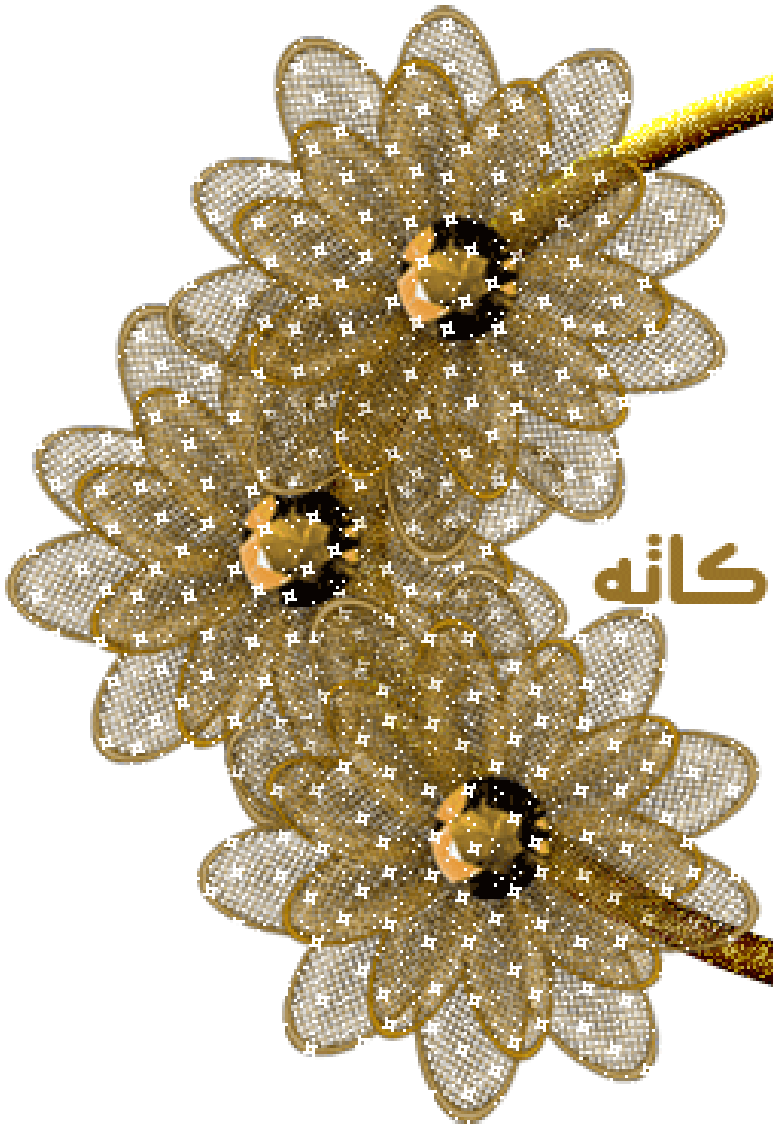


بسم الله الرحمن الرحيم

السلام عليكم ورحمه الله وبركاته

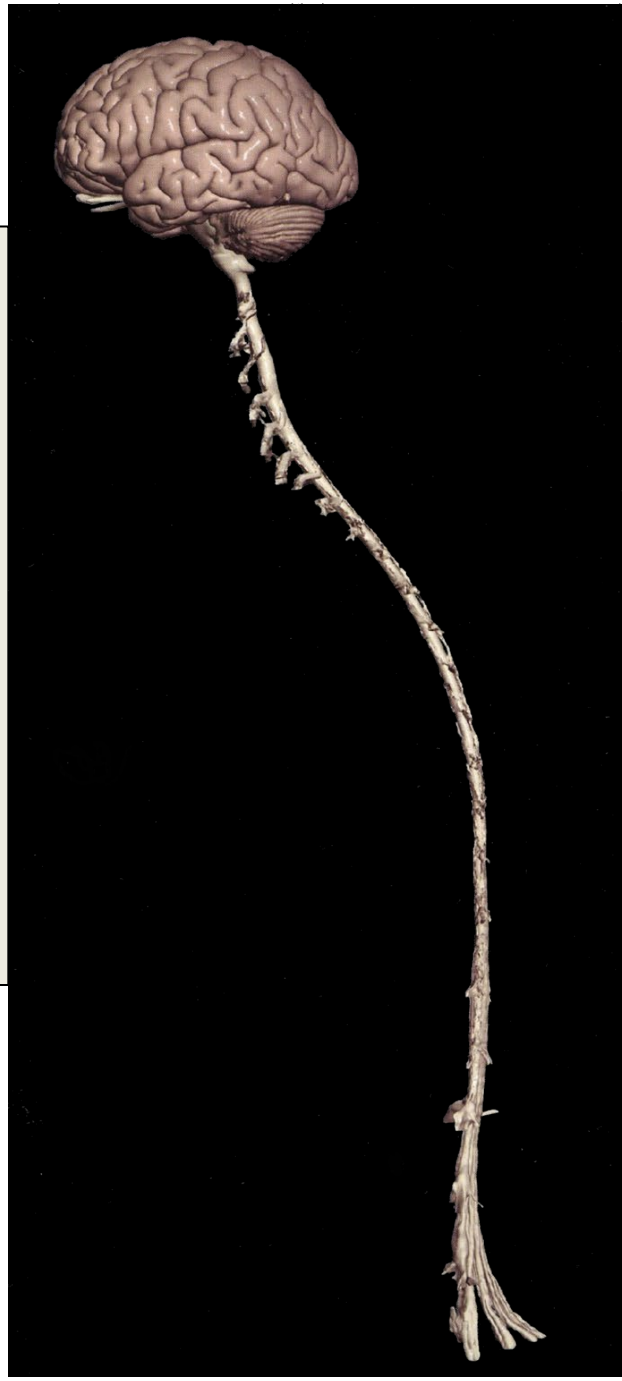
Sensory pathways
Ascending Tracts

Department of human Anatomy and Embryology
Faculty of Medicine
Mansoura National University, Egypt

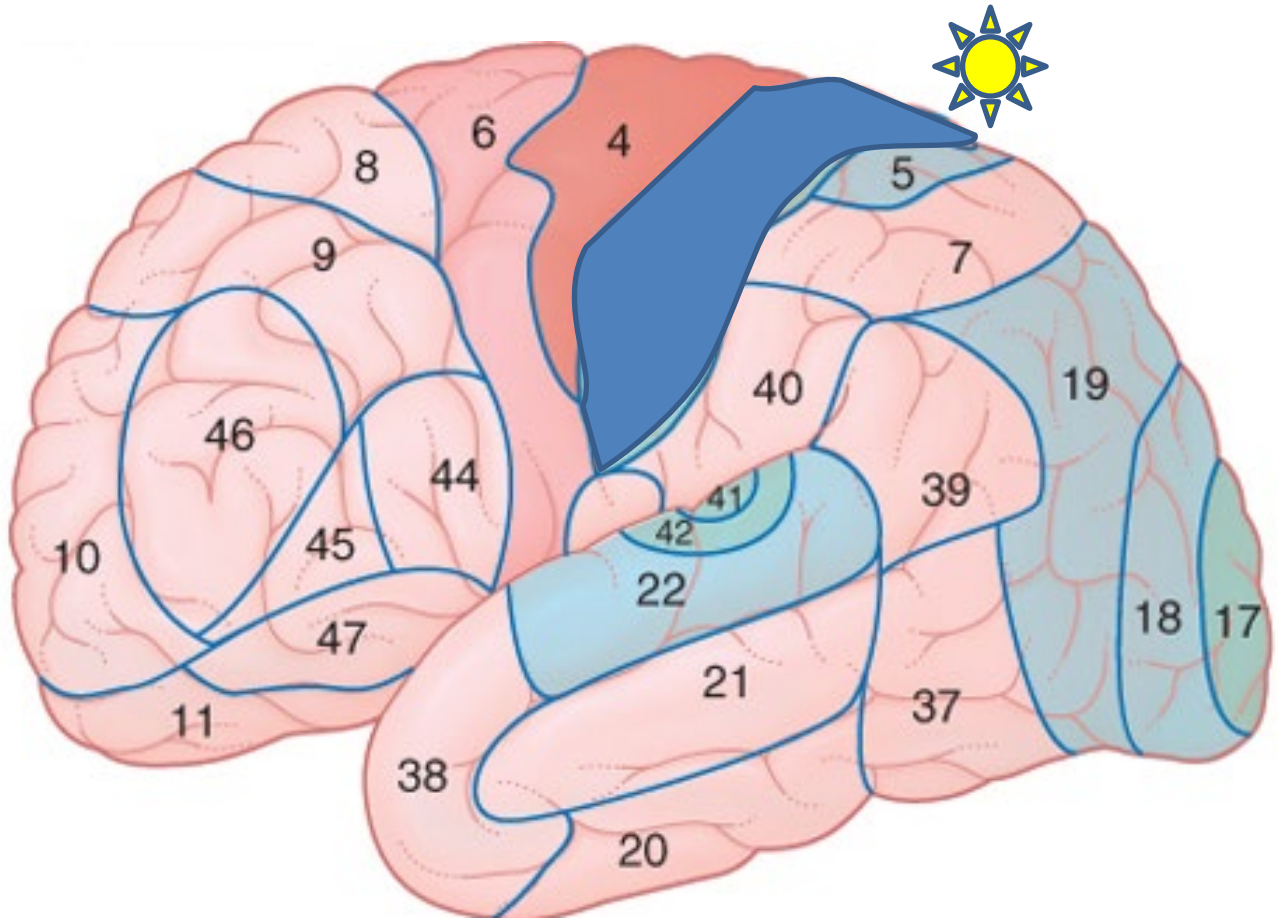
OBJECTIVES

By the end of the lecture, the student will be able to:

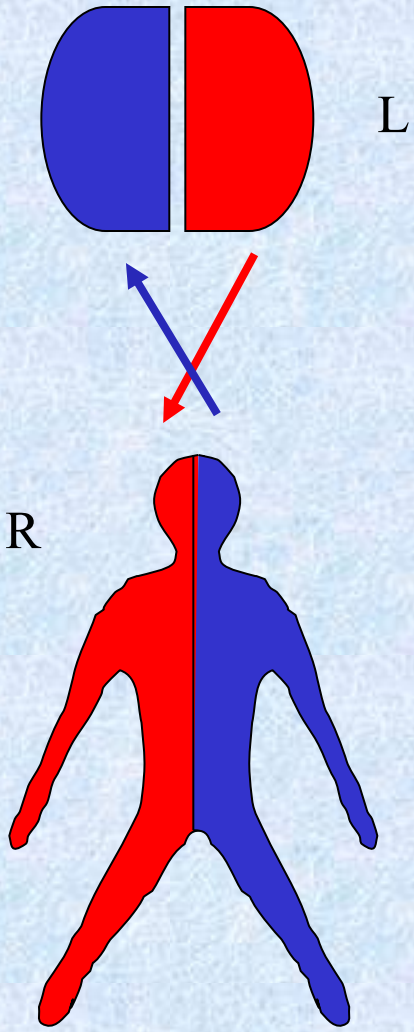
- **Define the meaning of a tract.**
- **Describe the sensory pathway.**
- **Locate the position and course of each tract.**
- **Correlate these information with clinical cases.**



The ascending tracts carry sensory information from the peripheries to the primary somatosensory cortex in the **post-central gyrus** of the cerebral cortex.



Control of the body by the brain



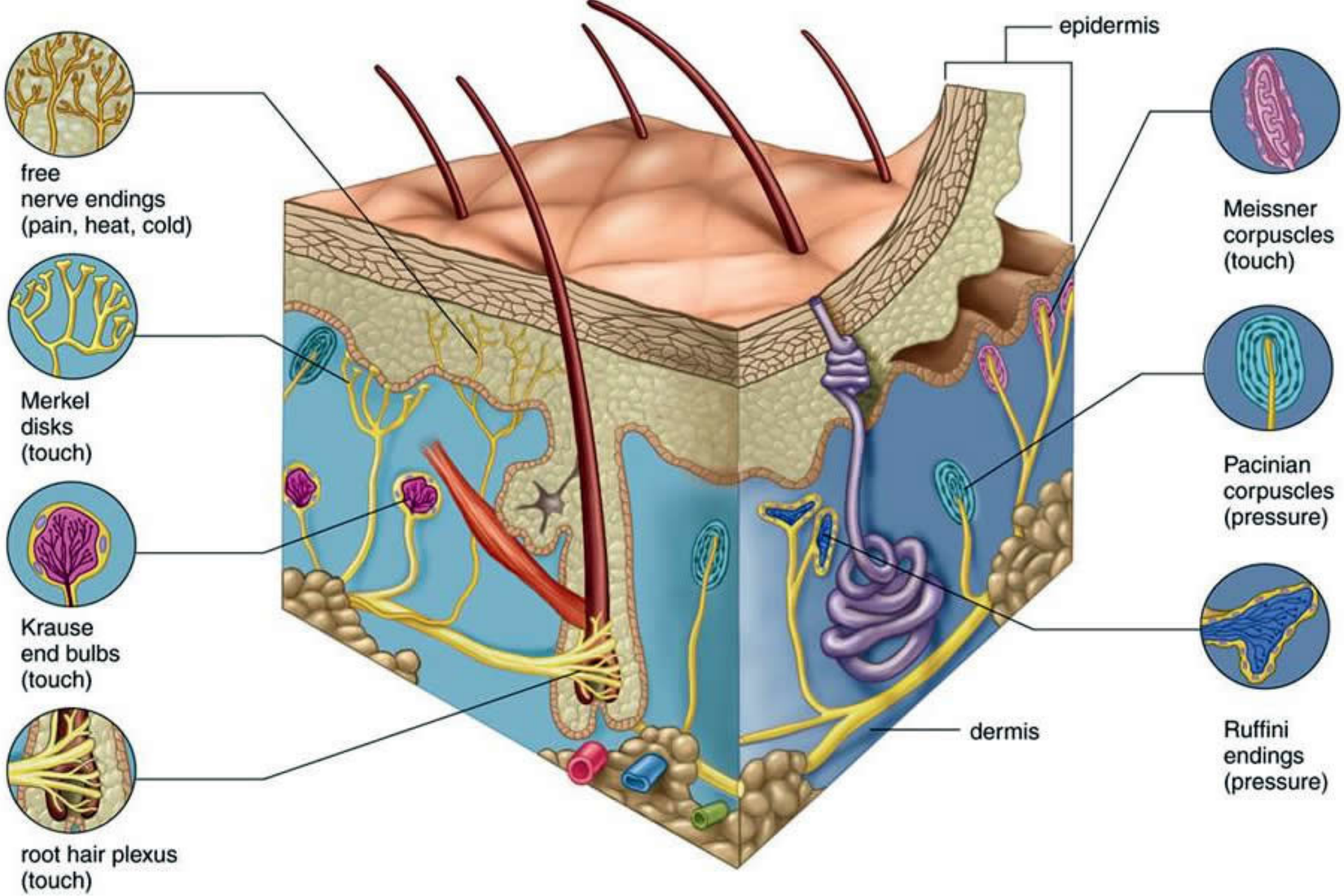
Contralateral representation

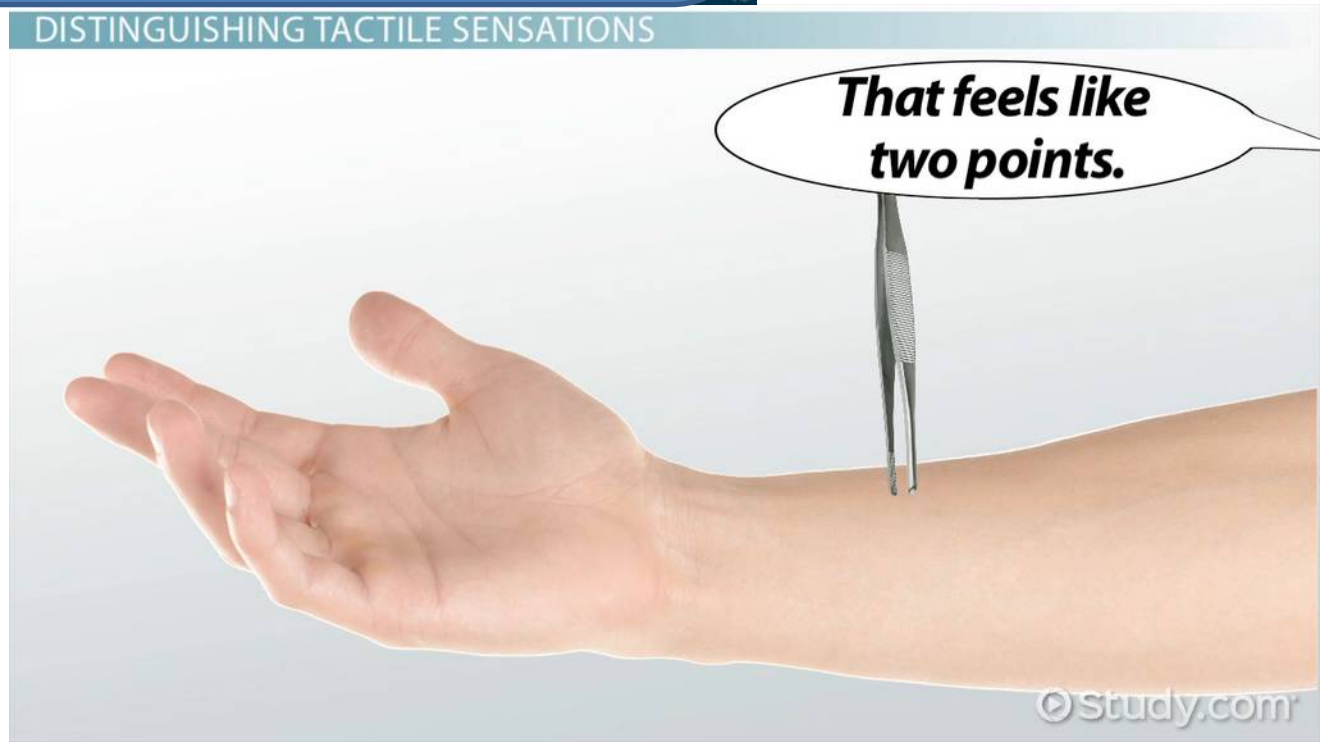
Decussation = Crossing

Contralateral = Opposite side
Ipsilateral = Same side

What are the general senses?

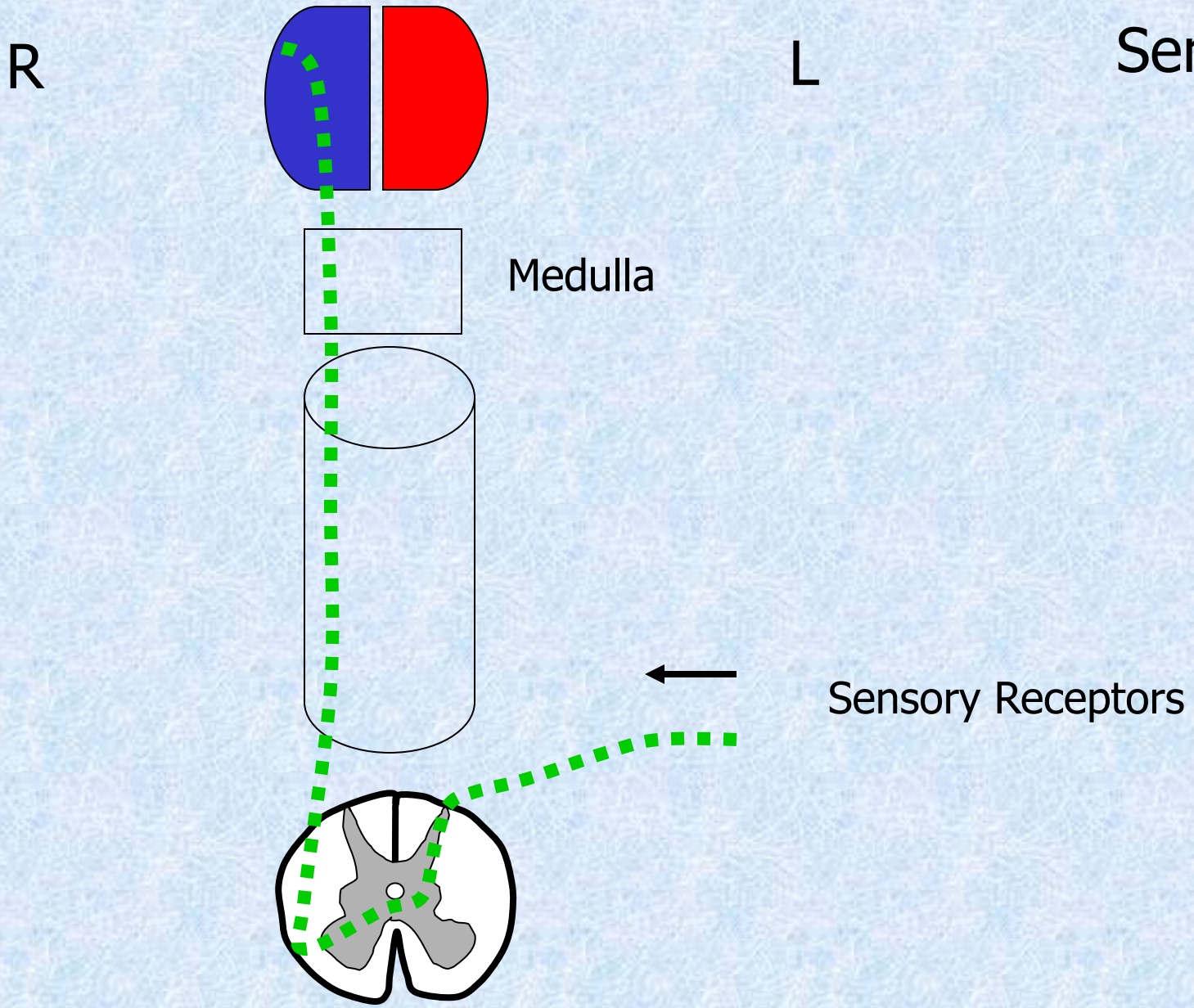
General Sense	Receptor
Temperature and pain	Free nerve ending
Discriminative Touch	Meissner corpuscle
Crude Touch	Ruffini ending
Deep pressure	Pacinian corpuscle


free
nerve endings
(pain, heat, cold)
Merkel
disks
(touch)
Krause
end bulbs
(touch)
root hair plexus
(touch)
epidermis
dermis
Meissner
corpuscles
(touch)
Pacinian
corpuscles
(pressure)
Ruffini
endings
(pressure)



- **Sensation** is a conscious or unconscious awareness of external or internal stimuli.

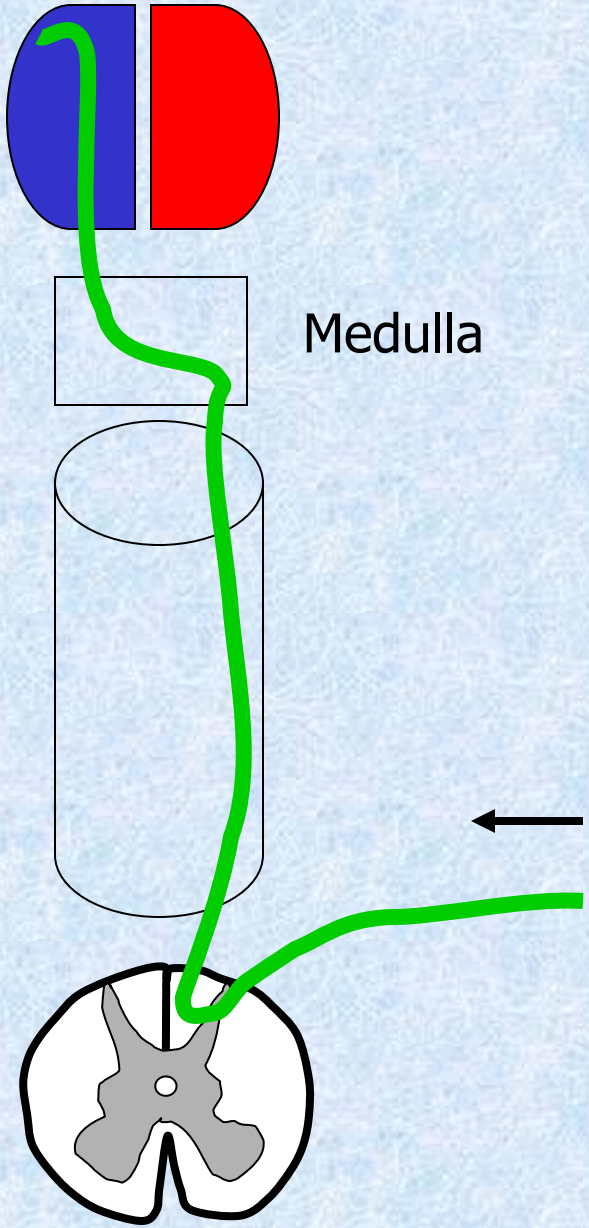
- **Perception** is the conscious awareness and interpretation of sensations.


R
L
Sensory
Medulla
Sensory Receptors

R

L

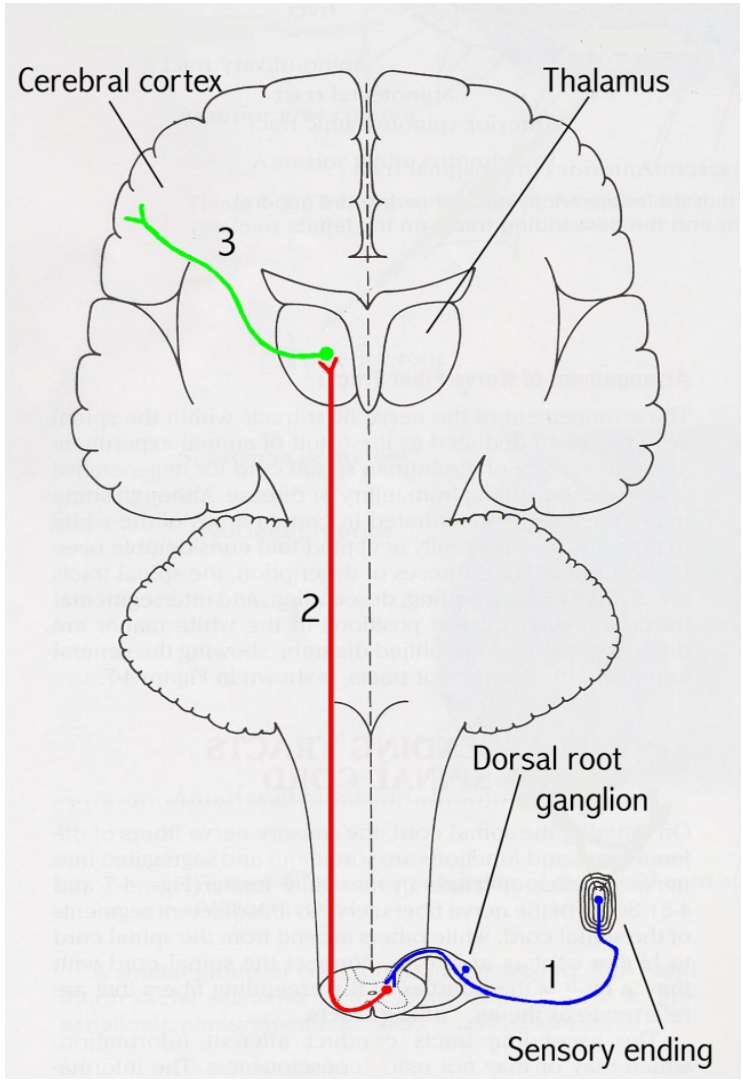
Sensory



How many sets of neurons are the main ascending tracts split into?

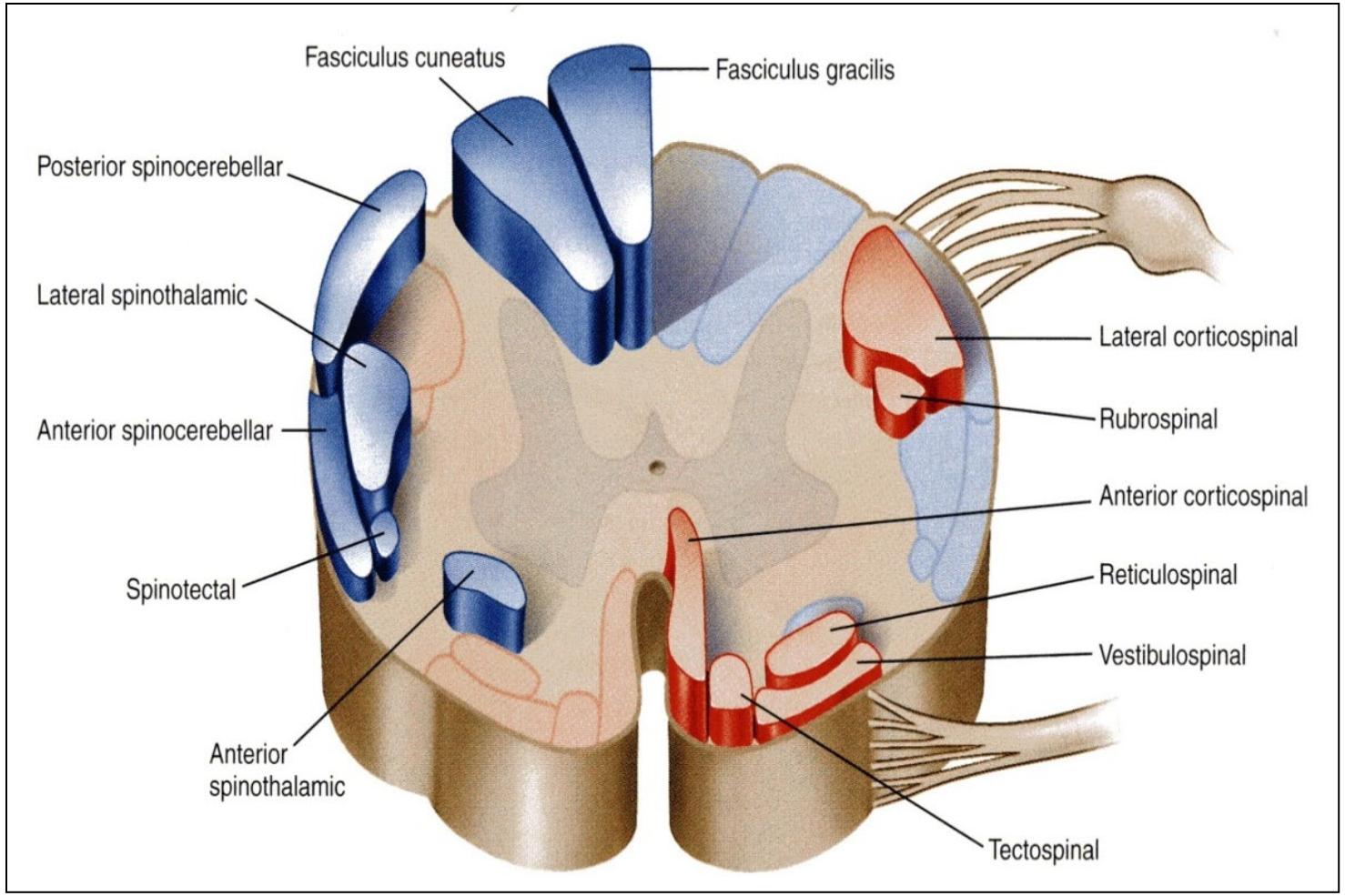
- 3

- 1st order, 2nd order and 3rd order neurons.



WHITE MATTER TRACTS

- Bundles or fasciculi of fibers have the same **Origin, Termination** and carry the same **Function.**

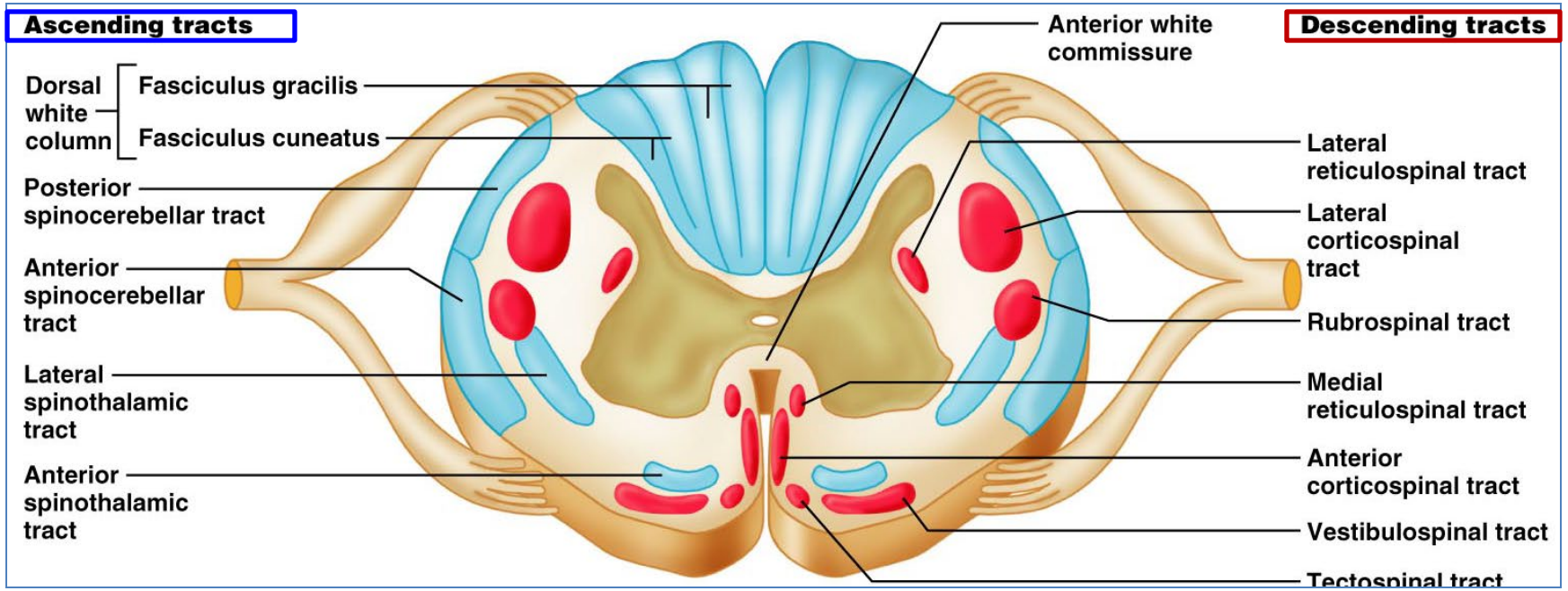


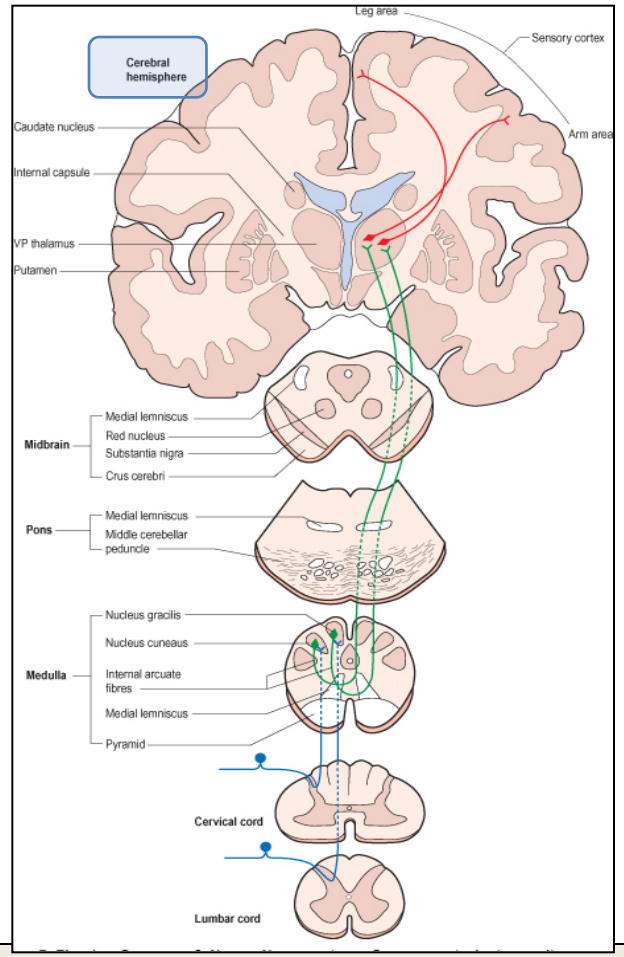
• Long Tracts:

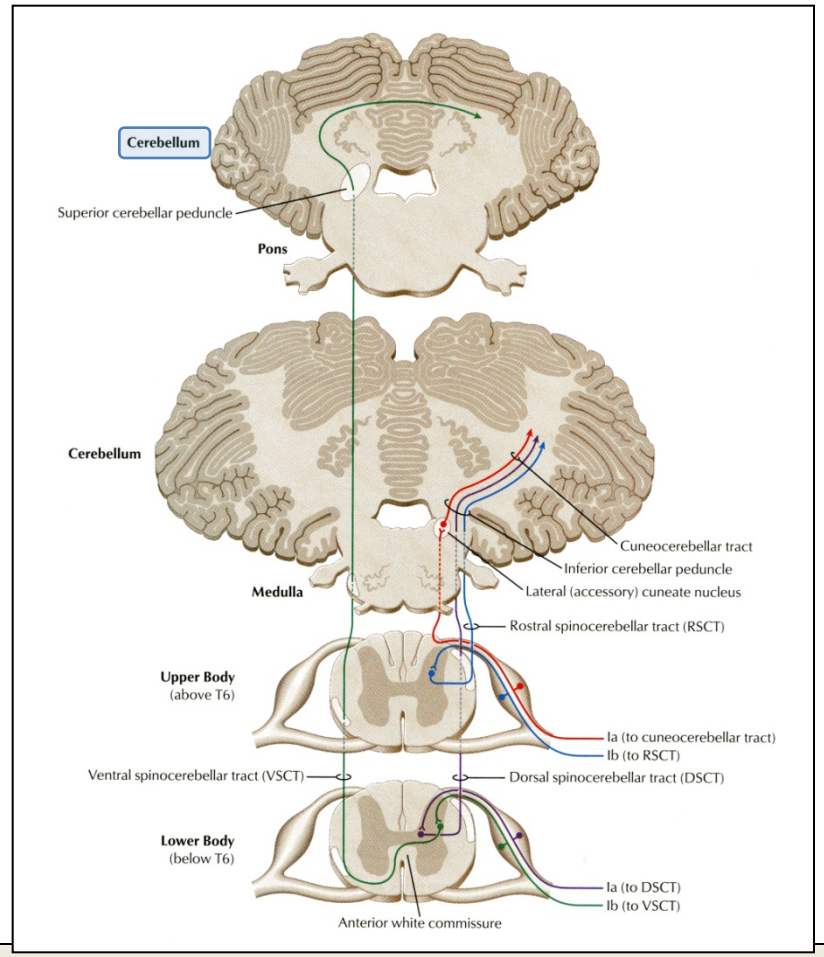
(a) Ascending (sensory or afferent).

(b) Descending (motor or efferent).

They serve to join the brain to the spinal cord.





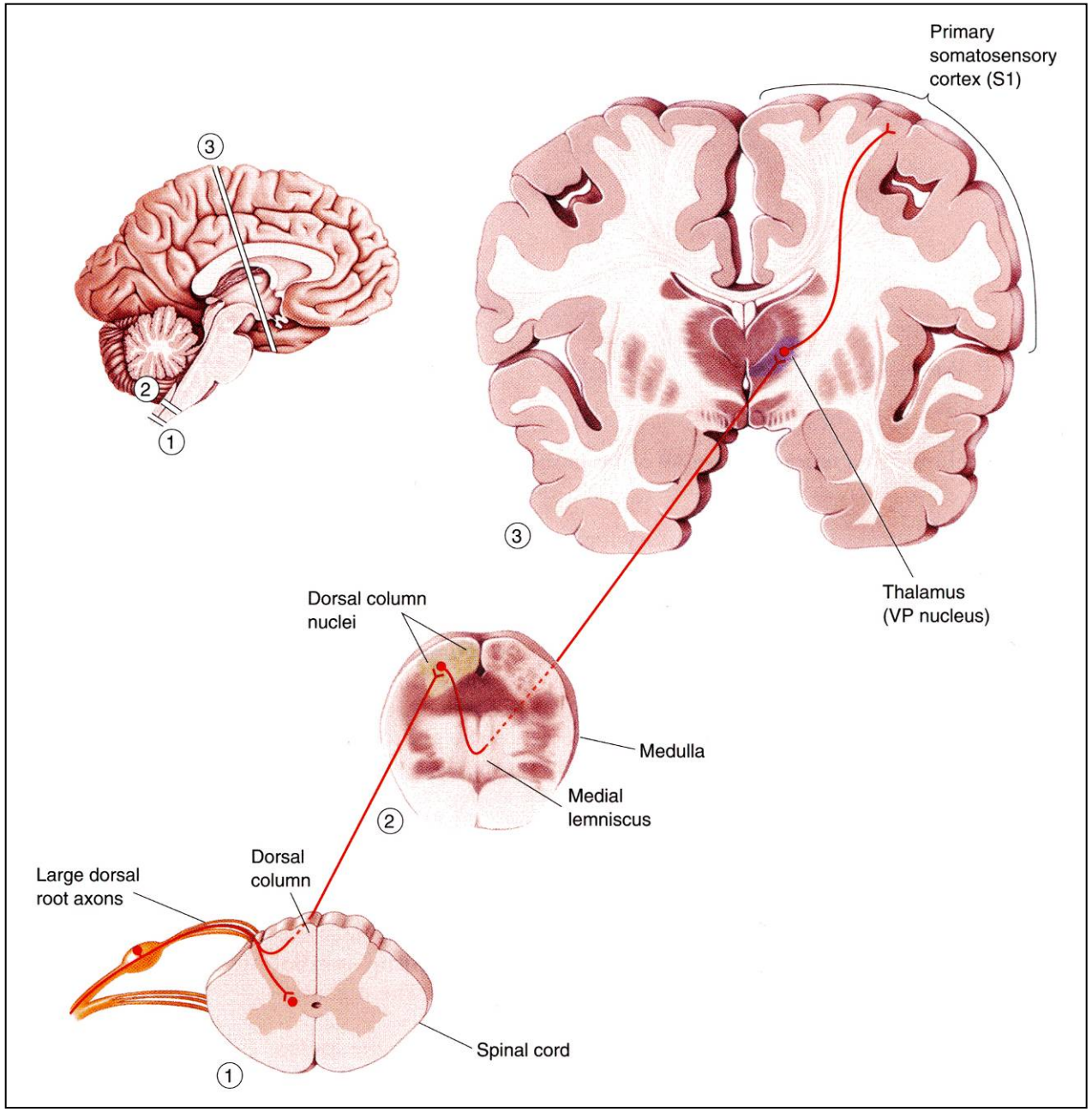


❑ Ascending Tracts:

- Carry impulses from pain, thermal, tactile, muscle and joint receptors to the brain.

- *Some of this information eventually reaches a **conscious level*** (at the **cerebral cortex),**

*while some is destined for **subconscious centers*** (at the **cerebellum**).

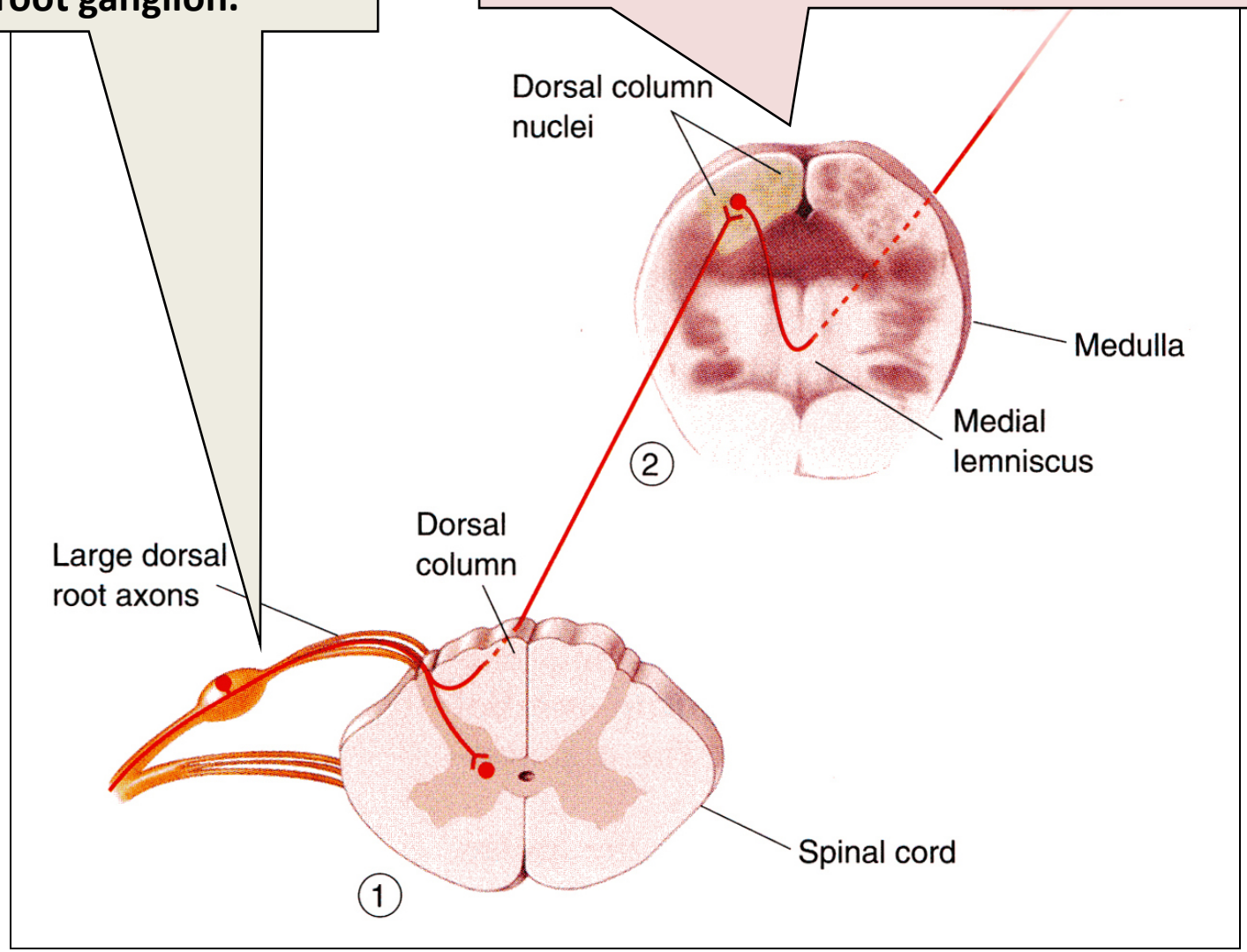


- Pathways that carry information to a **conscious level** share certain common characteristics:

There is a sequence of **Three Neurons** between the peripheral receptors and the cerebral cortex.

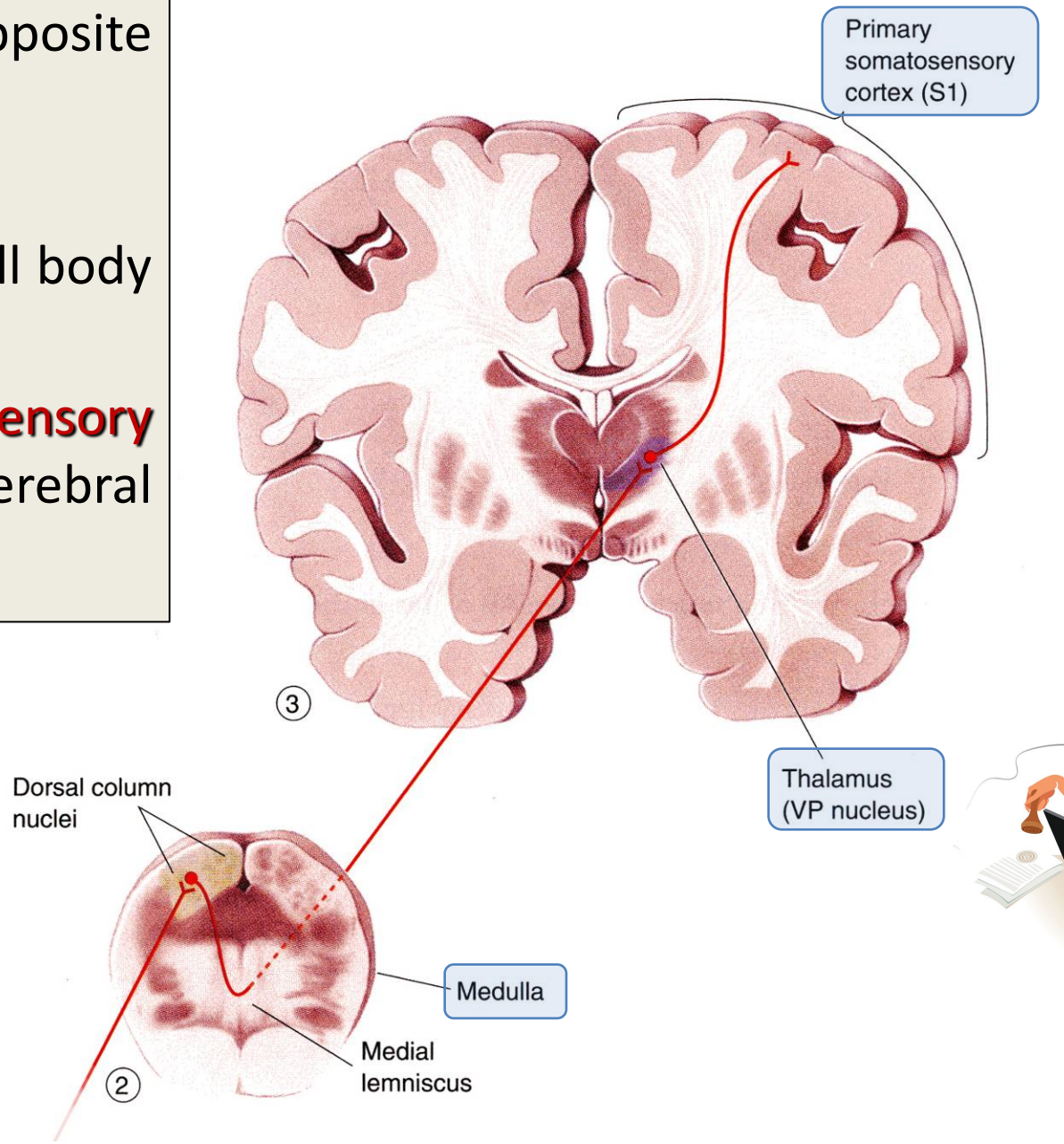
The axons of the **first-order neurone** or primary afferent neurone) enters the spinal cord through the dorsal root of a spinal nerve and its cell body lies in the **dorsal root ganglion.**

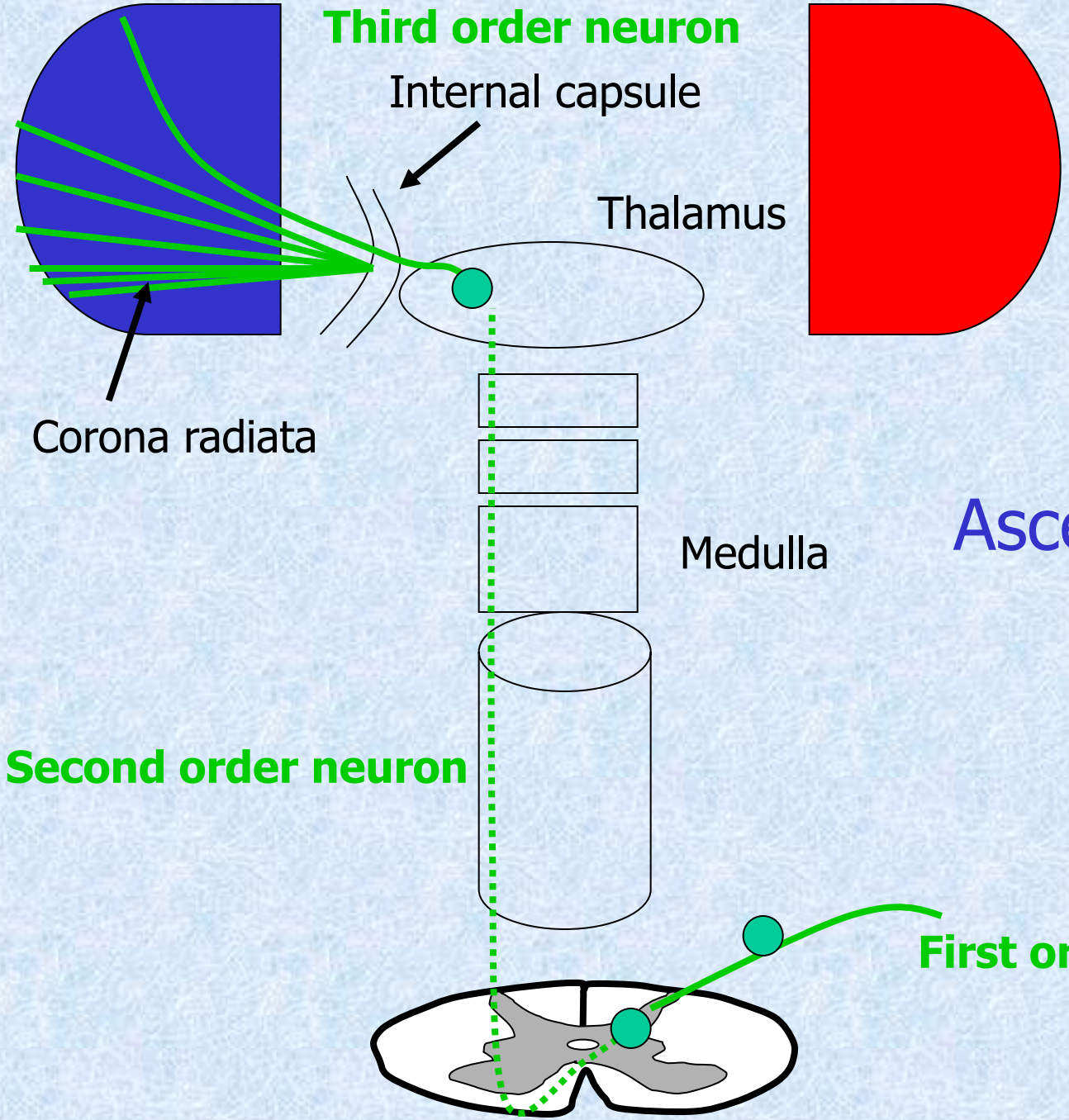
The main fiber remains on the ipsilateral side of the cord and terminates in synaptic contact with the **second neuron which lies** either in the **spinal grey matter** or in the **medulla oblongata of the brain stem**.



- The axon of the **second order neuron** **crosses over** (**decussates**) to the opposite side of the CNS.

- **The third-order neurone** has its cell body in the ***thalamus.***
- Its axon passes to the **somatosensory cortex** of the parietal lobe of the cerebral hemisphere.





Ascending tracts

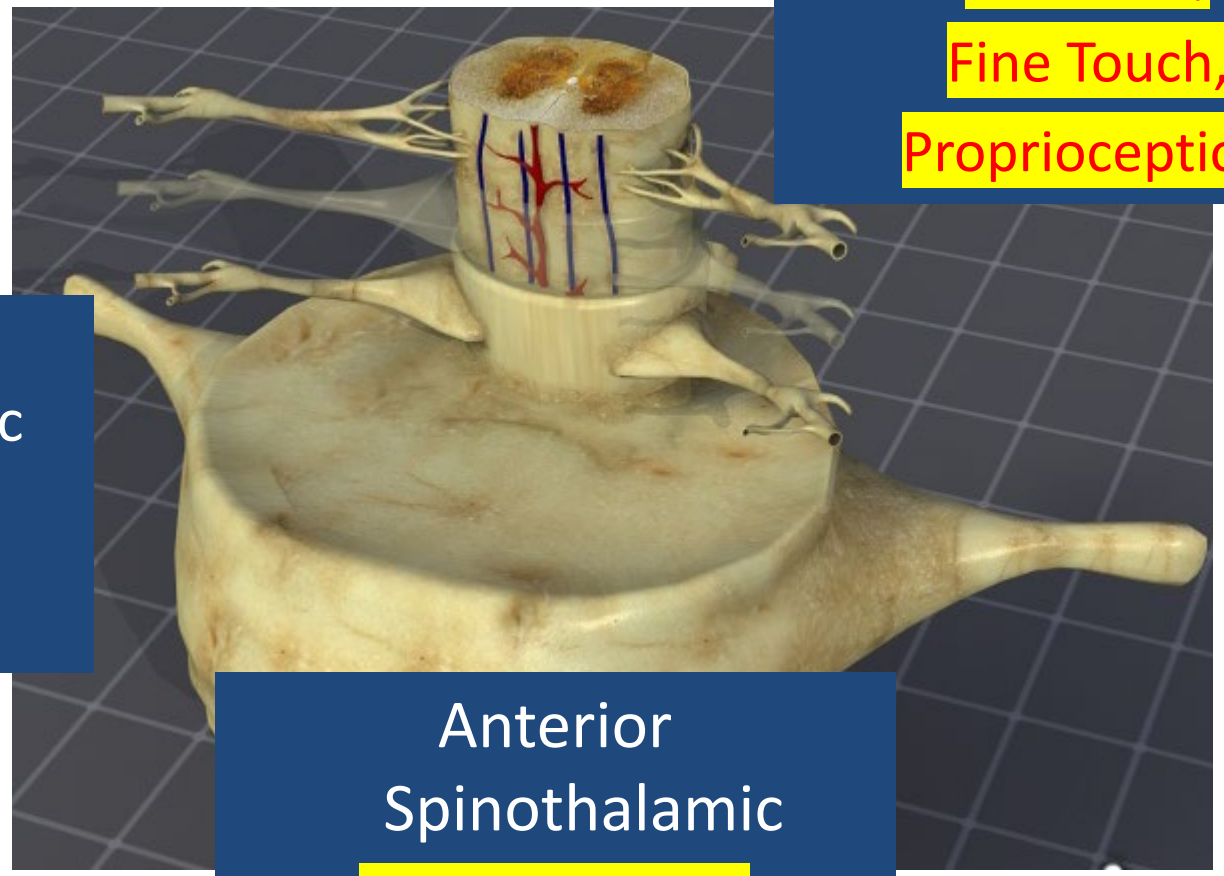
The 3 ascending tracts are...

Dorsal Columns

Vibration,

Fine Touch,

Proprioception



Lateral Spinothalamic

Pain,

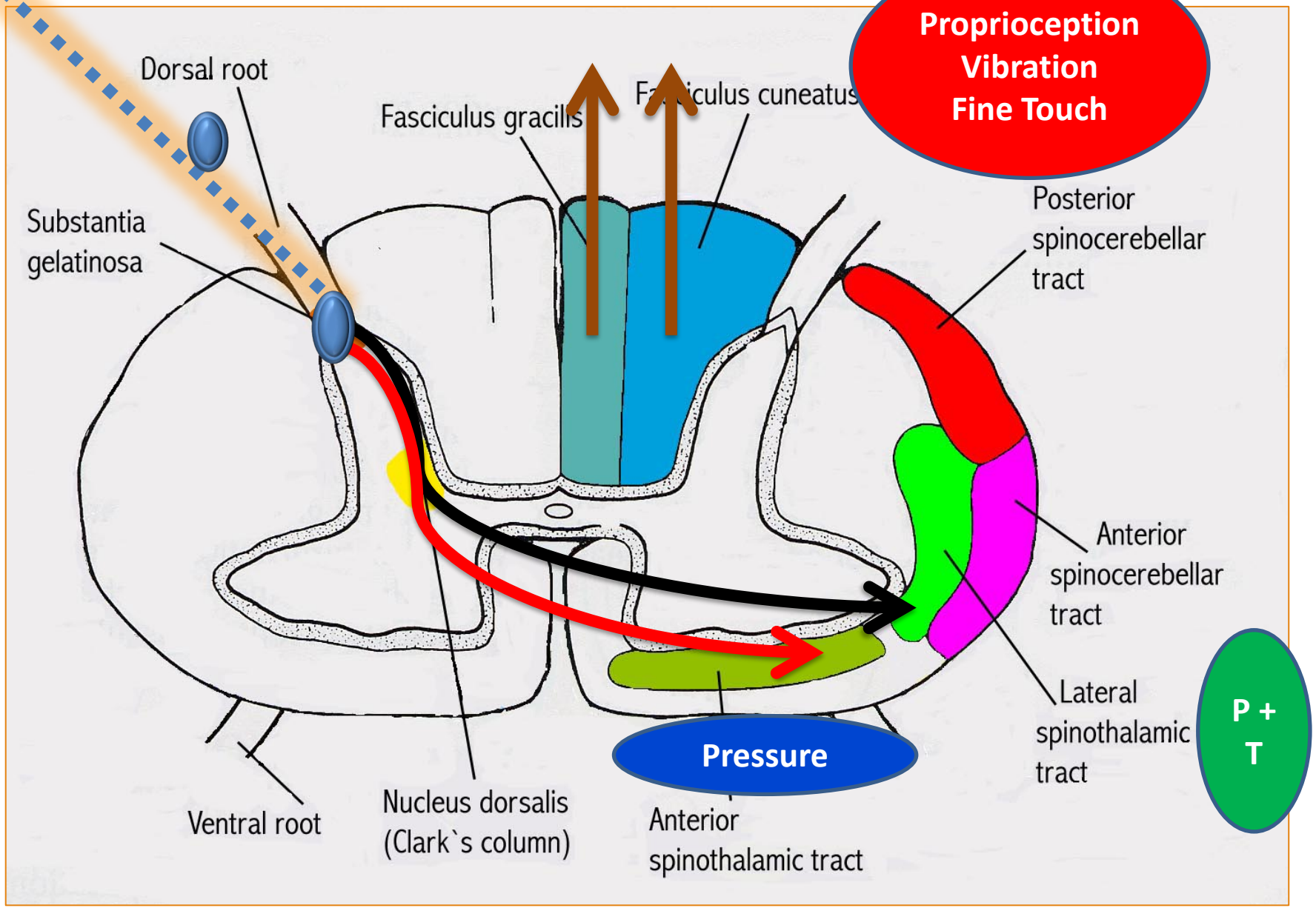
Temperature

Anterior Spinothalamic

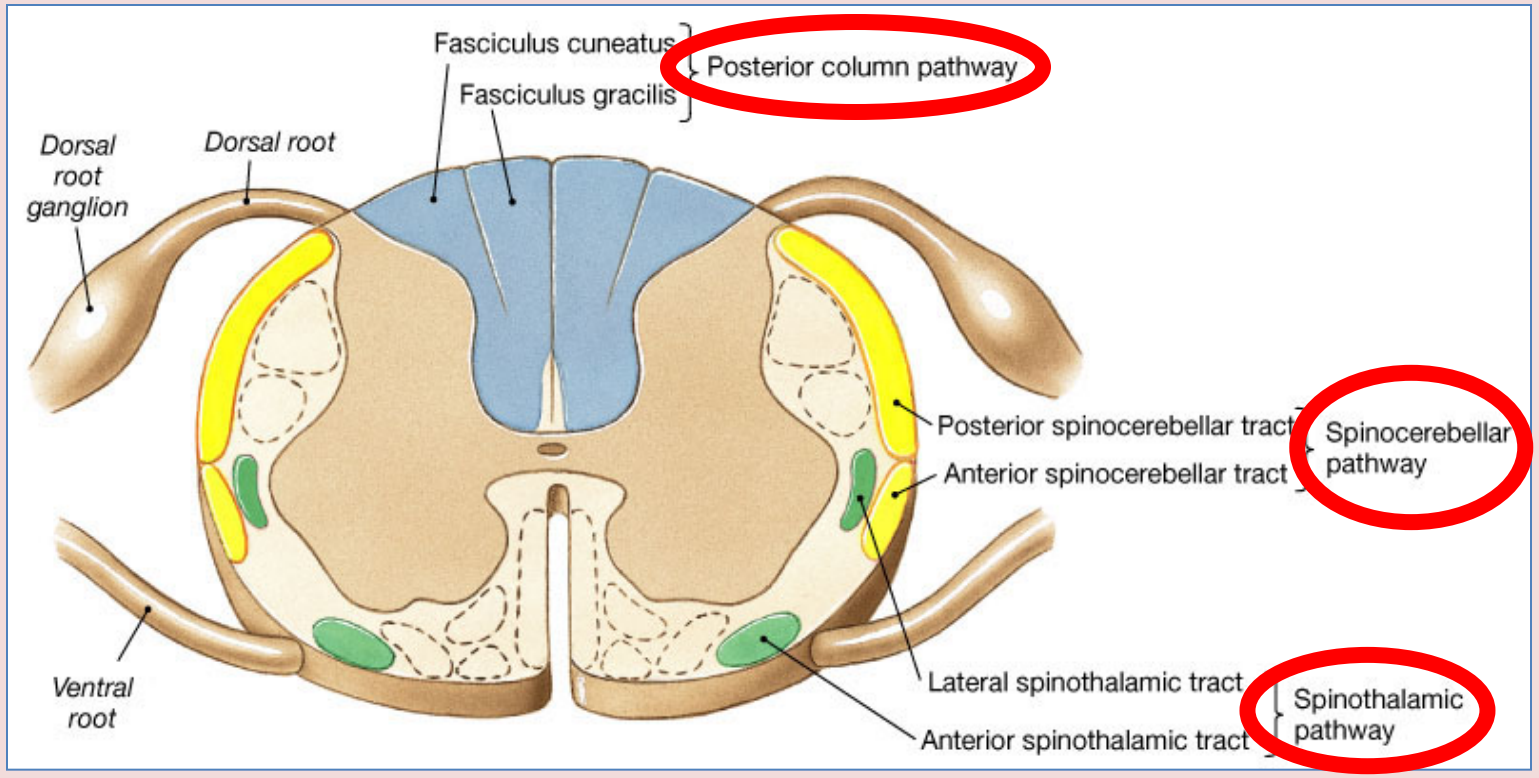
Crude touch,

Pressure

The spinal cord



- **Three major pathways** carry sensory information:
  - **Dorsal (Posterior)column (Gracile & Cuneate)**
  - **Antero-lateral pathway (Spino-thalamic)**
  - **Spino-cerebellar pathway**



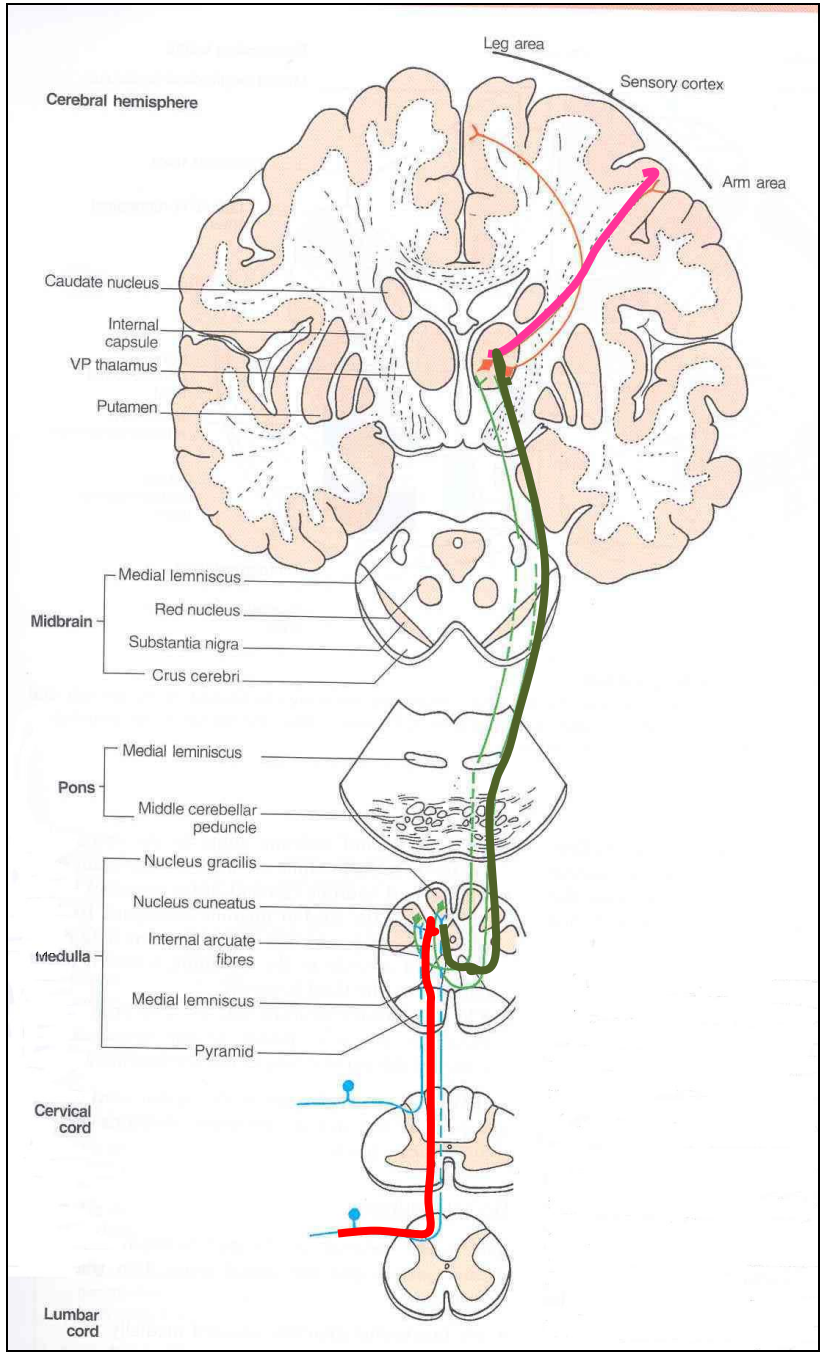
Dorsal (Posterior)column (Gracile & Cuneate)

Dorsal Columns
[Cross at Medulla]

3rd order neuron:
From VP nucleus in thalamus → though posterior limb of internal capsule → cortex

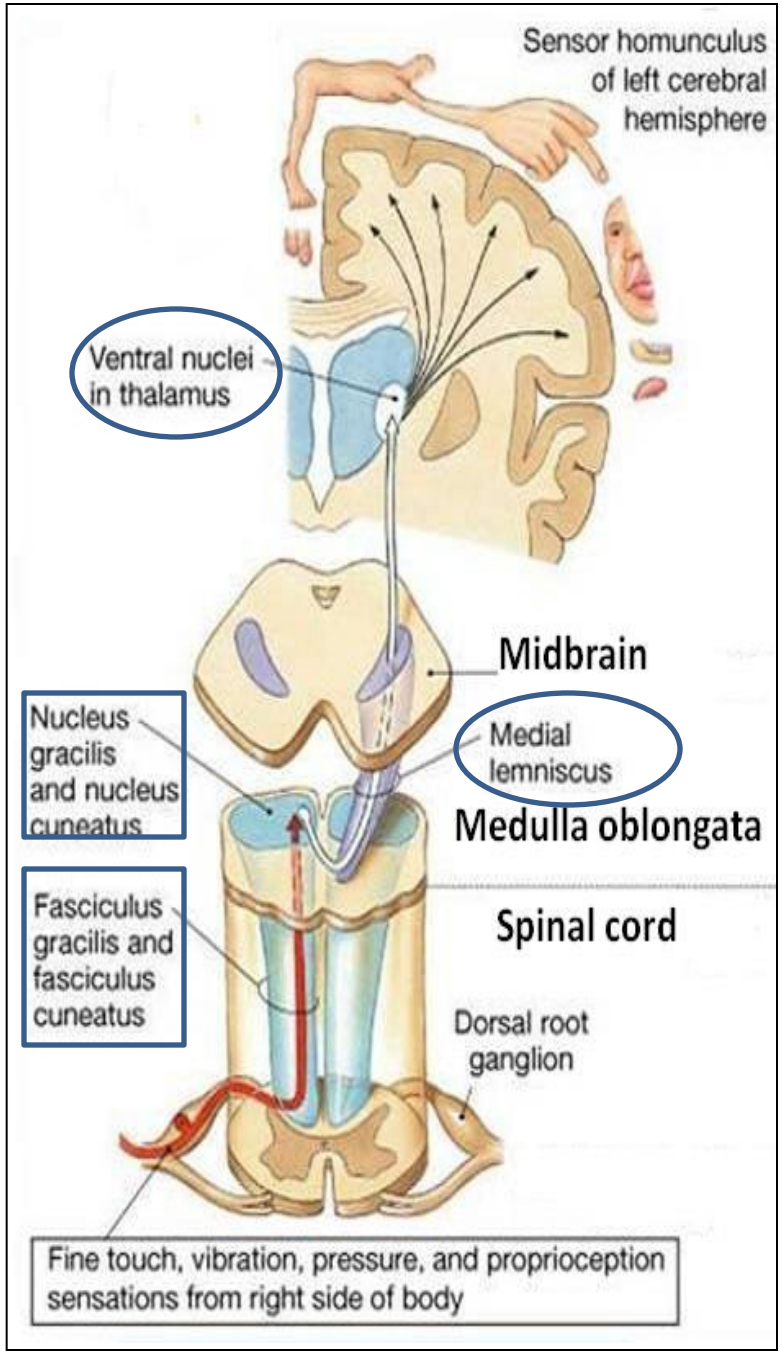
2nd order neuron:
From nuclei gracile and cuneate in medulla → decussate in medulla → become internal arcuate fibers → ascend brainstem as the medial lemniscus → VPL nucleus of thalamus

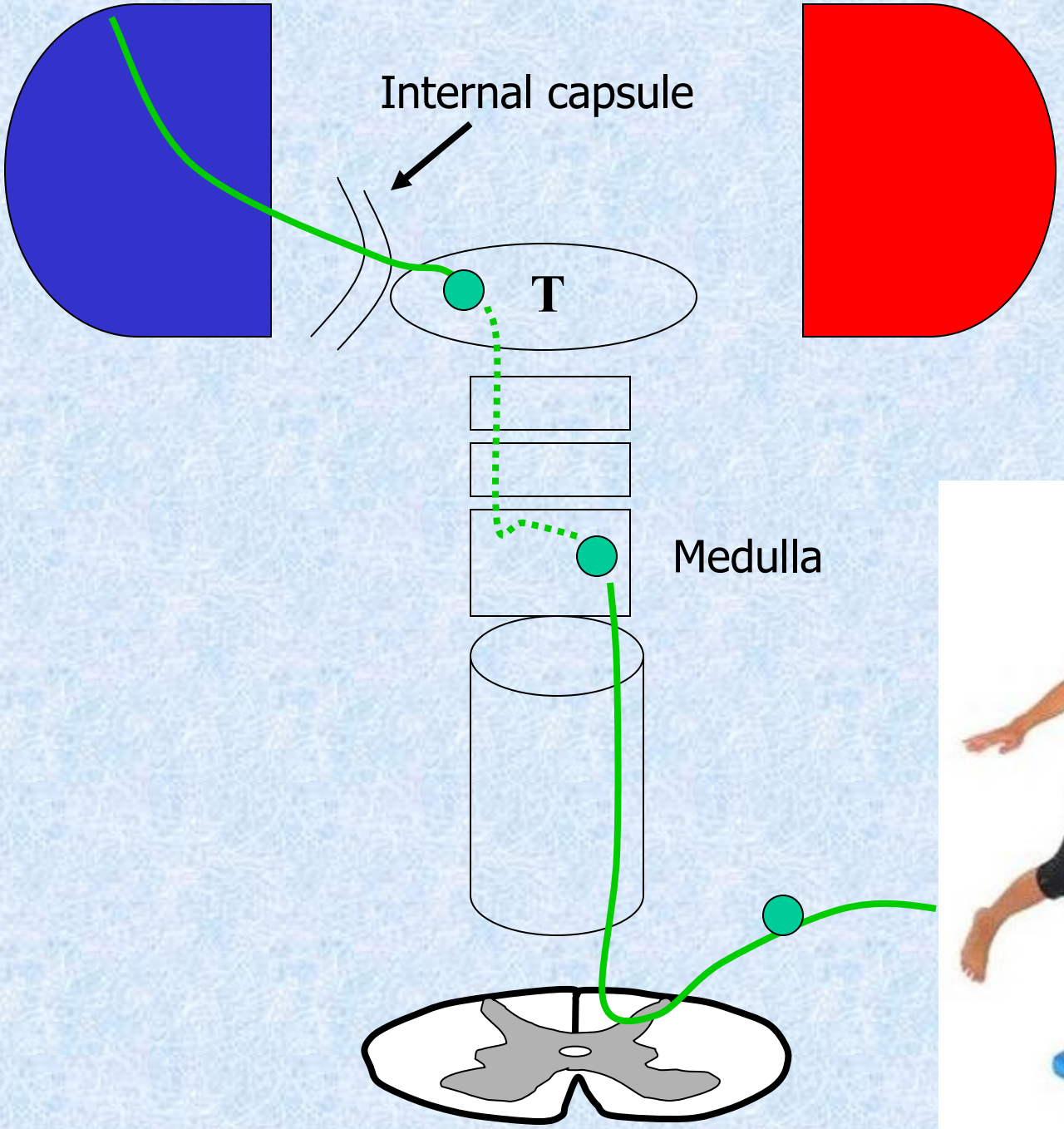
1st order neuron:
From receptors in periphery→ gracile and cuneate tracts → ascend to nuclei gracile and cuneate in medulla

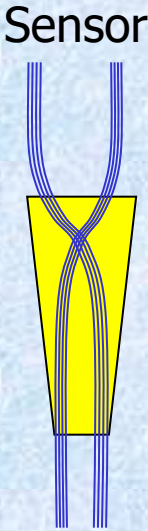


Dorsal Column

- Contains two tracts; ***Gracile & Cuneate***
- Carry impulses concerned with **proprioception** (**movement** and joint **position**) **, discriminative touch**
- ***Gracile*** contains fibers that are received at sacral, lumbar and lower thoracic levels.
- ***Cuneate*** contains fibers that are received at upper thoracic and cervical levels







Posterior surface

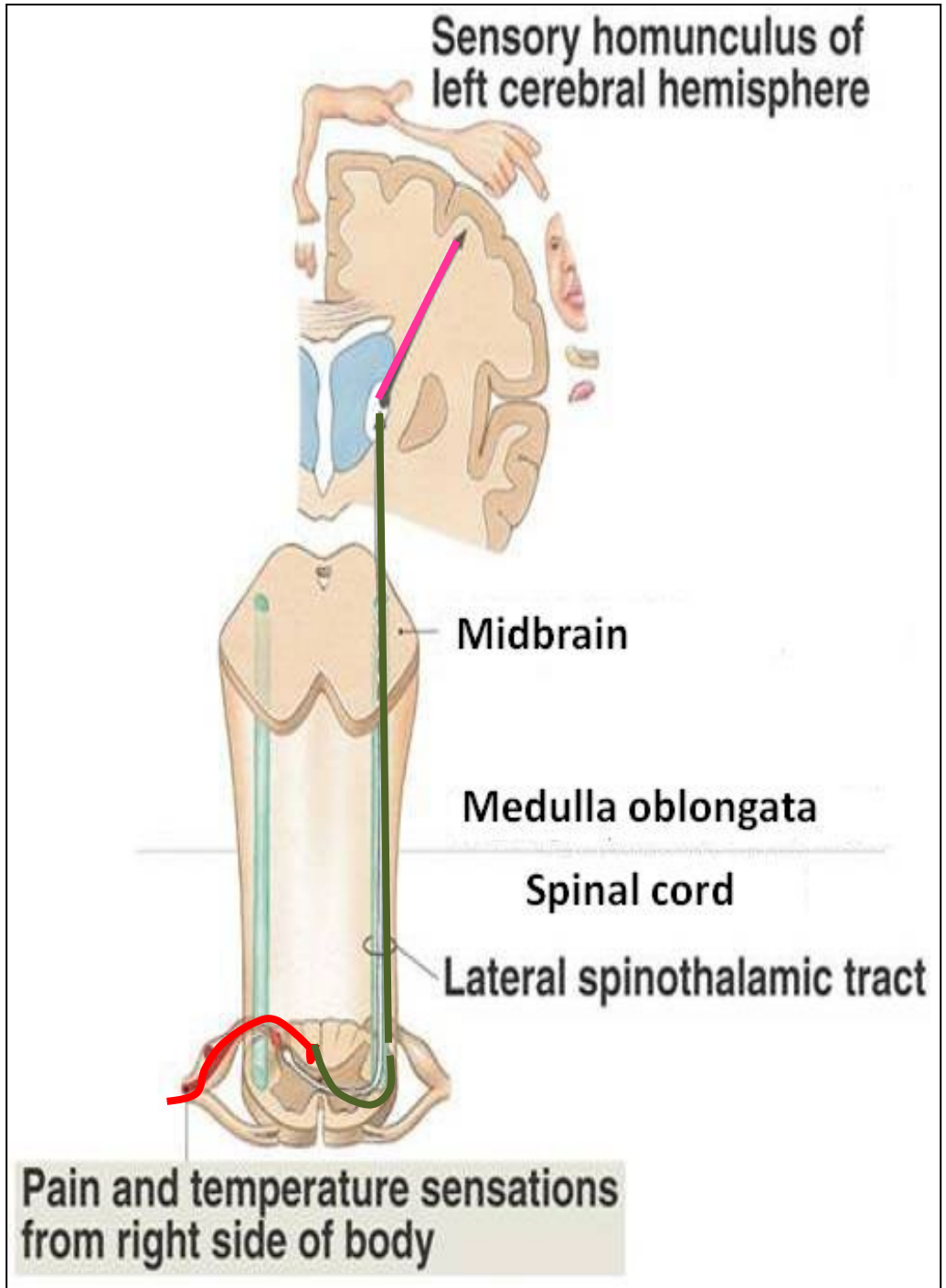
Spinothalamic pathway

Lateral Spinothalamic Tract

3rd order neuron:
From VP nucleus in thalamus → though posterior limb of internal capsule→ cortex

2nd order neuron:
From substantia gelatinosa → decussates within 1 spinal segment and ascends in lateral Spinothalamic tract → spinal lemniscus in brainstem → ventral posterolateral (VP) nucleus in thalamus

1st order neuron:
From receptors in periphery (fast (A) or slow (C) fibers) → substantia gelatinosa in dorsal horn



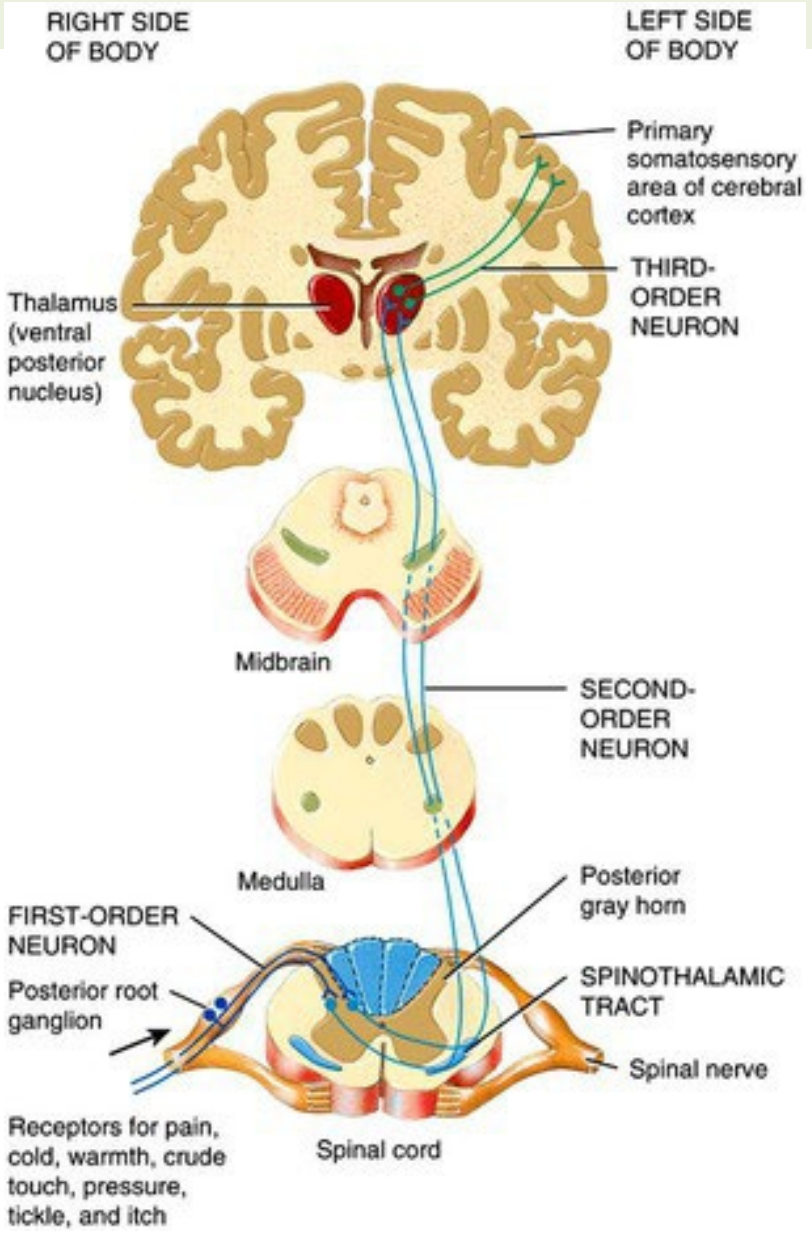
❑ Function:

Carries **pain & Temperature** to thalamus and sensory area of the cerebral cortex.

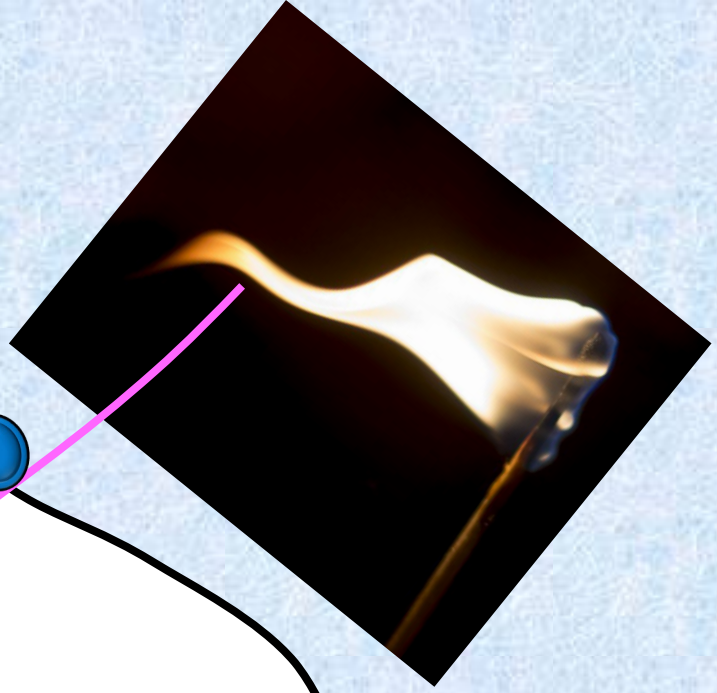
❑ Neurons: 3 Neurons

- **Neuron I:** **Small cells** in the dorsal root ganglia.
- **Neuron II:** Cells of **substantia gelatinosa of Rolandi in the posterior horn.**
- **Neuron III:** Cells of **(VP) nucleus of the thalamus.**

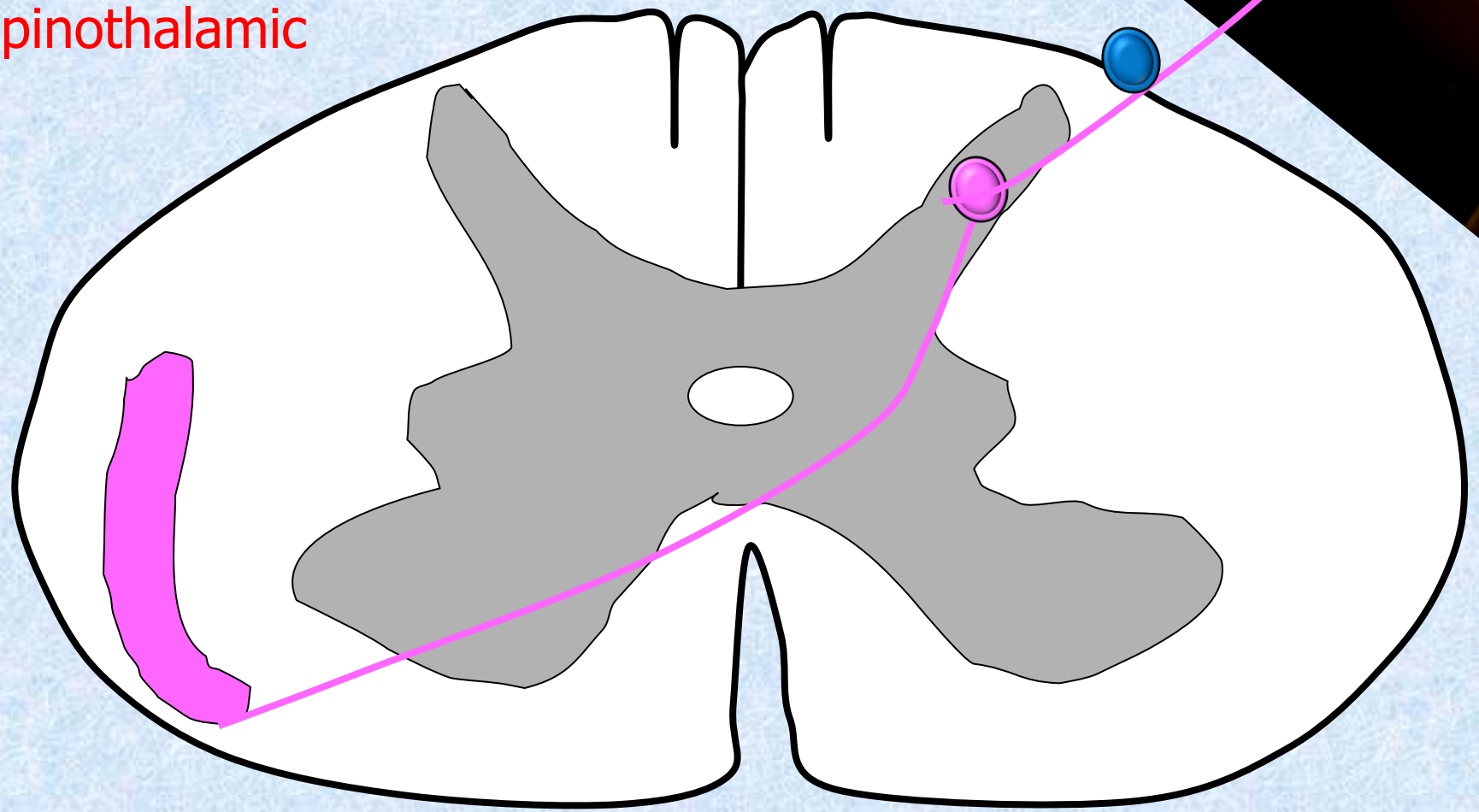
Lateral Spino-thalamic Tract



Pain & temperature



Lateral spinothalamic

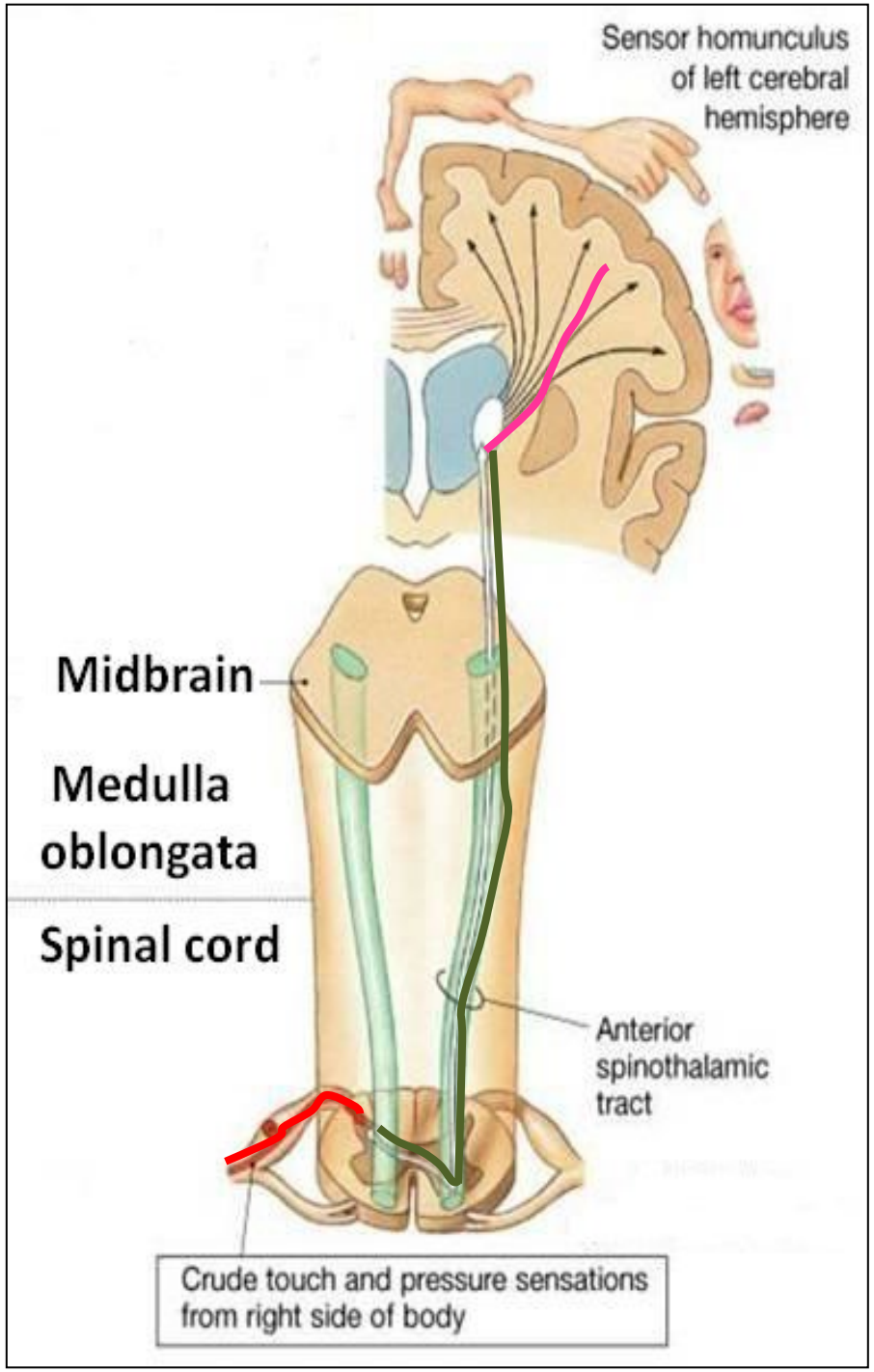


Anterior Spino-thalamic Tract

3rd order neuron:
From VP nucleus in thalamus → though posterior limb of internal capsule→ cortex

2nd order neuron:
From substantia gelatinosa → decussates over several spinal segments and ascends in anterior Spinothalamic tract → spinal lemniscus in brainstem → ventral posterolateral (VP) nucleus in thalamus

1st order neuron:
From various receptors in periphery →substantia gelatinosa in dorsal horn



Anterior Spino-thalamic Tract

❑ Function:

Carries **crude touch (non discriminative) & pressure** to thalamus and sensory cortex.

❑ Neurons: 3 Neurons

- **Neuron I:**

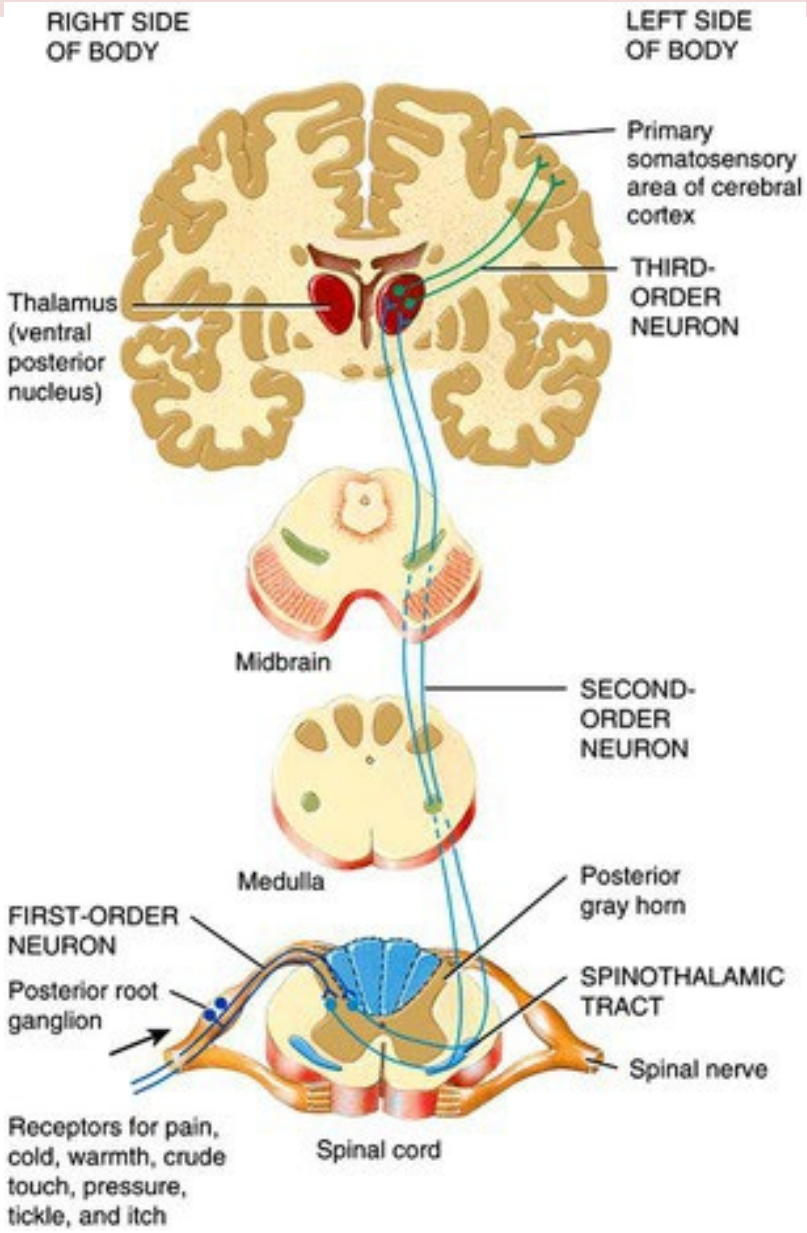
  Medium sized cells in the dorsal root ganglia.

- **Neuron II:**

  Cells of main sensory nucleus or (**nucleus proprius**).

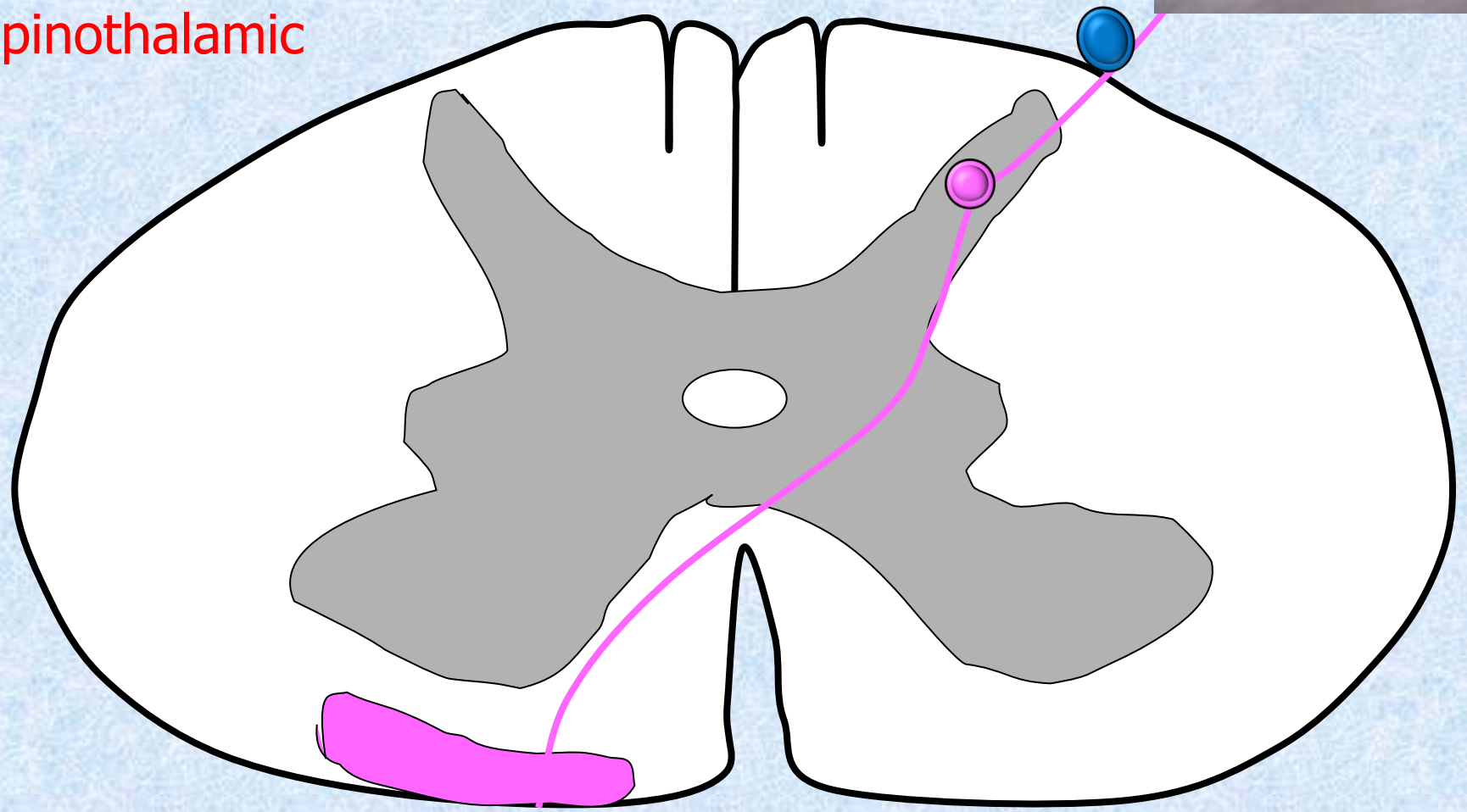
- **Neuron III:**

  Cells of VP nucleus of thalamus.



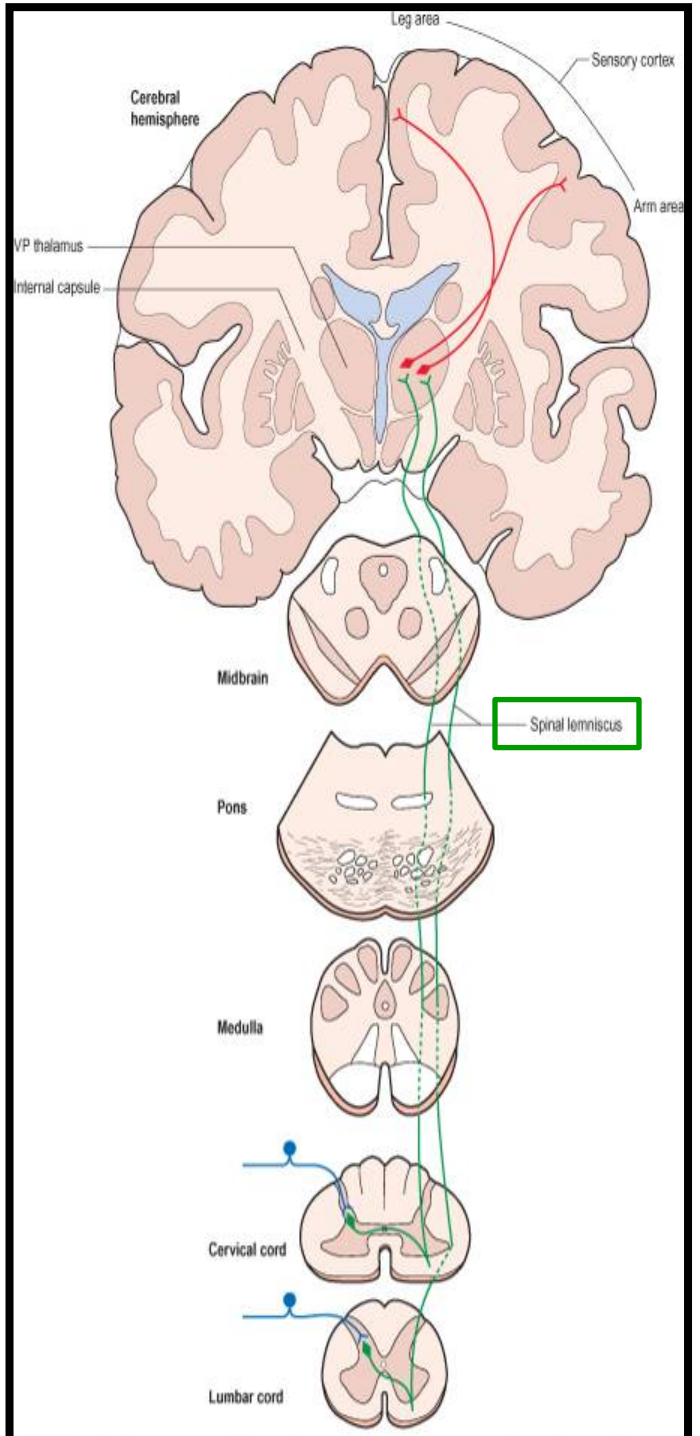
Crude touch & pressure

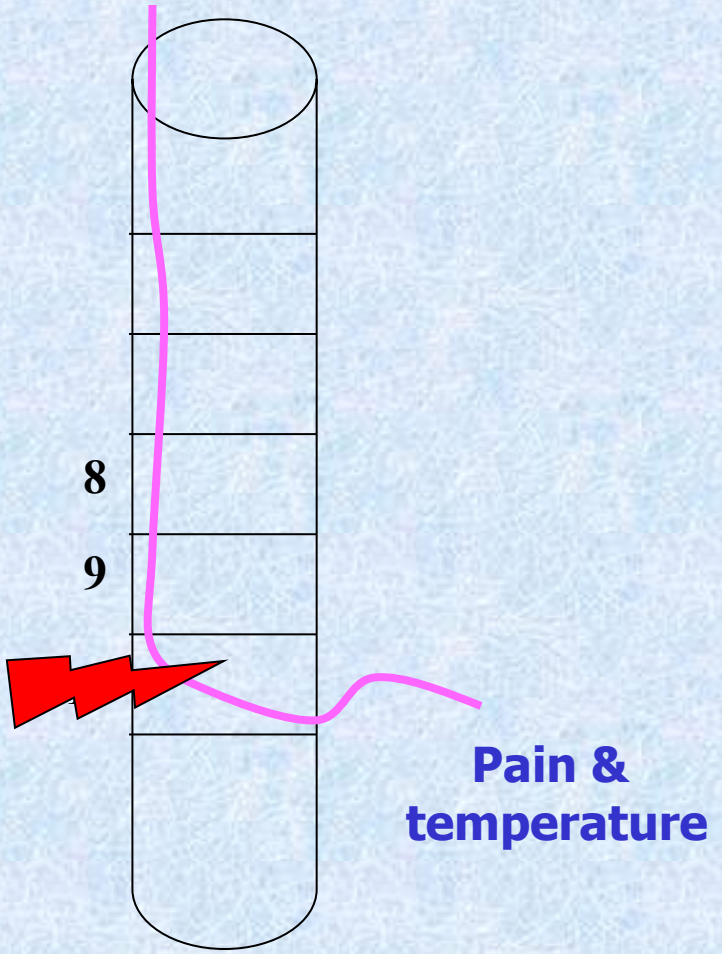
Anterior spinothalamic



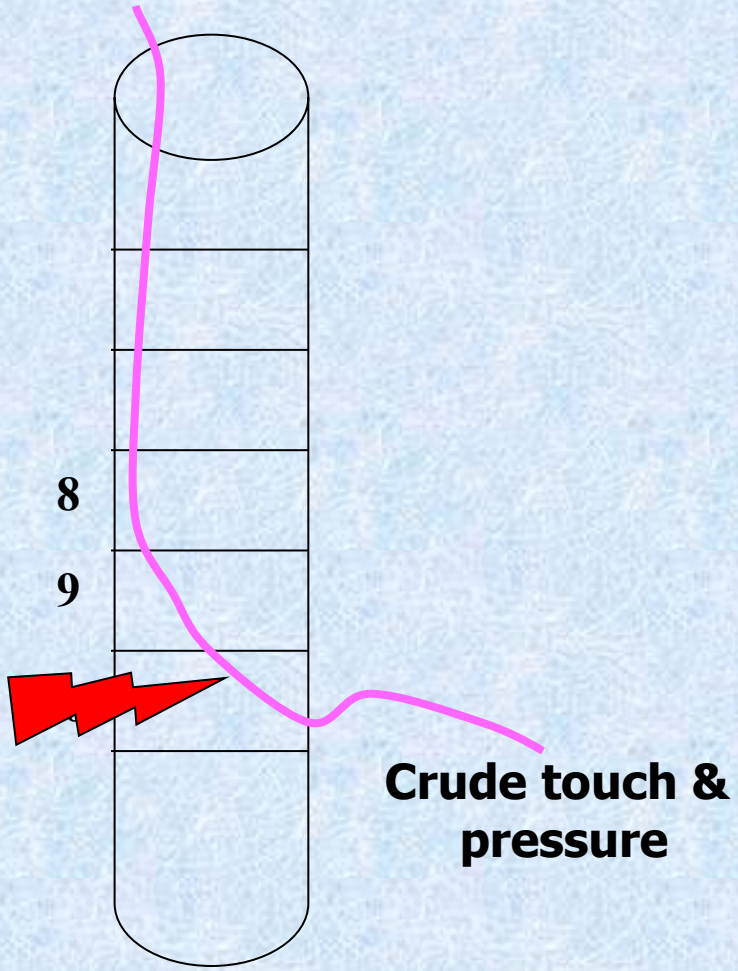
Spino-thalamic Tracts

- The spino-thalamic tracts contain axons of **second-order neurons**, the cell bodies of which lie in the **contralateral** dorsal horn.
- Carry impulses concerned with; **pain and thermal sensations (Lateral tract)** and **Non- Discriminative touch and pressure (Anterior tract),** from the contralateral side.
- In brain stem, the two tracts constitute the **Spinal Lemniscus**.
- Information is sent to the primary sensory cortex on the opposite side of the body.





Crosses within one spinal segment



Crosses within several spinal segments

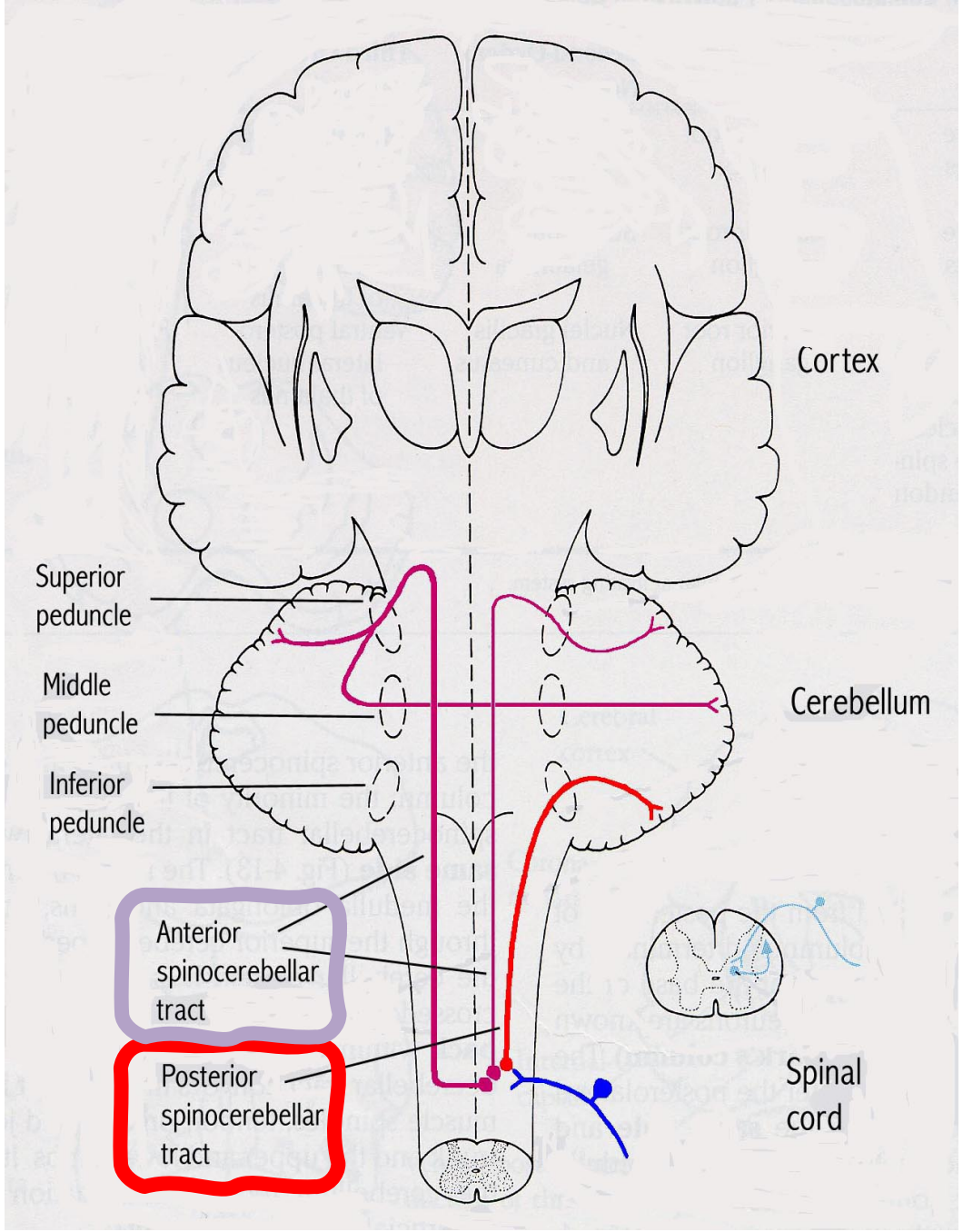
Spinocerebellar pathway

Spino-cerebellar Tracts

2nd order neuron:
Ventral TRACT
Nucleus dorsalis → Some fibers decussate as soon as enter spinal cord → ascend in anterior spinocerebellar tract to superior cerebellar peduncle in cerebellum

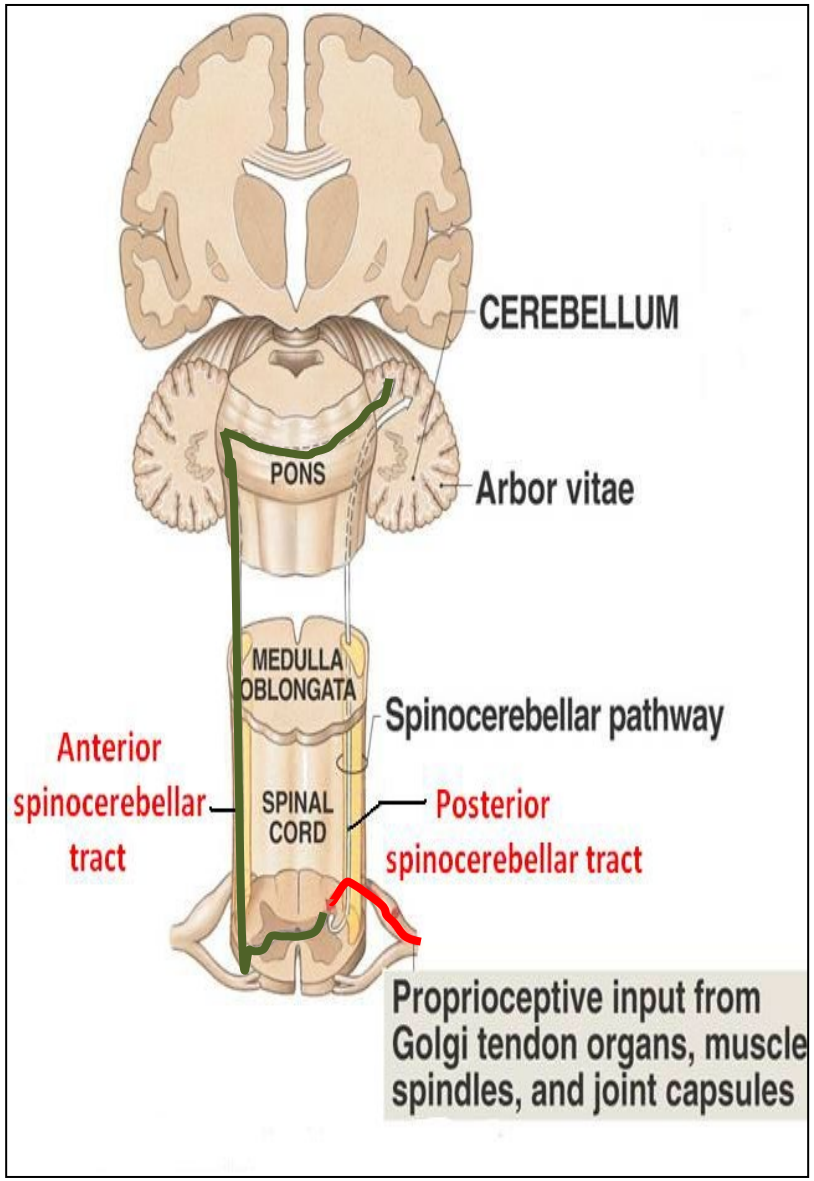
2nd order neuron:
Dorsal TRACT
Nucleus dorsalis → Remains uncrossed → ascend in post. Spinocerebellar tract → inferior cerebellar peduncle in cerebellum

1st order neuron:
From receptors in periphery → nucleus dorsalis



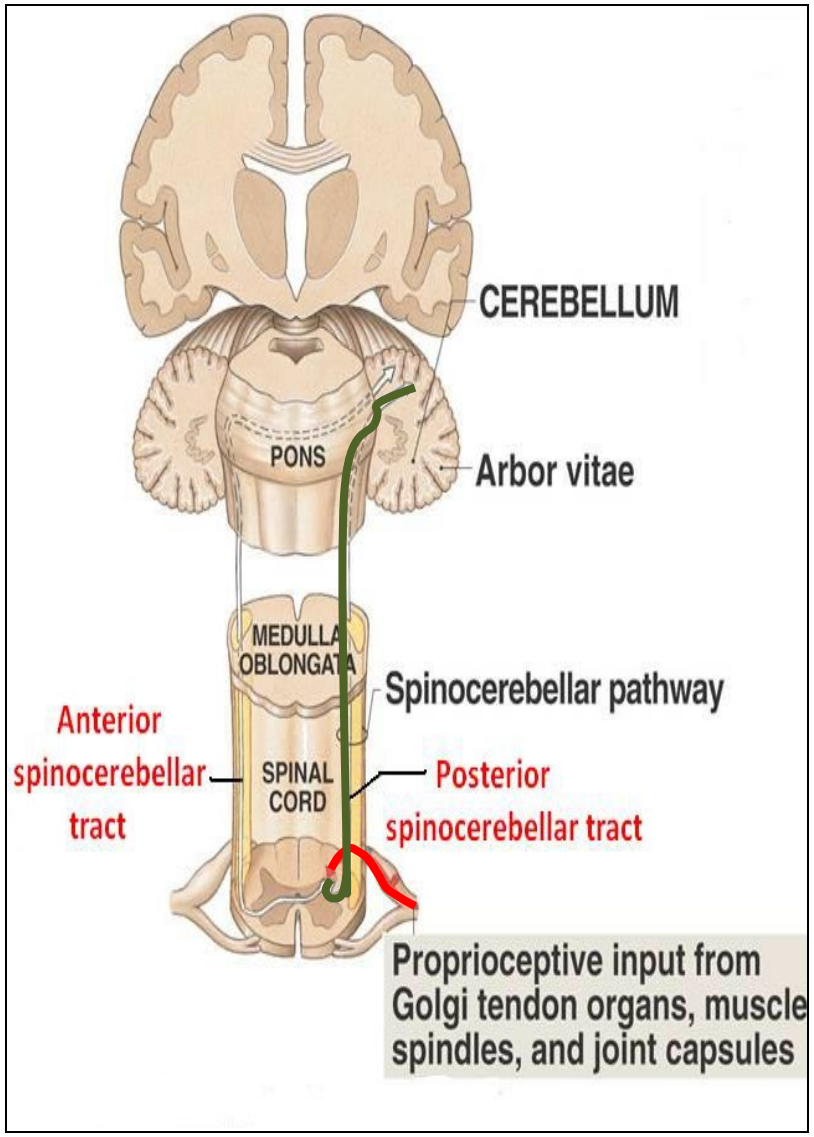
Ventral (Anterior) Spino-cerebellar Tract

The VSCT
crosses twice



Posterior (Dorsal) Spino-cerebellar Tract

The DSCT
Doesn't cross



Why doesn't the spinocerebellar tract have a 3rd neuron?

- There is no 3rd order neuron as it doesn’t reach consciousness

i.e., the cortex.

Spino-cerebellar Tracts

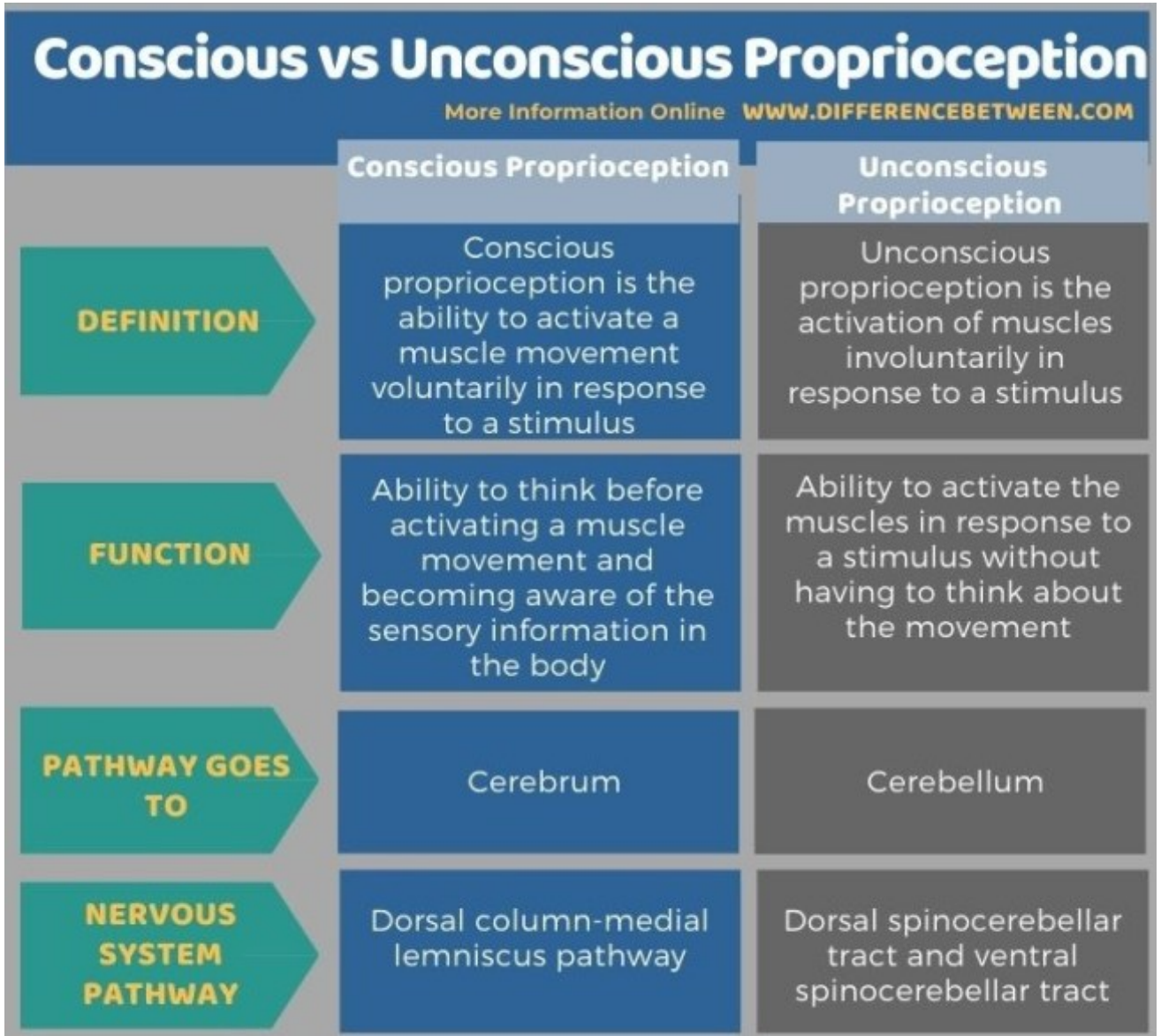
❑ **Function:**

Carry information derived from muscle spindles, Golgi tendon and tactile receptors to the cerebellum for the control of posture and coordination of movements

- The Spinocerebellar system consists of a sequence of **only two neurons;**

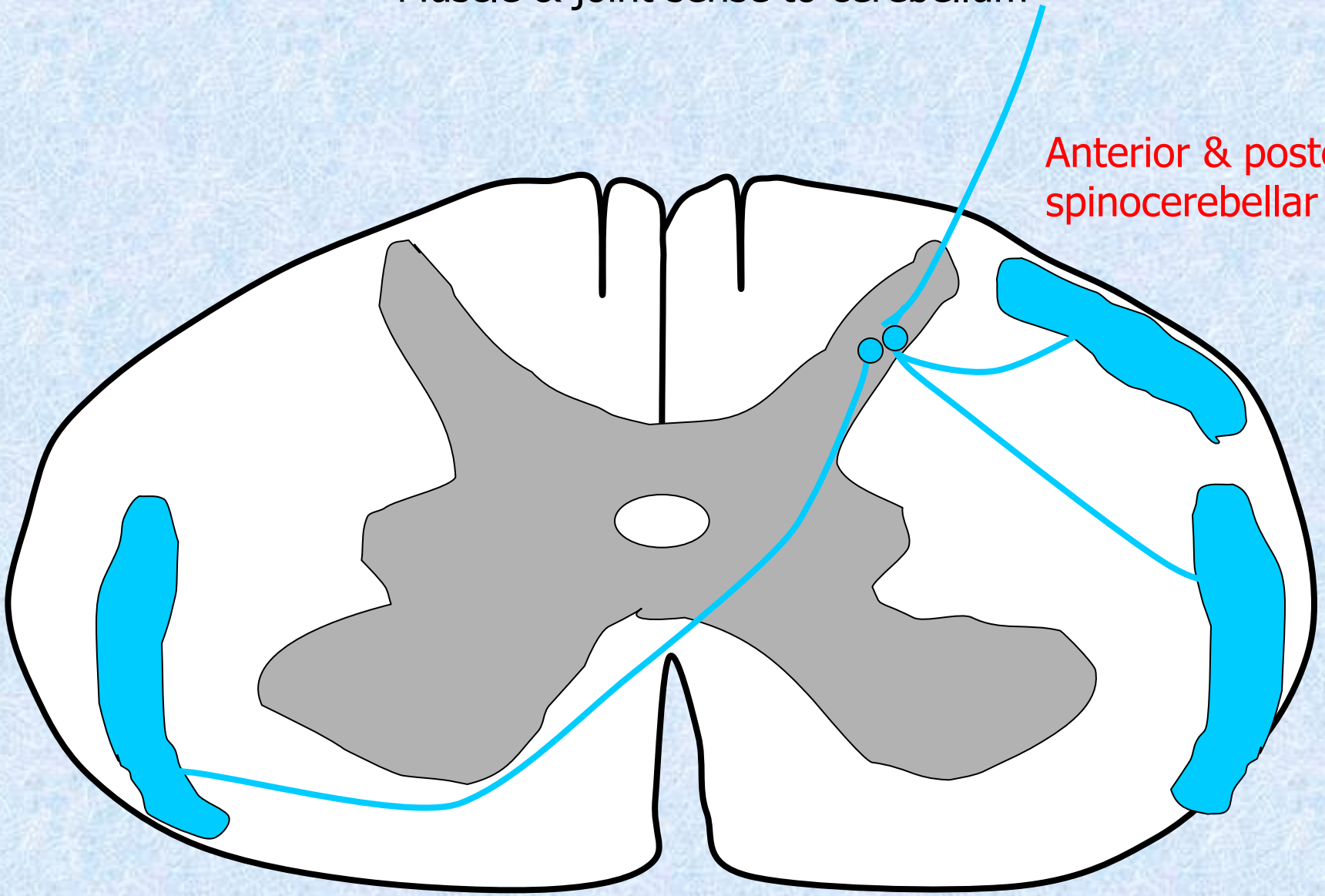
Neuron I:Large cells of dorsal root ganglia.

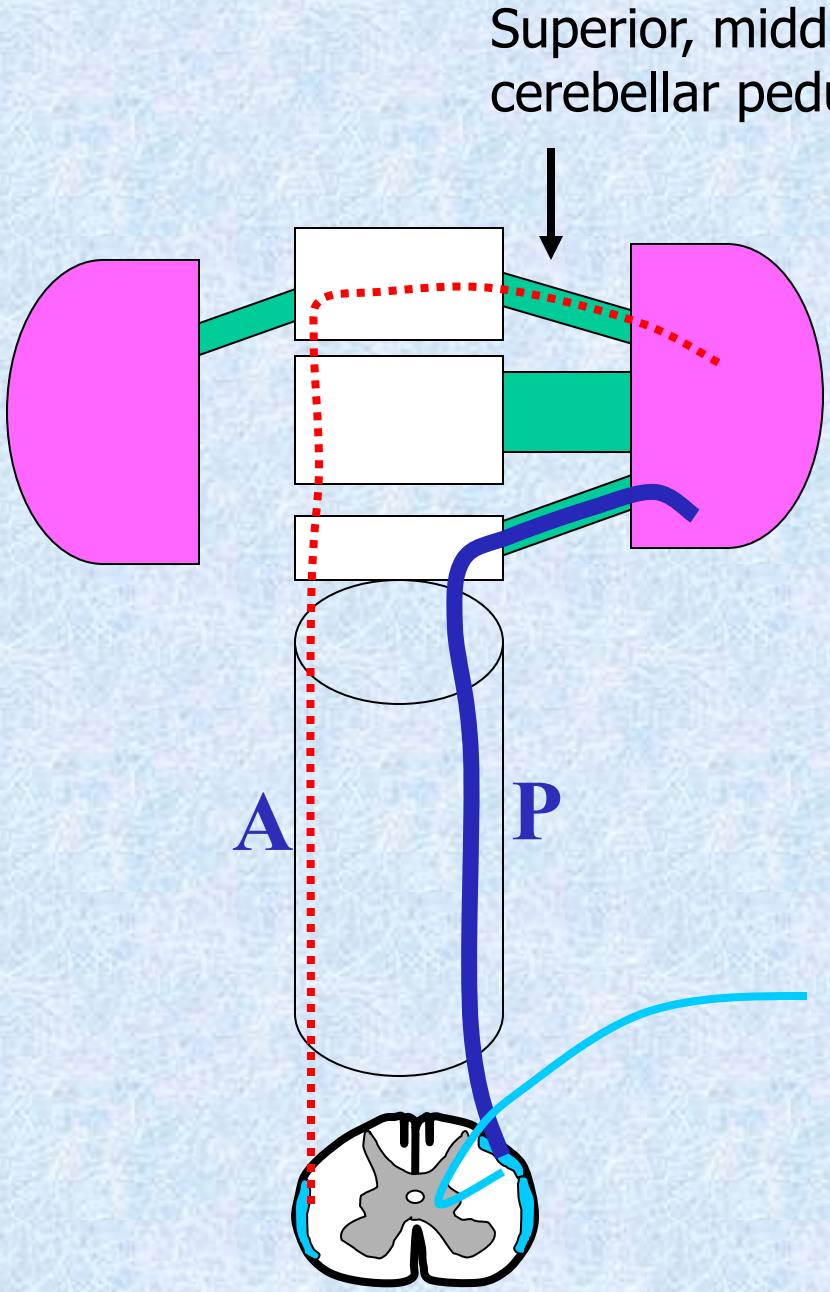
Neuron II: cells of the nucleus dorsalis; **Clark's nucleus** (column) .



Muscle & joint sense to cerebellum

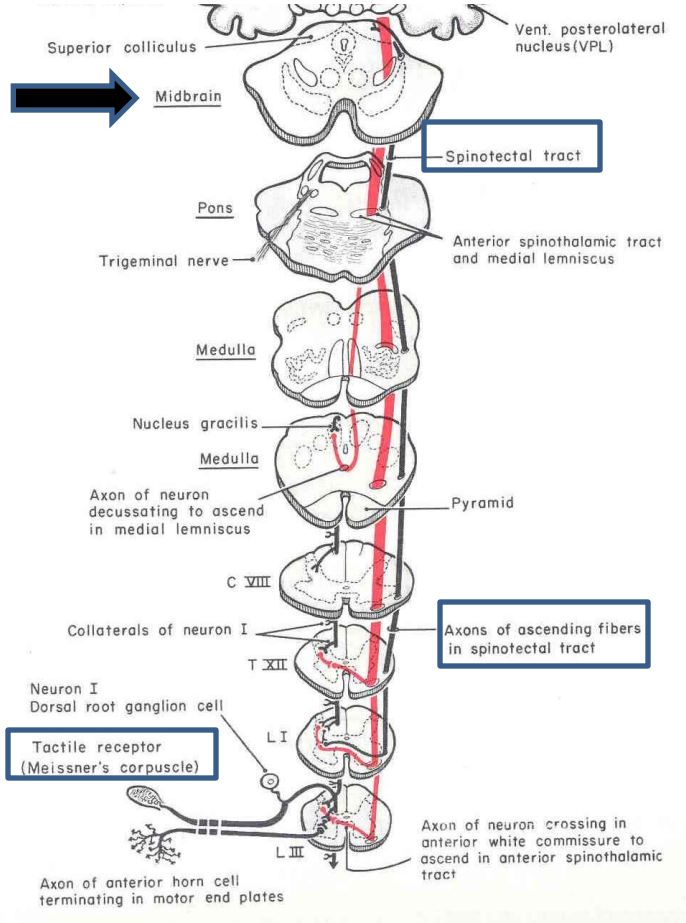
Anterior & posterior spinocerebellar




Superior, middle & inferior
cerebellar peduncles
A
P

Spino-tectal Tract

- Primary afferents reach dorsal horn through **dorsal roots** and terminate on 2nd order neurons
- The cell bodies of 2nd order neuron lie in **base of the dorsal horn**.
- Axons of 2nd order neuron cross to opposite side, and project to the **peri-aquiductal gray matter** and **superior colliculus in the midbrain**.
- **Involved in reflexive turning of the head and eyes toward a point of cutaneous stimulation.**



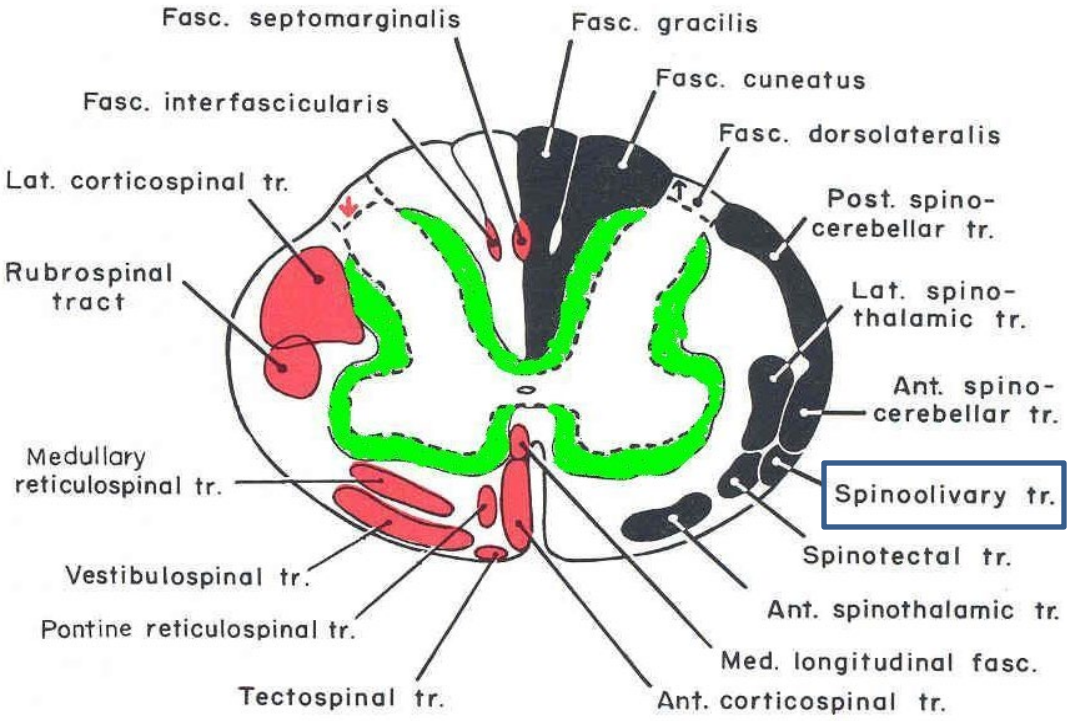
Spino - olivary Tract

Indirect spinocerebellar pathway (spino-olivo-cerebellar)

Impulses from the spinal cord are relayed to the cerebellum via inferior olivary nucleus.

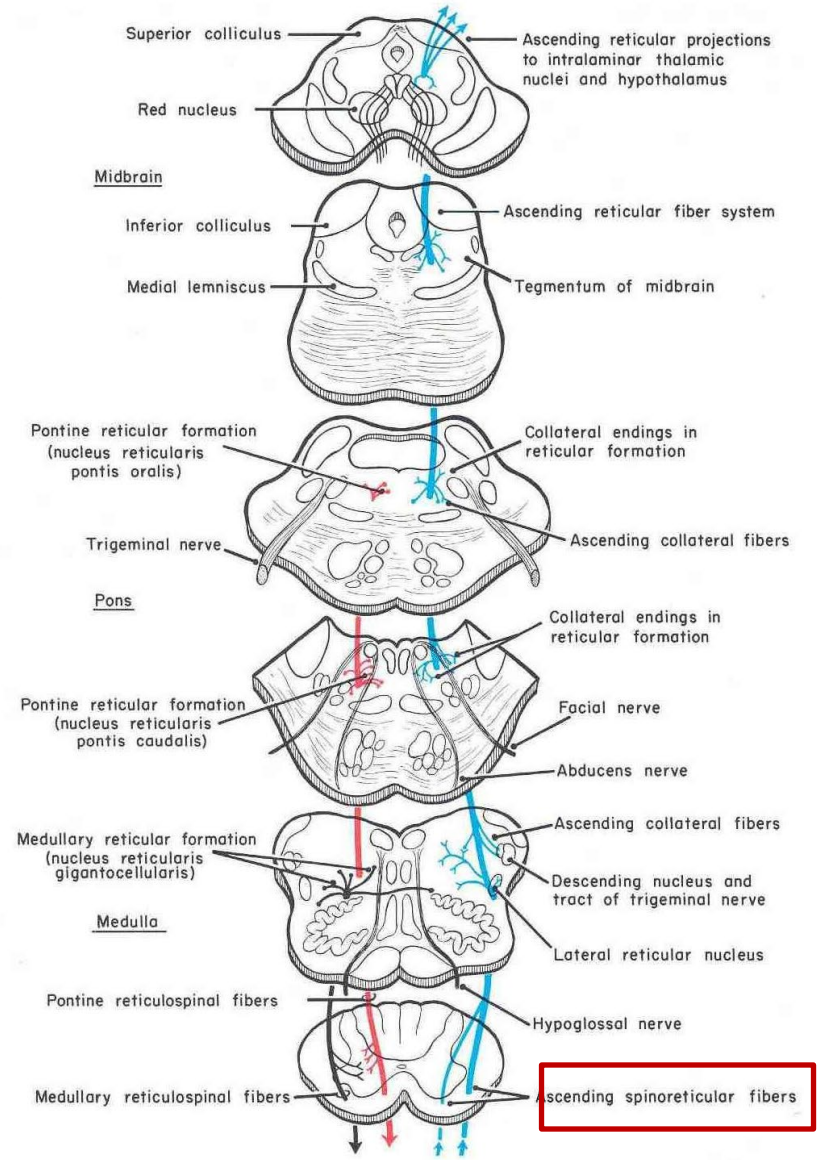
Conveys sensory information to the cerebellum.

Contribute to movement coordination associated primarily with balance.



Spino-reticular Tract

- Originates in the dorsal horn and ascend in the ventrolateral region of the cord.
- End in **medullary reticular formation** ------- > **pontine reticular formation,** finally to the thalamus; that activate the cerebral cortex
- Forms part of the ascending reticular activating system (RAS).
- **Involved also in perception of dull aching (slow pain)**



Nuclei of trigeminal nerve

It has got 4 nuclei :

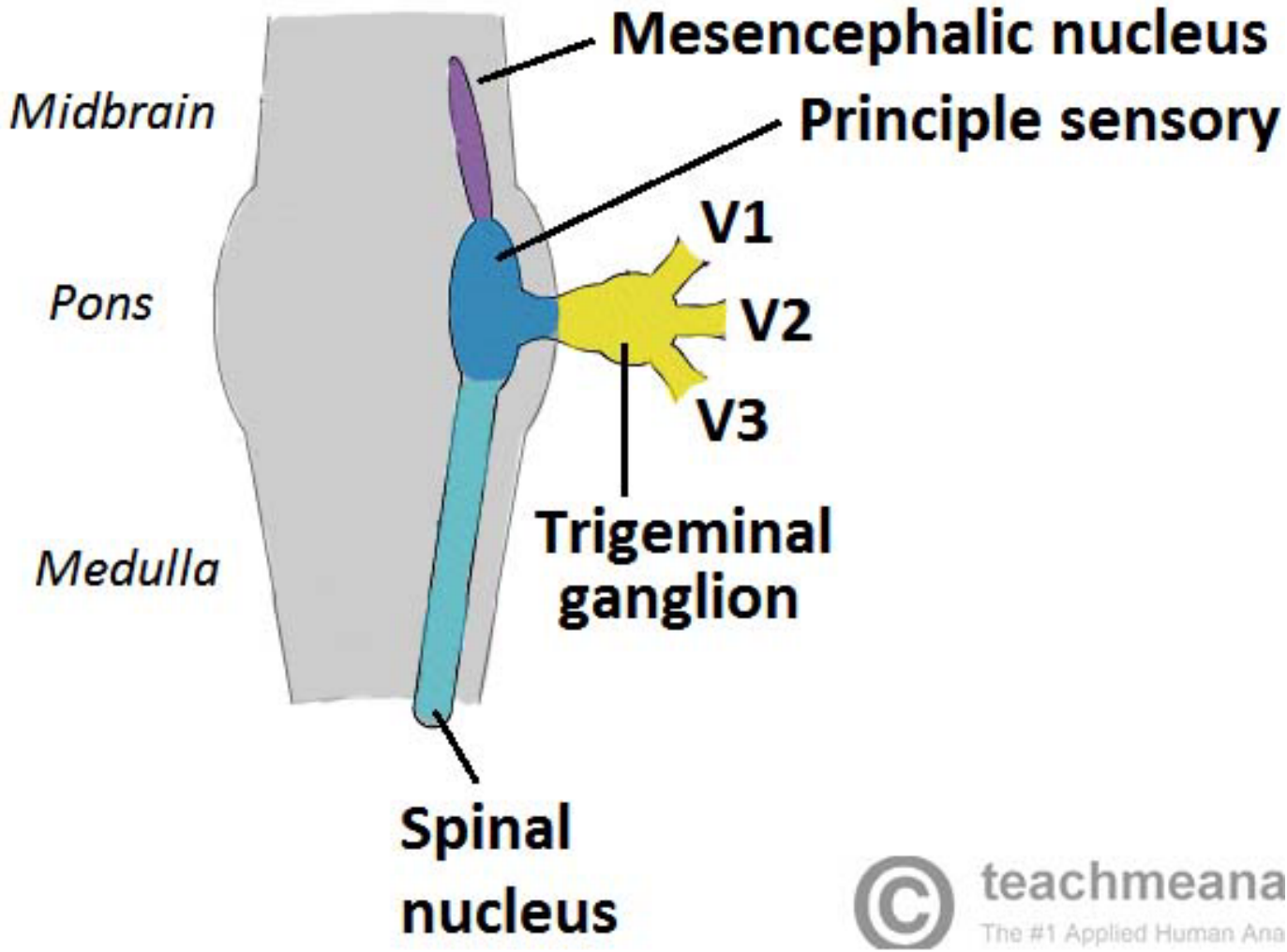
1.Mesencephalic nucleus: in midbrain. (proprioception)

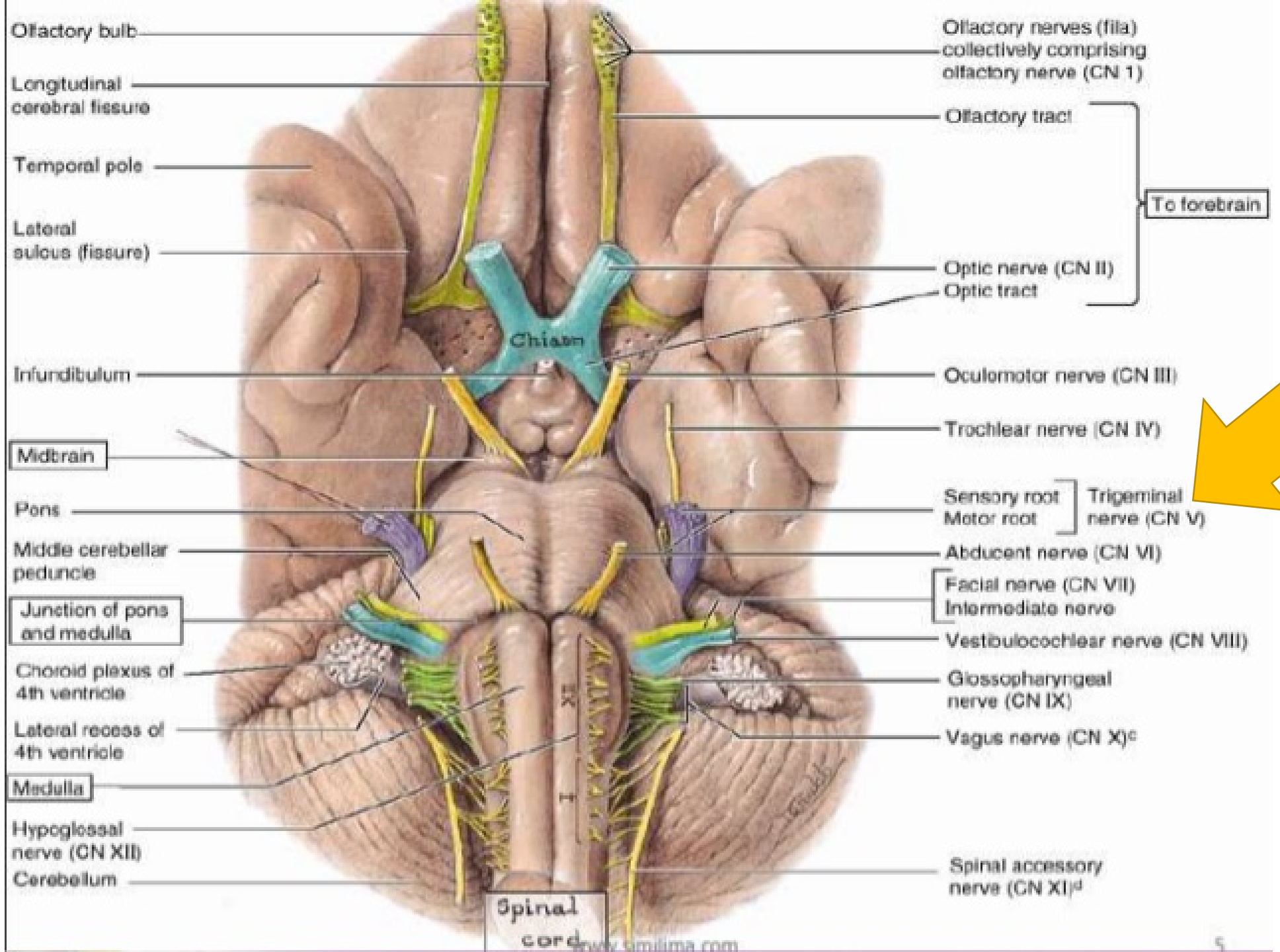
2.Main sensory nucleus: in upper pons. (touch and pressure)

3.Spinal nucleus: in upper pons to C2 segment of spinal cord.

(pain and temperature)

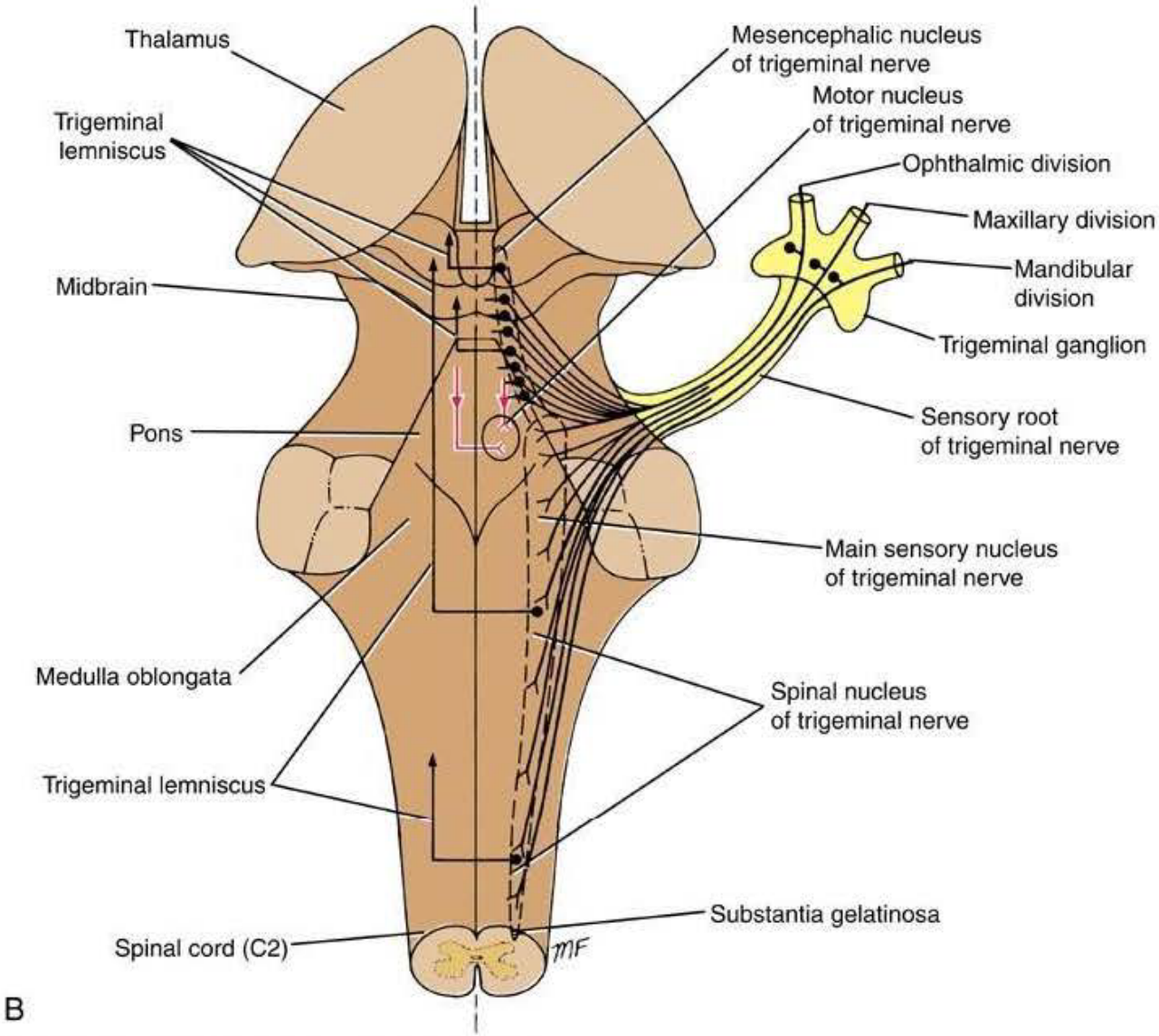
4.**Motor** nucleus: in upper pons.




Olfactory bulb
Longitudinal cerebral fissure
Temporal pole
Lateral sulcus (fissure)
Infundibulum
Midbrain
Pons
Middle cerebellar peduncle
Junction of pons and medulla
Choroid plexus of 4th ventricle
Lateral recess of 4th ventricle
Medulla
Hypoglossal nerve (CN XII)
Cerebellum
Olfactory nerves (fila) collectively comprising olfactory nerve (CN 1)
Olfactory tract
To forebrain
Optic nerve (CN II)
Optic tract
Chiasm
Oculomotor nerve (CN III)
Trochlear nerve (CN IV)
Sensory root
Motor root
Trigeminal nerve (CN V)
Abducent nerve (CN VI)
Facial nerve (CN VII)
Intermediate nerve
Vestibulocochlear nerve (CN VIII)
Glossopharyngeal nerve (CN IX)
Vagus nerve (CN X)c
Spinal accessory nerve (CN XI)d
Spinal cord

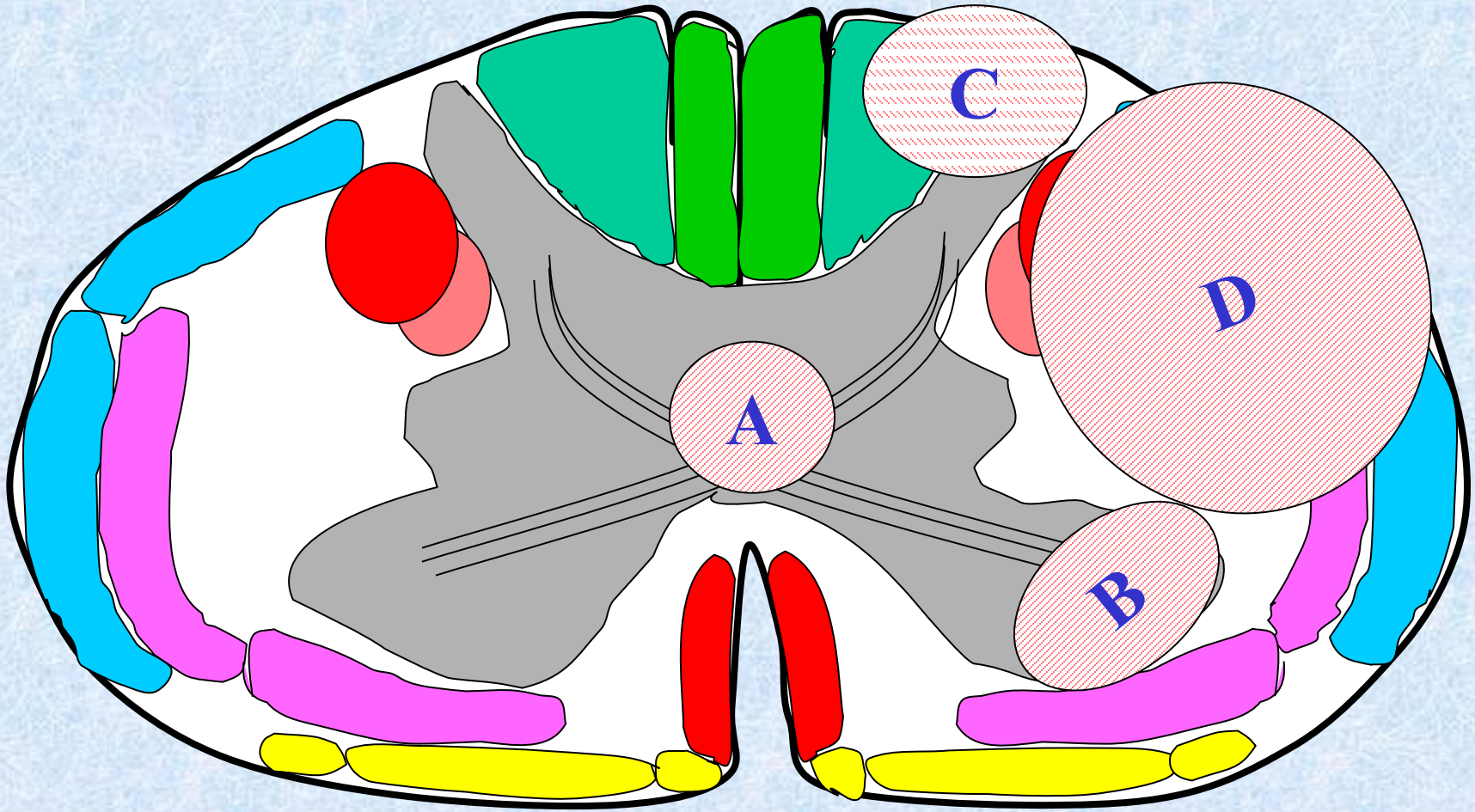
Trigeminal Nerve Sensory Nuclei

- 1st order neurons
  - Trigeminal ganglion
- 2nd order neurons
  - Trigeminal nerve sensory nuclei
  - Except mesencephalic nucleus
    - Contains 1st order neurons
  - Central axons cross midline
    - Form trigeminal lemniscus
- 3rd order neurons
  - VPM nucleus of thalamus
  - Internal capsule



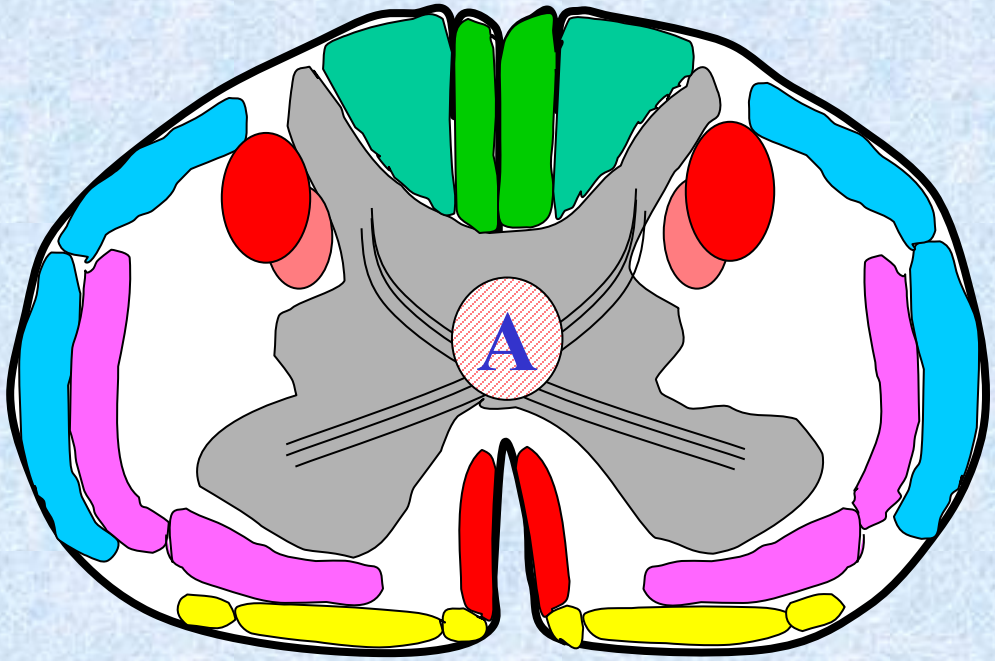
Spinal cord lesions

Spinal cord lesions



Refer Clinical Medicine by Kumar & Cleark’s

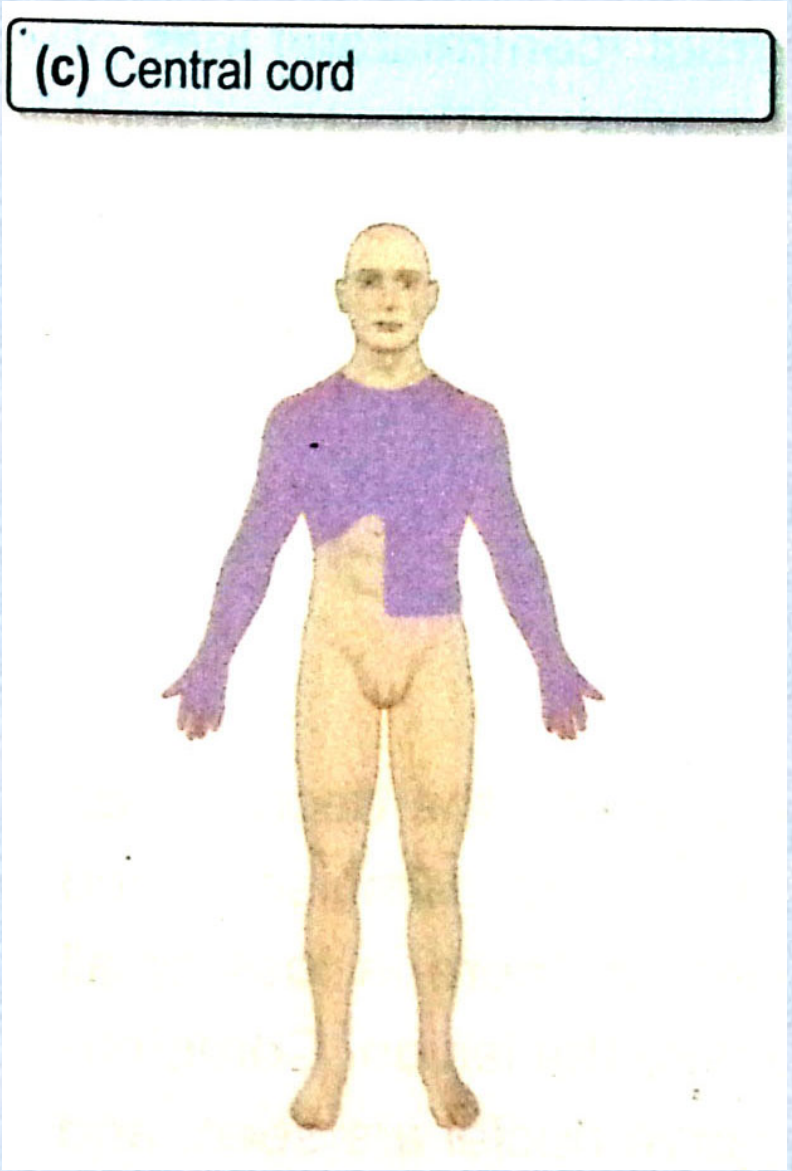
A – Syringomyelia



A – Syringomyelia

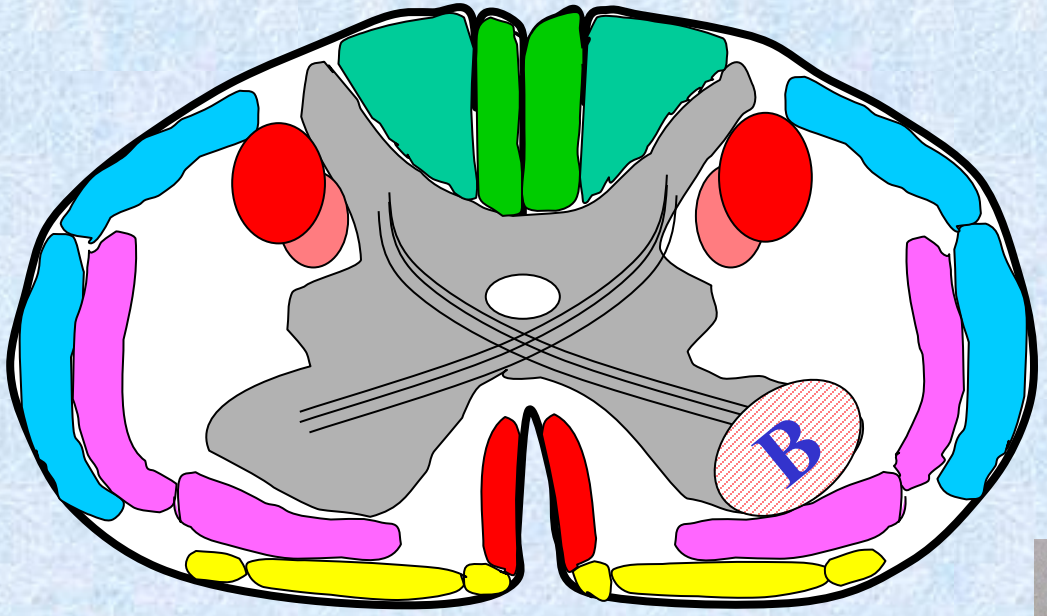
- The central canal becomes enlarged forming a cavity compressing the adjacent nerve fibers.
- Fibers serving pain and temperature are damaged as they decussate in the ventral white commissure close to the central canal causing selective loss of pain and temperature in the upper limbs (**dissociate sensory loss**)

- Fine touch and proprioceptive sensations are retained

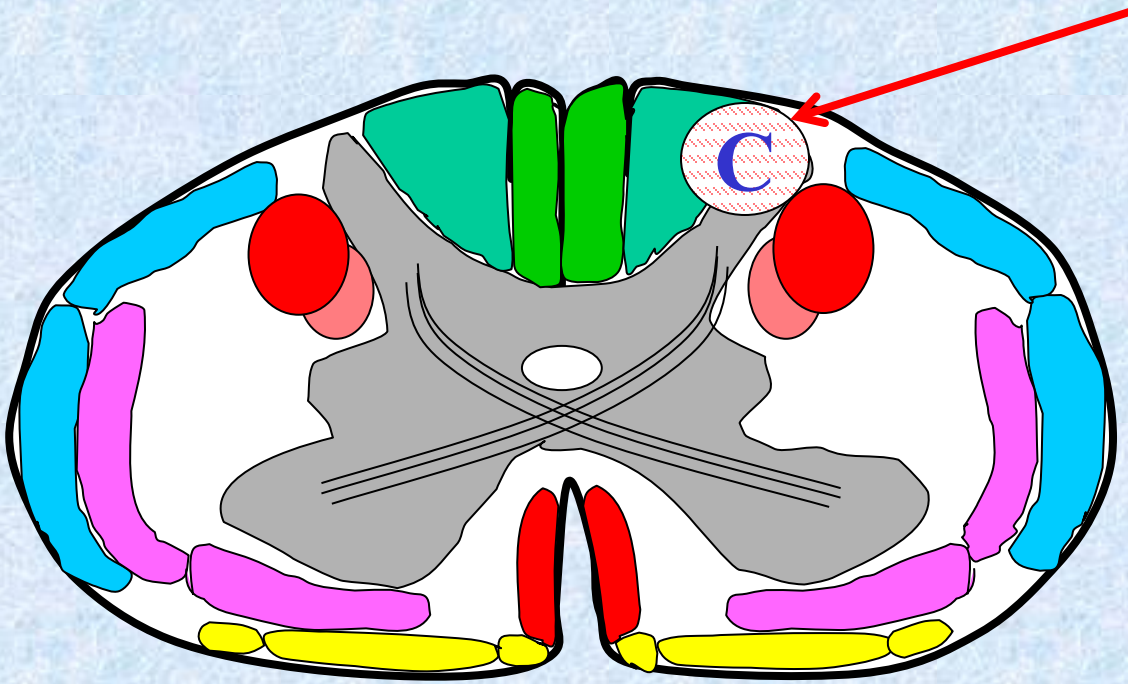


Clinical Medicine by Kumar & Cleark's

B – Poliomyelitis

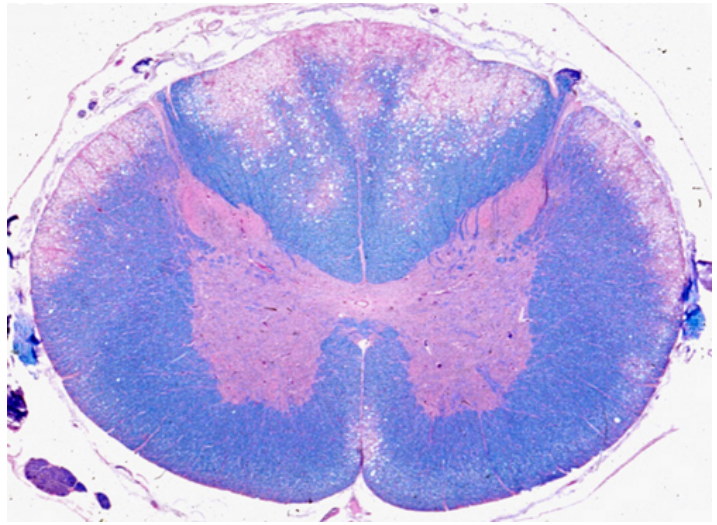


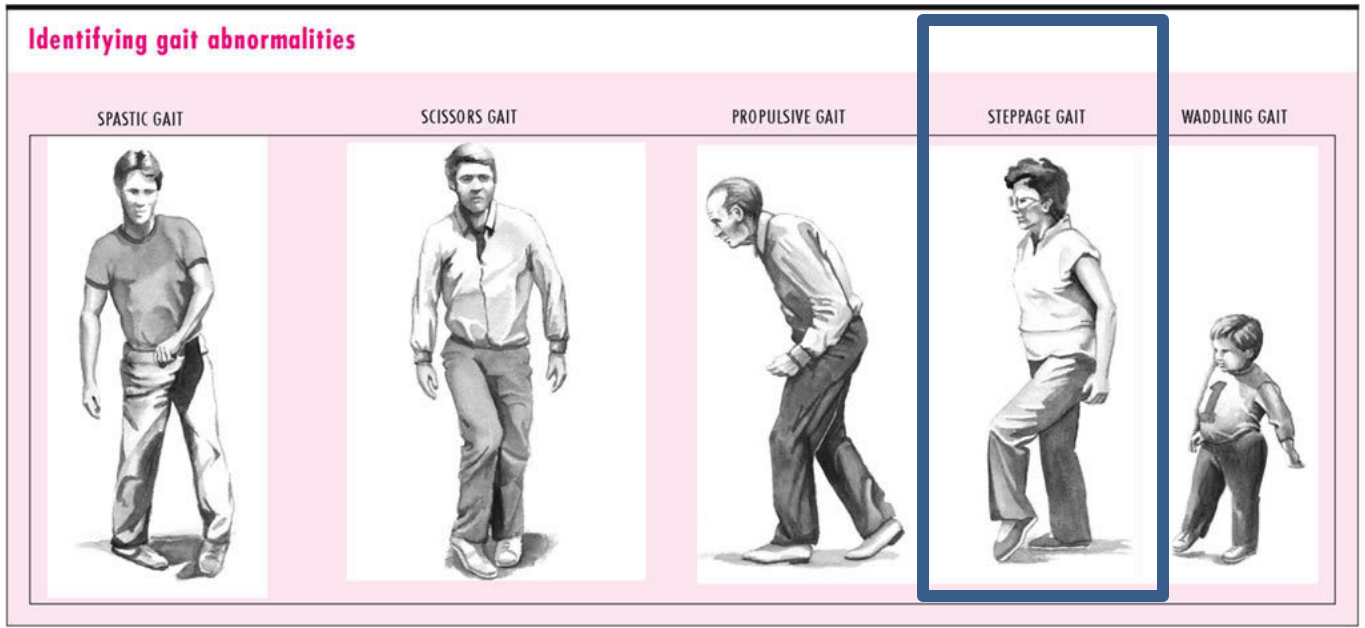
C – Tabes dorsalis

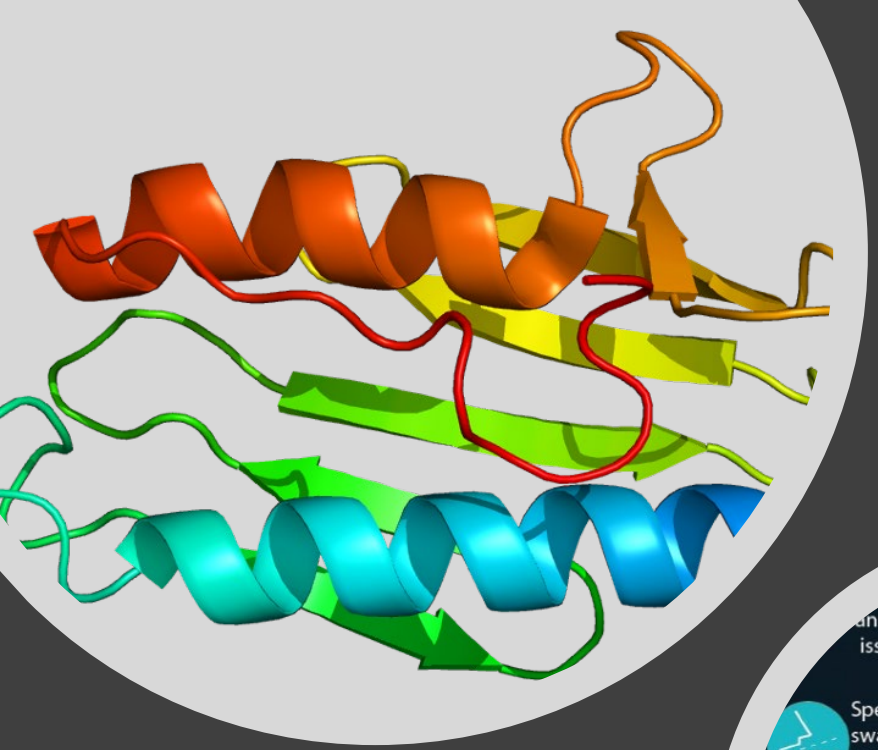


Tabes Dorsalis

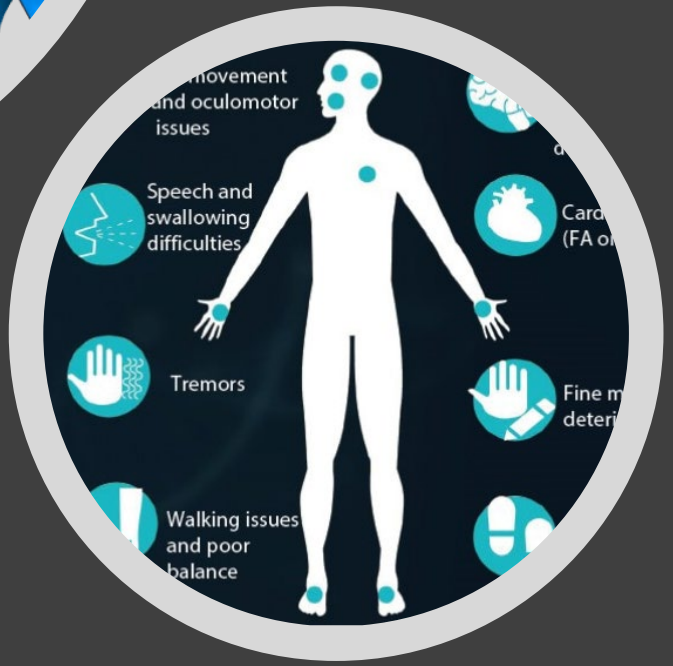
- A late manifestation of **syphilitic infection** on the CNS.
- Affects the **lumbosacral dorsal spinal roots and dorsal columns of the spinal cord.**
- Leads to **loss of proprioception** which is manifested by a **high Step** and **unsteady gait (**stamping**)** **(Sensory Ataxia)**





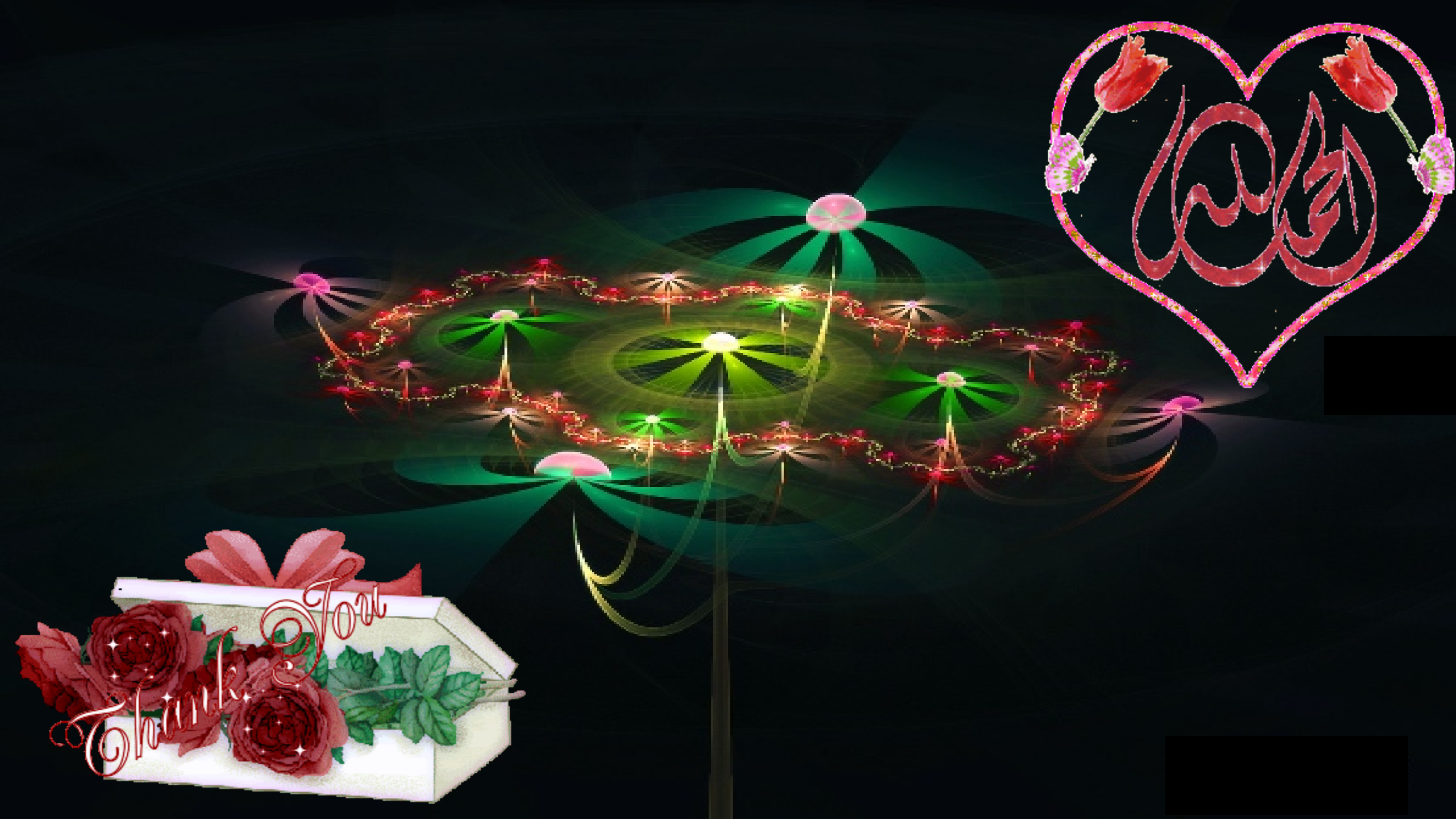


Lesion of the Spino-cerebellar Tracts



Friedrich's ataxia

- An inherited degenerated disease
- Leading to **incoordination of arms, intense tremor, wide base reeling gait, ataxia. [Impaired muscle coordination]**
- It begins in childhood
- Wheelchair is bound by 20 years of age


الحمد لله
Thank You