



Central Nervous System

Lecture 3: Ascending Tracts

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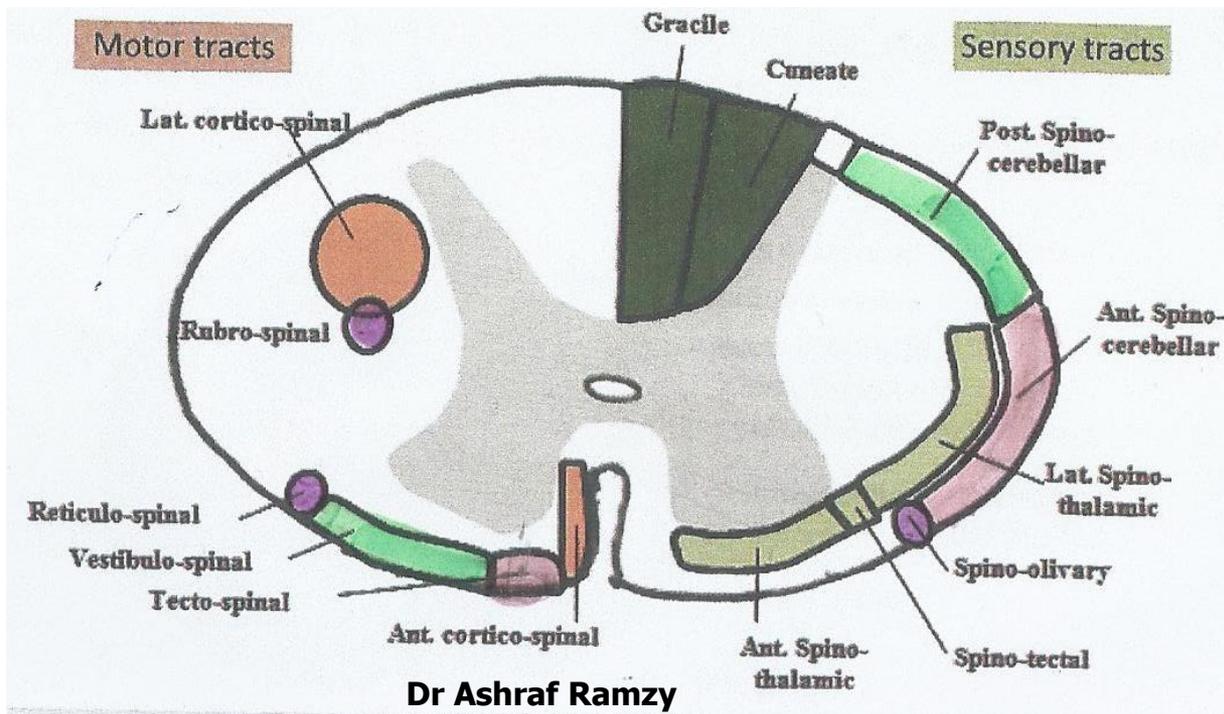
Tracts of white matter

I. Ascending tracts (sensory): includes 3 main groups:

A. Lemniscal system: lie in the dorsal column - carries conscious proprioception (from deep structures such as muscles & joints) to the cerebral cortex:

1. **Gracile tract** [lower body proprioception]

2. **Cuneate tract** [upper body proprioception]



B. Unconscious proprioceptive tracts (to cerebellum): lie superficially in the lat. Column: 1. Two spino-cerebellar tracts (Post. & Ant.).

2. Spino-olivary tract.

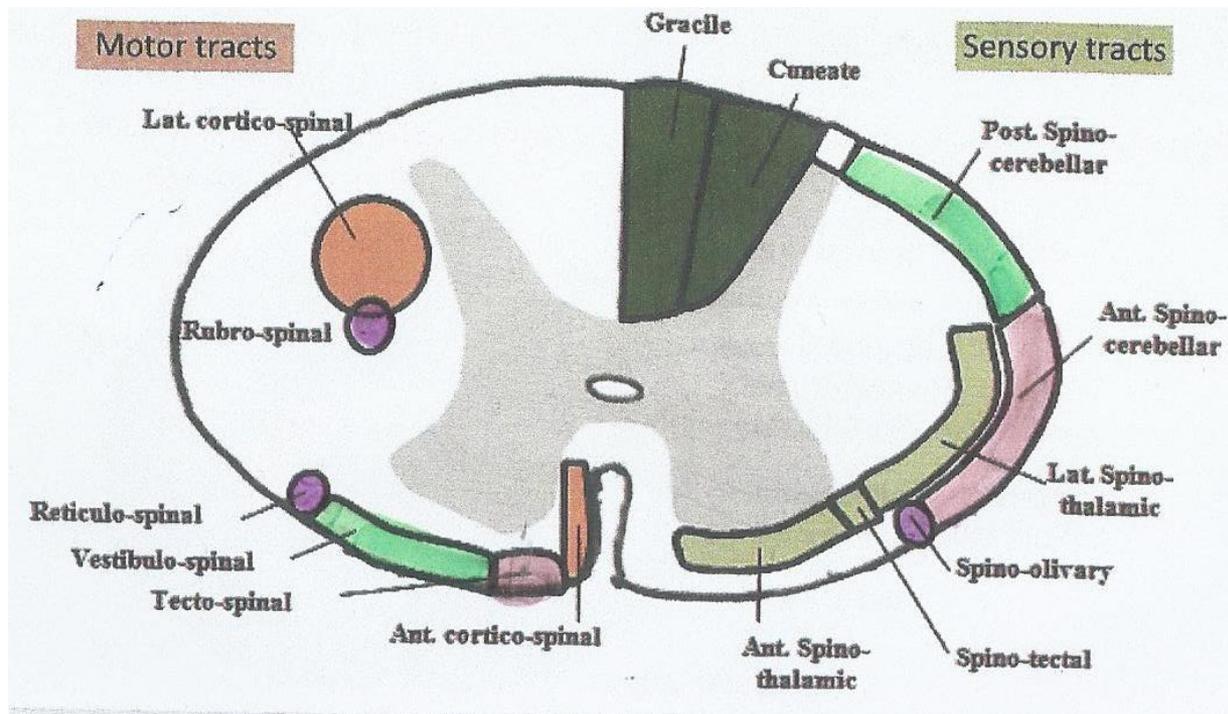
C. Anterolateral system: lie in the ant. and lat. columns - carries exteroception :

1. Lat. Spinothalamic tract [pain & temp].

2. Ant. spinothalamic tract [crude touch].

3. Spino-reticular tract.

4. Spino-tectal tract.

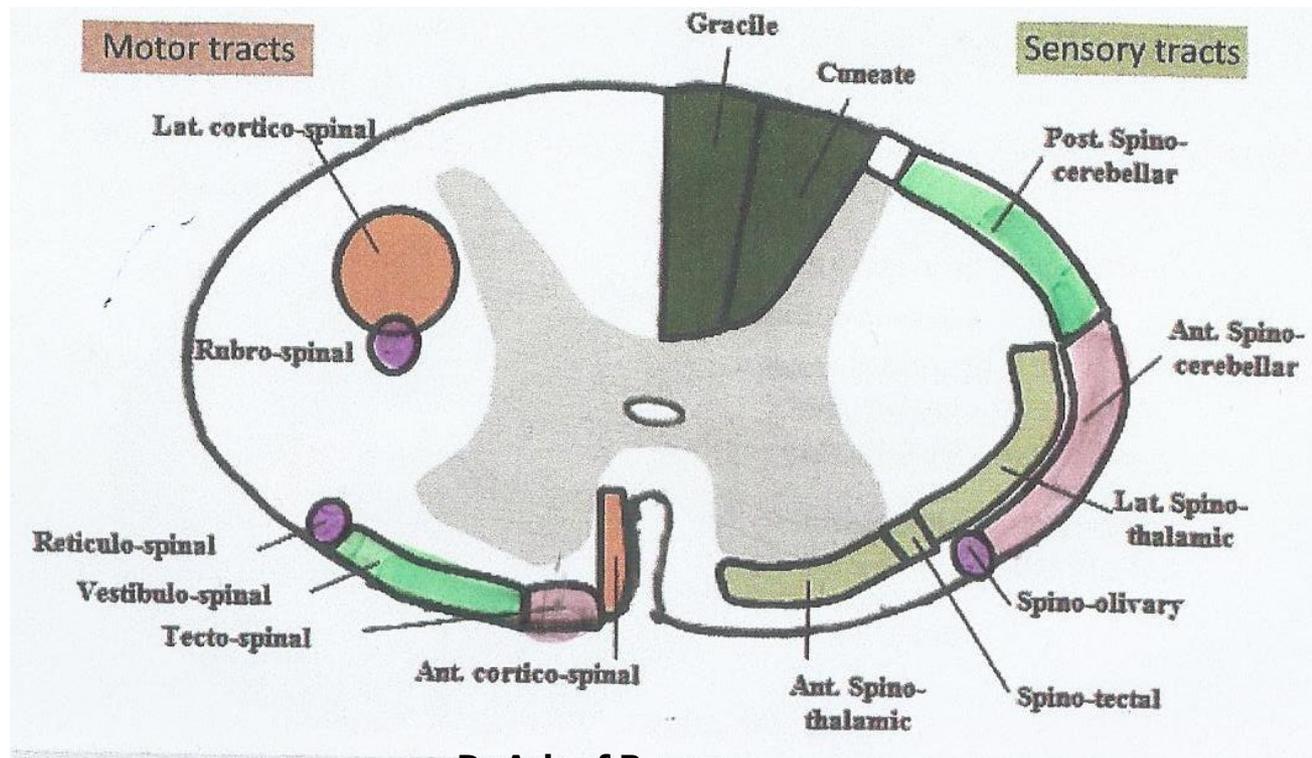


II. Descending tracts (motor):

A. Pyramidal: lateral & anterior corticospinal tracts.

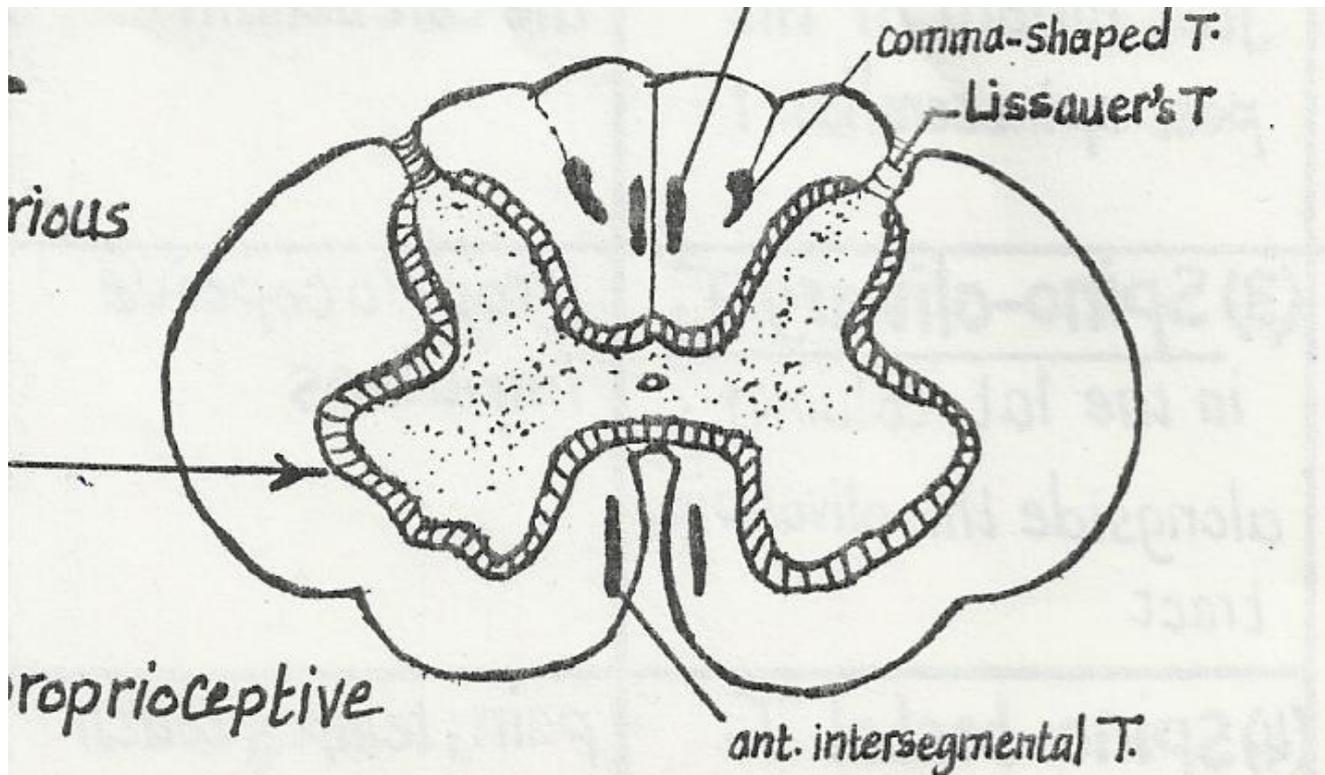
B. Extrapyramidal:

- * 2 from the midbrain: rubro-spinal tract & tecto-spinal tract
- * 2 reticulo-spinal tracts: medial & lateral.
- * 2 Vestibulo-spinal tracts: medial & lateral.
- * Olivo-spinal tract.



III. Intersegmental tracts (propriospinal):

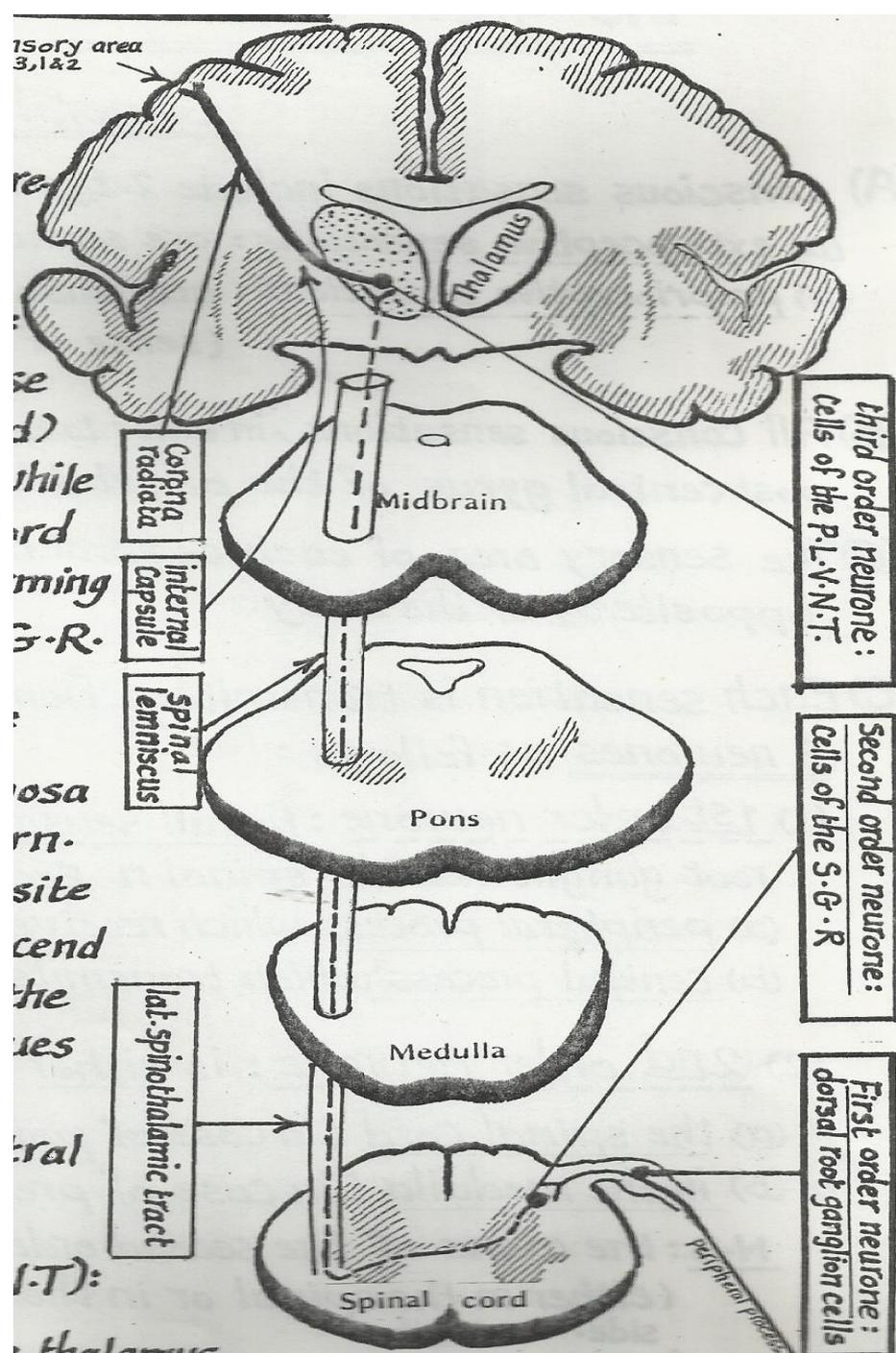
- * Surround the grey matter forming the fasciculus proprius anterior, lateralis & posterior.
- * Contains ascending and descending short axons of interneurons between adjacent segments of spinal cords.



Ascending Tracts

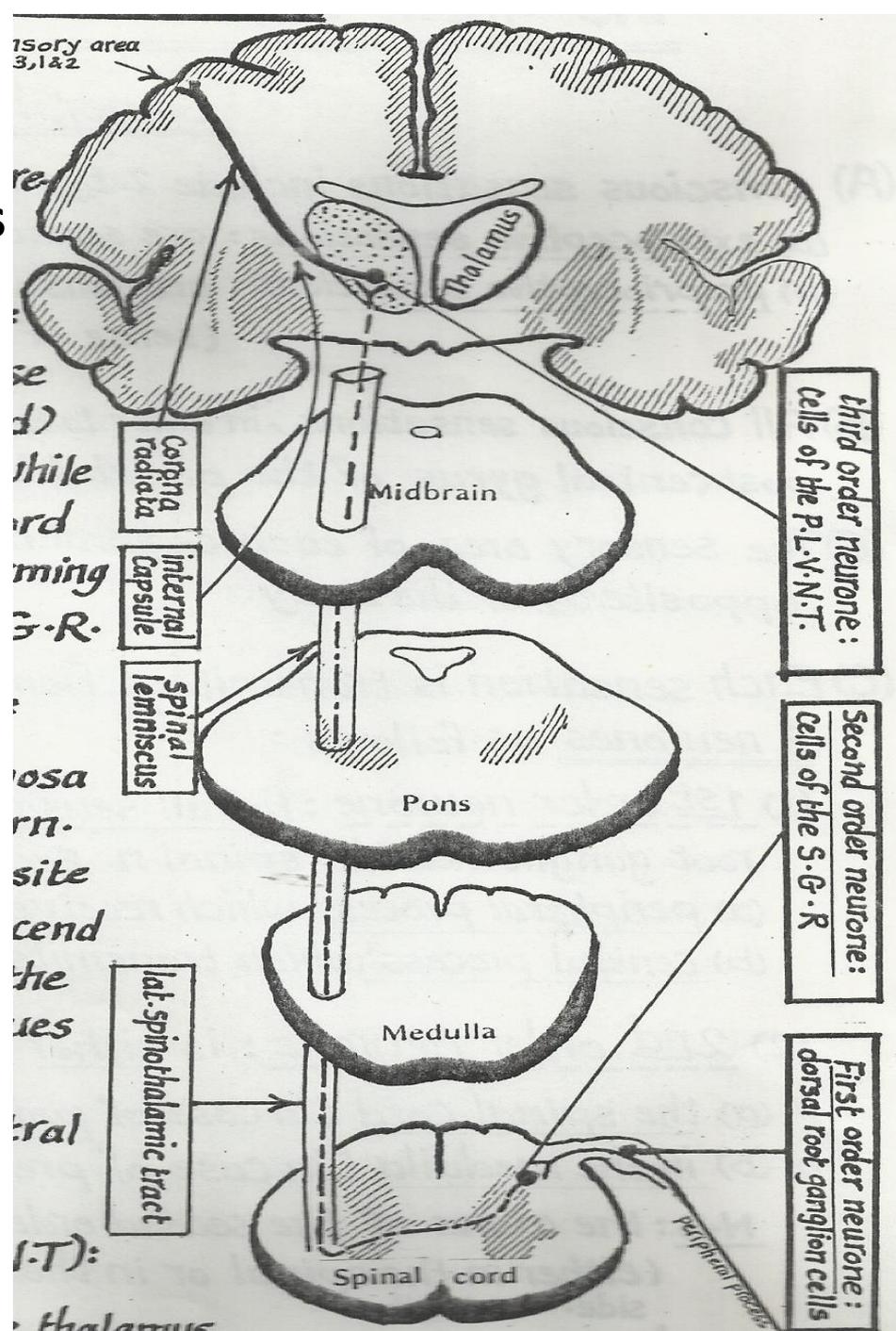
- * Form parts of the sensory pathways.
- * A sensory pathway is formed of three neurons:

1. **First-order Neuron:** is always a pseudounipolar cell of the Dorsal Root Ganglion. It carries sensation by its peripheral process from receptors & conveys this sensation by its central processes to the dorsal root to the spinal cord.



2. Second-order neuron: is always a cell in the CNS (spinal cord or medulla oblongata). Its axon always decussates to the opposite side and ascends in the brainstem as lemniscus to end in the thalamus.

3. Third-order Neuron: is always cells of the Ventral Postero-Lateral Nucleus of Thalamus (VPLN). Their axons pass through posterior limb of internal capsule, then through corona radiata to reach sensory area of cerebral cortex.

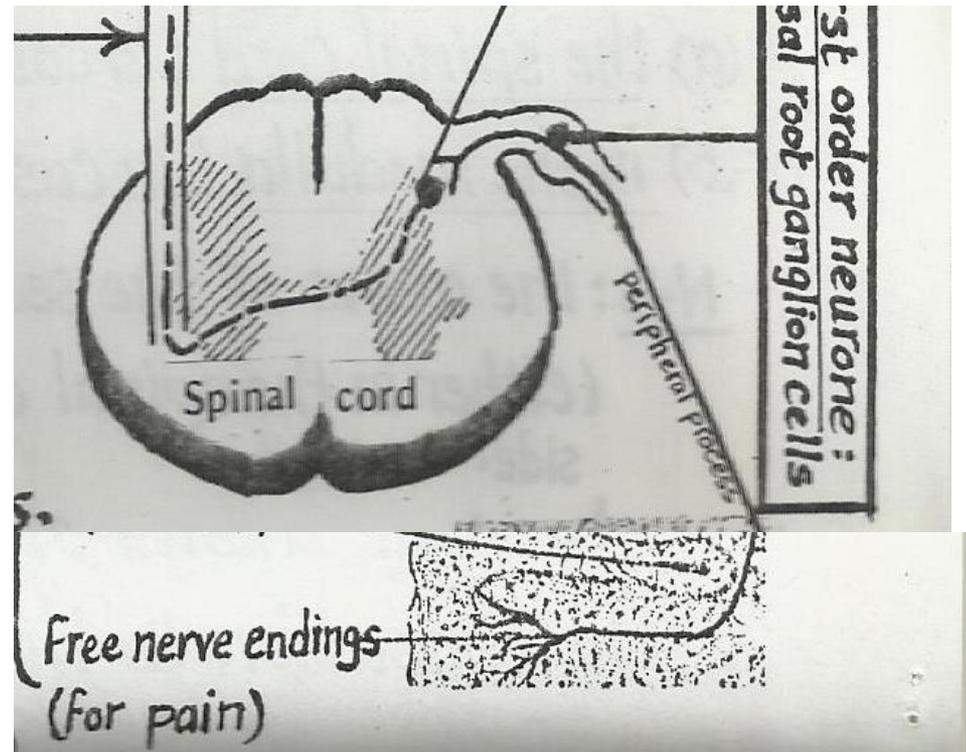


Pathway for pain & temperature from body (Lateral Spinothalamic Tract)

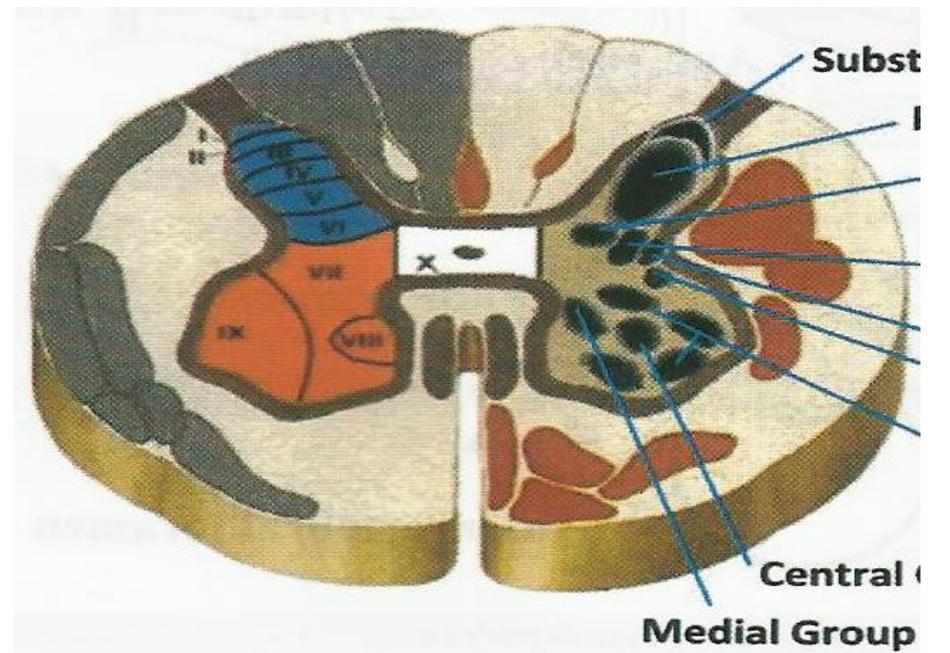
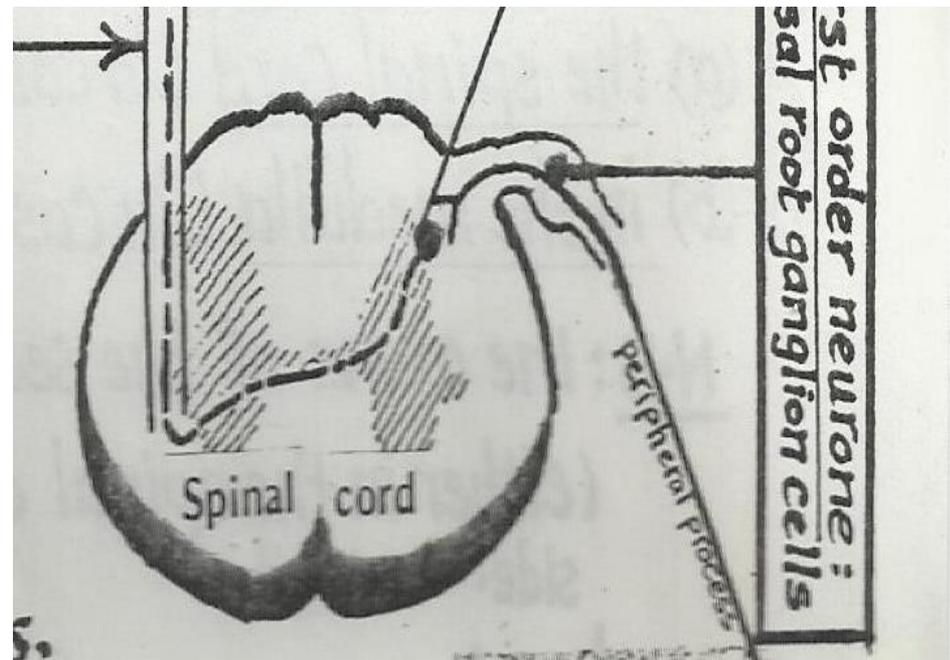
* Receptors: Free nerve endings in skin.

* 1st neuron:

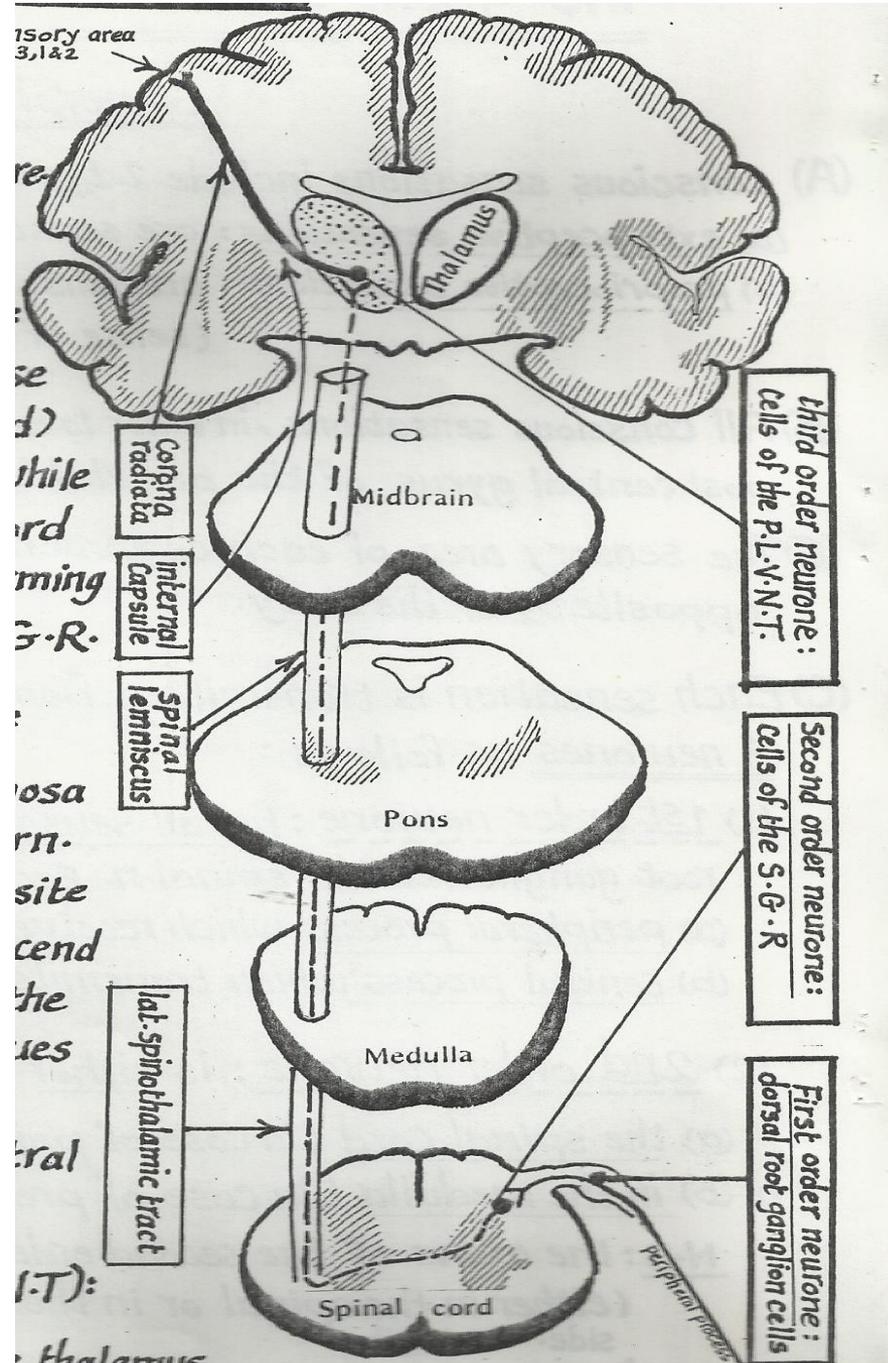
Dorsal root ganglion cells (pseudounipolar). Their peripheral processes carry pain & temperature sensations from the receptors.



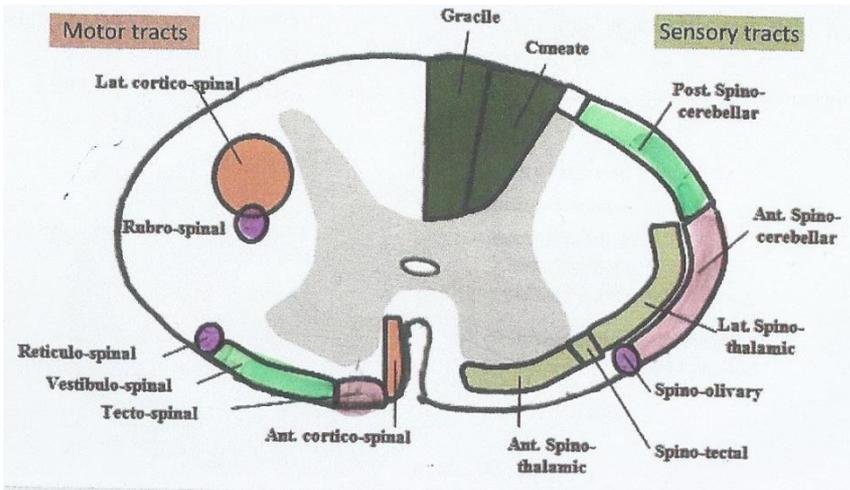
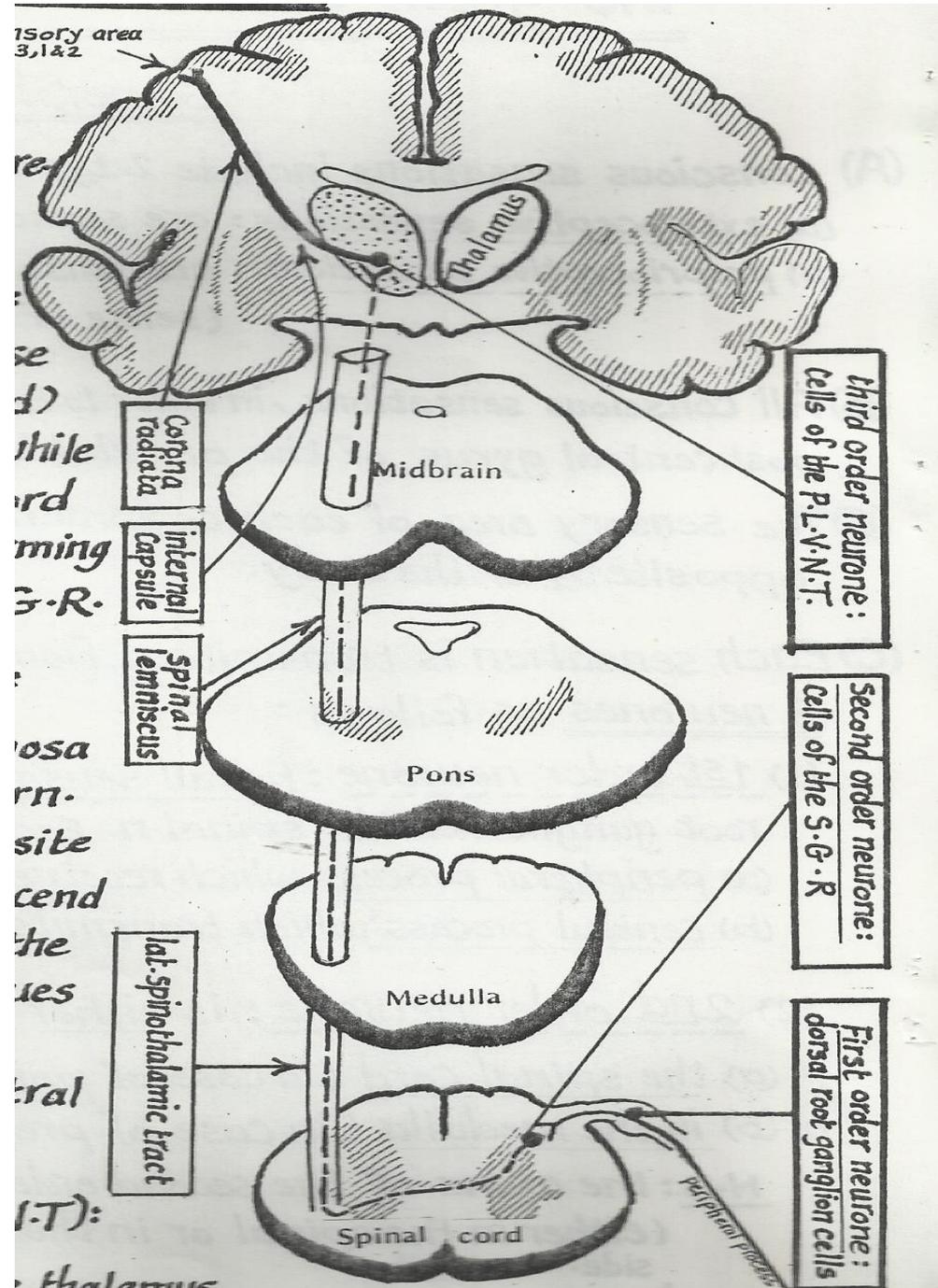
- * Their central processes enter the spinal cord via the dorsal root and divide into ascending & descending branches for few segments.
- * These fibers run in the dorsolateral (Lissauer's) tract which lies over the apex of the dorsal horn.
- * They end on neurons in many Laminae of the grey matter of the spinal cord mainly Lamina II & III (Substantia gelatinosa of Rolandi).



* **2nd Neuron: (Lateral spinothalamic tract):**
 Neurons in Laminae II & III (Substantia gelatinosa of Rolandi) of grey matter of spinal cord. Axons of these neurons cross to the opposite side in the ventral white commissure & ascend in the lateral white column as the lateral spinothalamic tract (medial to the ant. Spinocerebellar tract).



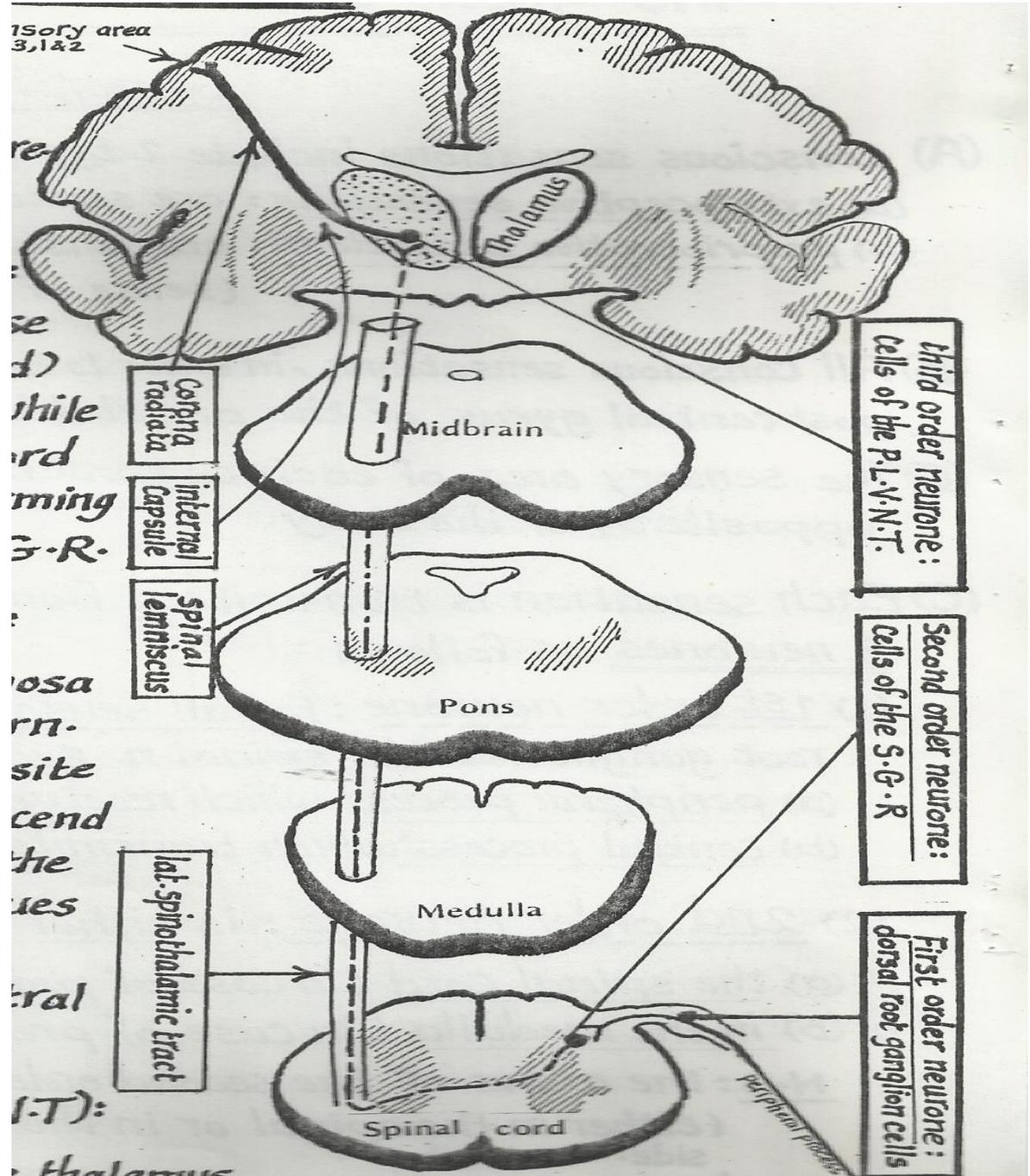
* As the tract ascends, its fibers are laminated so that cervical fibers are most medially and sacral fibers most laterally. The tract ascends in the brain stem as the spinal lemniscus. It reaches the thalamus where it ends on VPLN of thalamus.



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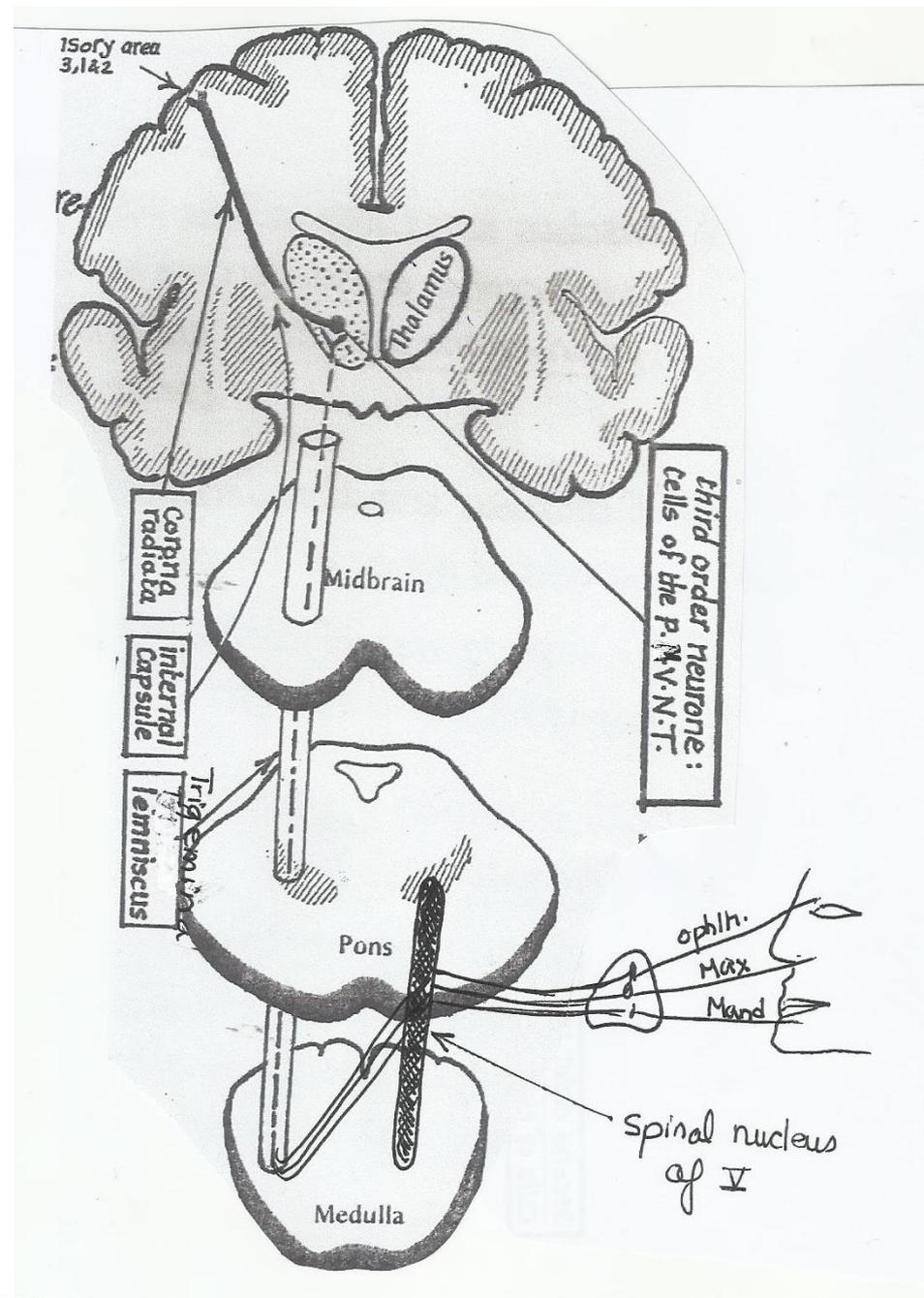
*** 3rd Neuron: VPLN**

**of thalamus.
Axons of VPLN
of thalamus
pass in posterior
limb of internal
capsule, then
through corona
radiata to reach
sensory area of
cerebral cortex.**



* Note: Pain & temperature from the face: is carried by the trigeminal nerve.

1. **First Neuron:** is Trigeminal Ganglion (formed of pseudounipolar cells as DRG).
2. **Second Neuron:** is Spinal Nucleus of Trigeminal. Its axons cross to opposite side forming trigemino-thalamic tract (lemniscus) which ascends to end on the **ventral posteromedial nucleus (VPMN)** of thalamus.
3. **Third Neuron:** is VPMN of thalamus whose axons pass in internal capsule, then the corona radiata to reach sensory area of face in cerebral cortex.



**** Applied:**

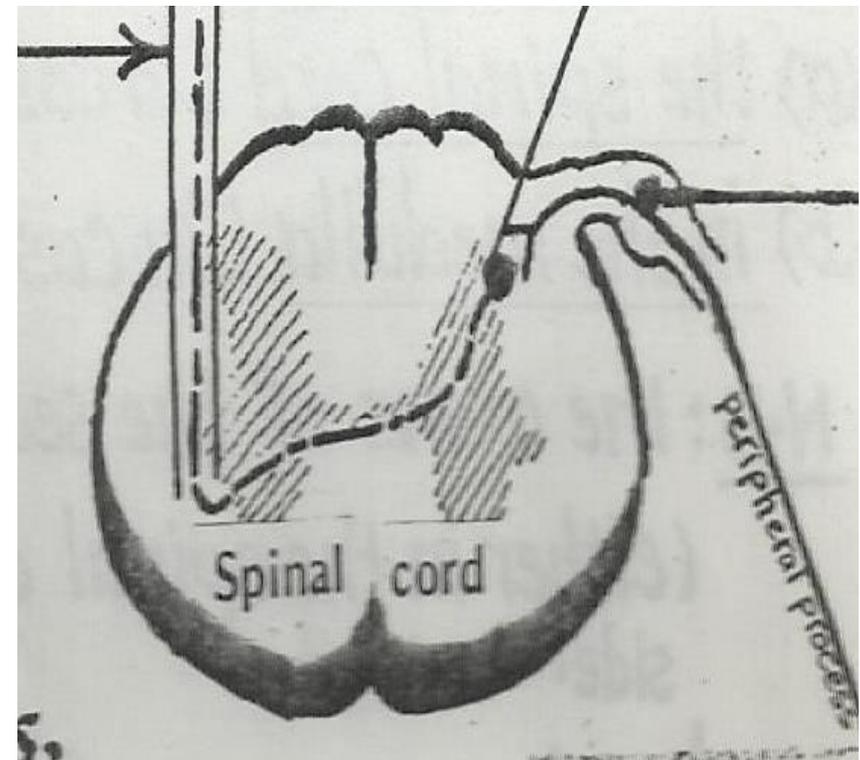
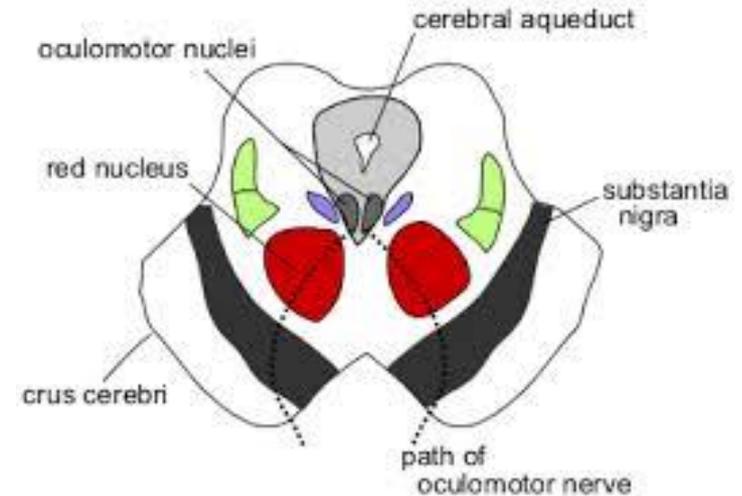
A. Herpes zoster: Viral inflammation of the DRG → pain & skin vesicles in the corresponding dermatome(s).

B. Pain Modulation: the feeling of pain can be attenuated or enhanced.

1. Pain suppression: e.g., soldiers fighting in a battle may get injured but don't feel the pain.

a. Descending fibers from the periaqueductal grey (PAG) of the midbrain → inhibit transmission of pain impulses in the synapse between the 1st & 2nd order neurons.

b. Gate theory: stimulation of touch fibers inhibits transmission of pain impulses in the synapse between the 1st & 2nd order neurons via activation of inhibitory interneurons called "gate cells".



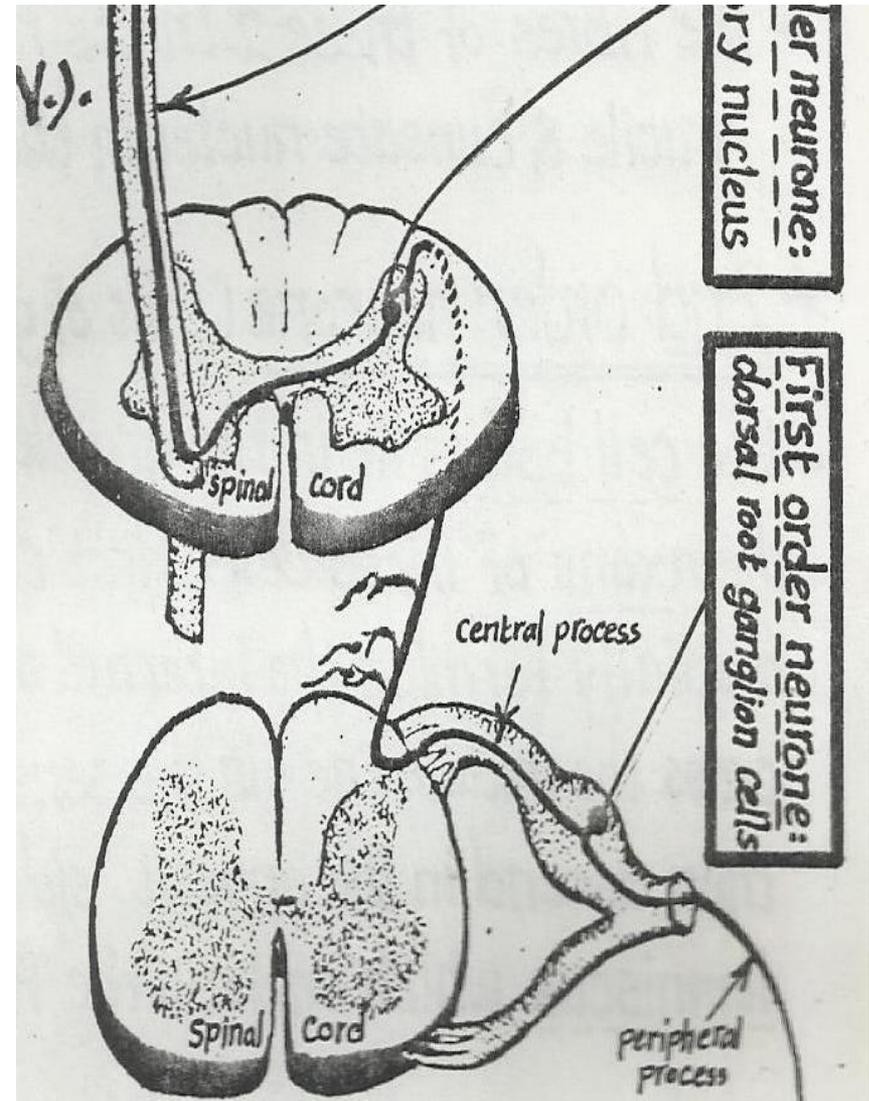
2. Pain sensitization: In contrast to touch (which shows adaptation) pain becomes greater, not less, when the stimulus is repeated. Non-painful stimuli cause pain. This is called hyperalgesia & occurs after surgical operations.

C. Treatment of chronic pain:

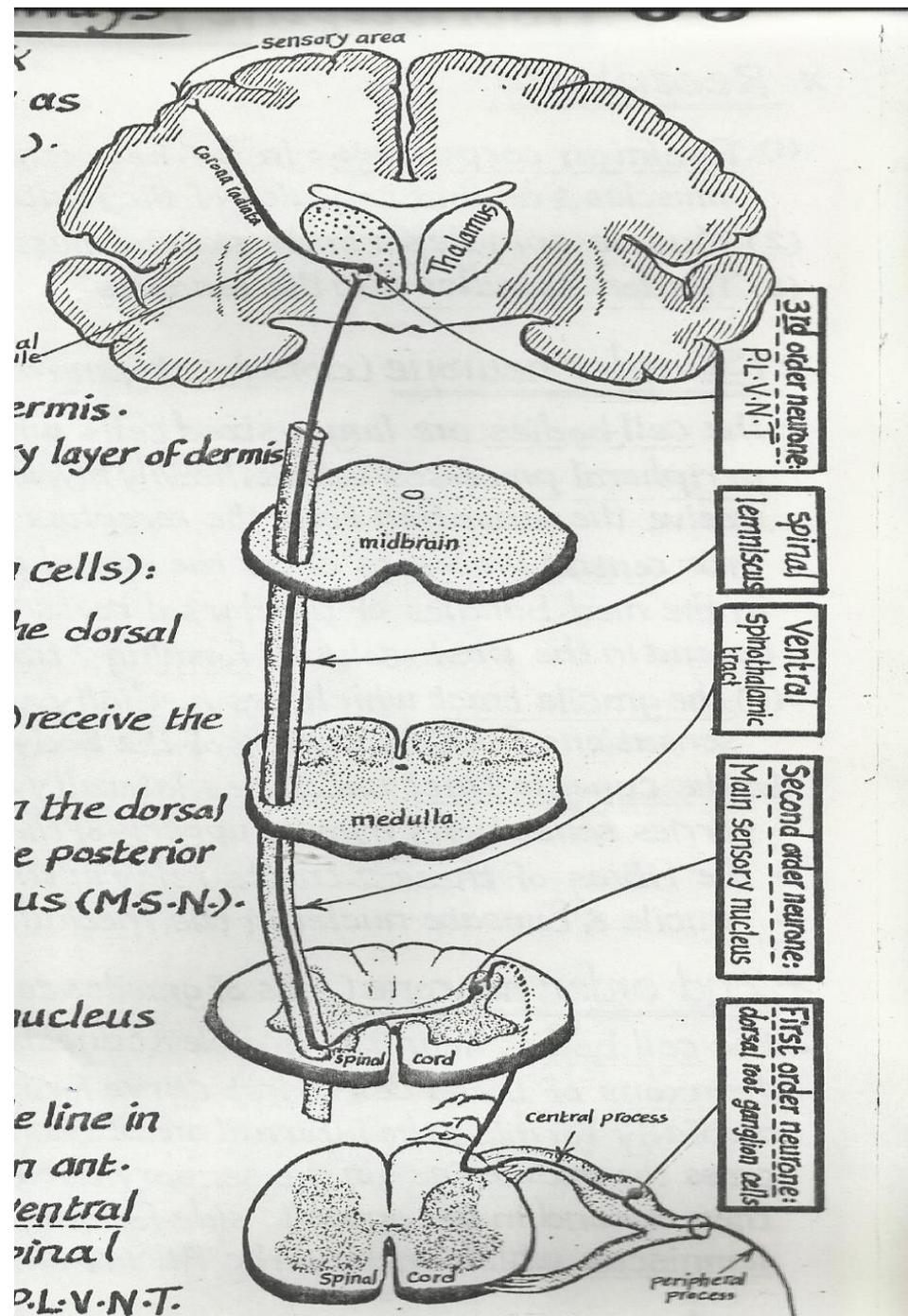
- 1. Drugs:** Narcotics (e.g. morphine) activate the periaqueductal grey.
- 2. Stimulation of the periaqueductal grey** (by electric device, acupuncture & hypnosis).
- 3. Surgery (for cancer pain):** Nerve block, Posterior rhizotomy (cutting the posterior root), Anterolateral cordotomy (cutting the anterolateral column of spinal cord) & frontal lobotomy (relieves the bad feeling associated with pain).

Pathway for crude touch & pressure (Ventral Spinothalamic Tract)

- * **1st Neuron:** Dorsal root ganglion cells. The peripheral processes of these cells carry touch & pressure from the receptors & their central processes enter the spinal cord via the dorsal root to end on neurons in several laminae of the grey matter of spinal cord mainly (Lamina IV – VII) (Main sensory nucleus).

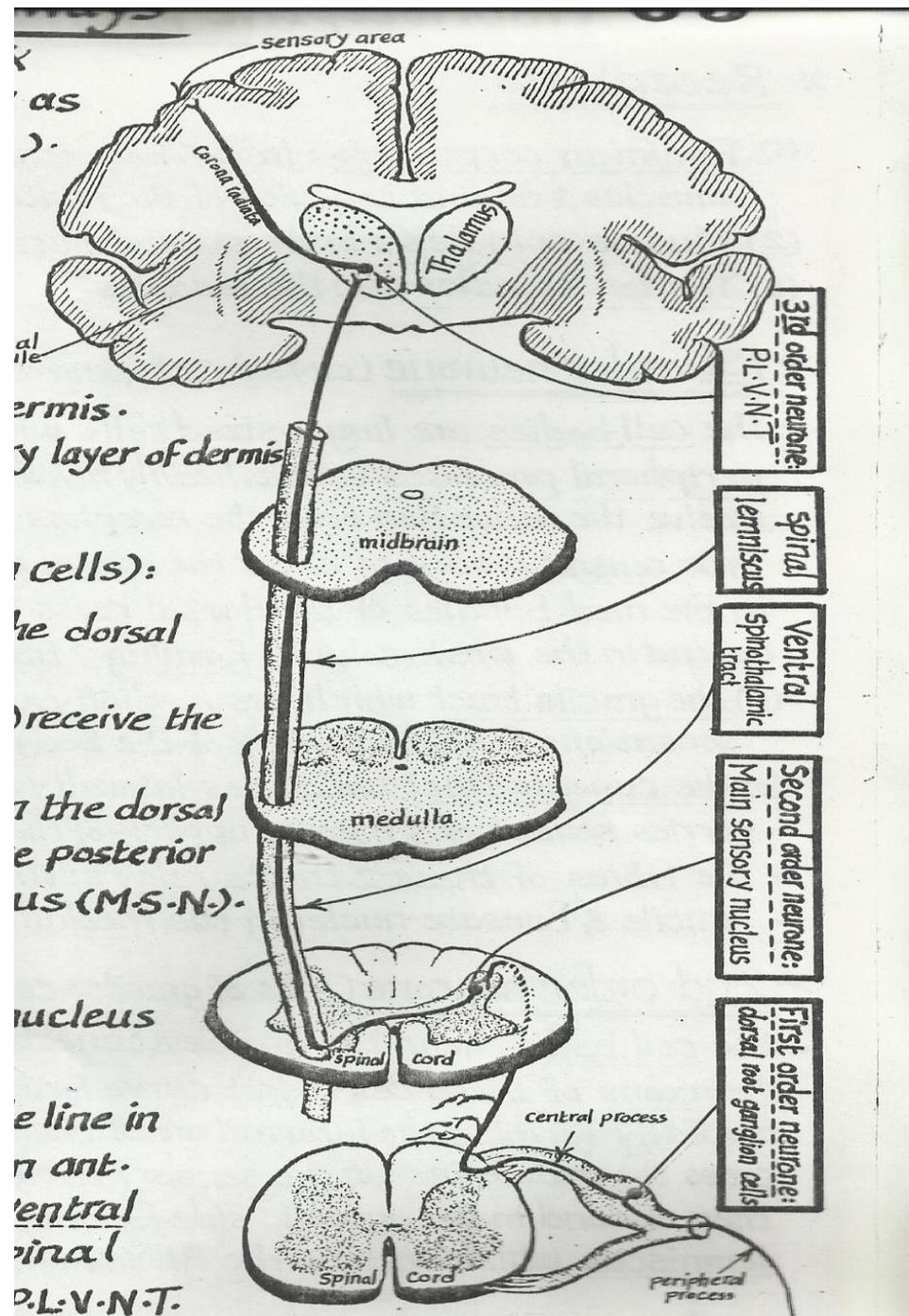


* **Second Neuron: (Ventral spinothalamic tract):**
 Neurons in laminae IV - VII. Their axons cross in the ventral white commissure to reach the opposite ventral white column & ascend as the ventral spinothalamic tract. Cervical fibers lie most medially while sacral fibers most laterally. The ventral spinothalamic tract ascends in the spinal cord & brain stem where it joins the spinal lemniscus & accompanies it to the thalamus to end on VPLN of thalamus.



***3rd Neuron:** VPLN of thalamus. Axons of VPLN of thalamus pass in posterior limb of internal capsule then through the corona radiata to reach the sensory area of the cerebral cortex.

*** Note:** Not all spinothalamic fibers end on VPLN of thalamus, some fibers end on intralaminar nuclei and midline nuclei. These fibers are probably involved in arousal behavior.



Pathway of conscious proprioception & fine touch (Gracile & Cuneate tracts) (Posterior column - Dorsal column tract)

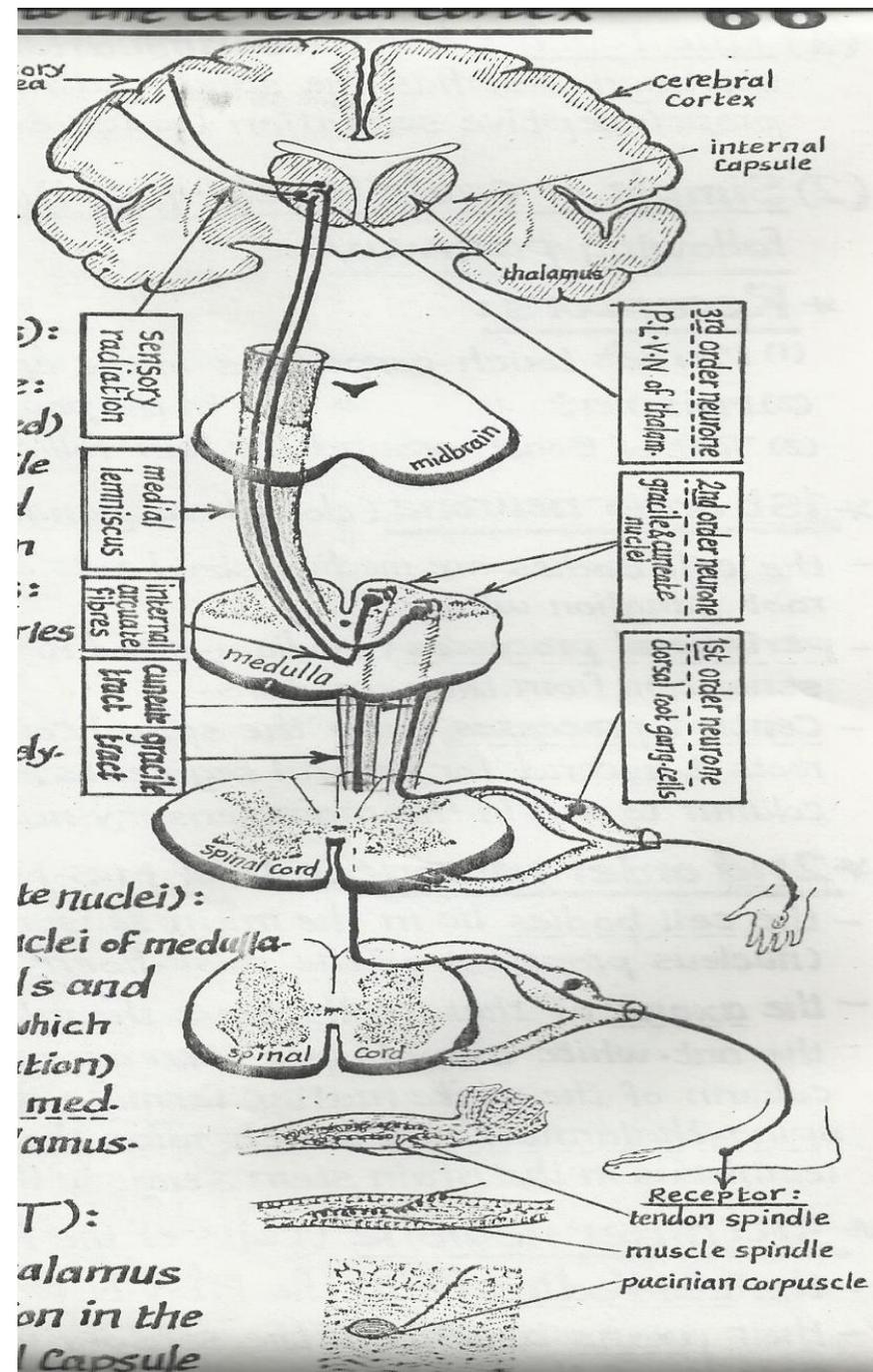
**** Proprioception (deep sensations):**

1. Sense of position.
2. Sense of movement.
3. Sense of vibration.

**** Fine touch (complex touch):**

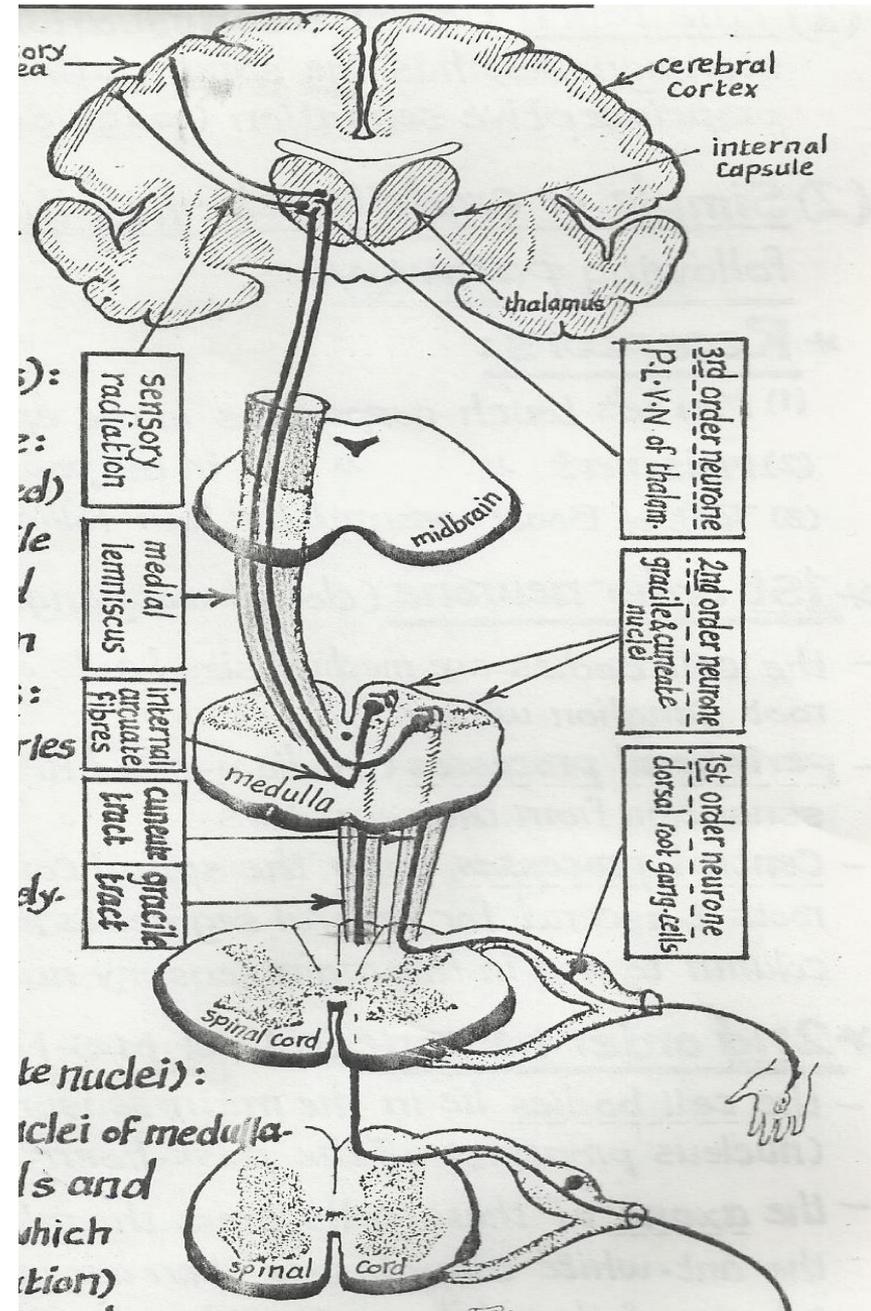
1. Tactile discrimination.
2. Tactile localization.
3. Stereognosis

- * **1st Neuron: (Gracile & cuneate tract):** Dorsal Root Ganglion cells which are pseudounipolar.
- * Their peripheral processes carry sensations from deep receptors (in muscles, tendons & joints).
- * Their central processes pass to the spinal cord via the dorsal root.
- * Fibers from the lower part of the body (below T6) ascend medially in the dorsal column forming the gracile tract.
- * Fibers from the upper part of the body (above T6) ascend laterally in the dorsal column forming the cuneate tract.
- * Lamination: sacral fibers are most medial & cervical fibers are most lateral.

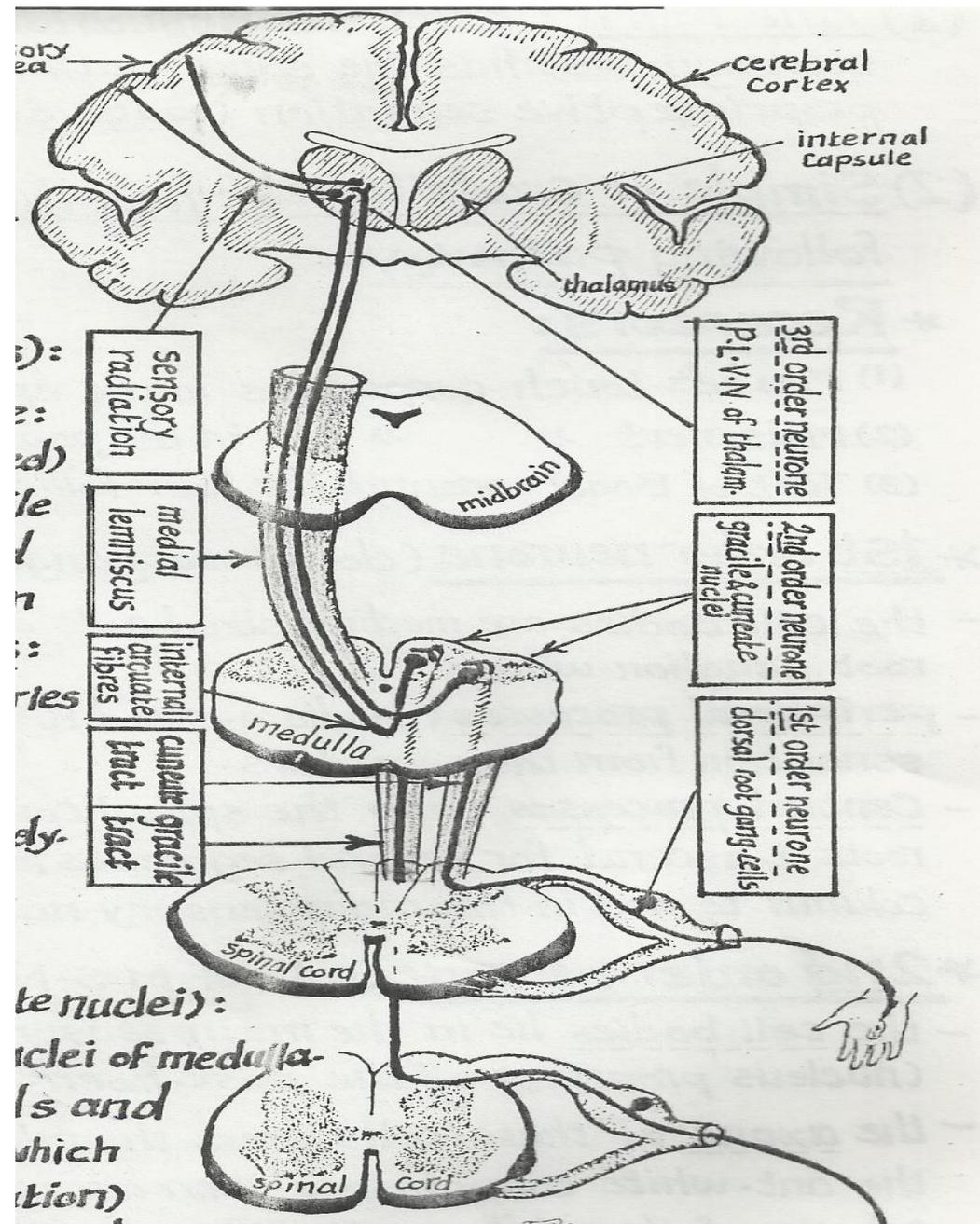


**** N.B:**

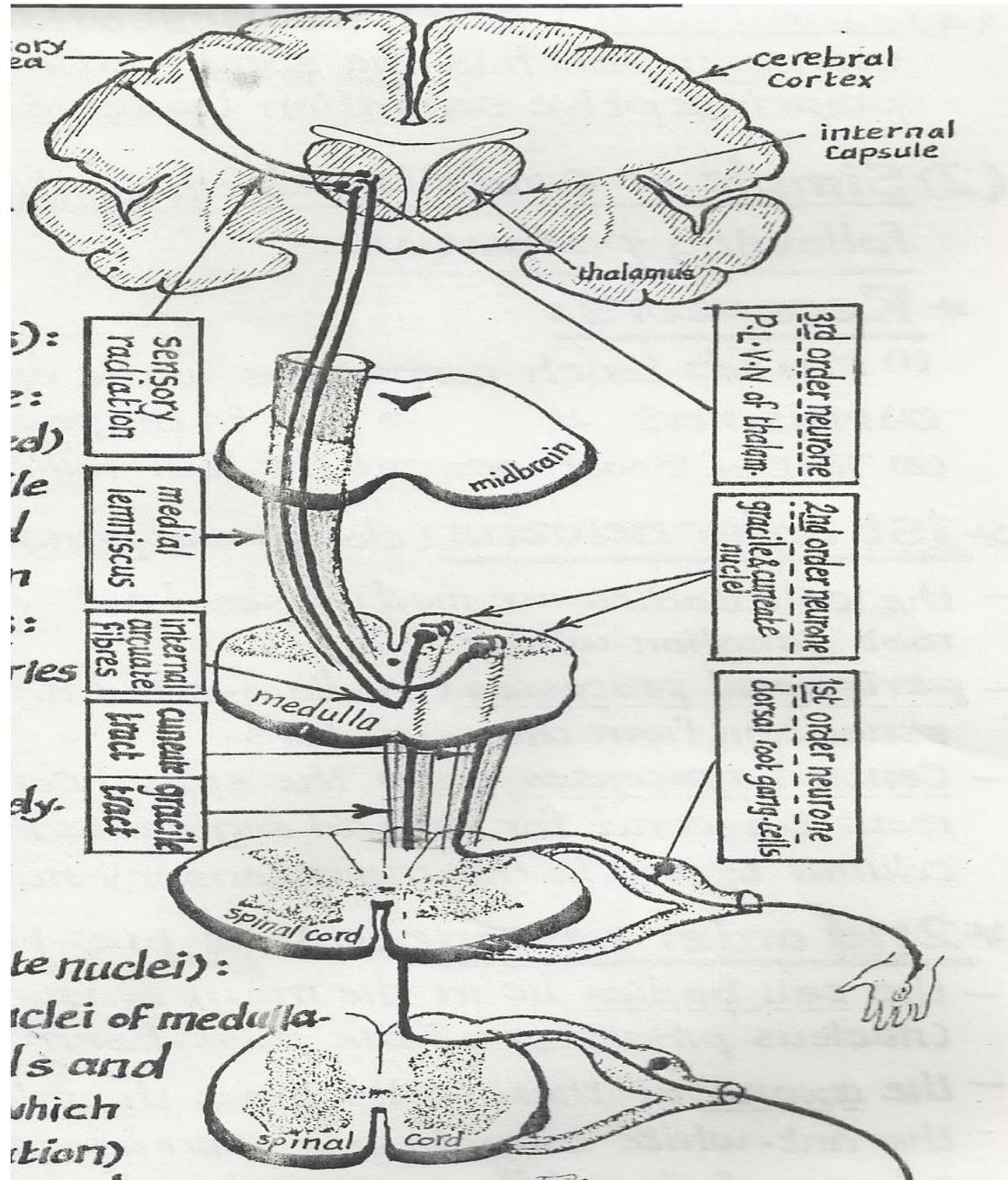
- * During their ascent, the fibers send collateral branches that end on the dorsal horn of spinal cord.
- * These form the septo-marginal tract (from Gracile) & Comma-shaped tract (from cuneate).
- * Some cervical fibers end on the accessory cuneate nucleus (posterior to the cuneate nucleus) & its axons (cuneo-cerebellar fibers) pass to the cerebellum.



* **2nd Neuron:** Gracile & Cuneate Nuclei of the medulla oblongata. Axons of these nuclei cross the median plane (forming the internal arcuate fibers (sensory decussation)). Fibers ascend in brain stem as the **medial lemniscus** to reach the thalamus.



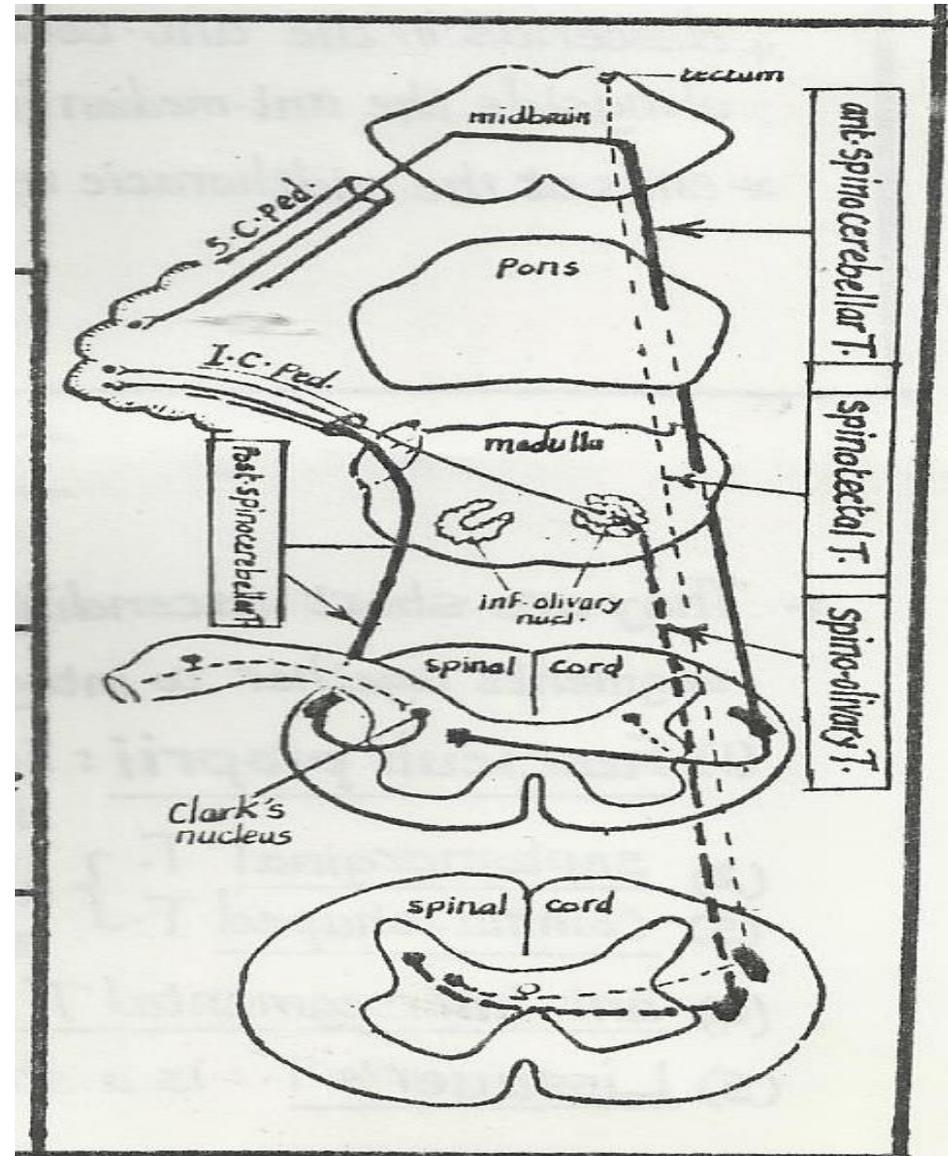
* **3rd Neuron:** Ventral posterolateral Nucleus of thalamus (VPLN). Axons of these cells pass through posterior limb of internal capsule, then through corona radiata to reach sensory area of cerebral cortex.

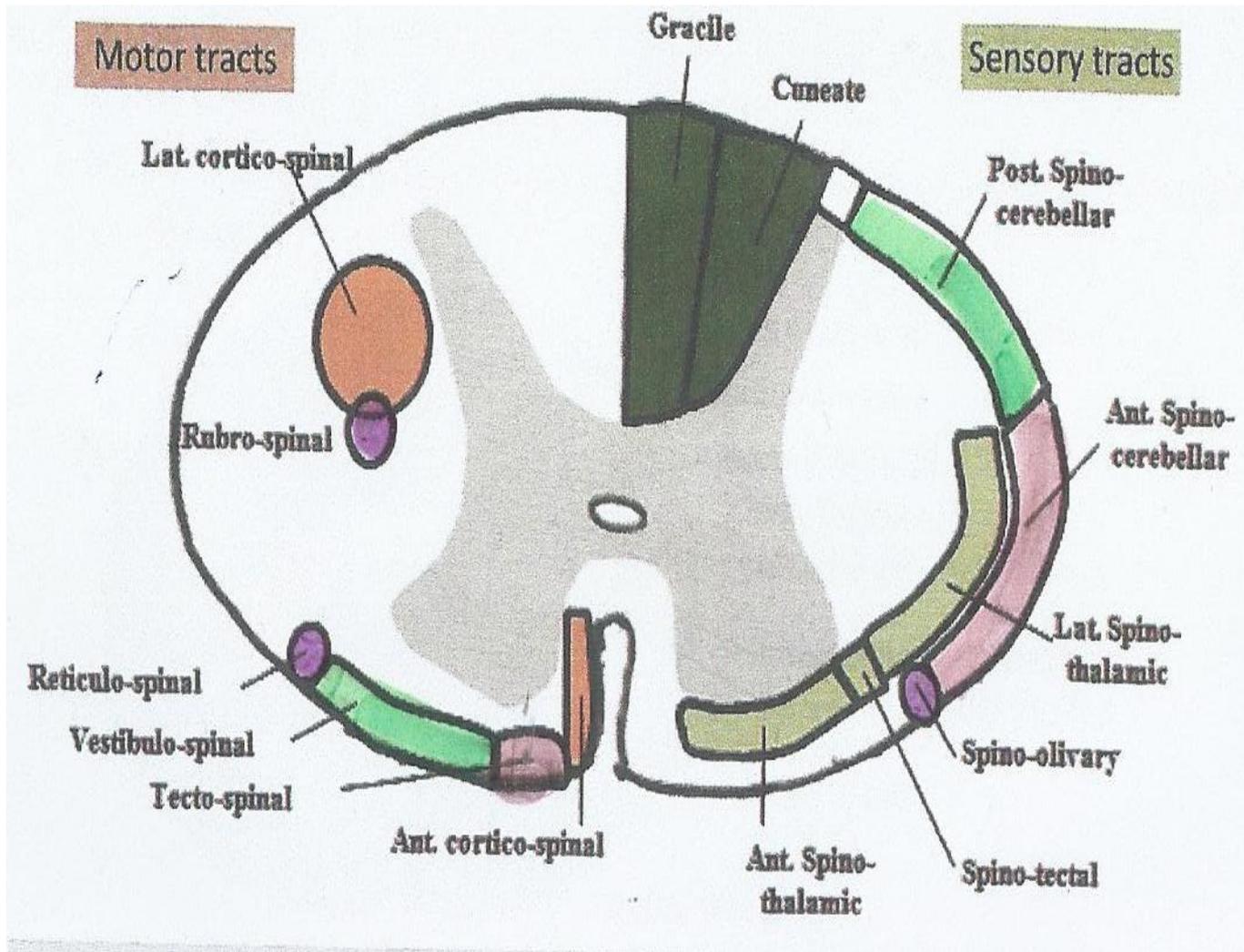


Four tracts carry unconscious proprioception to cerebellum (For coordination of movement)

1. Posterior spinocerebellar tract:

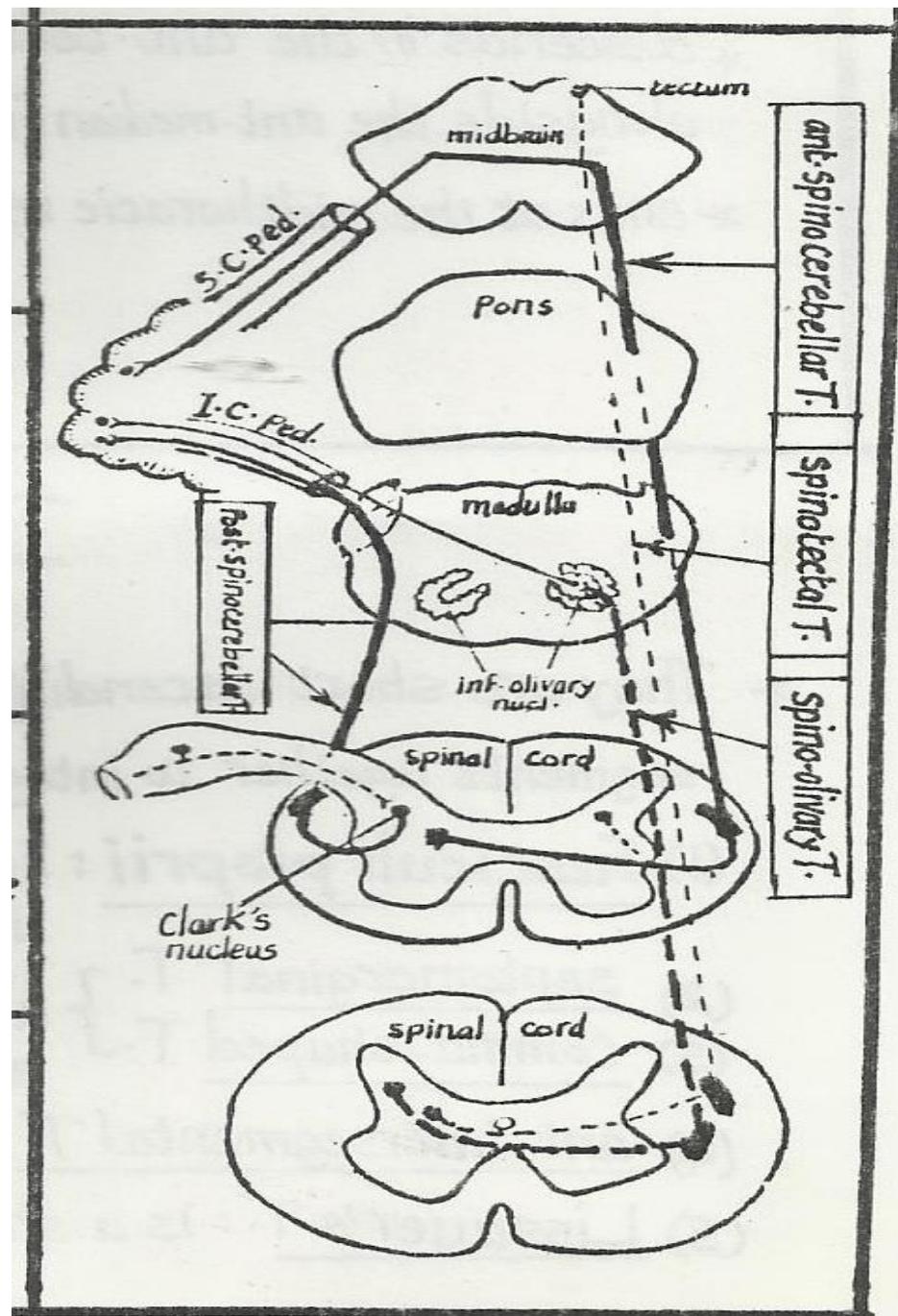
- * Carries proprioception from the lower limb & trunk.
- * The central processes of DRG cells enter the spinal cord via the dorsal root to end on **ipsilateral Clarke's nucleus**.
- * The tract ascends ipsilaterally in the lateral white column, posterior to the anterior spinocerebellar tract & enters the ipsilateral cerebellum via the inferior cerebellar peduncle (ICP).





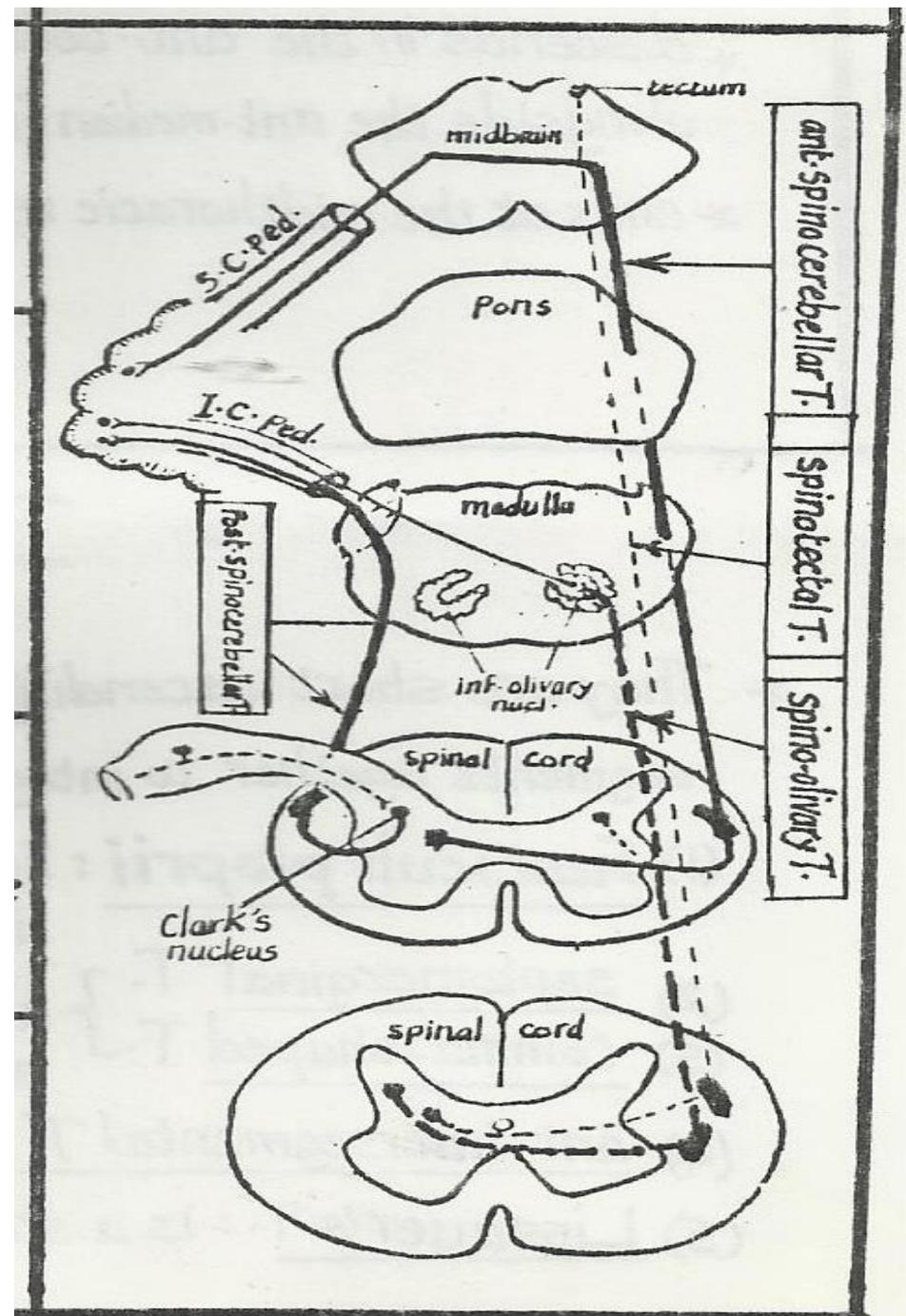
2. Anterior spinocerebellar tract:

- * Carries proprioception from the lower limb.
- * The central processes enter the spinal cord via the dorsal root to end on Clarke's nucleus.
- * Axons forming the tract mostly decussate but few remain ipsilateral.
- * They enter the cerebellum via the superior cerebellar peduncle (SCP) after crossing again to reach the ipsilateral cerebellum.



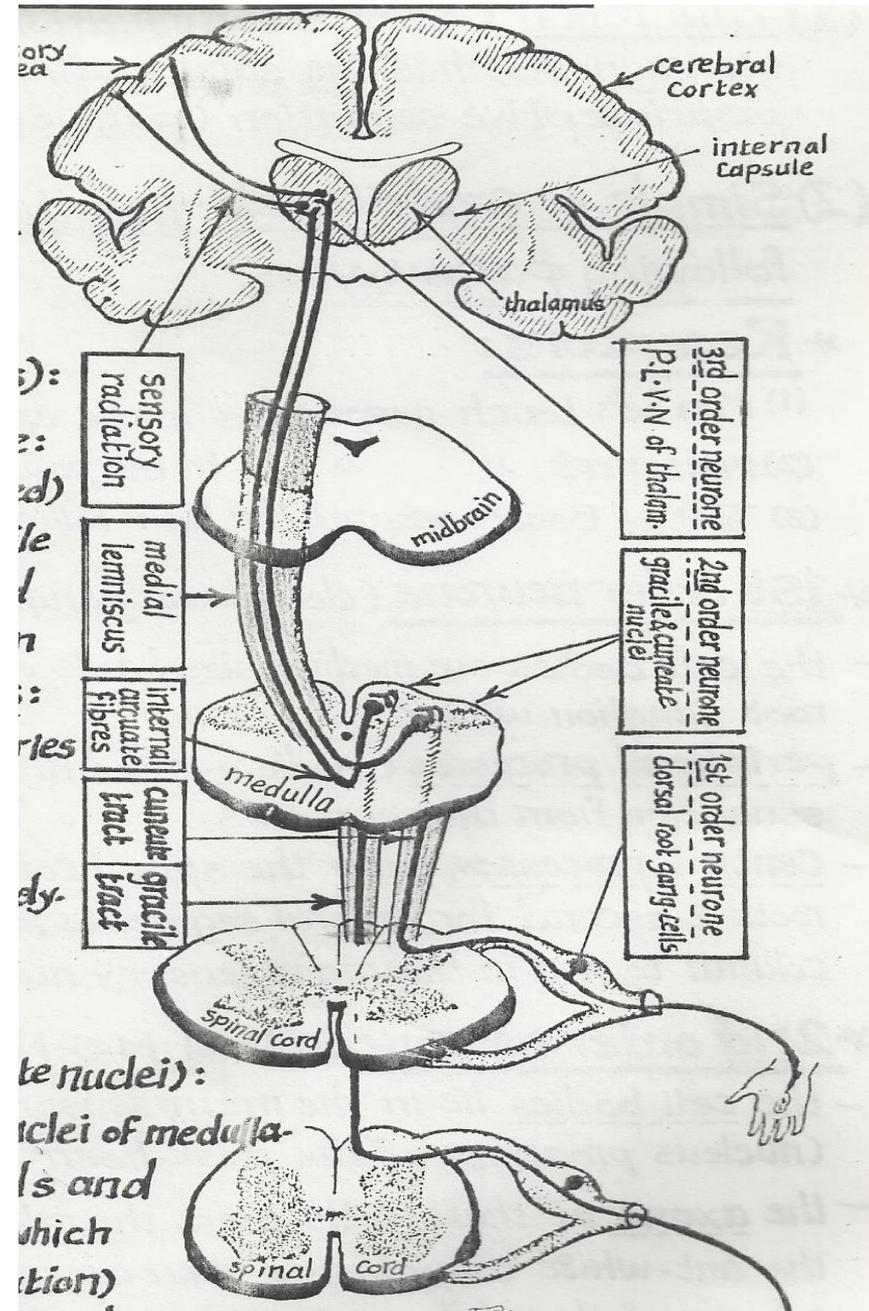
3. Spino-olivary Tract:

- * It carries proprioception from both upper & lower limbs.
- * Its fibers cross & ascend at the junction of lateral & ventral white columns to end on the contralateral olivary nuclei.
- * Olivocerebellar fibers cross & pass via the ICP to reach the ipsilateral cerebellum.



4. Collaterals from cuneate tract:

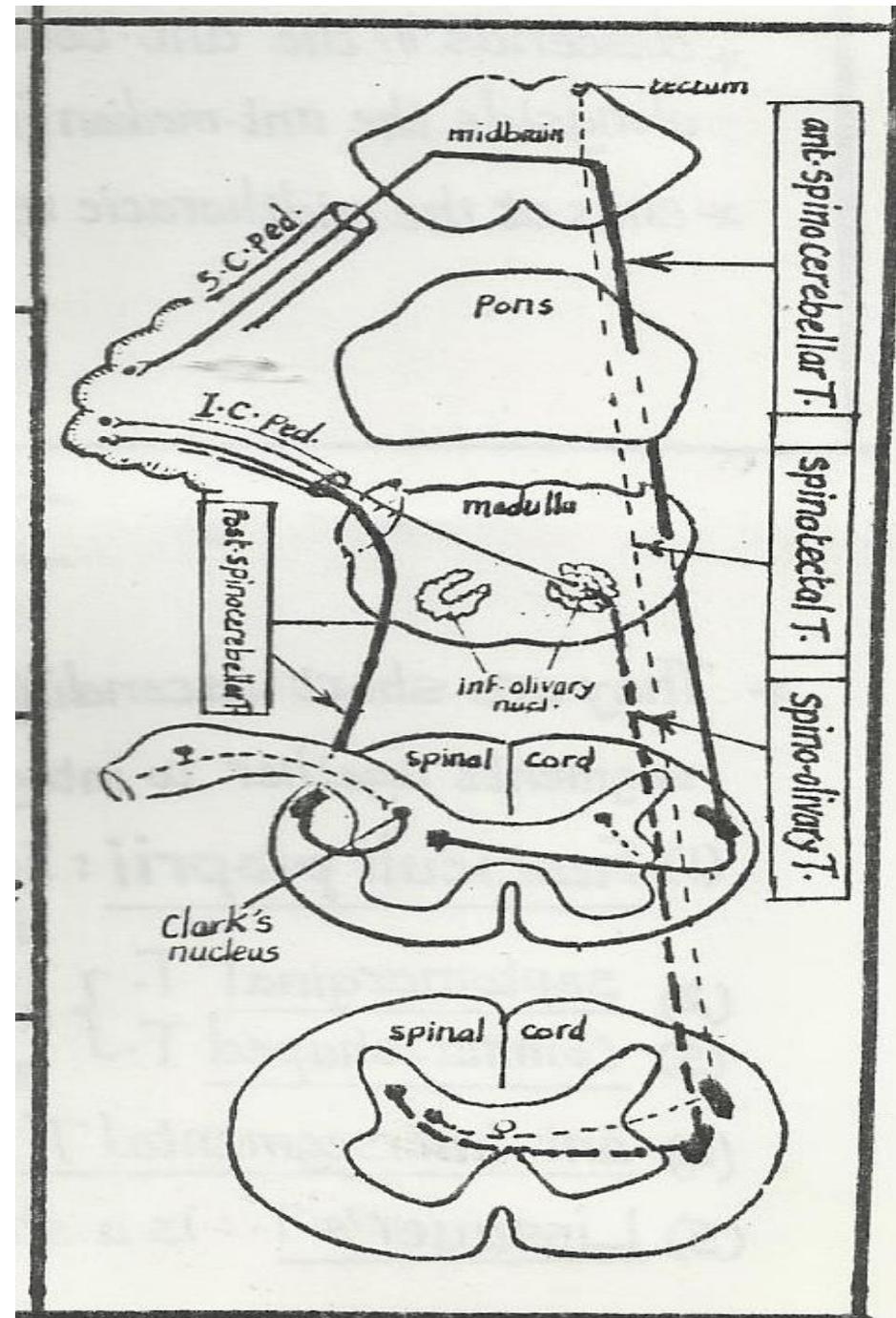
- * Carry proprioception from the upper limb to the accessory cuneate nucleus of the medulla.
- * Axons of the accessory cuneate nucleus form the external arcuate fibers (Cuneocerebellar tract) which reach the ipsilateral cerebellum via the ICP.



Other Ascending Tracts

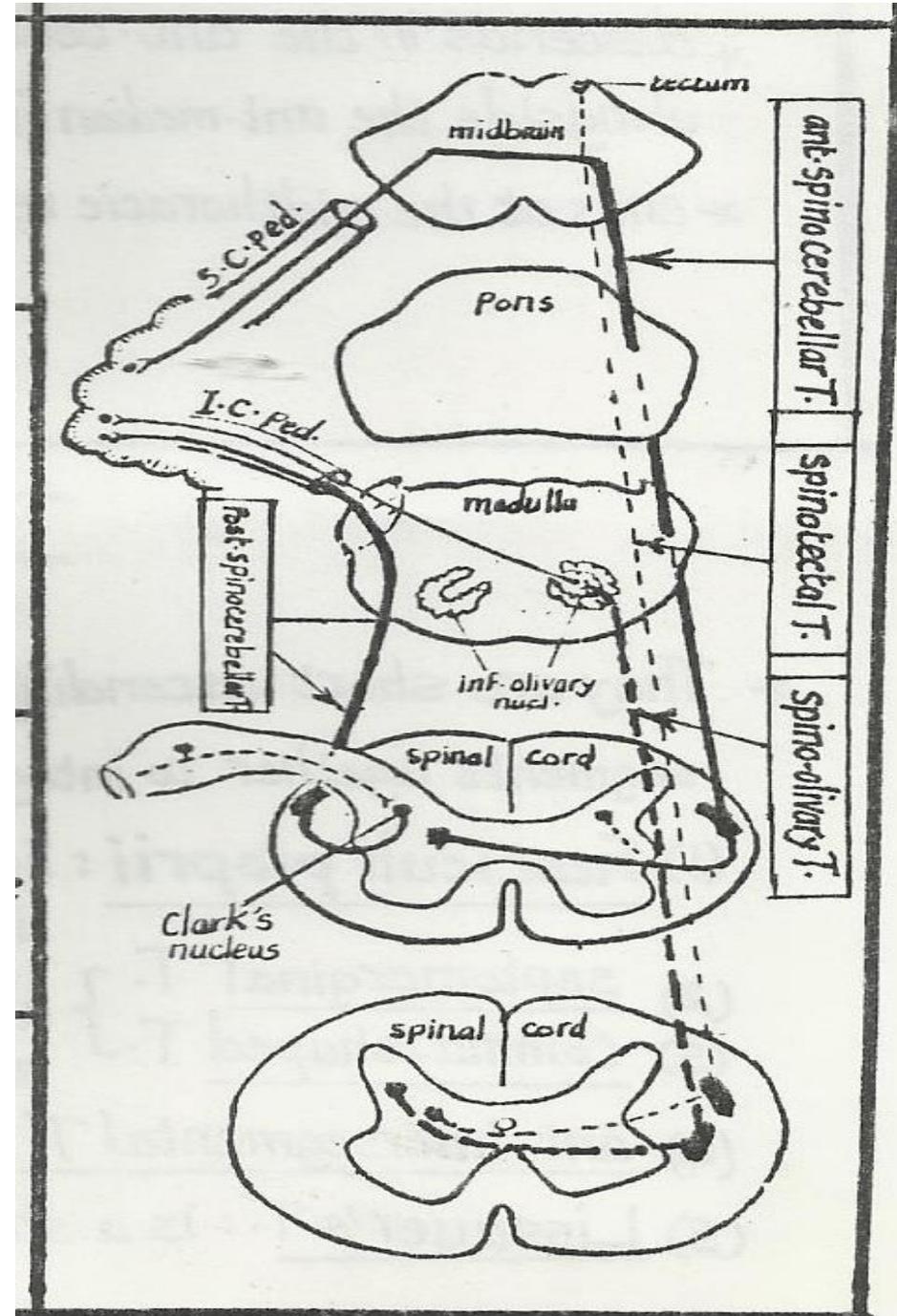
1. Spino-reticular Tract

- * Its fibers ascend in the lateral & ventral white columns where it is intermingled with the spino-thalamic tracts.
- * Most fibers cross to the opposite side & ascend to end on neurons of the ponto-medullary reticular formation.
- * A spino-reticulo-thalamo-cortical pathway was suggested as a route for slow dull-aching pain sensation.



2. Spino-tectal Tract

- * Most fibers cross to the opposite side & ascend in the lateral white column to end in the superior colliculi of the midbrain.
- * The spino-tectal tract is concerned with spino-visual reflexes (head turning towards source of pain stimulus).



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