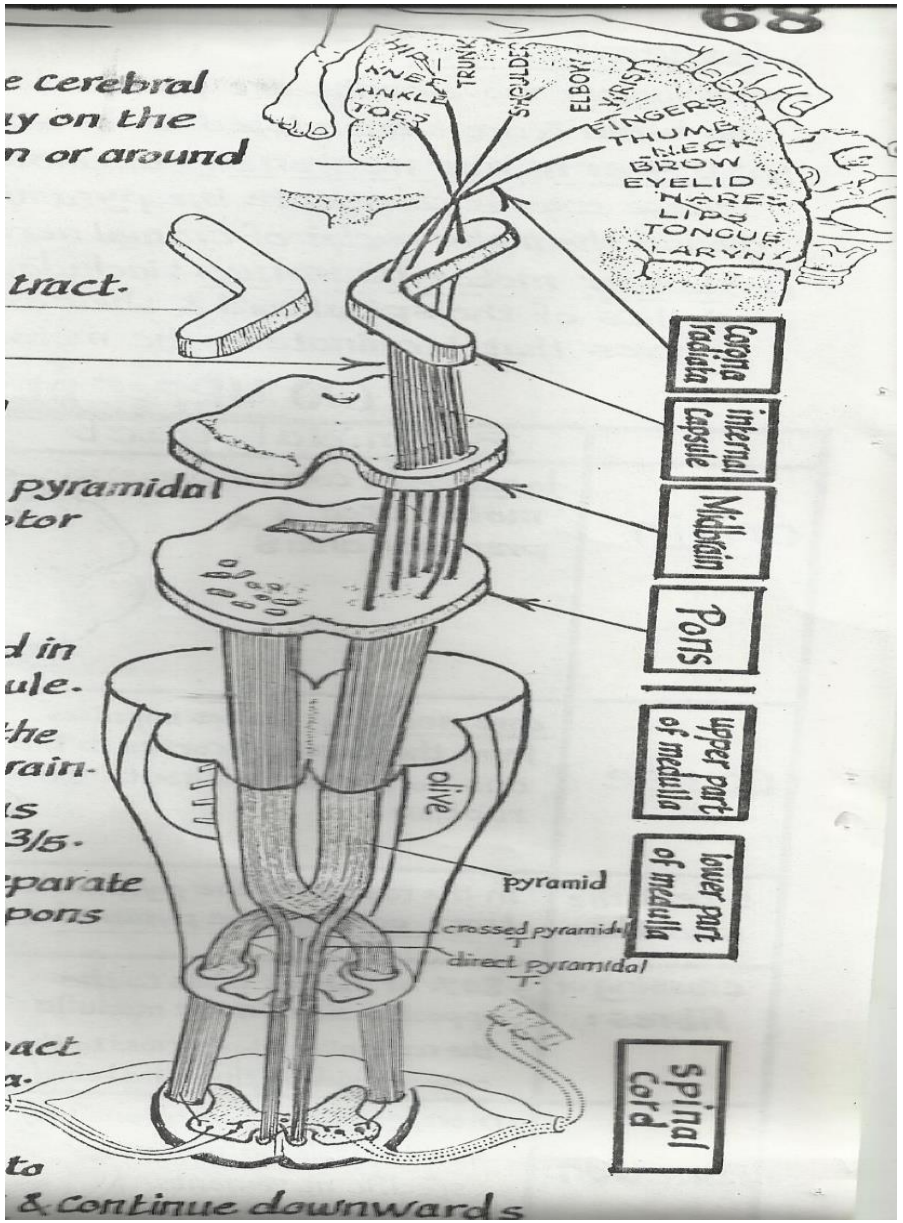
1. **The part of motor nucleus of facial nerve that controls muscles of the lower part of the face.**
2. **The part of the hypoglossal nucleus that controls genioglossus muscle (the most bulky muscle of the tongue).**

* **These muscles receive contralateral corticonuclear fibers only.**



Upper & Lower Motor Neuron Lesions

* Neurons from the cerebral cortex that descend to end on the AHCs or motor nuclei of cranial nerves form → the upper motor neuron.
* Neurons of AHCs or motor cranial nerves nuclei form → the lower motor neuron.



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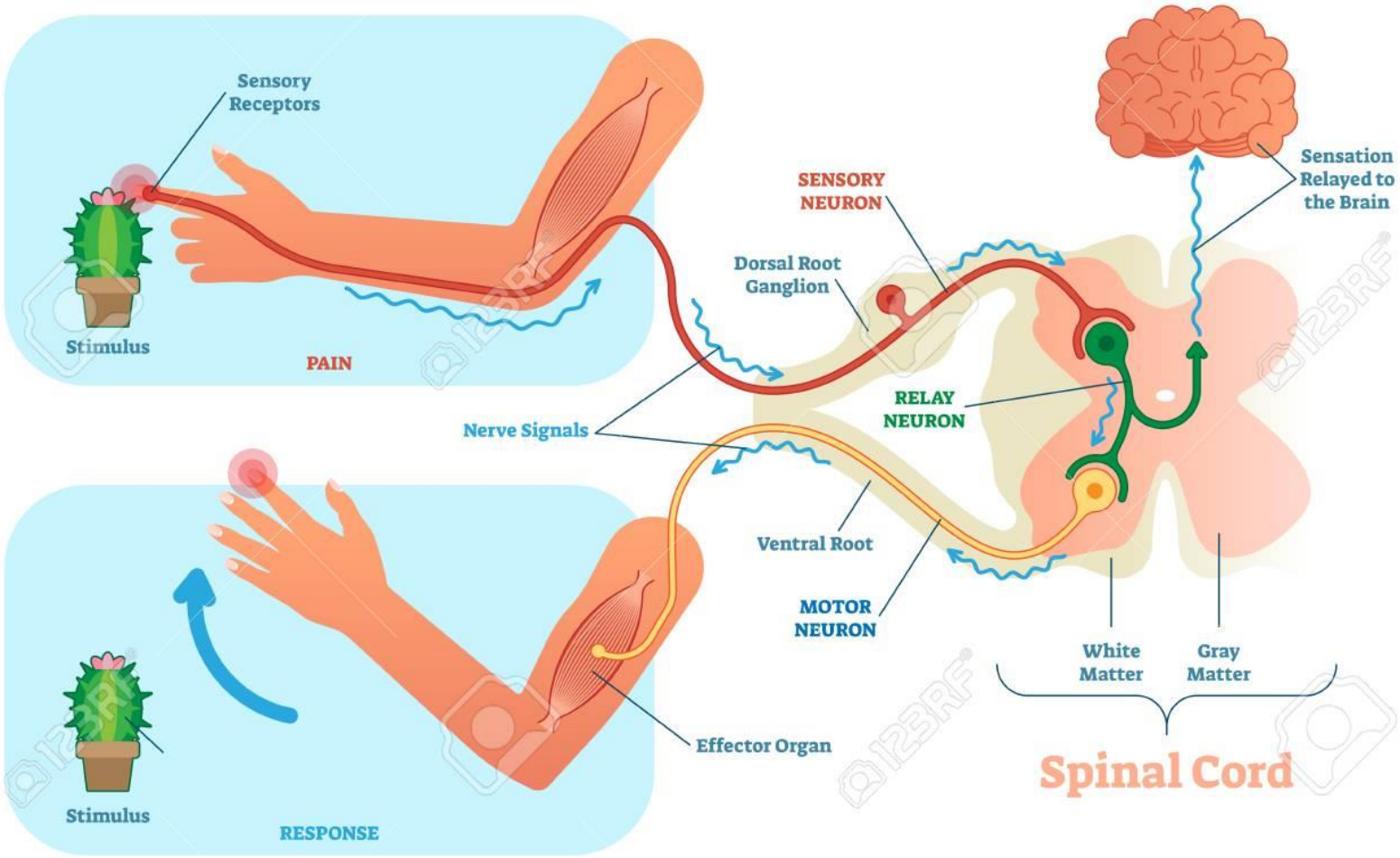
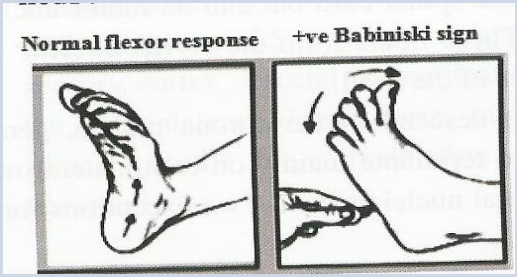

Sensory Receptors
Stimulus
PAIN
SENSORY NEURON
Dorsal Root Ganglion
Sensation Relayed to the Brain
RELAY NEURON
Nerve Signals
Ventral Root
MOTOR NEURON
White Matter
Gray Matter
Spinal Cord
Effector Organ
Stimulus
RESPONSE

Upper & Lower Motor Neuron Lesions

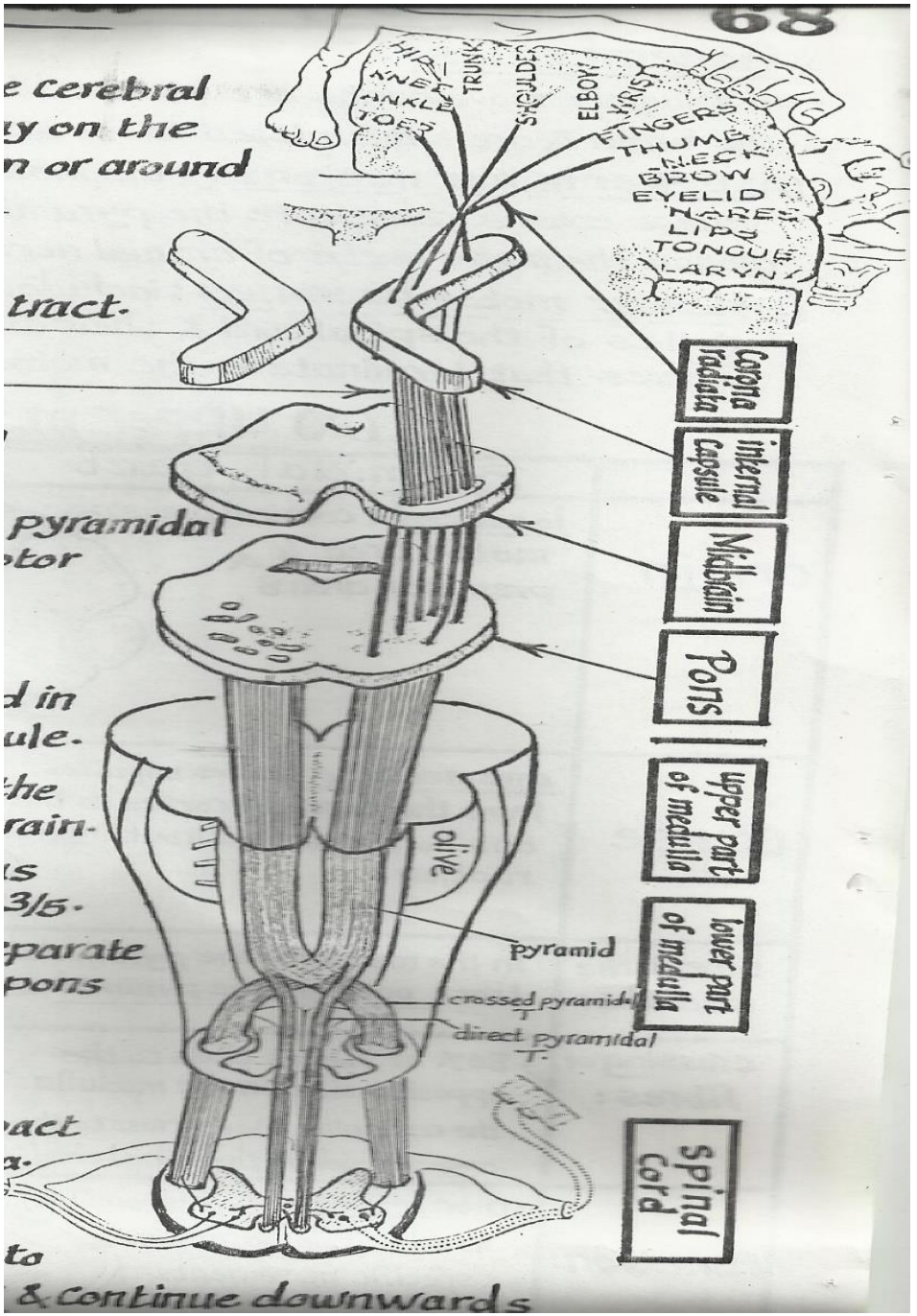
	Upper Motor Neuron Lesion [UMNL]	Lower Motor Neuron Lesion [LMNL]
1. Means:	Lesion of the pyramidal tract e.g. capsular hemiplegia.	Lesion of AHCs or motor cranial nuclei e.g. poliomyelitis.
2. Movements:	Only voluntary movements are lost while the involuntary & emotional movements are intact i.e. it is Paralysis of movement.	All movements are lost & the muscle cannot be moved by any means i.e. it is Paralysis of muscle.
3. Muscle tone:	Clasp knife spasticity occurs due to interruption of inhibitory fibers (from area 4 S) which suppress the stretch reflex arc.	Hypotonia [flaccidity] occurs due to Interruption of the stretch reflex arc.

Upper & Lower Motor Neuron Lesions

	Upper Motor Neuron Lesion [UMNL]	Lower Motor Neuron Lesion [LMNL]
4. Tendon jerks:	Exaggerated & clonus may occur.	Lost.
5. Superficial reflexes:	Abdominal & cremasteric reflexes are absent.	Usually not affected.
6. Plantar response:	Extensor response [+ve Babinski sign] ⟶ scratching the lateral side of foot causes dorsiflexion of big toe & fanning of outer toes.	Lost.  **N.B: the normal plantar response is flexion of all the toes.**
7. Atrophy:	Does not occur.	Disuse atrophy occurs.
8. Electric stimuli:	Give normal response.	Give reaction of degeneration.

N.B: Flaccid UMNL

occurs in selective lesion of the medullary pyramid because the suppressor fibers from area 4S run away from the pyramid thus escape from injury.



II. Extrapyramidal Tracts

** These are descending tracts, apart from the pyramidal tract, that influence the AHCs.

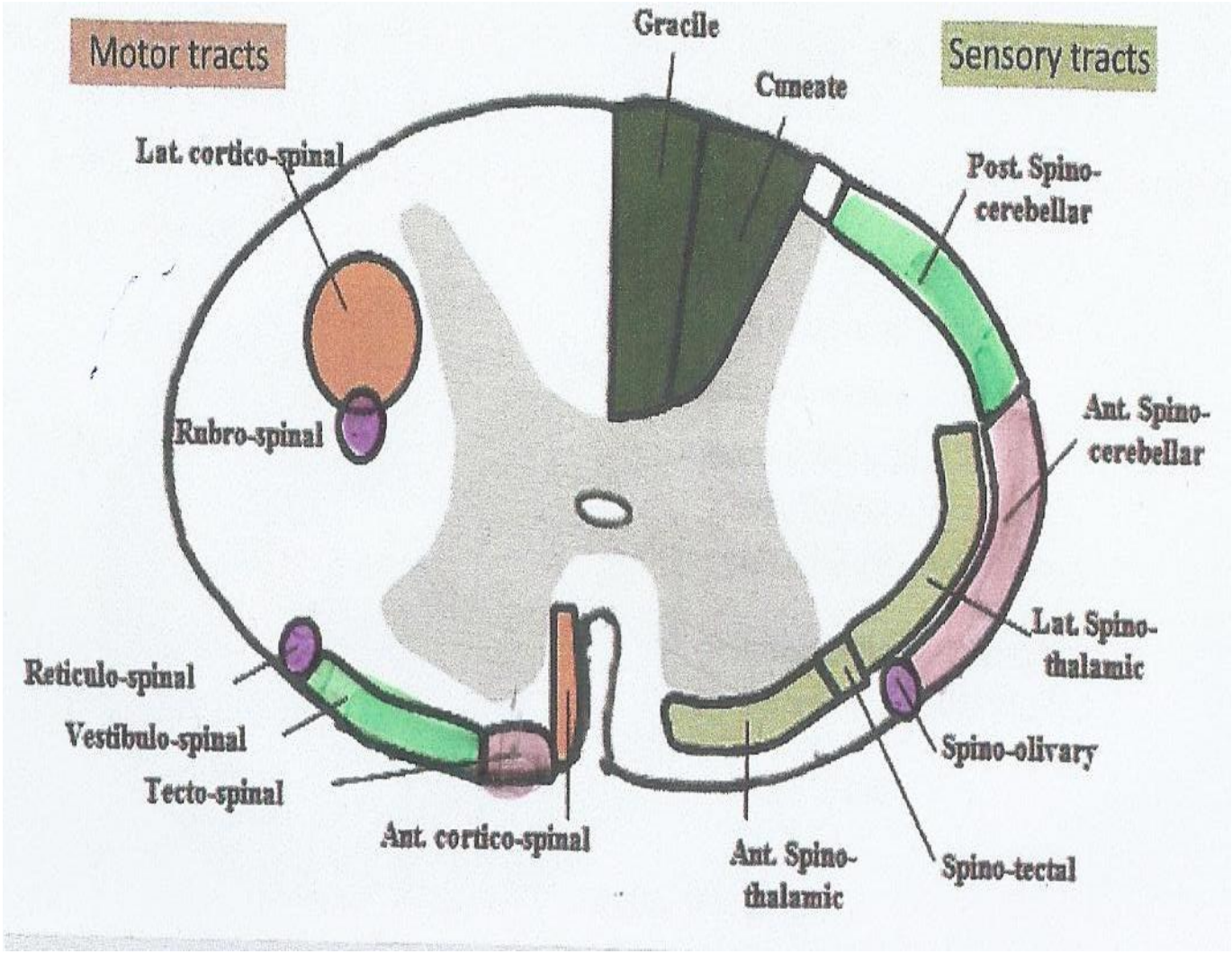
** These tracts are named according to their starting point.

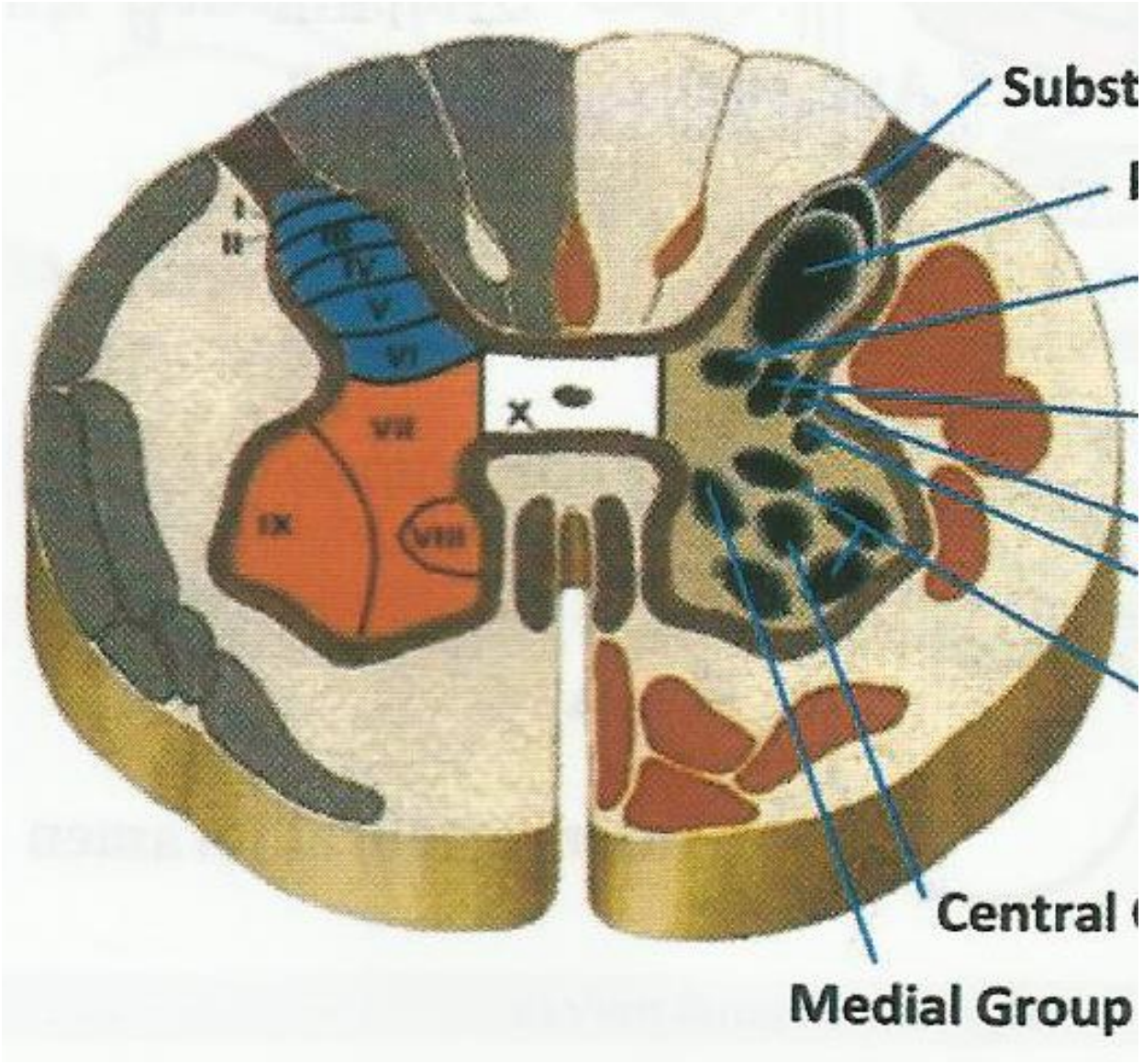
** They are formed of either crossed, uncrossed, or a combination.

** They may be excitatory or inhibitory to muscles.

** They are responsible for adjusting muscle tone, posture and the semiautomatic movements such as swinging the arm during walking.

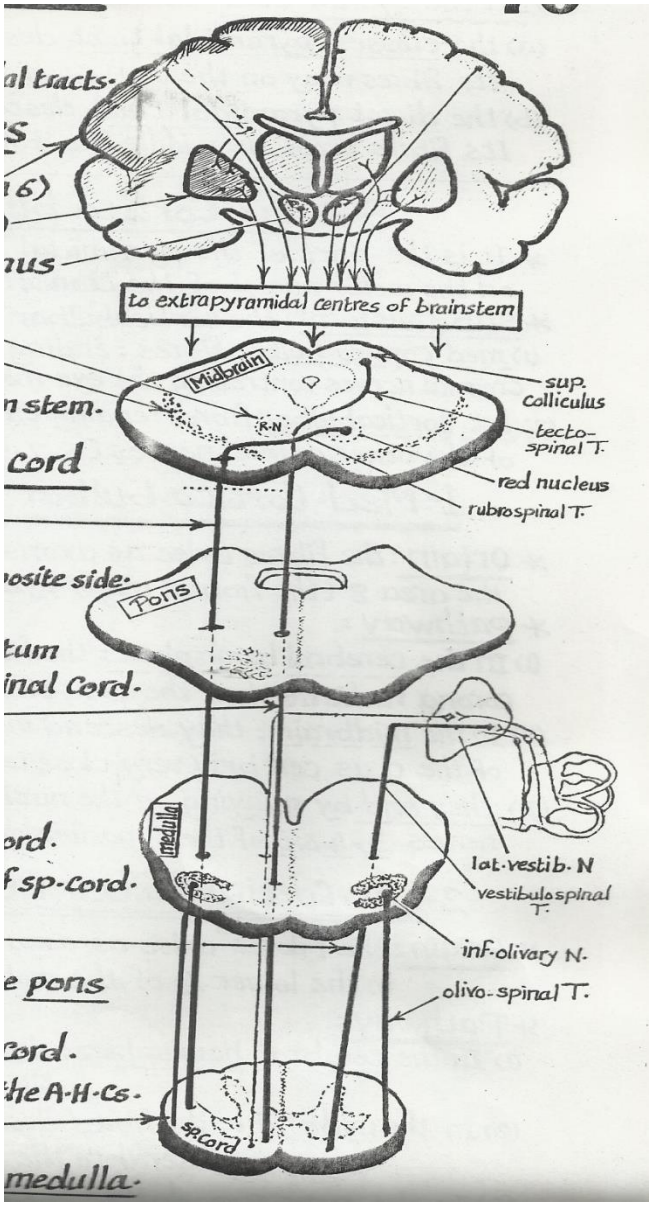
** On the other hand, the pyramidal tract is responsible for skilled voluntary movements in the distal parts of the limbs.


Motor tracts
Sensory tracts
Gracile
Cuneate
Lat. cortico-spinal
Post. Spino-cerebellar
Rubro-spinal
Ant. Spino-cerebellar
Lat. Spino-thalamic
Reticulo-spinal
Vestibulo-spinal
Tecto-spinal
Spino-olivary
Ant. cortico-spinal
Ant. Spino-thalamic
Spino-tectal


Subst
Central
Medial Group

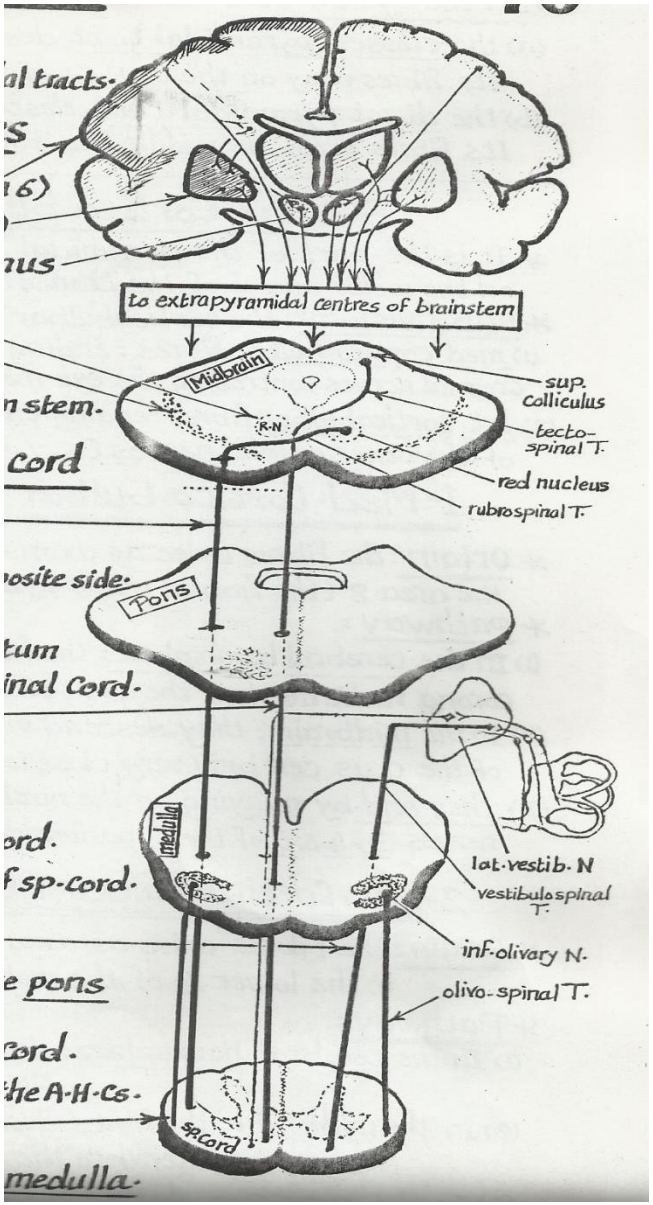
Tecto-spinal & Rubro-spinal Tracts

	Tecto-spinal Tract	Rubro-spinal Tract
1. Origin:	superior colliculus in upper level of midbrain.	Red nucleus in upper level of midbrain.
2. Crossing:	In dorsal tegmental decussation.	In ventral tegmental decussation.
3. Site:	In anterior white column of cervical segments.	In lateral white column of cervical segments.
4. Ends:	Med. group of cervical AHCs → neck muscles.	Lat. group of cervical AHCs → upper limb.
5. Function	turning of head & neck in response to auditory, visual & cutaneous stimuli.	Stimulates flexor muscle tone in upper limb (with pyramidal tract).



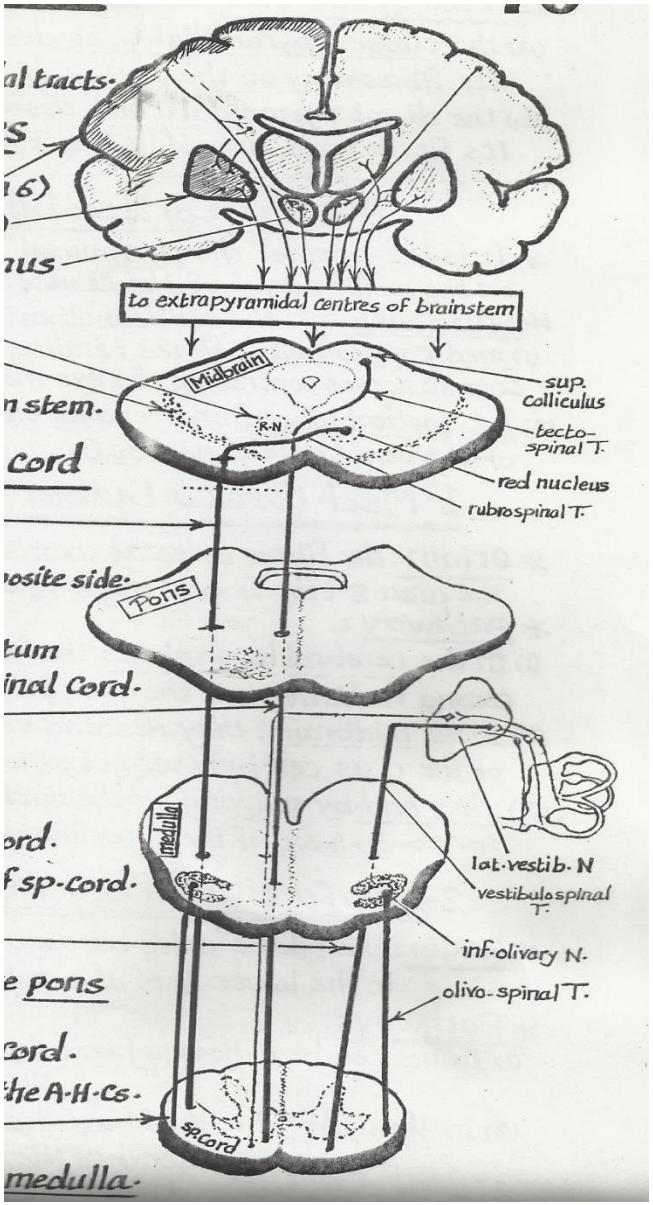
Med. & lat. Vestibulo-spinal Tracts

	Med. Vestibulo-spinal Tract	Lat. Vestibulo-spinal Tract
1. Origin:	Med. vestibular nucleus.	Lat. vestibular nucleus.
2. Crossing:	Crossed & uncrossed (in med longitudinal bundle).	Uncrossed.
3. Site:	Ant column (down to T3).	Ant. column (whole cord).
4. Ends:	Alpha & gamma neurons of extensor muscles.	
5. Function	head-rightening reflex to keep the head & vision horizontal when the body is tilted.	Adjusts body posture in response to cerebellar impulses to the vestibular nuclei.



Med. & lat. Reticulo-spinal Tracts

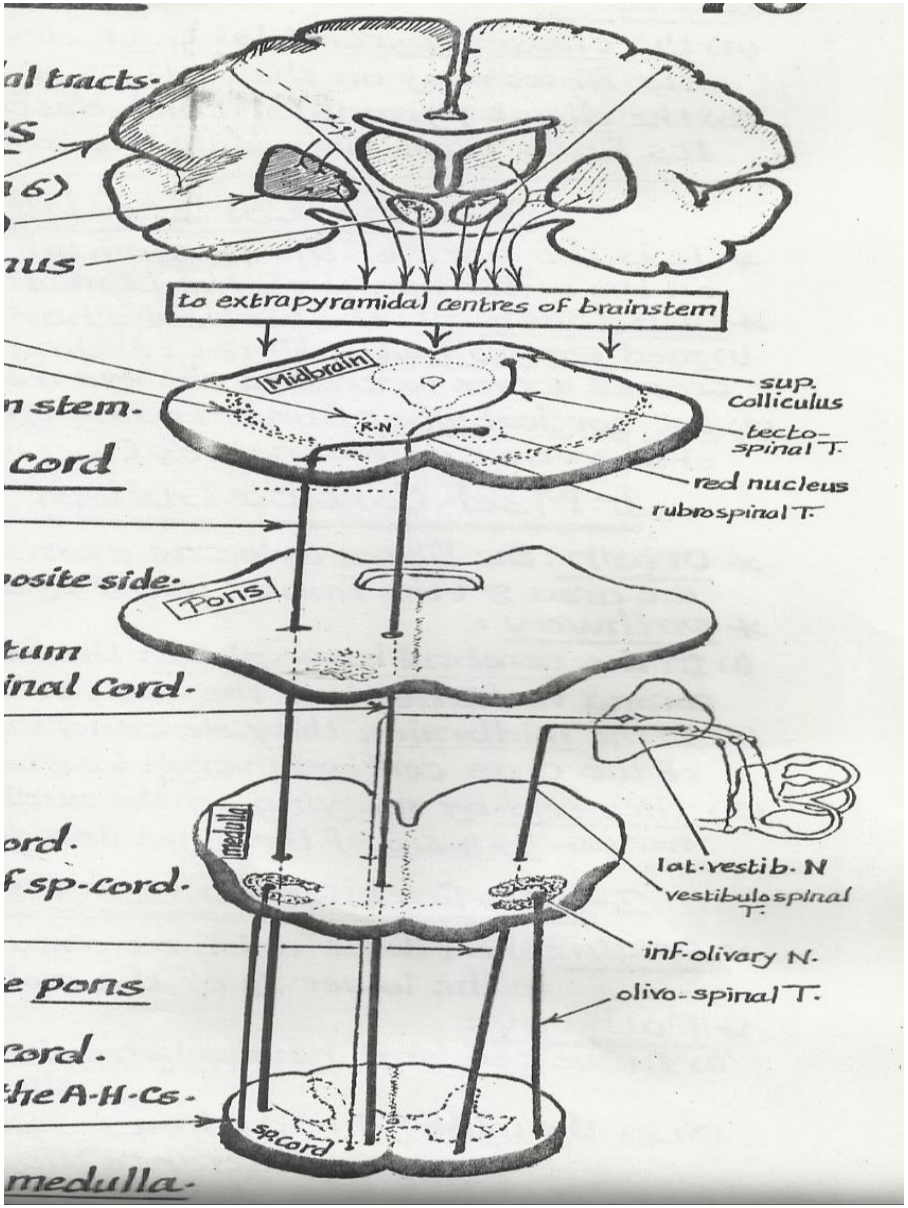
	Med. Reticulo-spinal Tract	Lat. Reticulo-spinal Tract
1. Origin:	Pontine reticular formation.	Medullary reticular formation.
2. Crossing:	Uncrossed.	Crossed.
3. Site:	Ant column (whole cord).	Lat. column (whole cord).
4. Ends:	Gamma motor neurons of lamina IX.	
5. Function	Facilitates extensor tone.	Inhibits extensor tone.



Olivo-spinal Tract

** Origin: inferior olivary nucleus of medulla oblongata which receives input from the cerebellum.

** Axons cross & descend to AHCs.



Arterial Supply of Spinal Cord

** The spinal cord is supplied by three sets of arteries: two longitudinal (anterior & posterior spinal arteries) and many segmental radicular arteries.

1. Anterior Spinal Artery:

* Origin: a single artery formed by union of two anterior spinal arteries, each is a branch of the vertebral artery inside the skull.

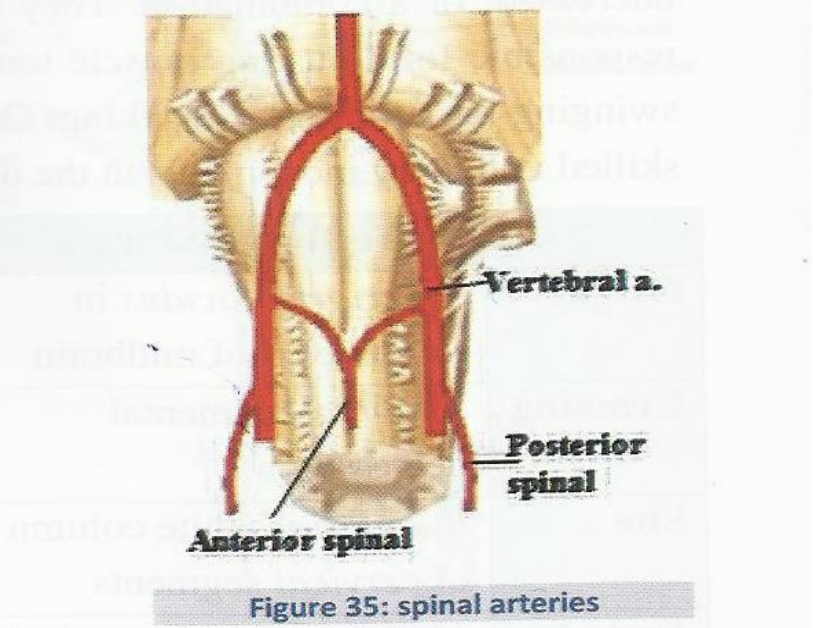
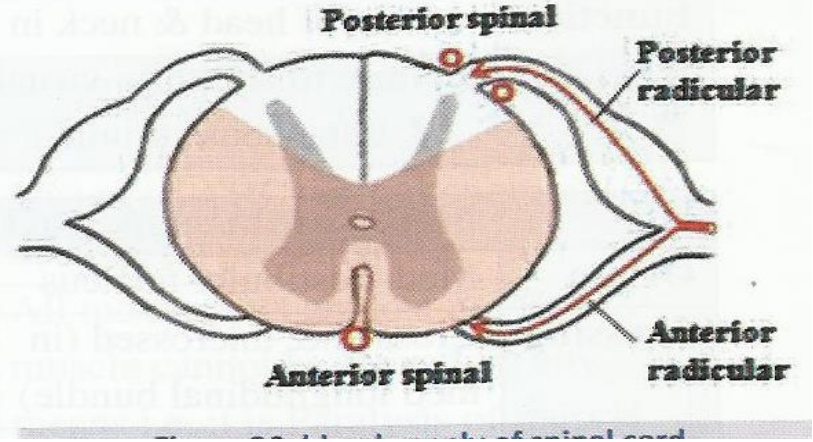


Figure 35: spinal arteries

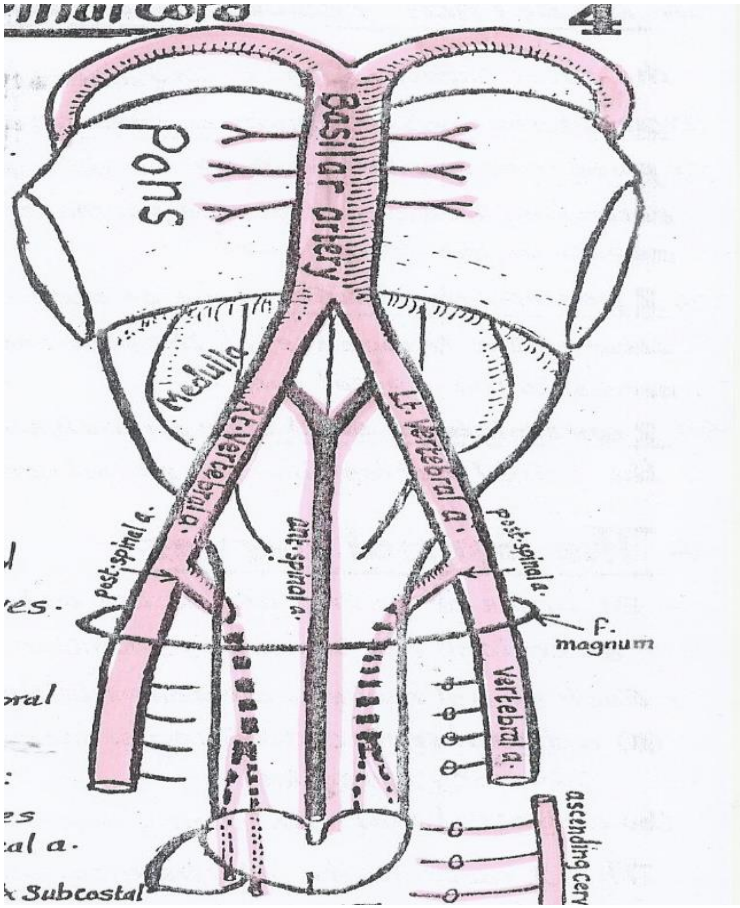


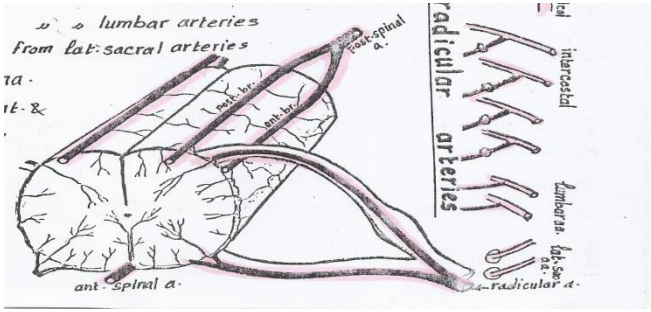
Arterial Supply of Spinal Cord (contd)

** **Course:** It descends through the foramen magnum then runs in the anterior median fissure of the spinal cord.

** **Distribution:** It supplies:

1. The medial part of medulla oblongata.
2. The anterior 2/3 of the cross-sectional area of the spinal cord i.e. anterior & lateral white columns & ventral horn, lateral horn & base of dorsal horn.





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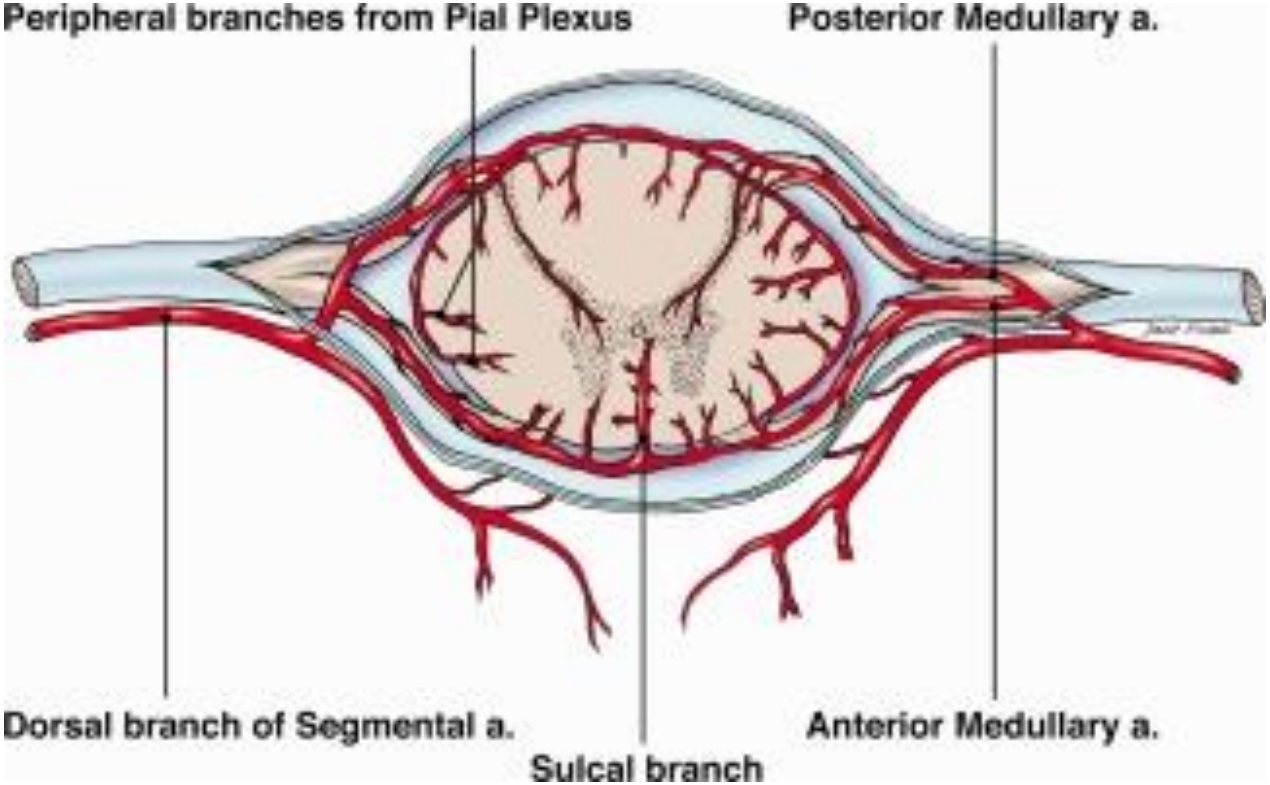

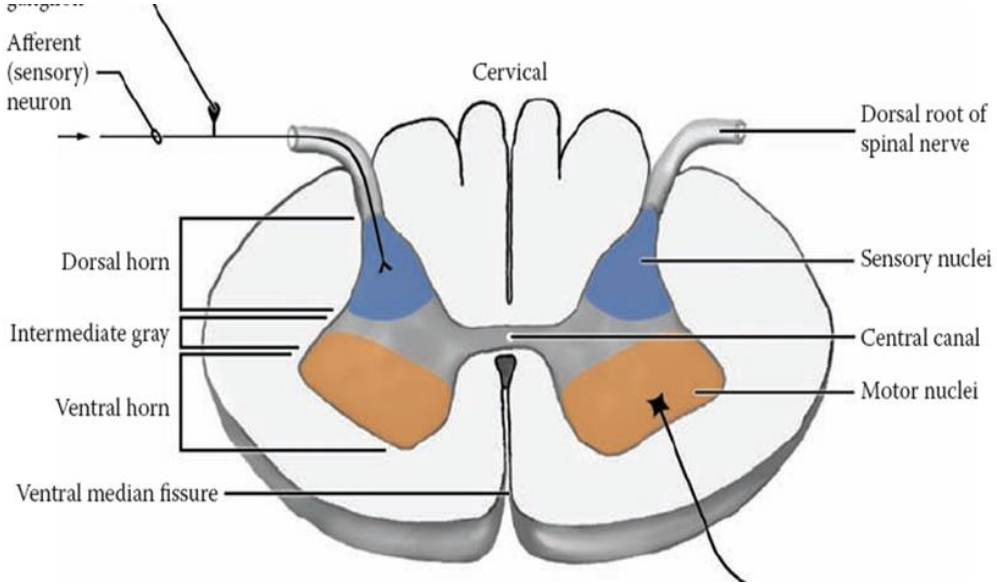

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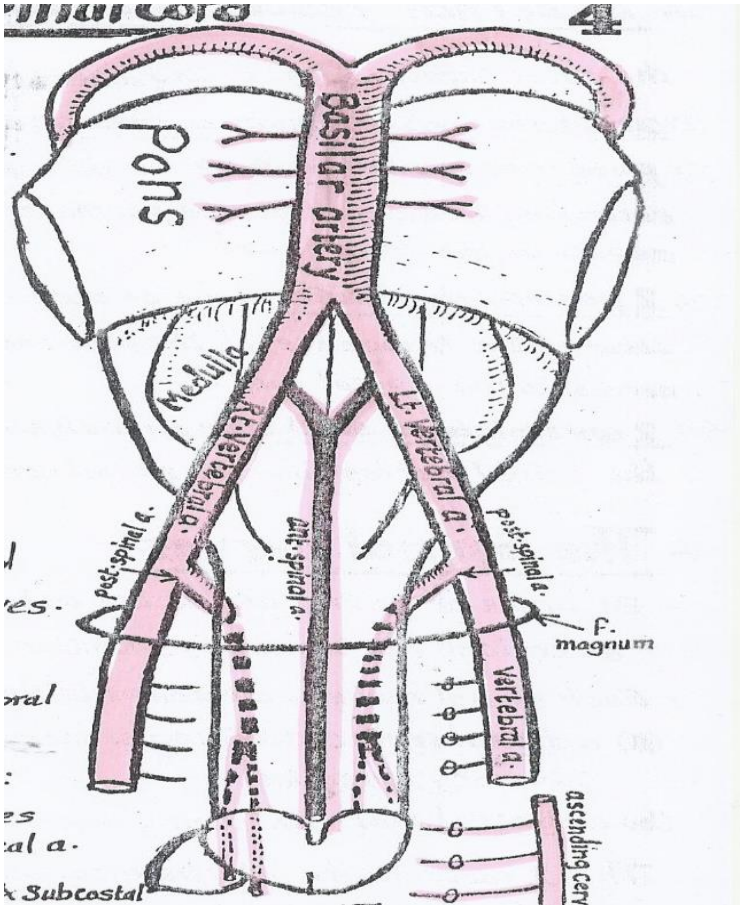
Arterial Supply of Spinal Cord (contd)

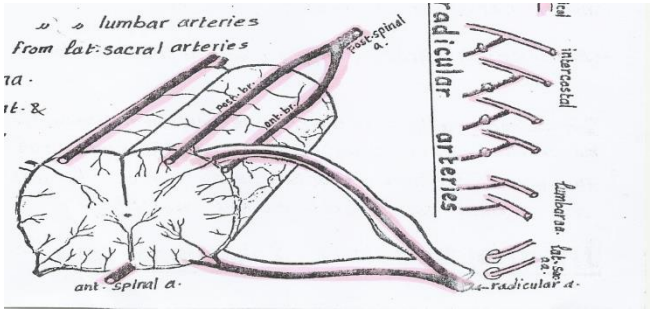
2. Posterior Spinal Arteries:

** **Origin:** Each posterior spinal artery arises from the vertebral artery or more commonly from its posterior inferior cerebellar branch.

** **Course:** It descends through the foramen magnum then along the postero-lateral sulcus dividing into two branches, one descends anterior & the other posterior to the dorsal roots of the spinal nerves.

** **Distribution:** It supplies the posterior 1/3 of the spinal cord i.e. posterior white column & posterior horn.





Arterial Supply of Spinal Cord (contd)

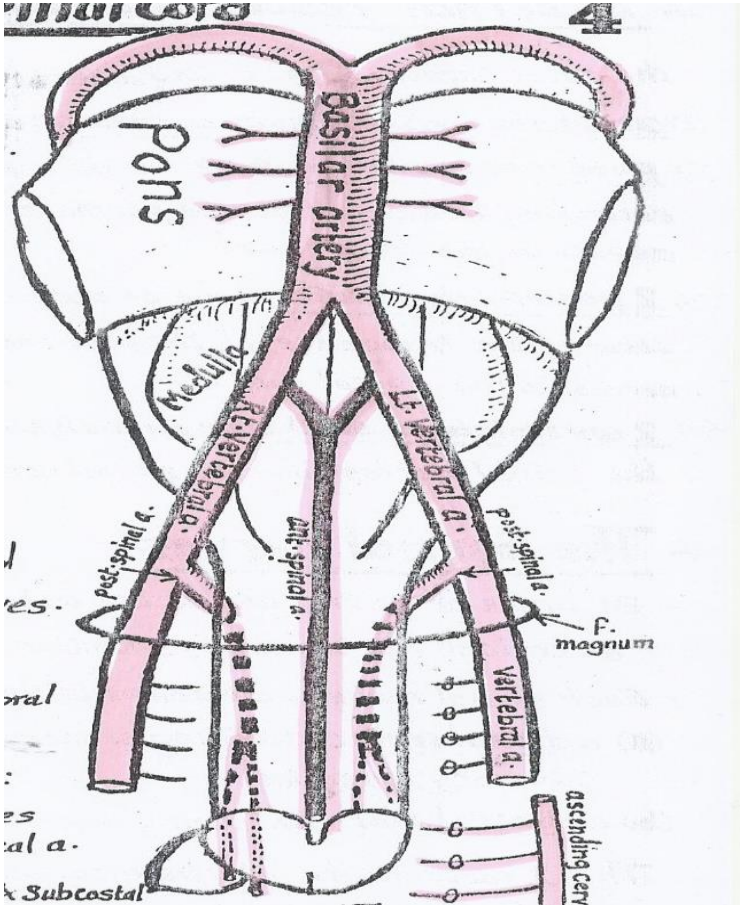
3. Segmental (Radicular) Arteries:

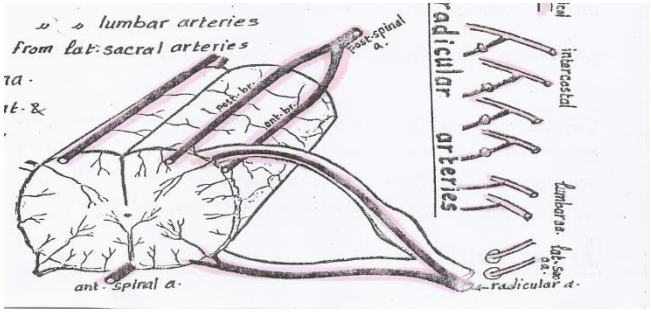
** **Origin:** arise as twigs from the vertebral, ascending cervical, posterior intercostal &1st lumbar artery.

** **Course:** They enter the vertebral canal through the intervertebral foramina.

* **They give anterior & posterior radicular branches** that pass along the ventral & dorsal roots to reach the surface of the spinal cord & form an arterial circle of anastomosis with the branches of anterior & posterior spinal arteries **"arterial vasacorona".**

* Branches from this circle supply the periphery of the spinal cord.





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Arterial Supply of Spinal Cord (contd)

** Some radicular arteries may be large & are called feeder arteries. One of the feeder arteries is called artery of Adamkiewicz which arises from 11th intercostal artery & may be the main supply to the lower two-thirds of the cord.

** Note:

* Once an artery enters the substance of the spinal cord, it is an end artery.

* The cervical part of the spinal cord depends more on anterior & posterior spinal arteries, while lower segments depend more on the radicular arteries.

* The mid-thoracic segments of the cord are the most liable to become ischemic. The richest blood supply is to the lumbar region.

Venous Drainage of Spinal Cord

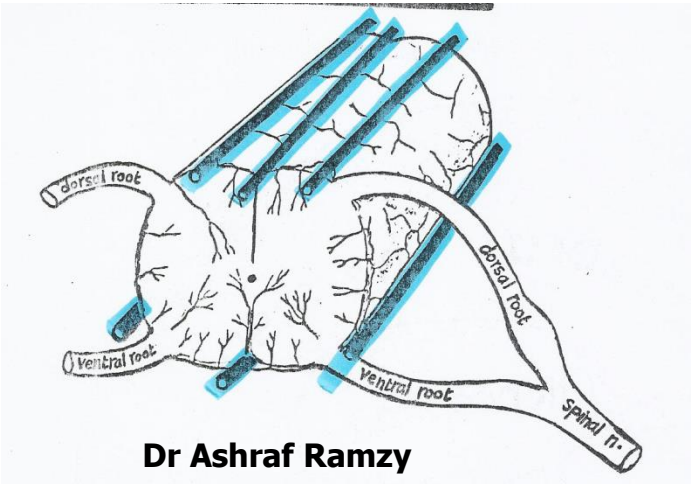
** Six longitudinal veins ascend on surface of spinal cord:

1. Anteromedian vein along the anterior median fissure.
2. Postermedian vein along the posterior median sulcus.
3. Four veins that run on either side of the ventral & dorsal roots.

** These veins communicate freely with each other.

** They drain into the internal vertebral venous plexus and communicate with the intervertebral veins.

** Near the base of the skull, the longitudinal veins communicate with the cerebellar veins & cranial venous sinuses.



SPINAL CORD LESIONS

I. Complete transverse section (transection) of the cord:

* Above C5 → death (due to paralysis of diaphragm & intercostal muscles).
* Between C5 –T1 → Quadriplegia.
* Below T1 → Paraplegia.

SPINAL CORD LESIONS (contd)

II. Hemisection of the cord:

* This leads to **Brown Sequard syndrome**:

1. At the same level of the lesion:

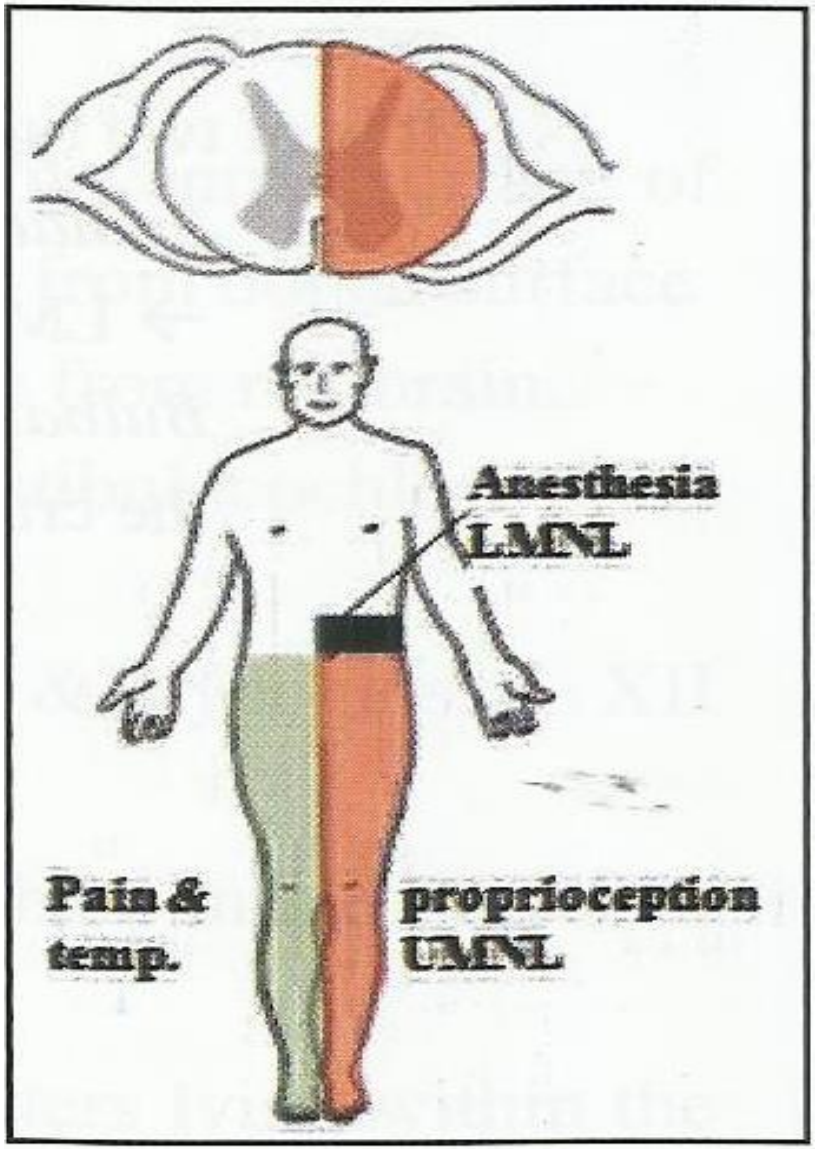
* Ipsilateral loss of all types of sensations (destruction of posterior (dorsal) root).
* Ipsilateral LMNL (damage of anterior horn cells).

2. Below the level of the lesion: ipsilateral:

* Loss of proprioceptive sensations (affection of the posterior column).
* UMNL (affection of the lateral corticospinal tract).

3. Below the level of the lesion: contralateral:

* Loss of pain & temperature sensations (affection of lateral spinothalamic tract).



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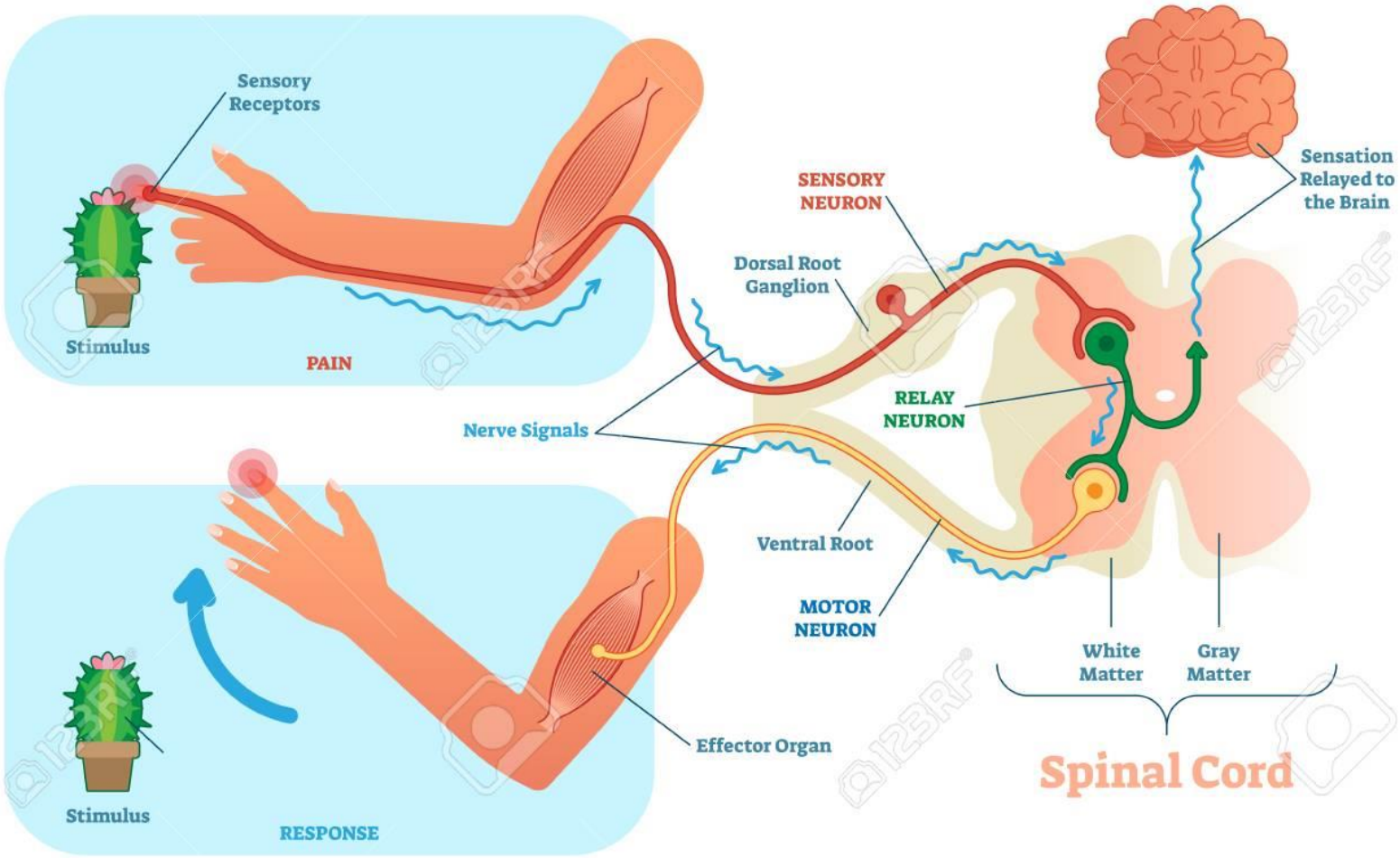
Sensory Receptors
Stimulus
PAIN
SENSORY NEURON
Dorsal Root Ganglion
Sensation Relayed to the Brain
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MOTOR NEURON
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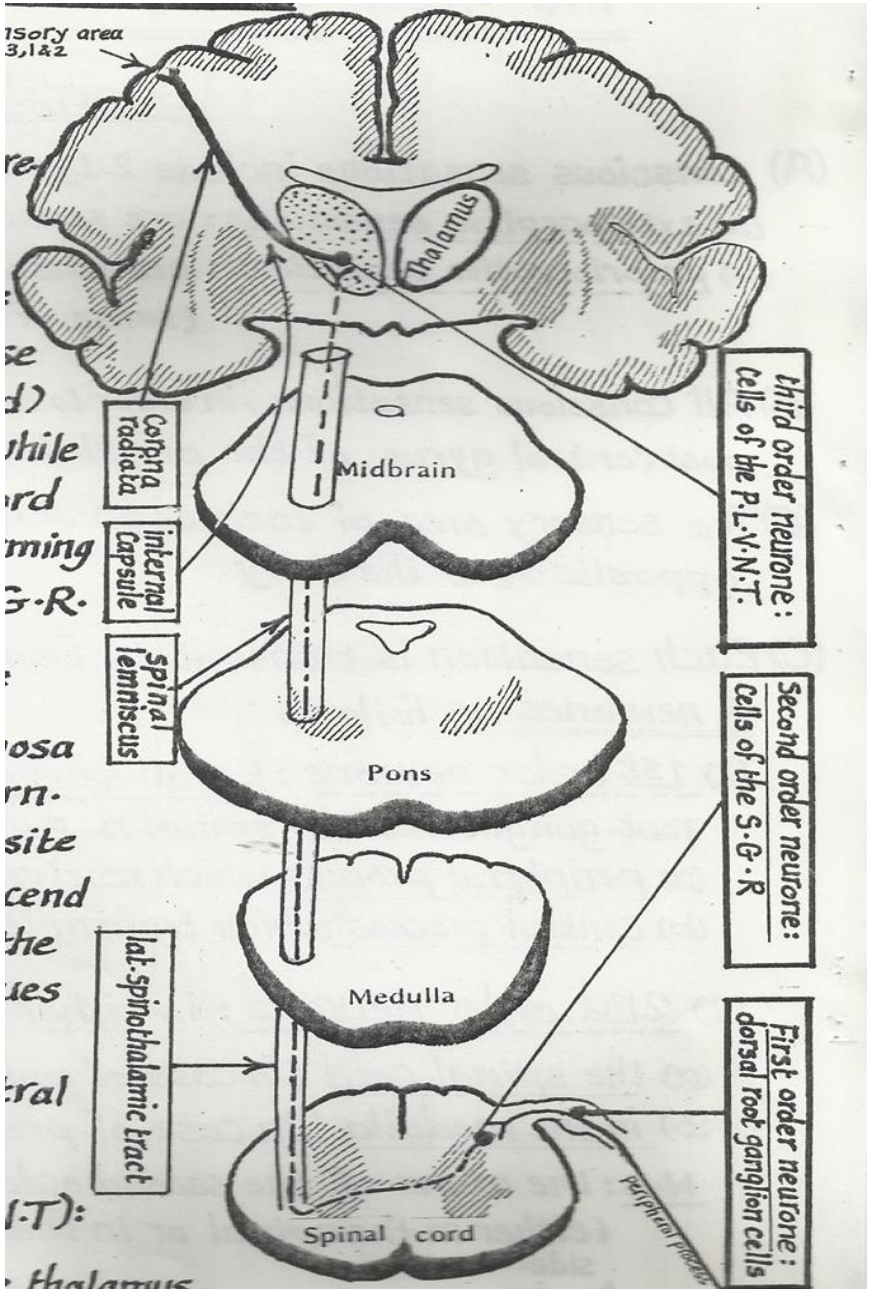
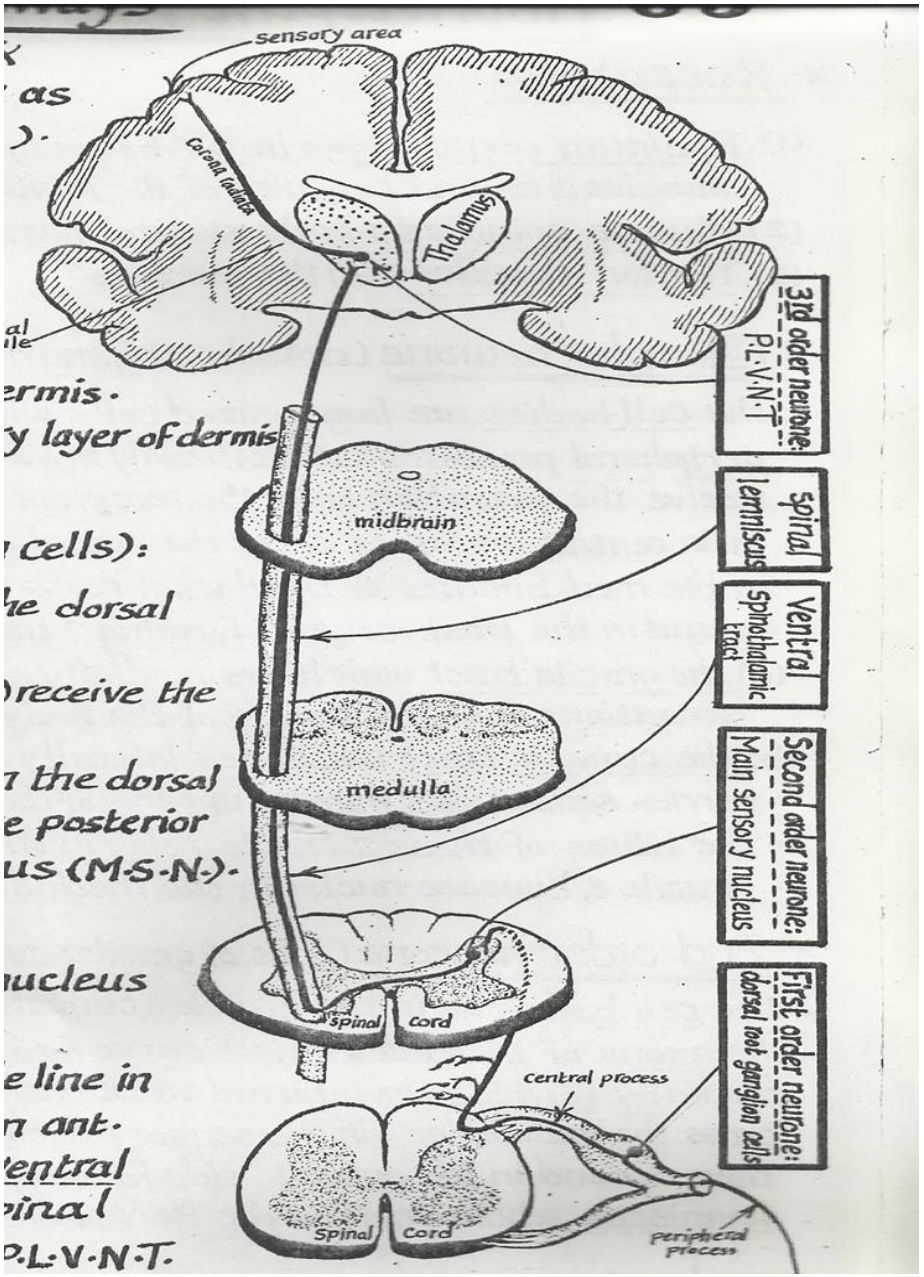
Spinal Cord
Effector Organ
Stimulus
RESPONSE





Lateral spinothalamic T.
(Pain & temperature)

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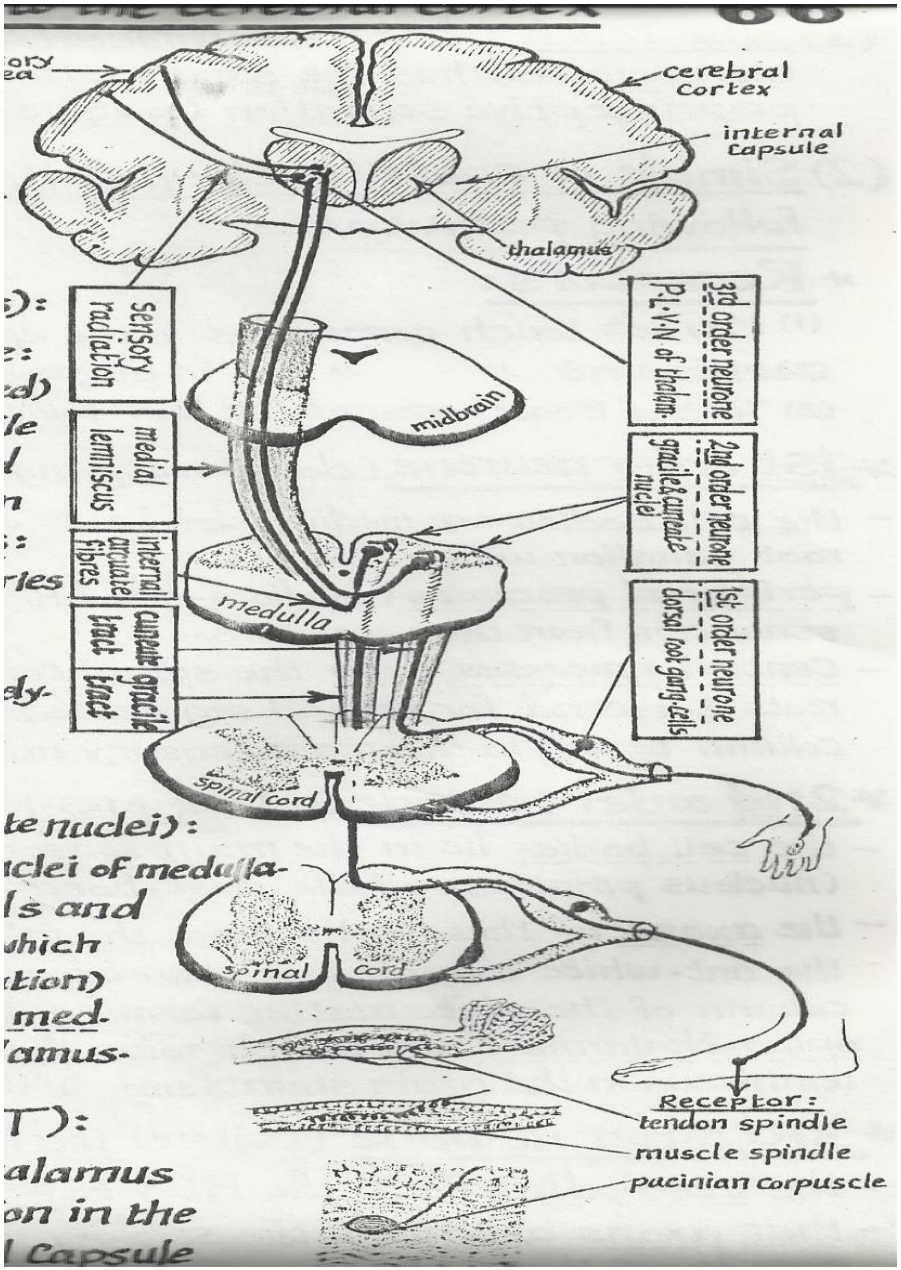
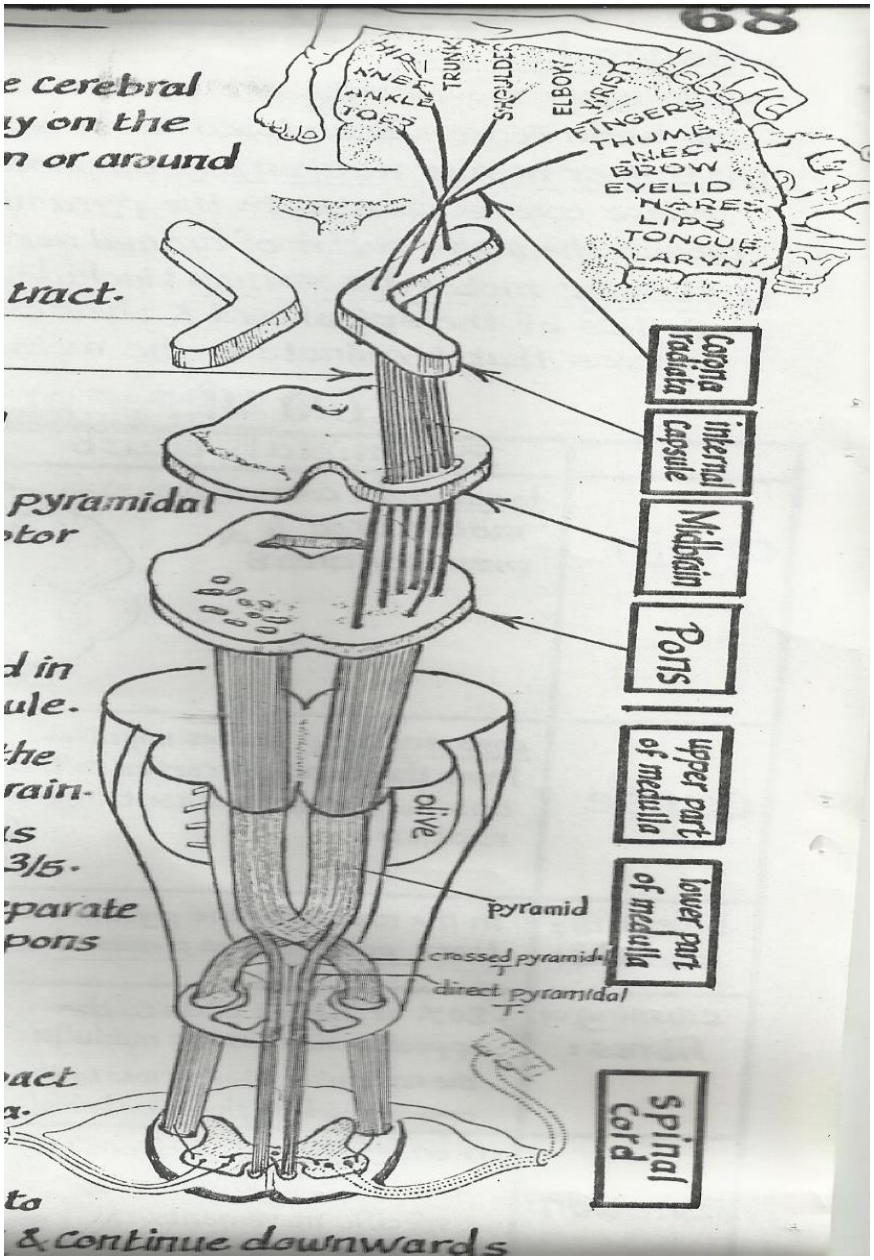
Ventral spinothalamic T.
(Crude touch & pressure)



Gracile & Cuneate T.
(Fine touch & proprioception)



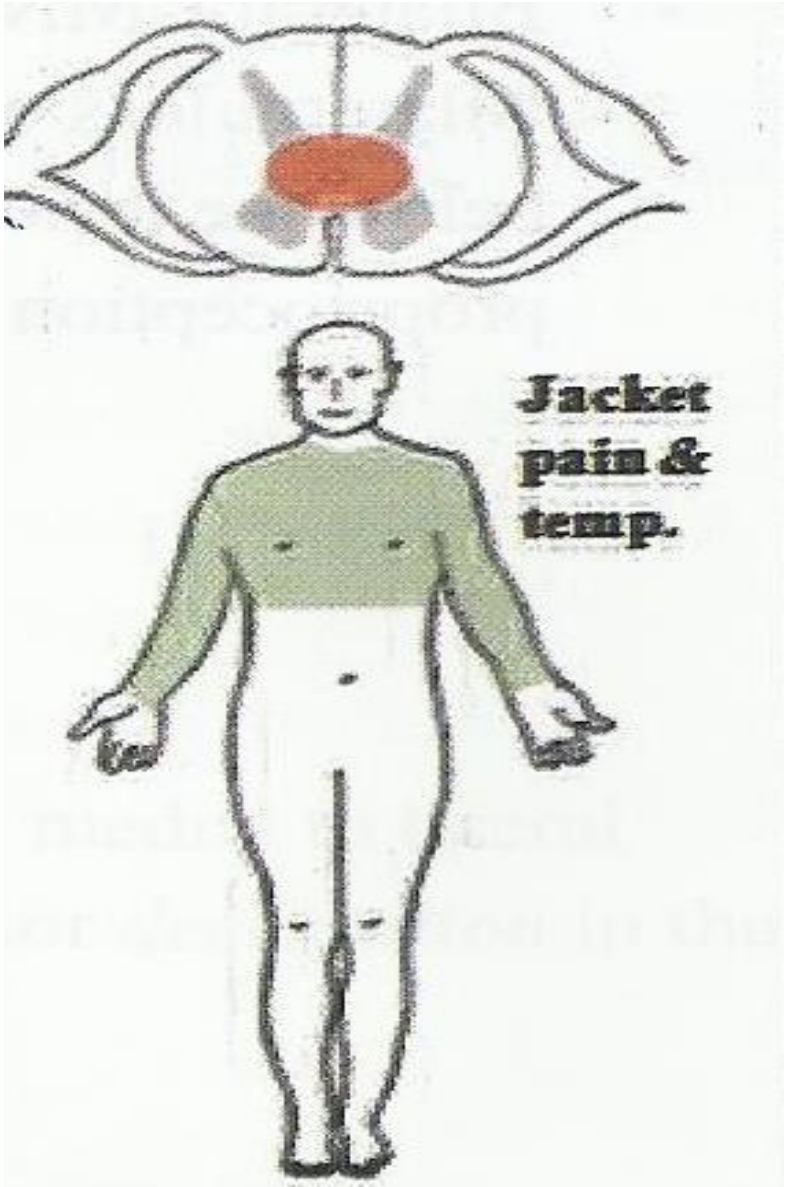
Pyramidal Tract
(Control voluntary movement)

SPINAL CORD LESIONS (contd)

III. Selective lesions:

1. Syringomyelia:

* Cavitation around the central canal in the cervical and upper thoracic segments of the spinal cord → degeneration of the crossing fibers carrying pain & temperature sensations.
* There is bilateral loss of pain & temperature sensations in dermatomes corresponding to the levels of crossing affected (jacket distribution of anesthesia).

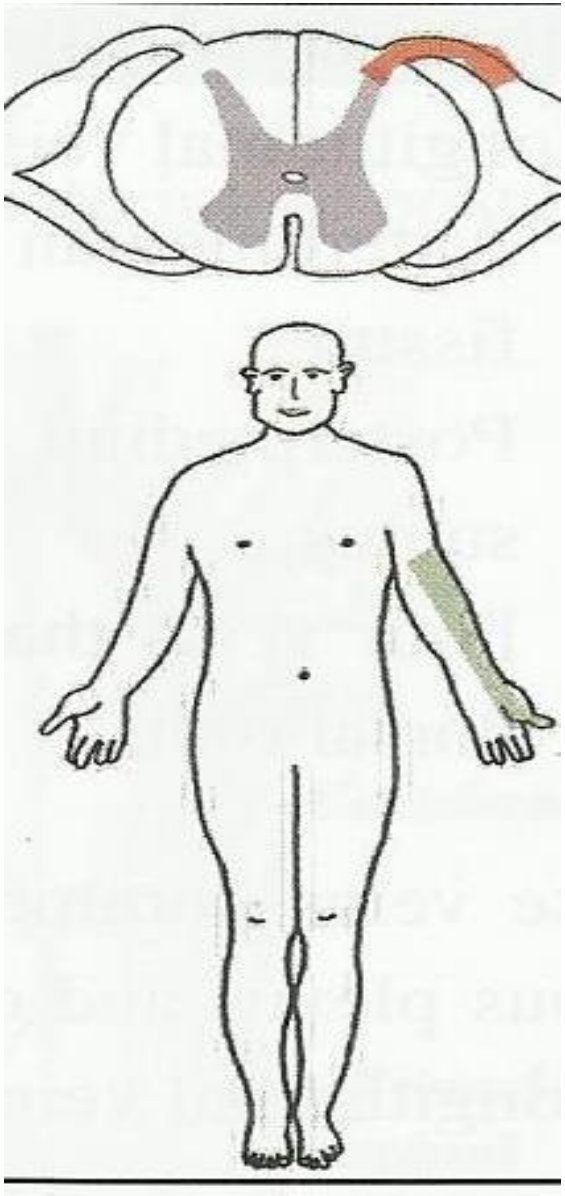


SPINAL CORD LESIONS (contd)

2. Tabes dorsalis:

* This is caused by syphilis - destruction of nerve fibers of the dorsal root of spinal nerves.
* Initially, irritation of the pain fibers → severe pain in the dermatomes supplied by the affected dorsal roots.
* Later on, degeneration of nerve fibers leads to:

1. Loss of deep sensations (e.g. squeezing tendocalcaneus).
2. Loss of proprioception → sensory ataxia.
3. Loss of tendon reflexes.
4. Hypotonia of muscles.



SPINAL CORD LESIONS (contd)

3. Poliomyelitis:

* It is caused by virus affecting lower motor neurons.

* It is of two types:

1. Spinal type: affecting anterior horn cells → LMNL.
2. Bulbar type: affecting motor nuclei of the cranial nerves → LMNL.

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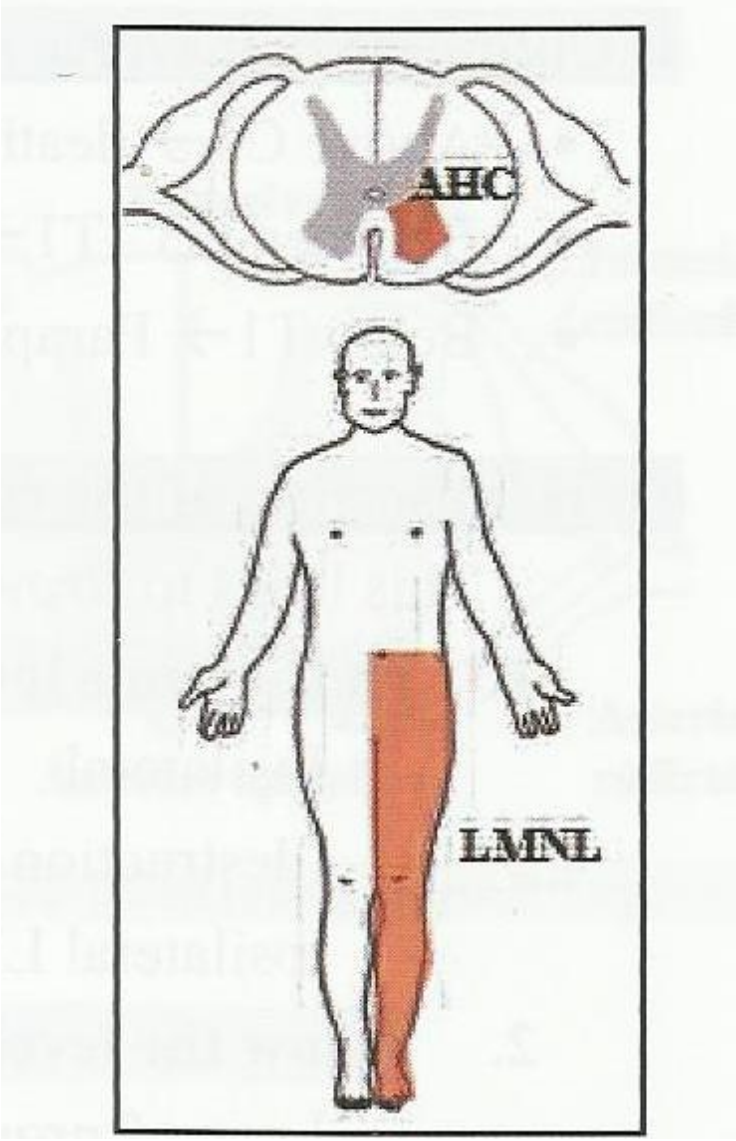
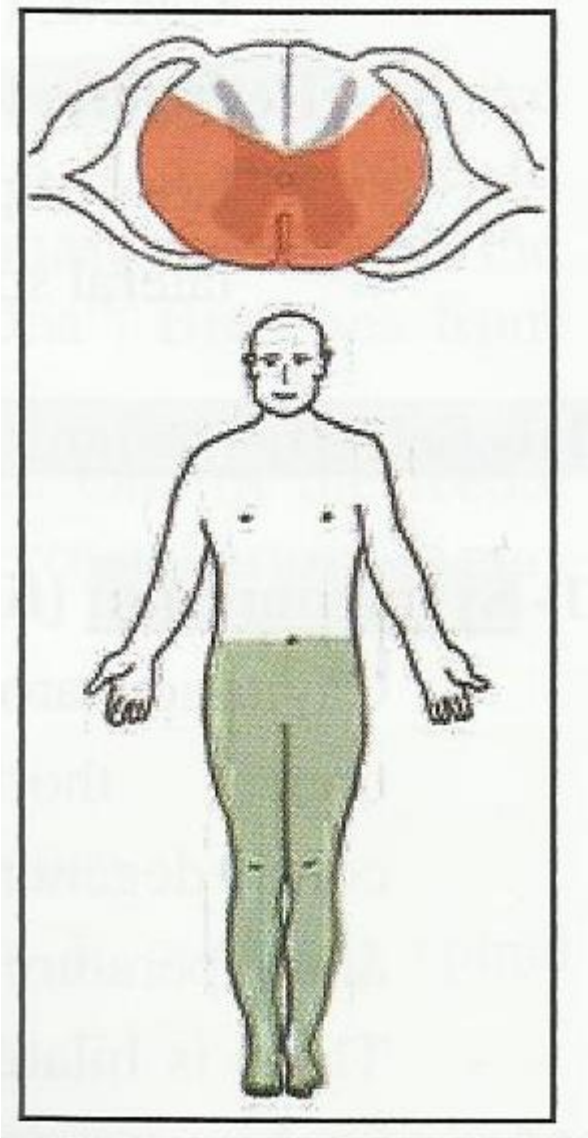


SPINAL CORD LESIONS (contd)

4. Anterior Spinal artery occlusion:

** Leads to:

1. Bilateral UMNL paralysis below the lesion.
2. Bilateral loss of pain & temperature sensations below the lesion with preservation of proprioception & touch.



THANK YOU