

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ  
السَّلَامُ عَلَيْكُمْ وَرَحْمَةُ اللَّهِ وَبَرَكَاتُهُ



# Sensory pathways Ascending Tracts

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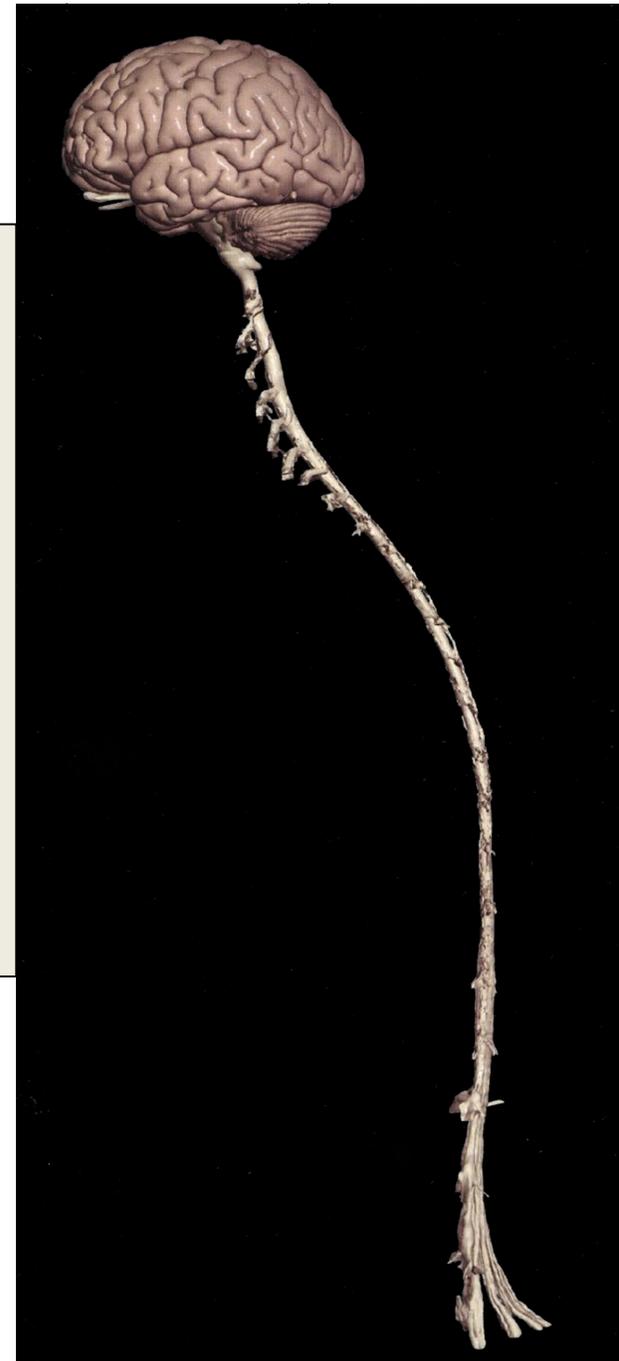
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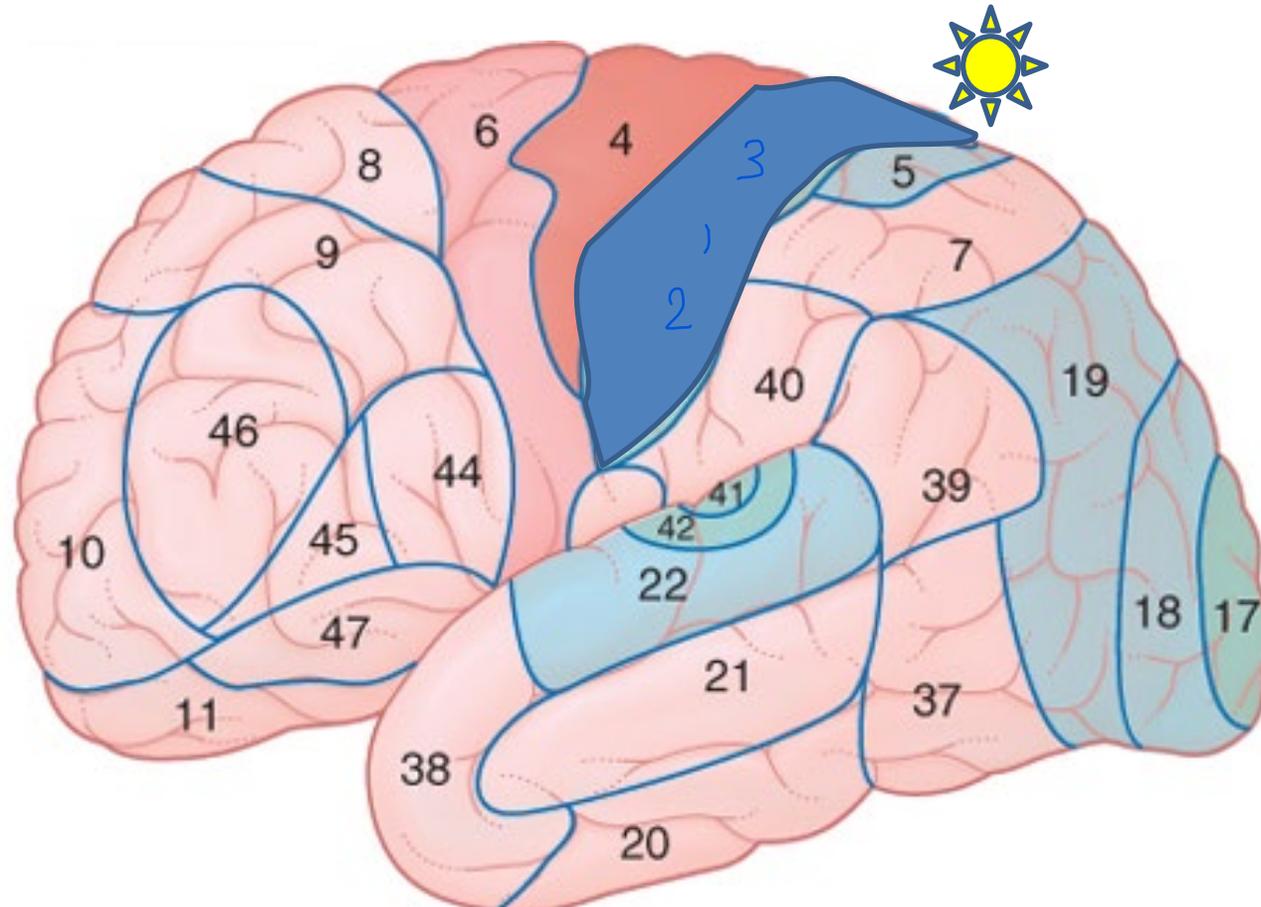
# OBJECTIVES

**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

كل اللي مطلوب مننا في المحاضرة  
contralateral

Contralateral = Opposite side **MCQ**  
Ipsilateral = Same side

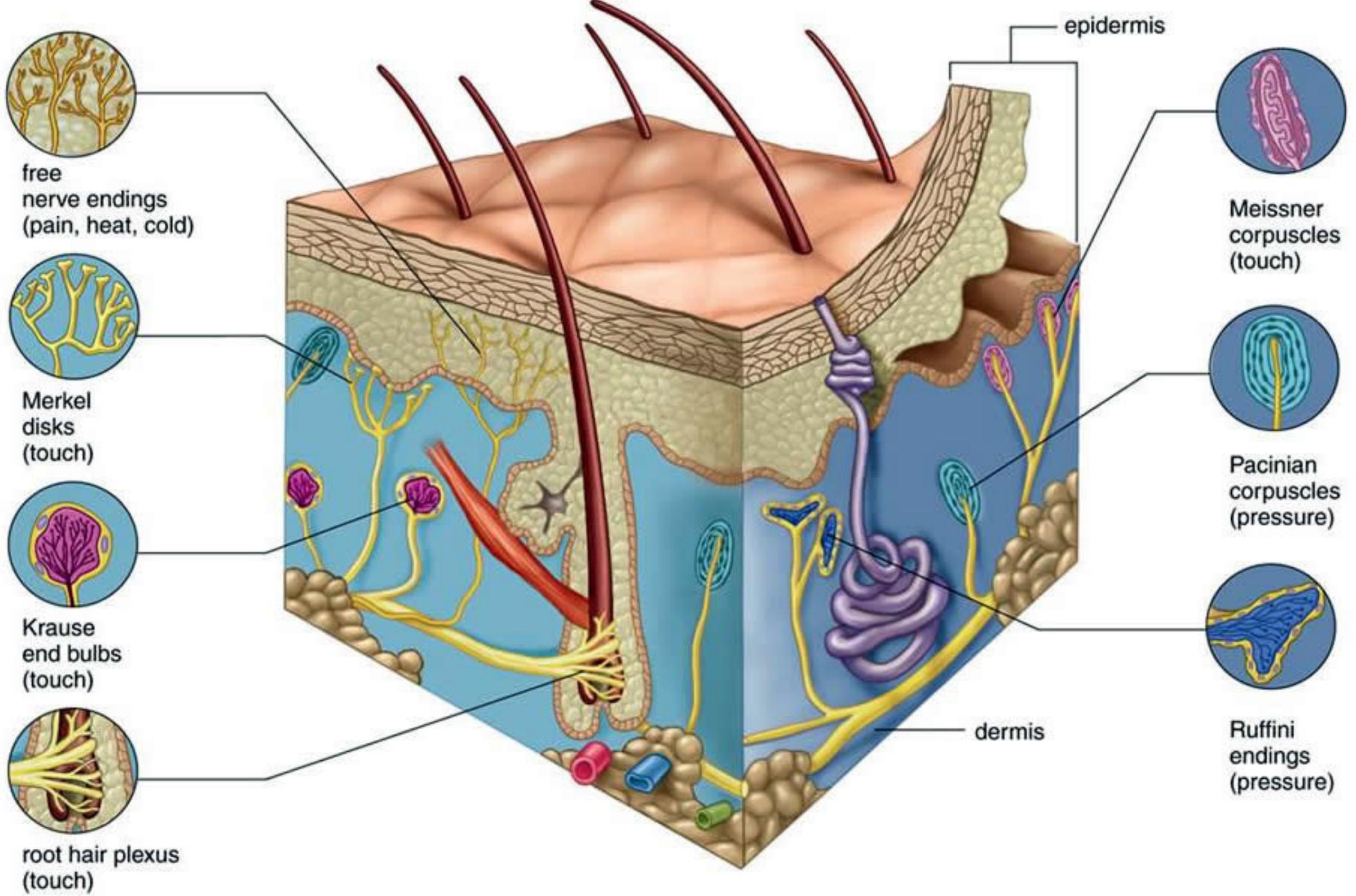
# What are the general senses?

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

- Proprioception

→ ms spindle, GTO & other joint receptors





## الفرق بين الشعور والإحساس



### DISTINGUISHING TACTILE SENSATIONS

*That feels like  
two points.*



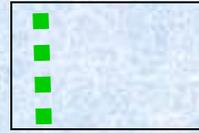
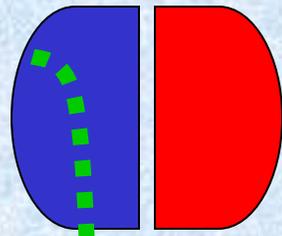
- **Sensation** is a conscious or unconscious awareness of external or internal stimuli.

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

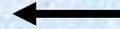
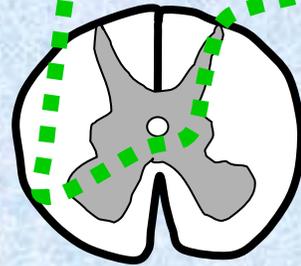
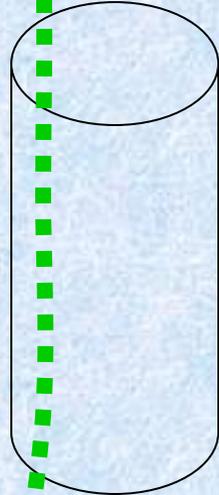
R

L

Sensory



Medulla

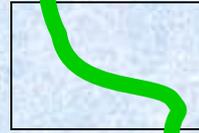
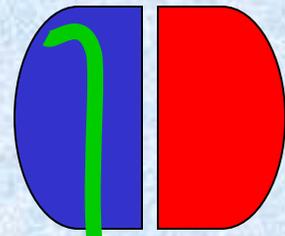


Sensory Receptors

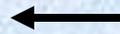
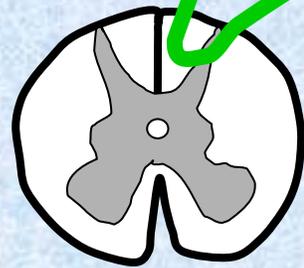
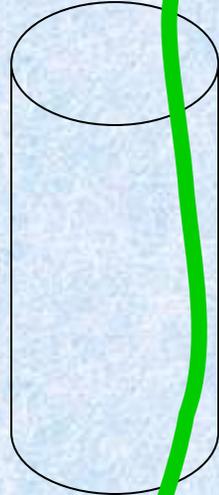
R

L

Sensory



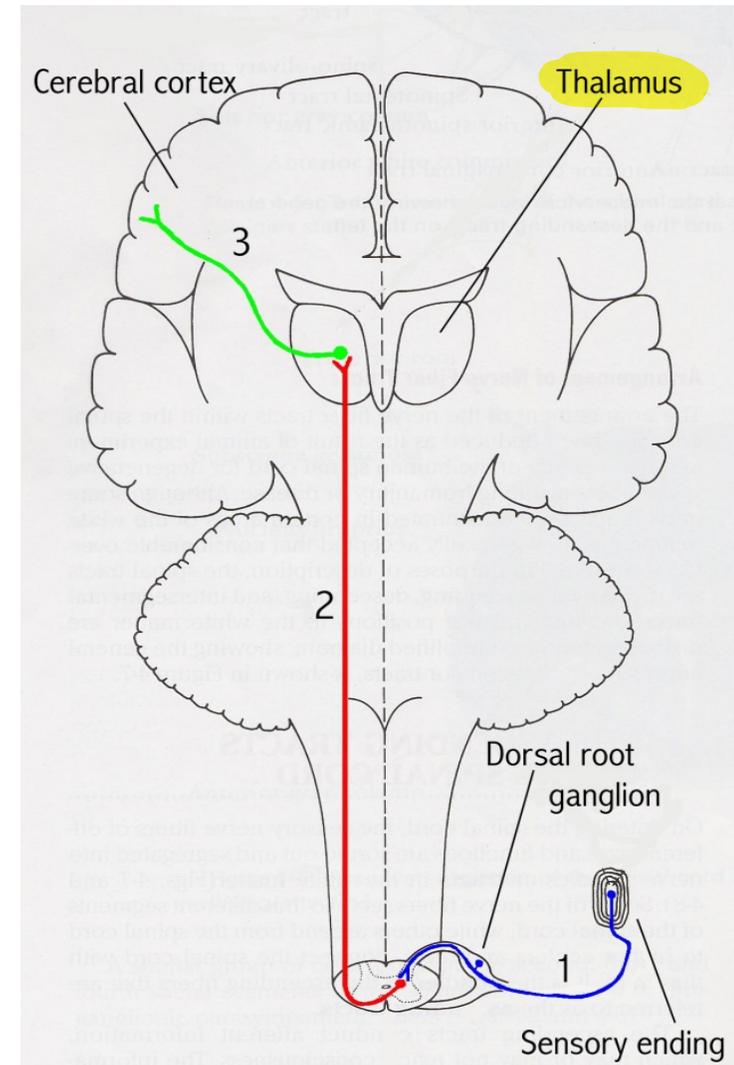
Medulla



Sensory Receptors

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

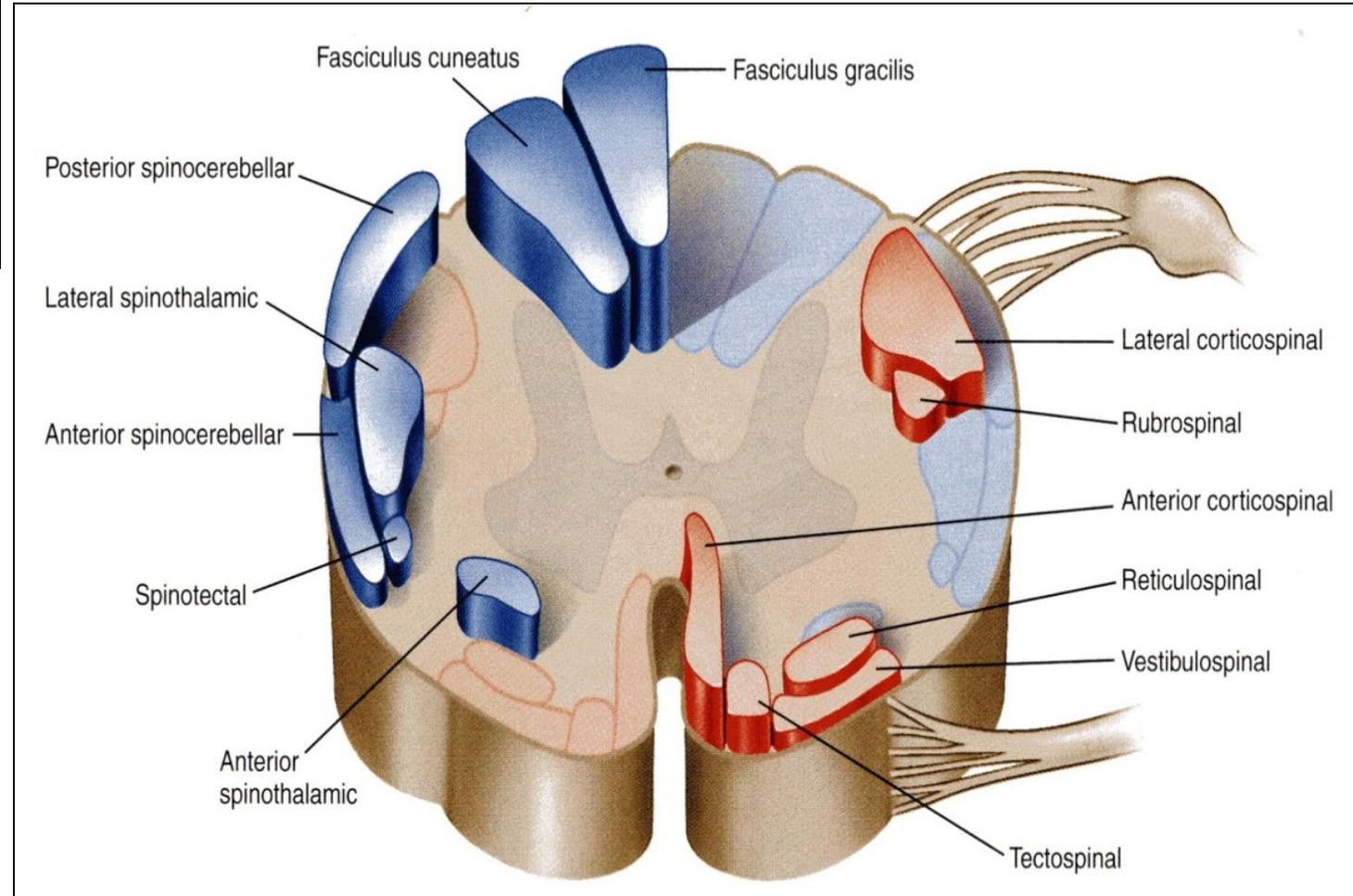
- 3
- 1<sup>st</sup> order, 2<sup>nd</sup> order and 3<sup>rd</sup> order neurons.



# WHITE MATTER TRACTS

مجموعة الـ tracts ← hemiscus

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

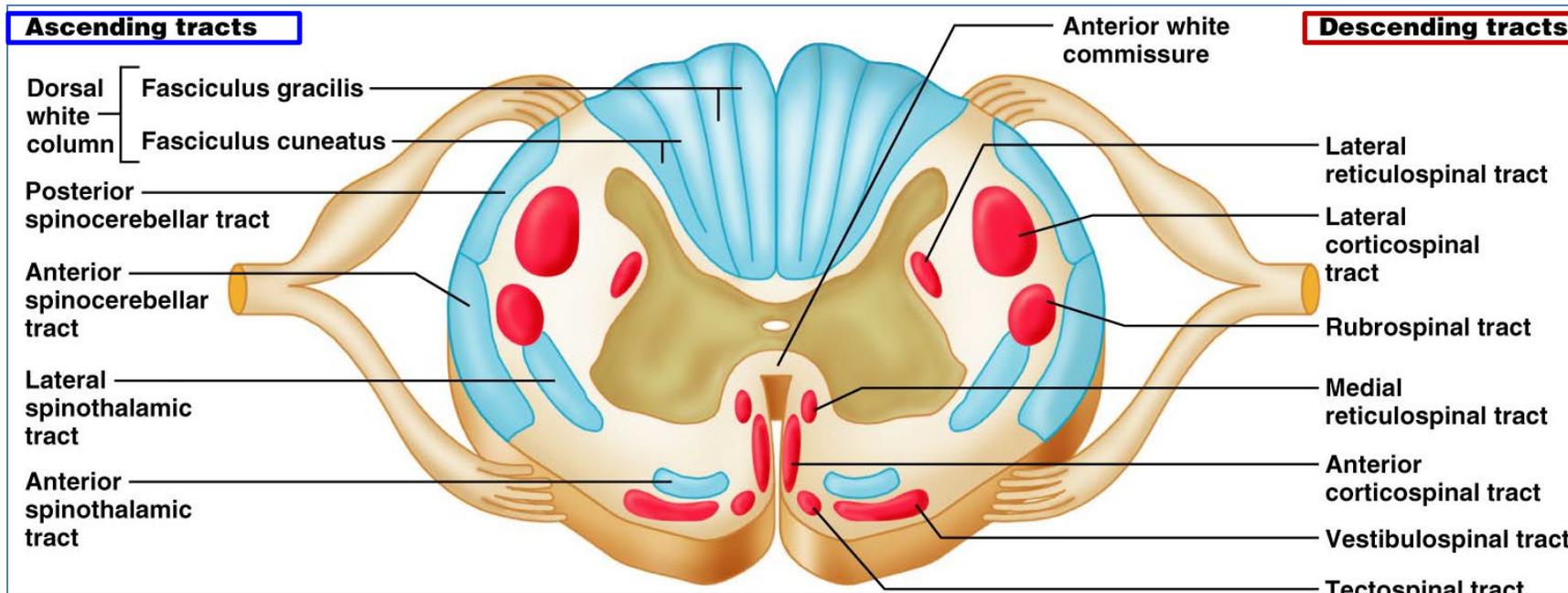


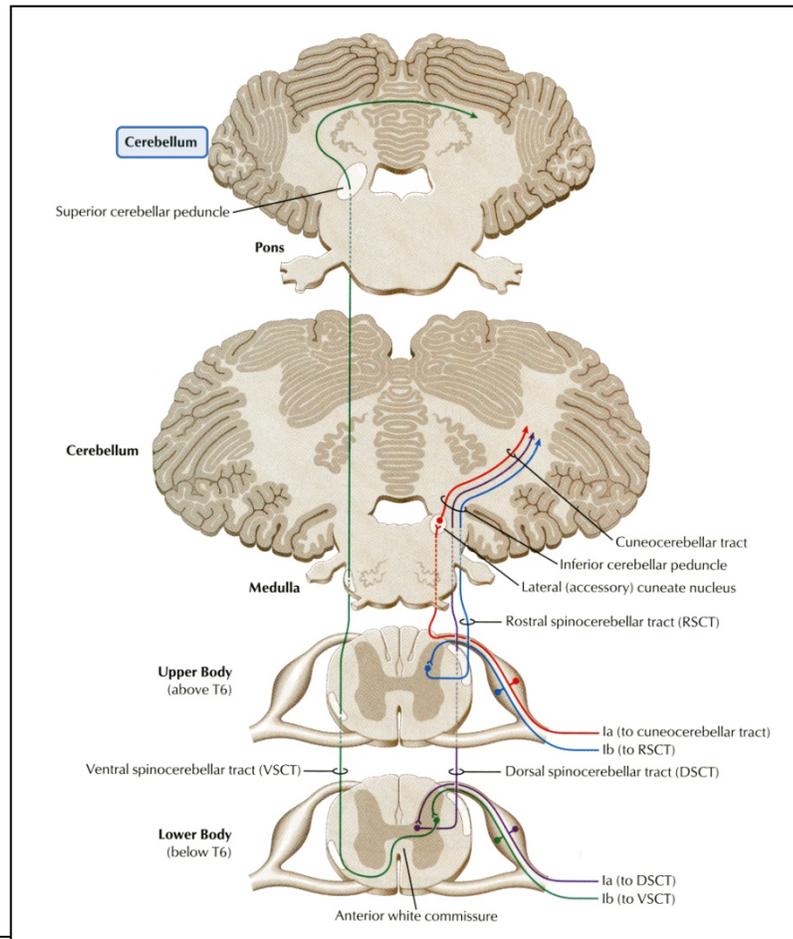
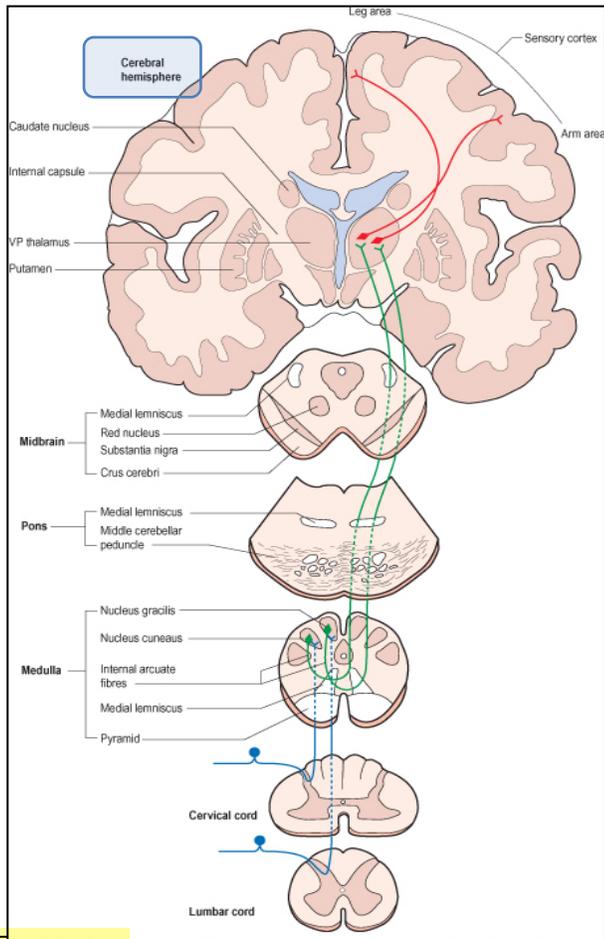
# • Long Tracts:

*(a) Ascending (sensory or afferent).*

*(b) Descending (motor or efferent).*

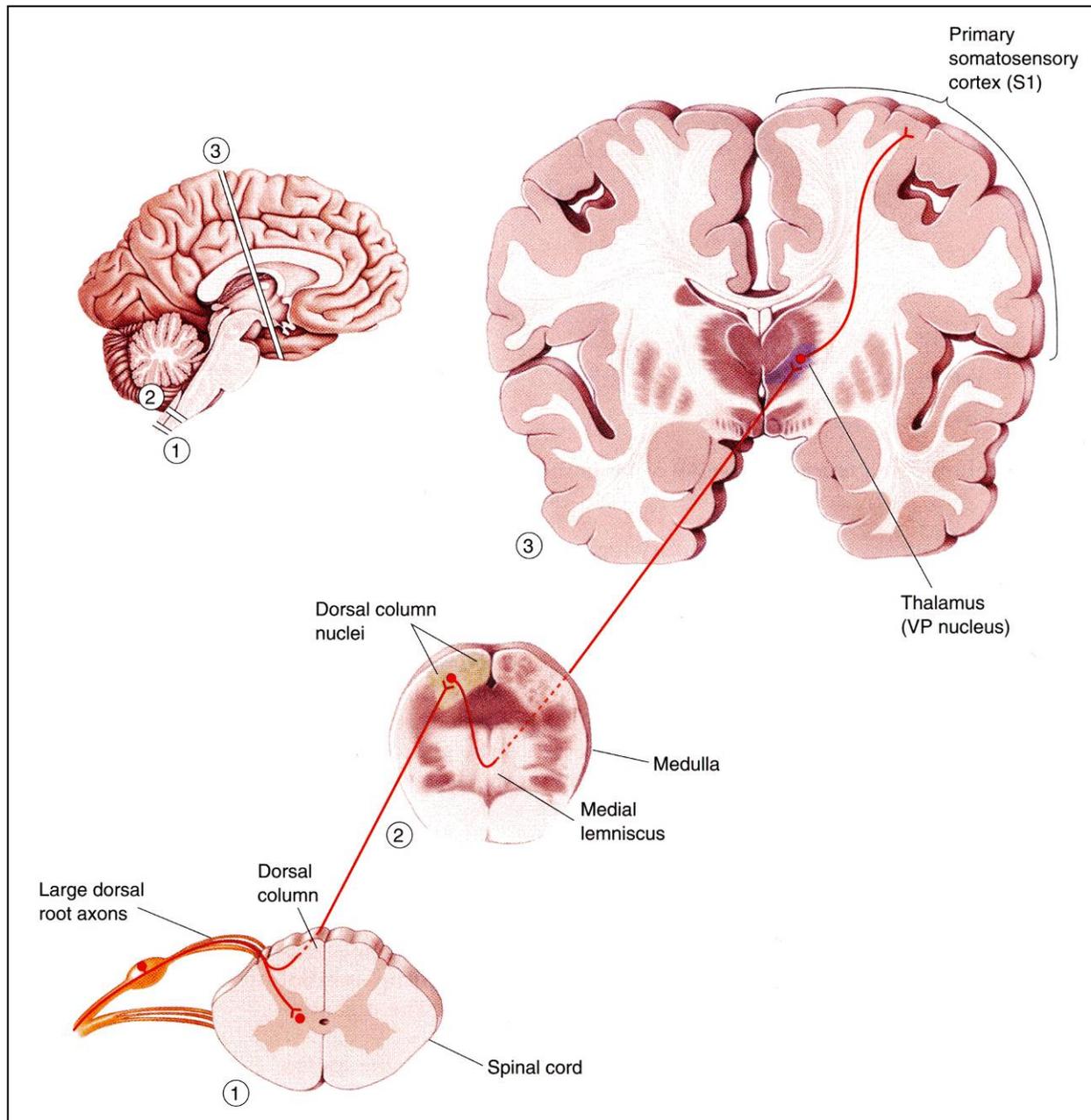
They serve to join the brain to the spinal cord.





## □ 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:

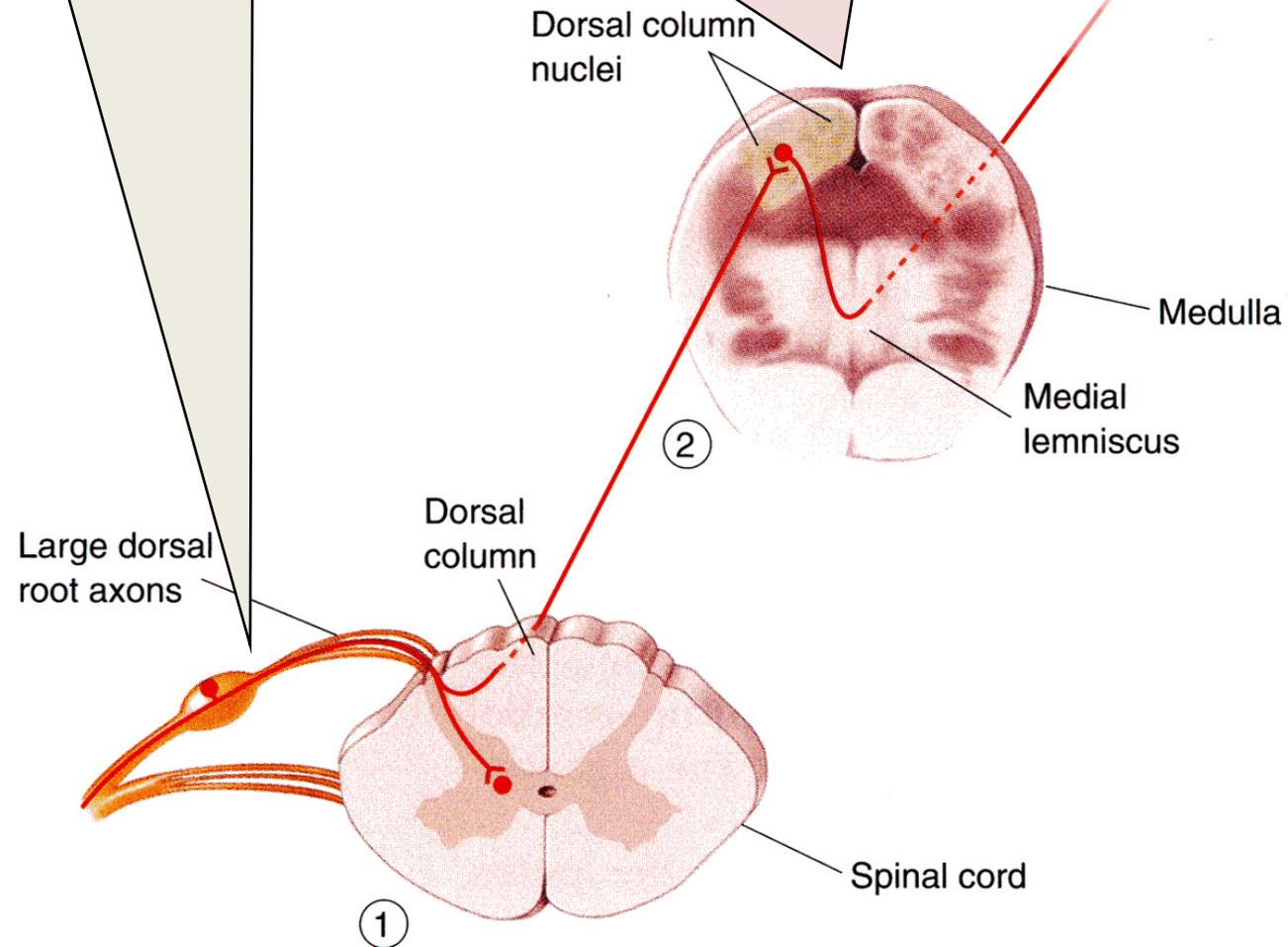
There is a sequence of **Three Neurons** between the peripheral receptors and the cerebral cortex.

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**.

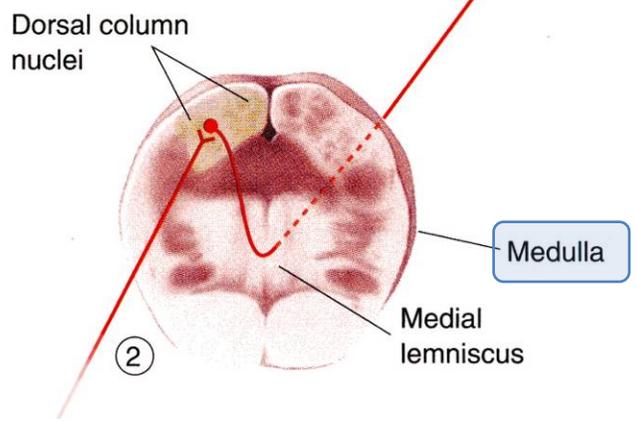
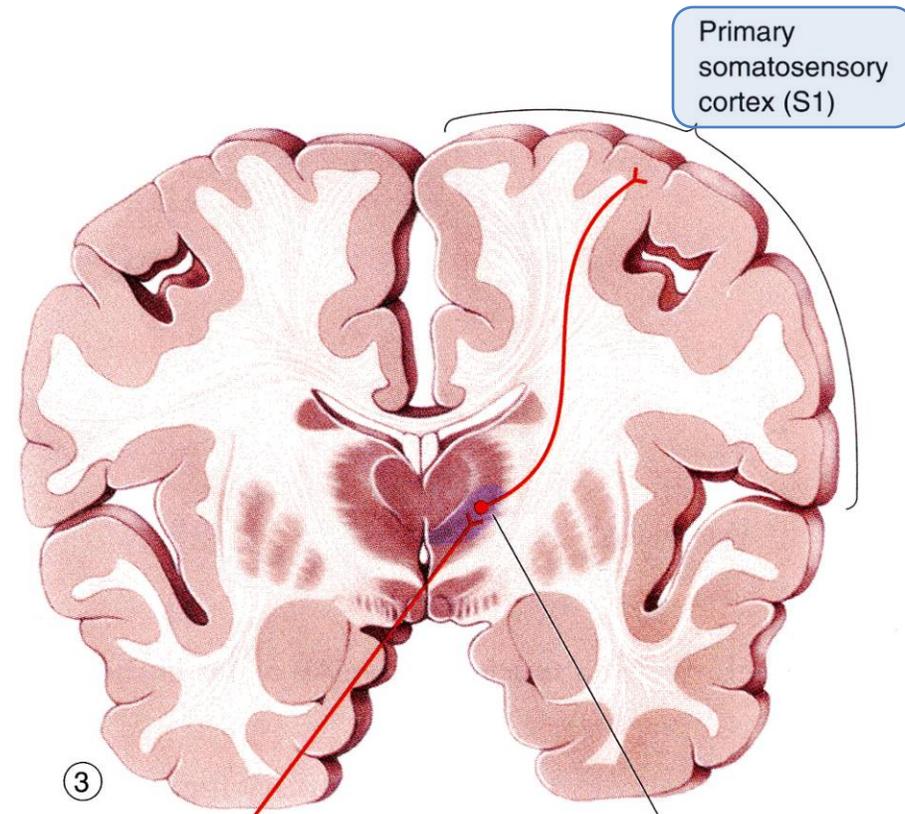
The main fiber remains on the ipsilateral side of the cord and terminates in synaptic contact with the **second neuron which lies** either in the **spinal grey matter** or in the **medulla oblongata of the brain stem**.

**MCQ: "Ascending tract" first order neuron is:**

↳ Dorsal root ganglia

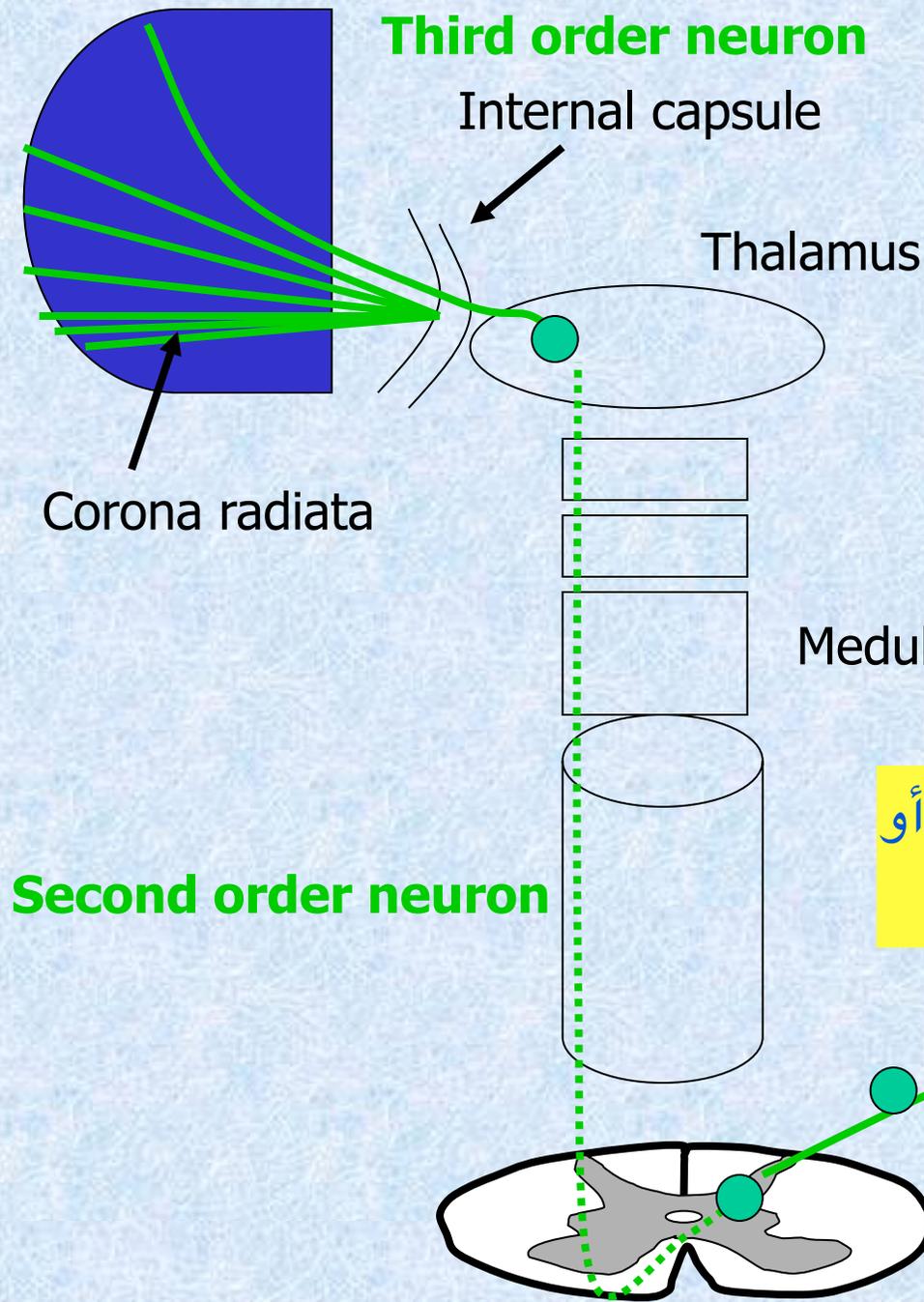


- The axon of the **second order neuron** **crosses over (decussates)** to the opposite side of the CNS.
- The **third-order neurone** has its cell body in the **thalamus**.
- Its axon passes to the **somatosensory cortex** of the parietal lobe of the cerebral hemisphere.



**MCQ: "Ascending tract" second order neuron is:**

spinal cord  
 medulla  
 \* decussation



**MCQ : "Ascending tract" third order neuron is :**

Thalamus  
 لو كنت جيم  
 دي هتأخذ  
 الدرجة  
 lateral  
 medial

**Ascending tracts**

**أي tract في المحاضرة دي هنتسأل عن الfunction أو order neuron 3 , 2 , 1**

# The 3 ascending tracts are...

Dorsal Columns

Vibration,

Fine Touch,

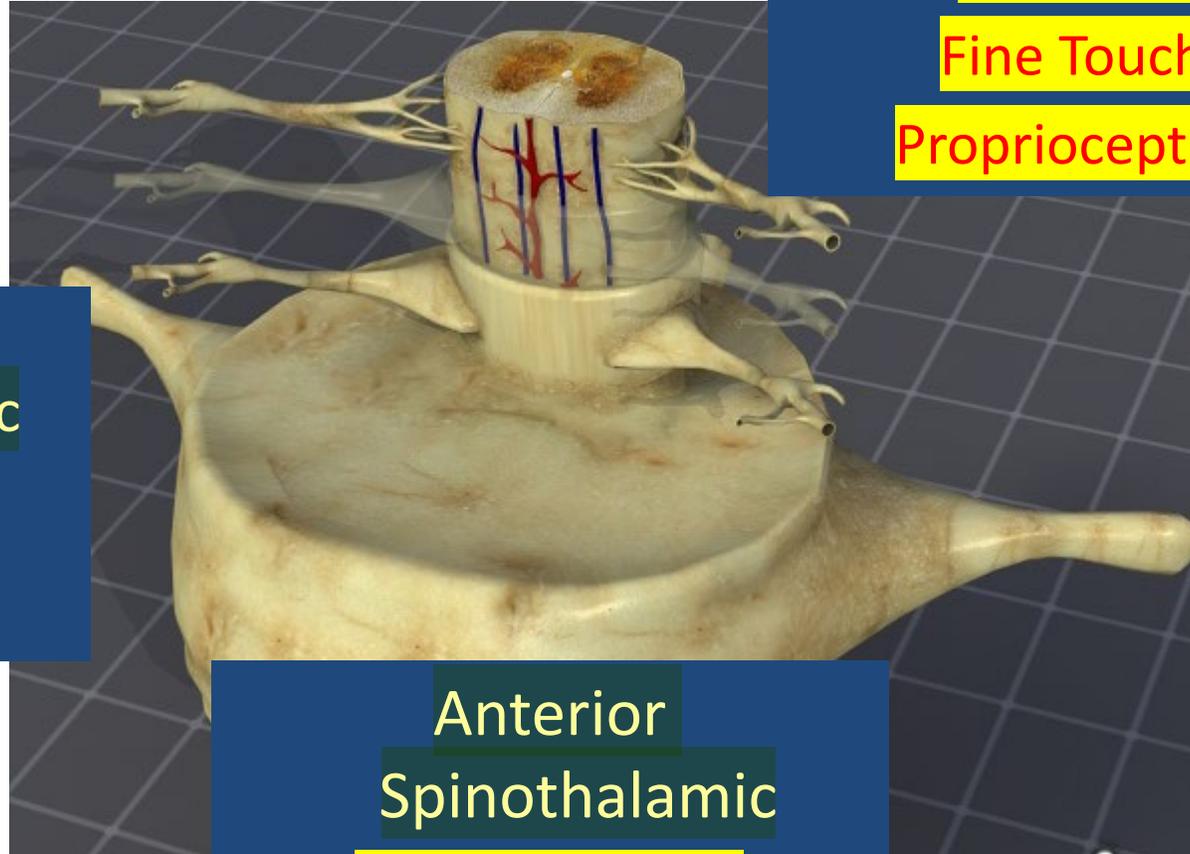
Proprioception

Lateral  
Spinothalamic

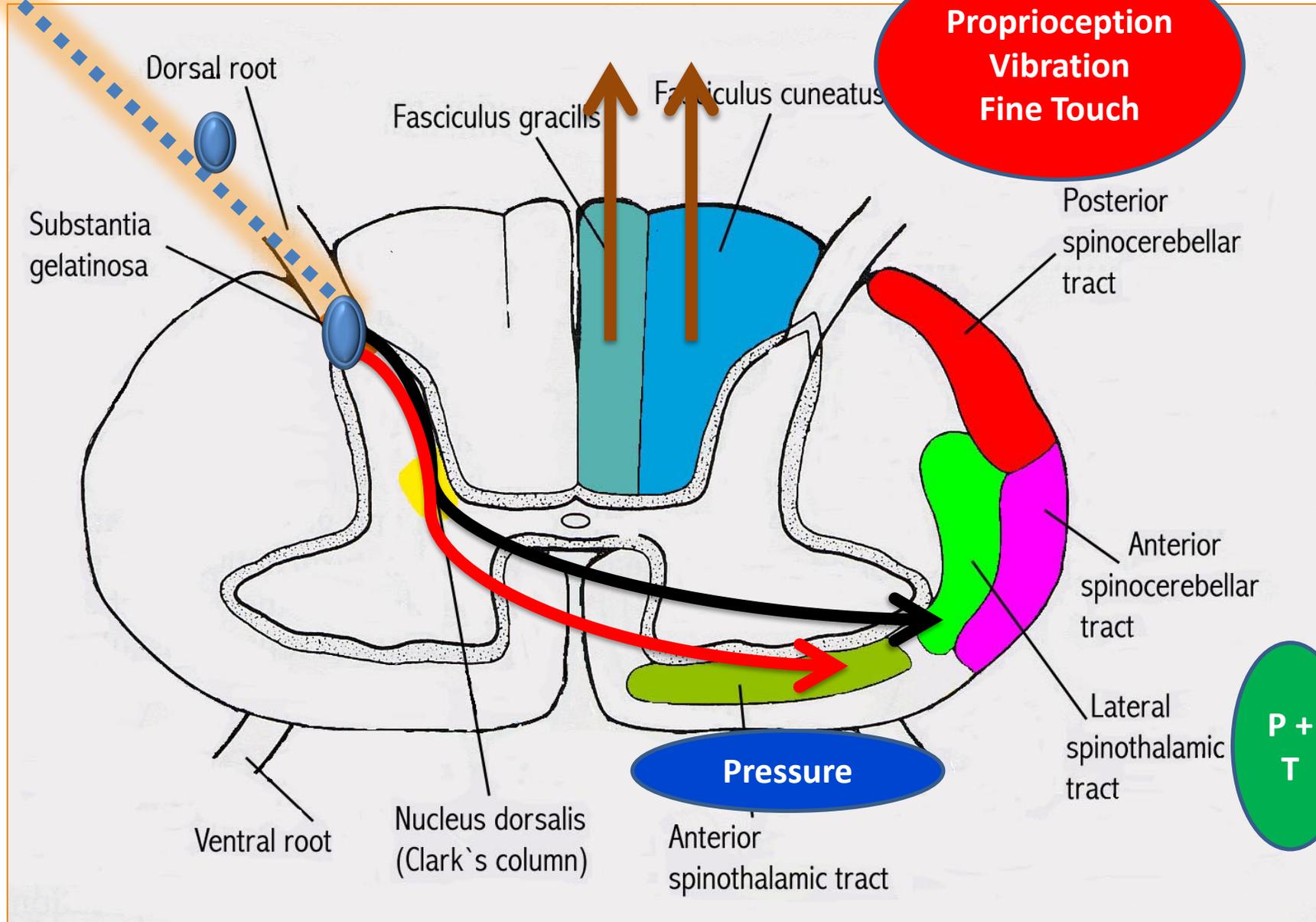
Pain,  
Temperature

Anterior  
Spinothalamic

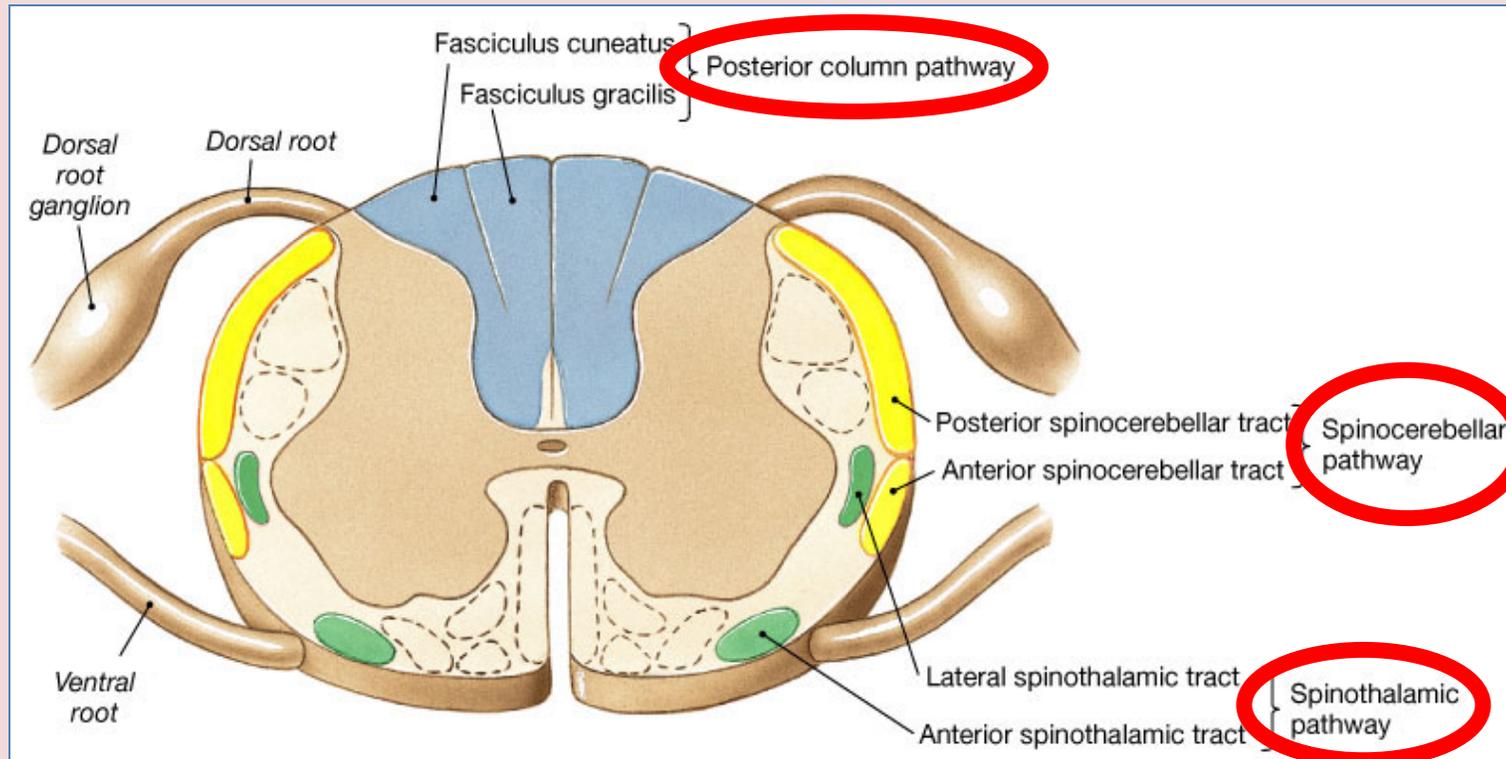
Crude touch,  
Pressure



# The spinal cord



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



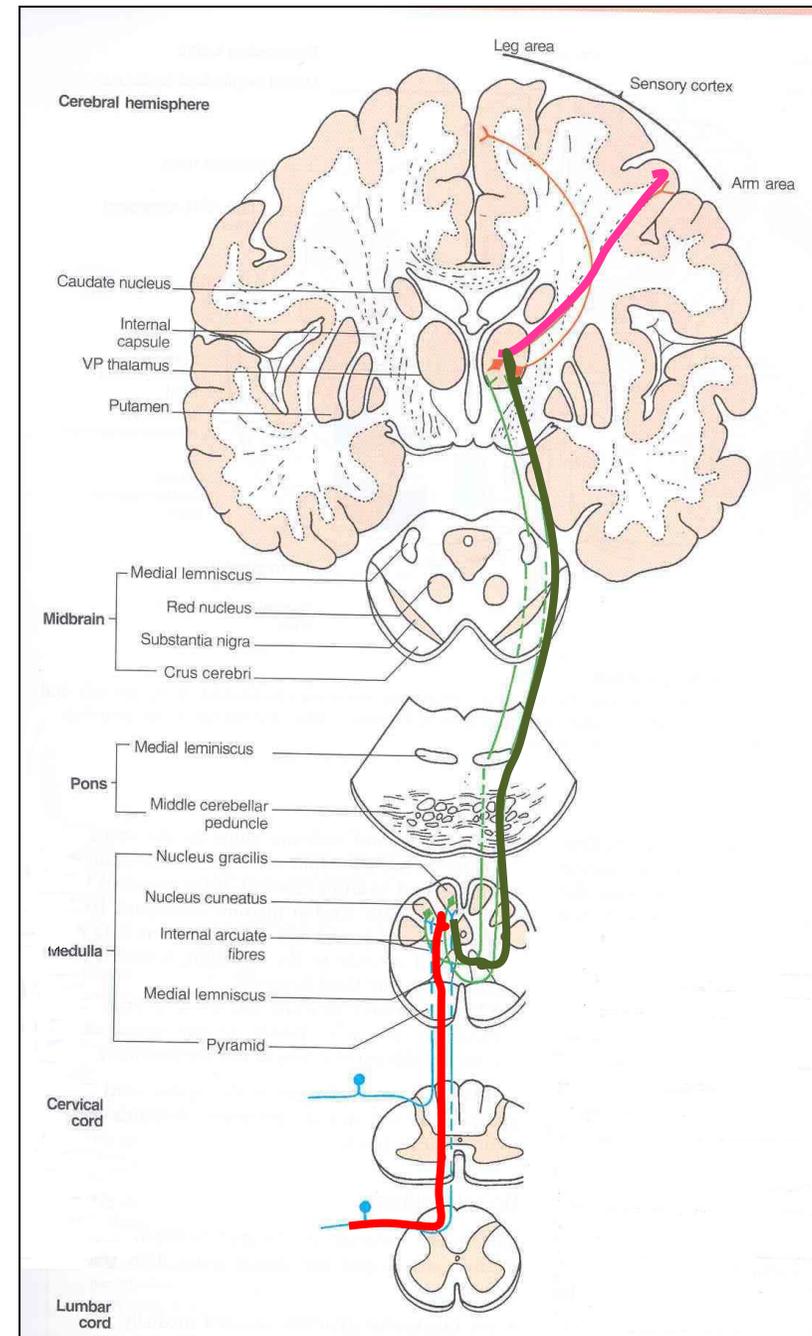
*Dorsal (Posterior) column (Gracile & Cuneate)*

# Dorsal Columns [Cross at Medulla]

3<sup>rd</sup> order neuron:  
From **VP nucleus in thalamus** → through  
posterior limb of internal capsule → cortex

2<sup>nd</sup> 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

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



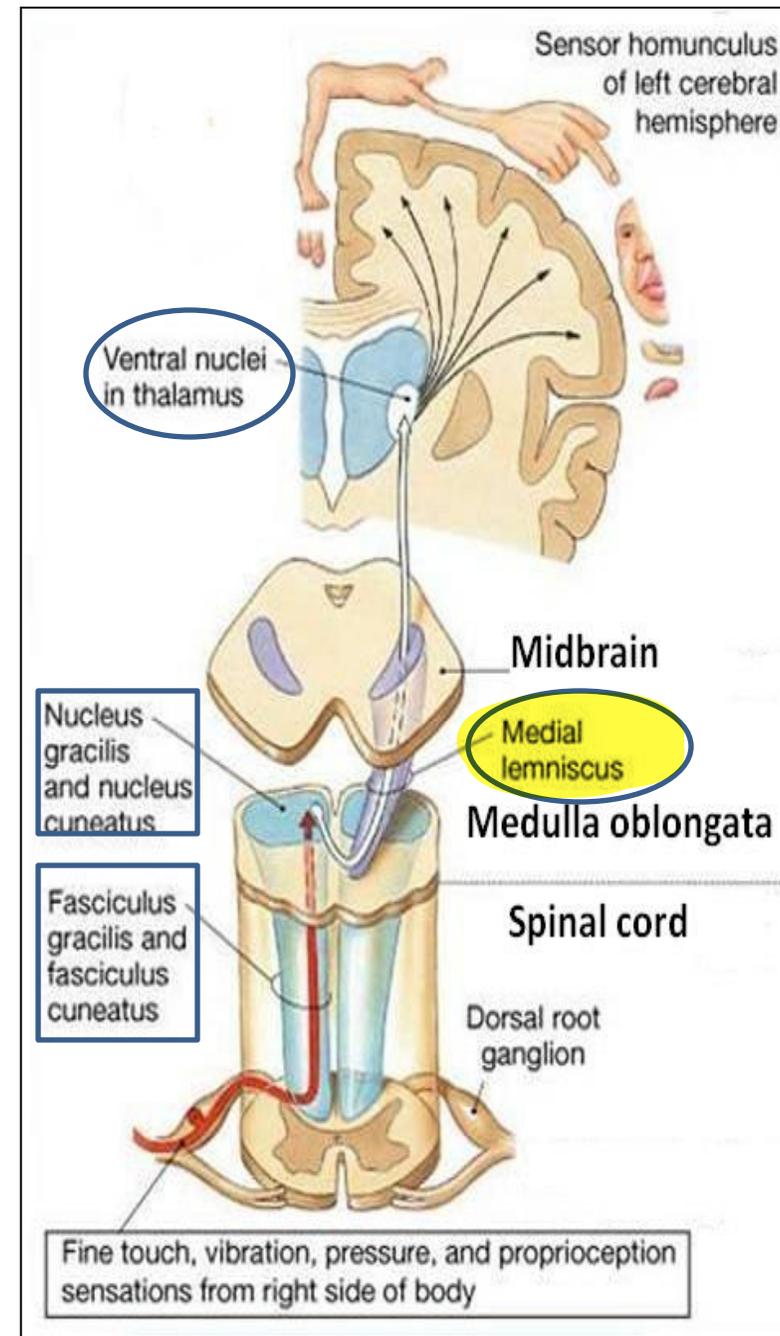
مهمة جدا

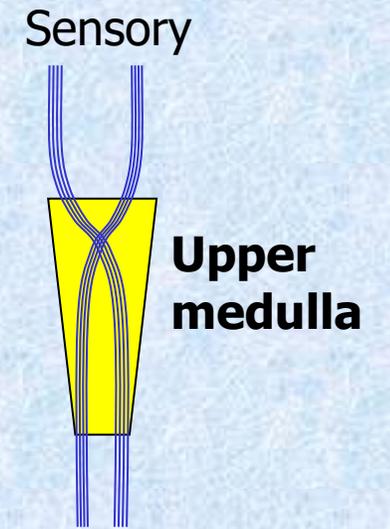
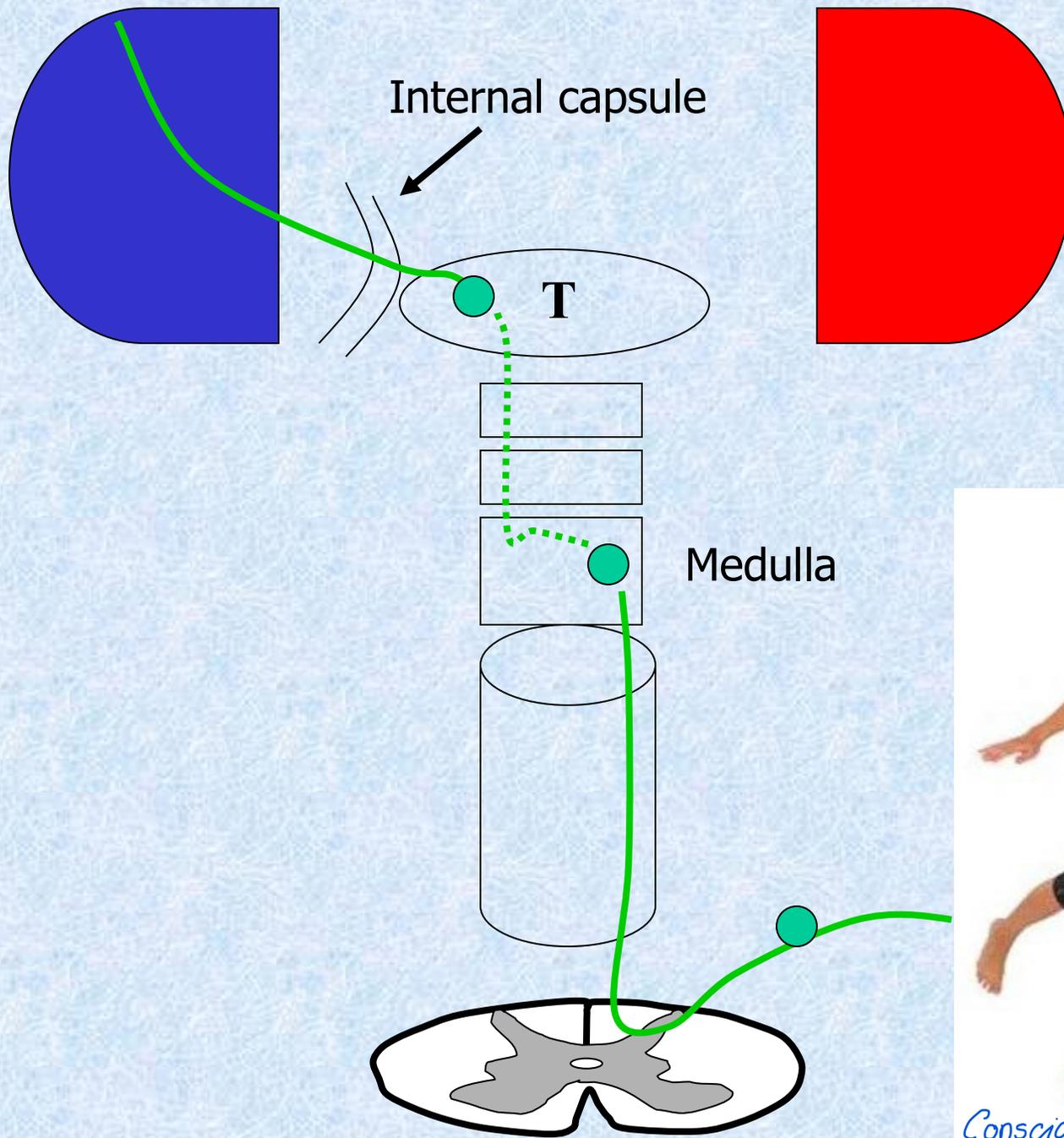
# Dorsal Column

- 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

**MCQ : Which of the following carrying proprioception from big toe ?**

↳ Gracile





Posterior surface



# *Spinothalamic pathway*

## Lateral Spinothalamic Tract

3<sup>rd</sup> order neuron:

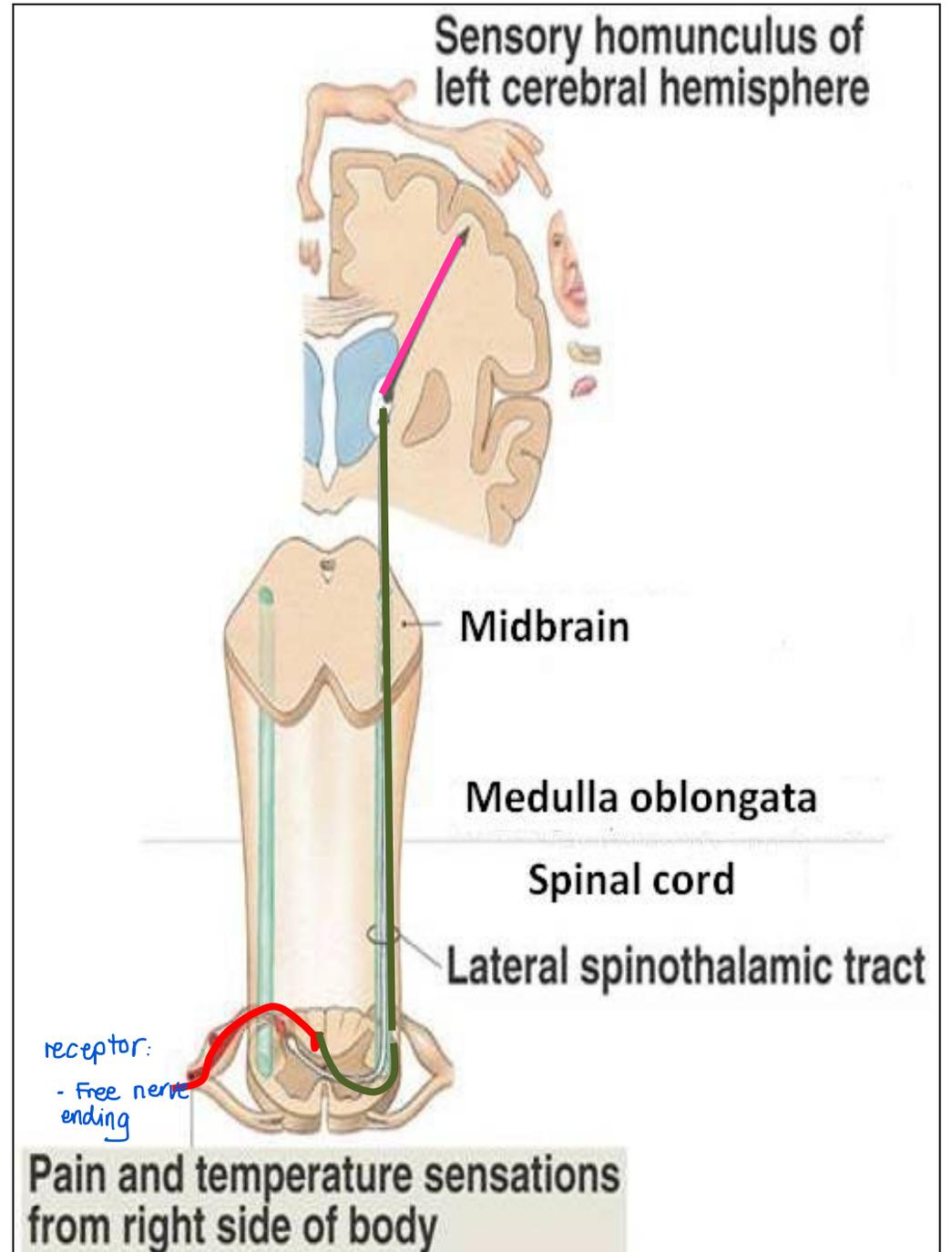
From VP nucleus in thalamus → through posterior limb of internal capsule → cortex

2<sup>nd</sup> 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**

1<sup>st</sup> order neuron:

From receptors in periphery (fast (A) or slow (C) fibers) → substantia gelatinosa in dorsal horn  
*\*Lamina of Rexed (1-4)*



## □ Function:

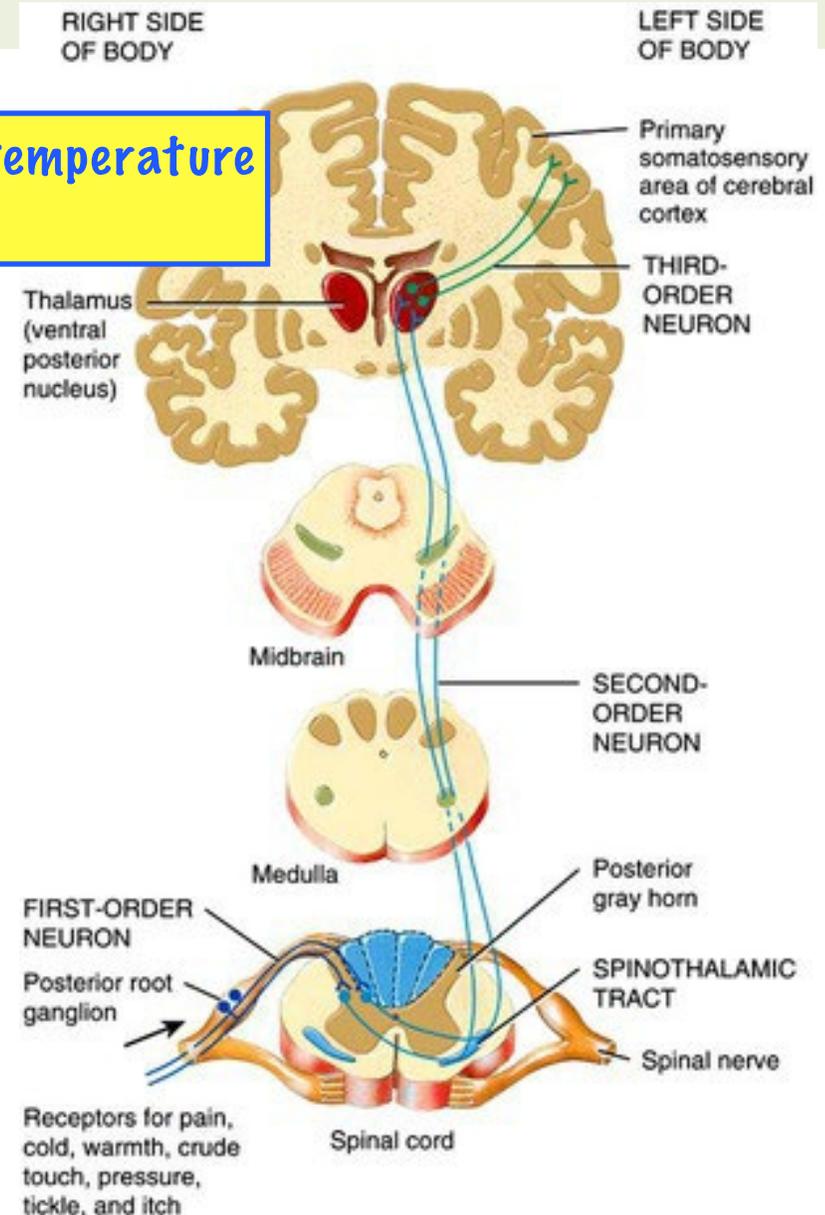
Carries **pain & Temperature** to thalamus and sensory area of the cerebral cortex.

## □ 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**.

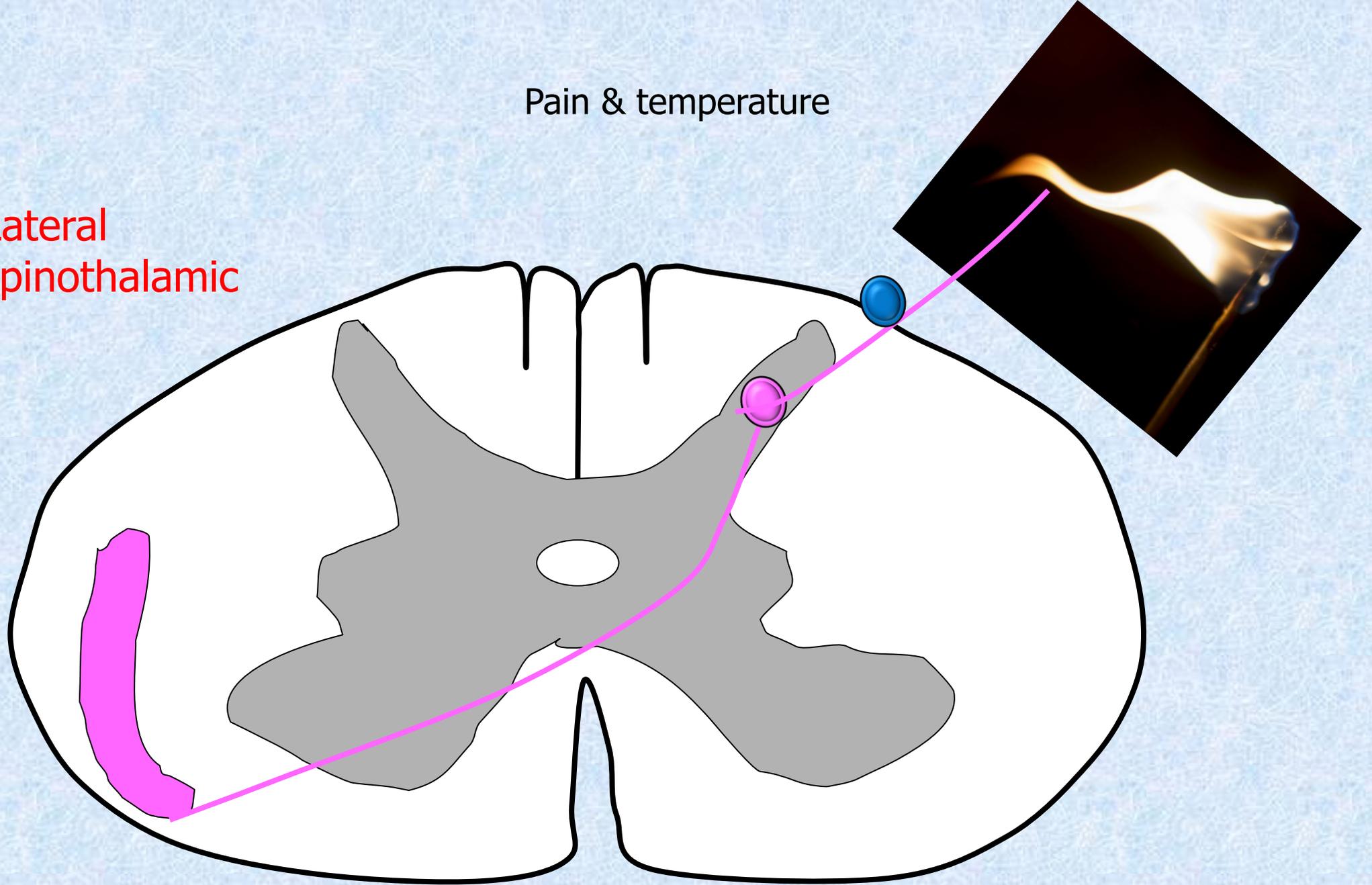
Lesion: loss of pain & temperature in contralateral side

## Lateral Spino-thalamic Tract



Pain & temperature

Lateral  
spinothalamic



## Anterior Spino-thalamic Tract

3<sup>rd</sup> order neuron:

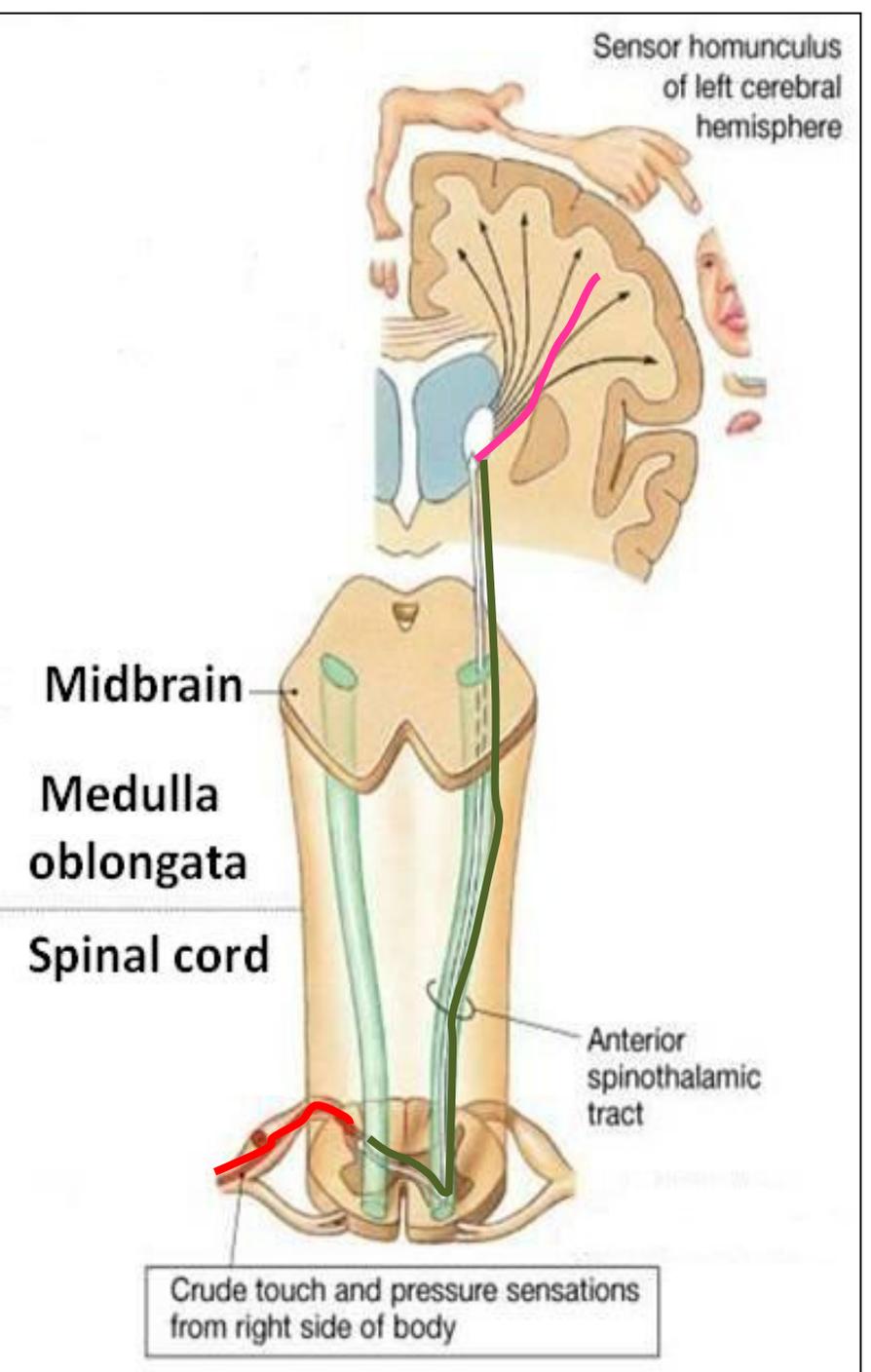
From VP nucleus in thalamus → through posterior limb of internal capsule → cortex

2<sup>nd</sup> 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

1<sup>st</sup> 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. **MCQ**

## ❑ Neurons: 3 Neurons

### • **Neuron I:**

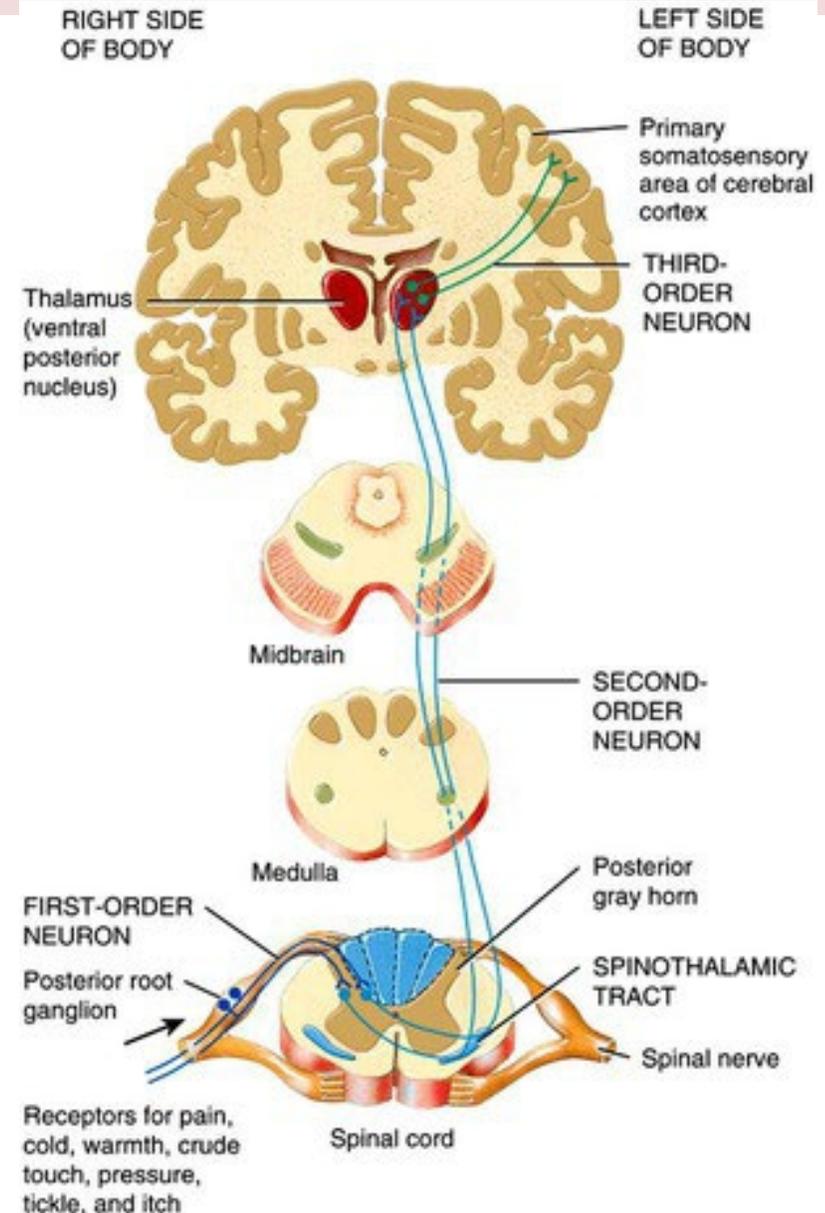
**Medium sized** cells in the dorsal root ganglia.

### • **Neuron II:**

Cells of main sensory nucleus or (**nucleus proprius**). *lamina of Rexed (I-IV)*

### • **Neuron III:**

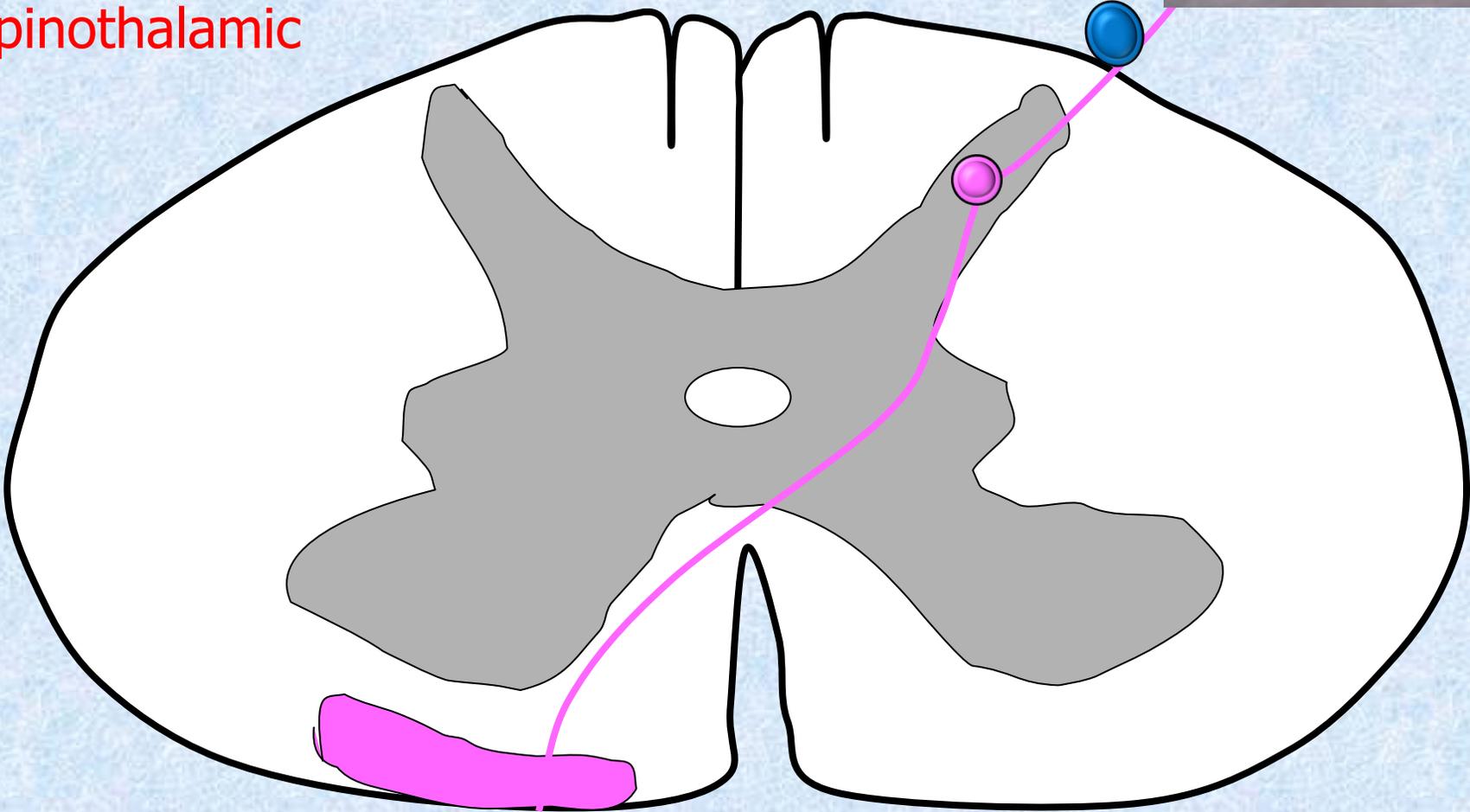
Cells of VP nucleus of **thalamus**.



Crude touch & pressure

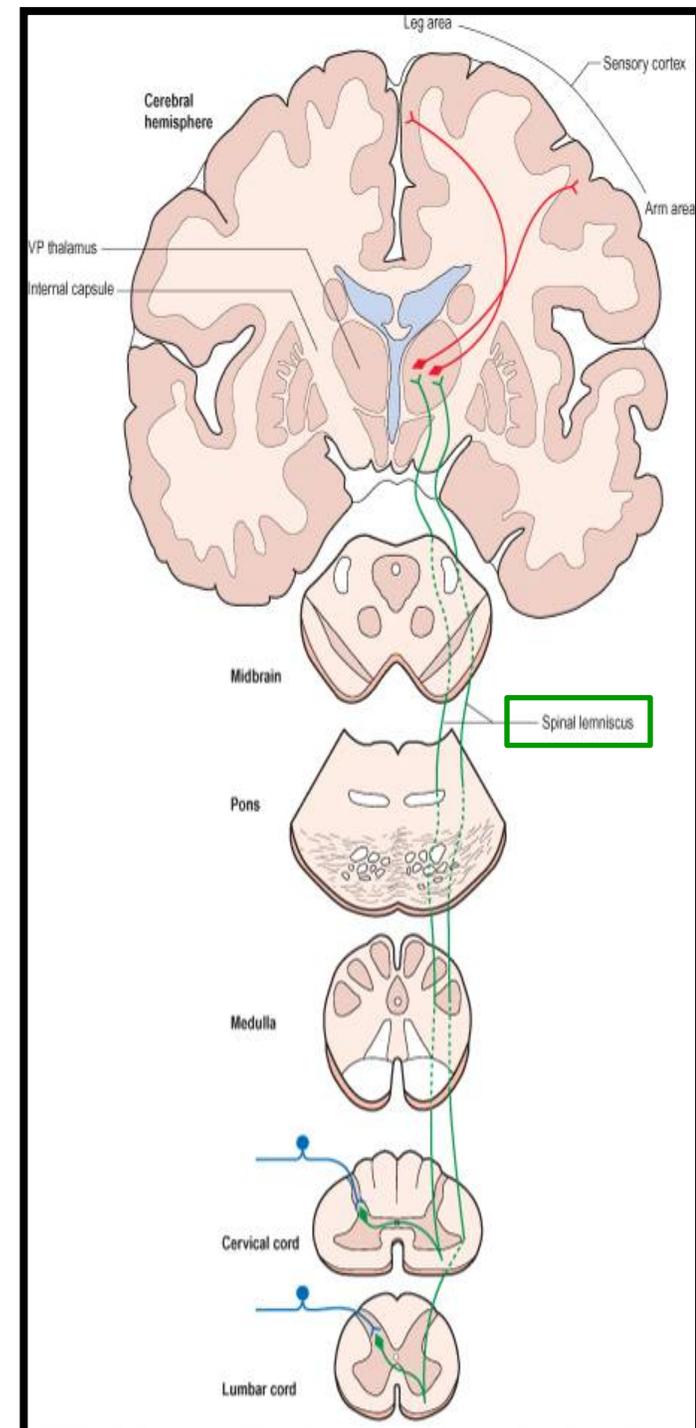


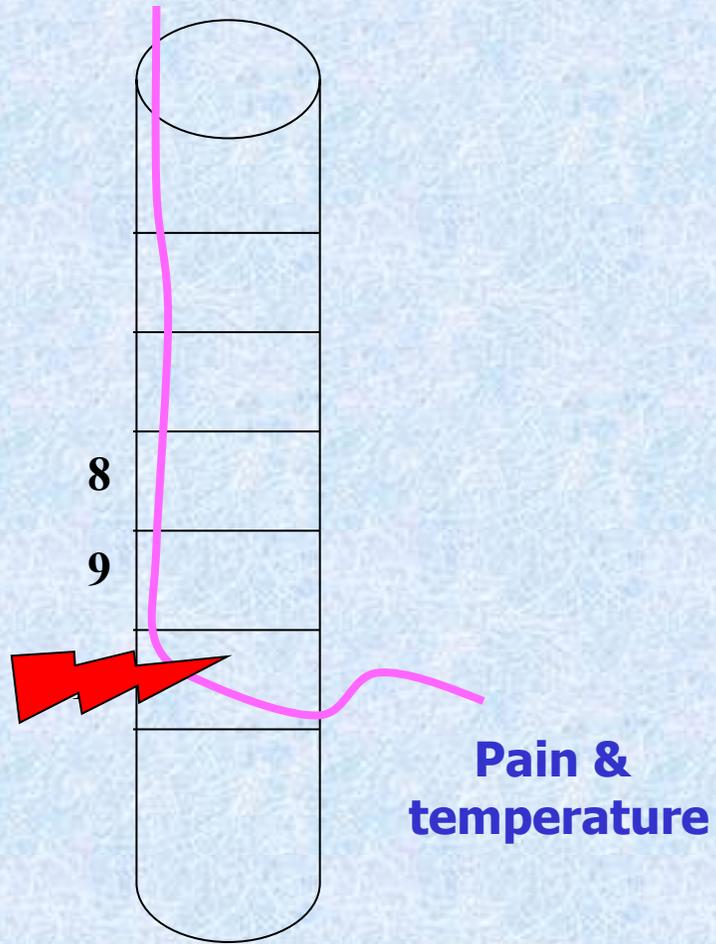
Anterior  
spinothalamic



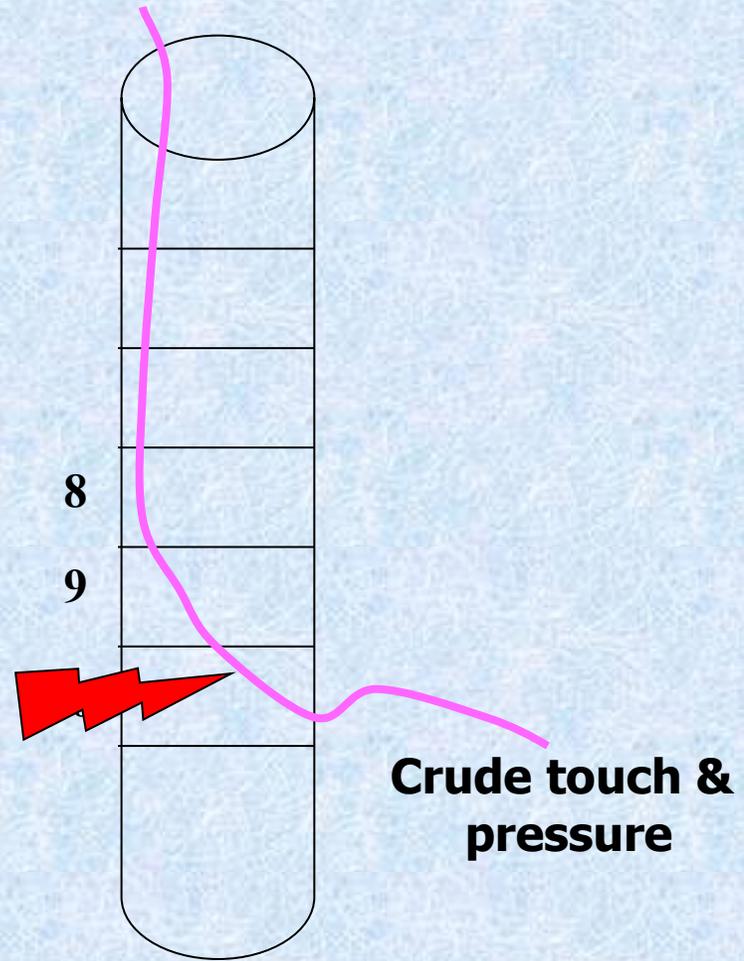
# Spino-thalamic Tracts

- 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

2<sup>nd</sup> 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

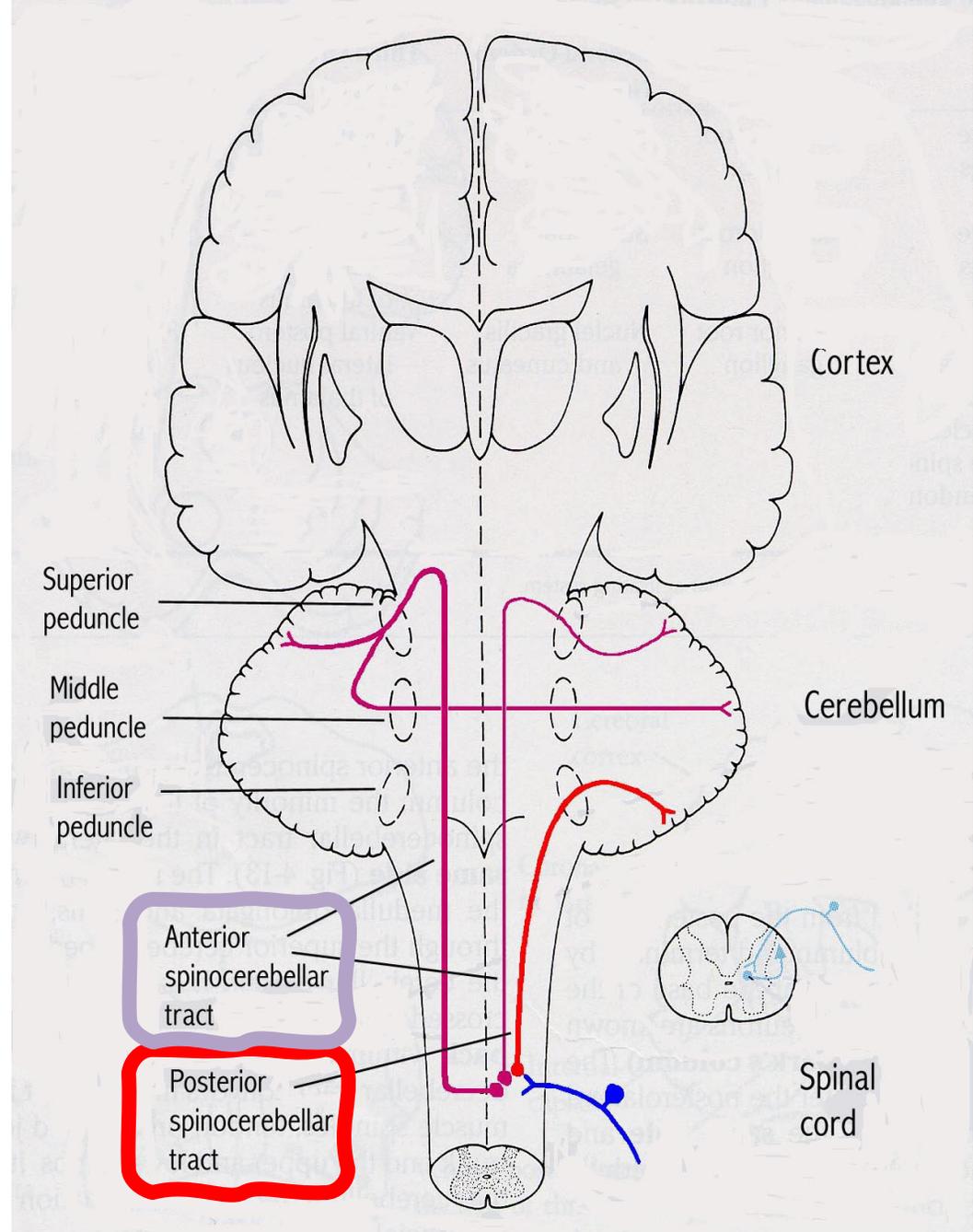
2<sup>nd</sup> order neuron:

## Dorsal TRACT "Clark Nucleus"

Nucleus dorsalis → Remains uncrossed → ascend in post. Spinocerebellar tract → **inferior** cerebellar peduncle in cerebellum

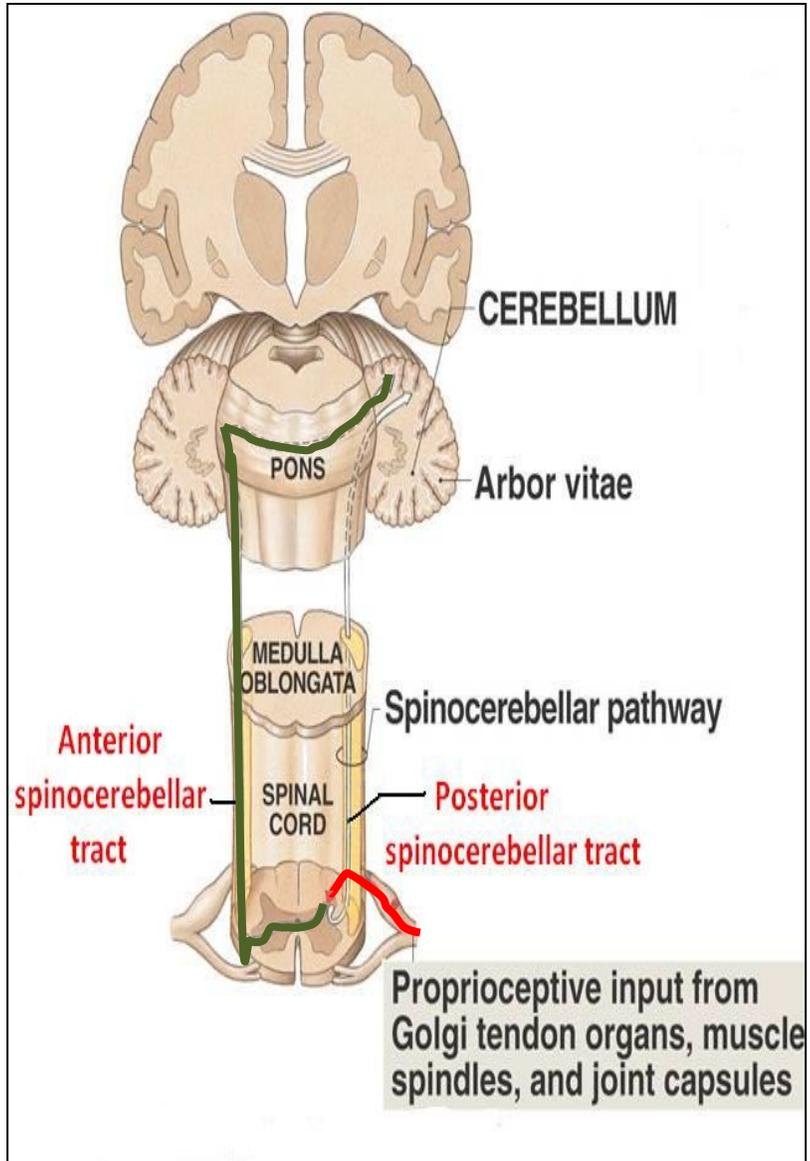
1<sup>st</sup> order neuron:

From receptors in periphery → nucleus dorsalis *DRG*



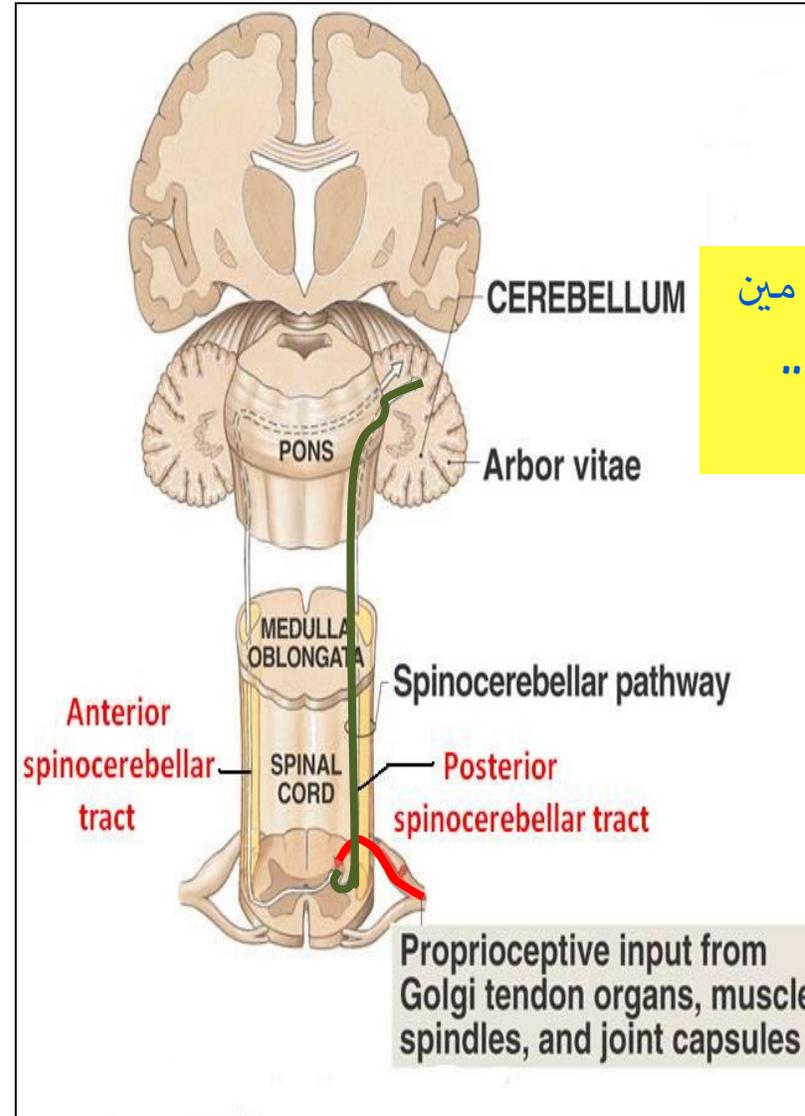
# Ventral (Anterior) Spino-cerebellar Tract

The VSCT crosses twice



# Posterior (Dorsal) Spino-cerebellar Tract

The DSCT Doesn't cross



#مش جاي في الامتحان مين  
الcross ومين لا من دول ..  
سكيب 🙄

# Why doesn't the **spinocerebellar** tract have a 3<sup>rd</sup> neuron?

- There is **no 3<sup>rd</sup> order neuron** as it **doesn't reach consciousness** i.e., the cortex.

**MCQ : Posterior (dorsal) spinocerebellum enter the cerebellum via : inferior cerebellar peduncle**

**MCQ : Ventral (anterior) spinocerebellum enter the cerebellum via: superior cerebellar peduncle**

**- Function : Unconscious proprioception**

# 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**; مهمة

**Neuron I:** Large cells of dorsal root ganglia.

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

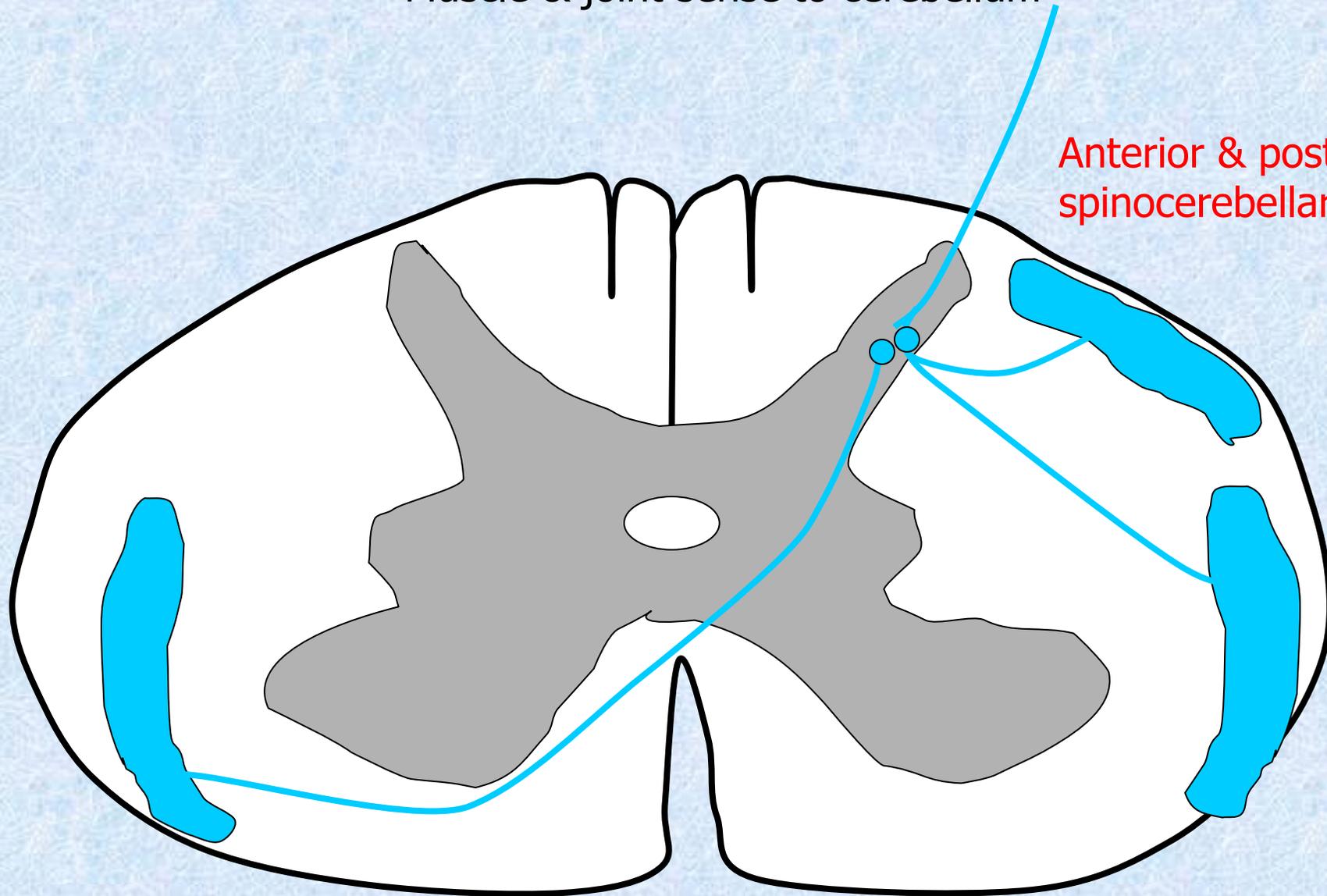
- Unconscious proprioception reach : cerebellum & carried by : spino cerebellar tract

- Conscious proprioception reach : cerebrum & carried by : gracile & cuneate tracts

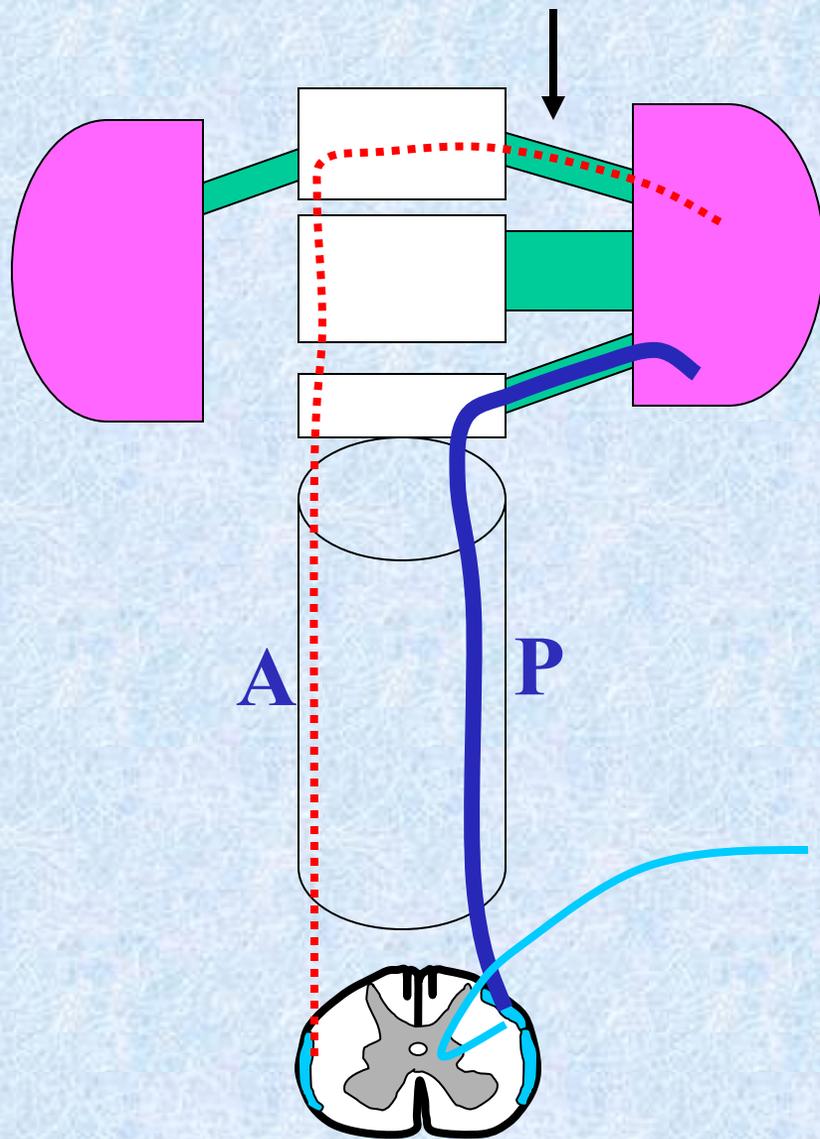
| Conscious vs Unconscious Proprioception |  |  |
|---|--|--|
|   | More Information Online <a href="http://WWW.DIFFERENCEBETWEEN.COM">WWW.DIFFERENCEBETWEEN.COM</a>               |  |
|   | Conscious Proprioception   | Unconscious Proprioception   |
| DEFINITION                              | Conscious proprioception is the ability to activate a muscle movement voluntarily in response to a stimulus    | Unconscious proprioception is the activation of muscles involuntarily in response to a stimulus      |
| FUNCTION                                | Ability to think before activating a muscle movement and becoming aware of the sensory information in the body | Ability to activate the muscles in response to a stimulus without having to think about the movement |
| PATHWAY GOES TO                         | Cerebrum   | Cerebellum   |
| NERVOUS SYSTEM PATHWAY                  | Dorsal column-medial lemniscus pathway   | Dorsal spinocerebellar tract and ventral spinocerebellar tract                                       |

Muscle & joint sense to cerebellum

Anterior & posterior  
spinocerebellar



Superior, middle & inferior cerebellar peduncles



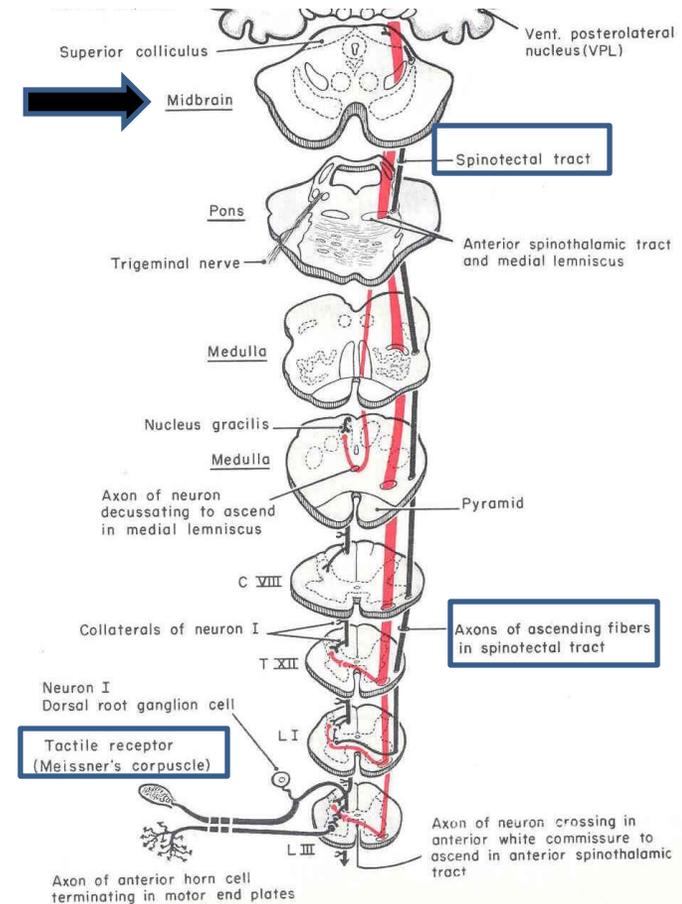
\* أي نوى به العاصرة  
هتكون في medulla "عشان مدا بيشتقوا بيها"

\* في الكتار Cuneocerebellum

# 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.**

# مش جاي في الامتحان .. سكيب 🙄



Indirect spinocerebellar pathway  
(spino-olivo-cerebellar)

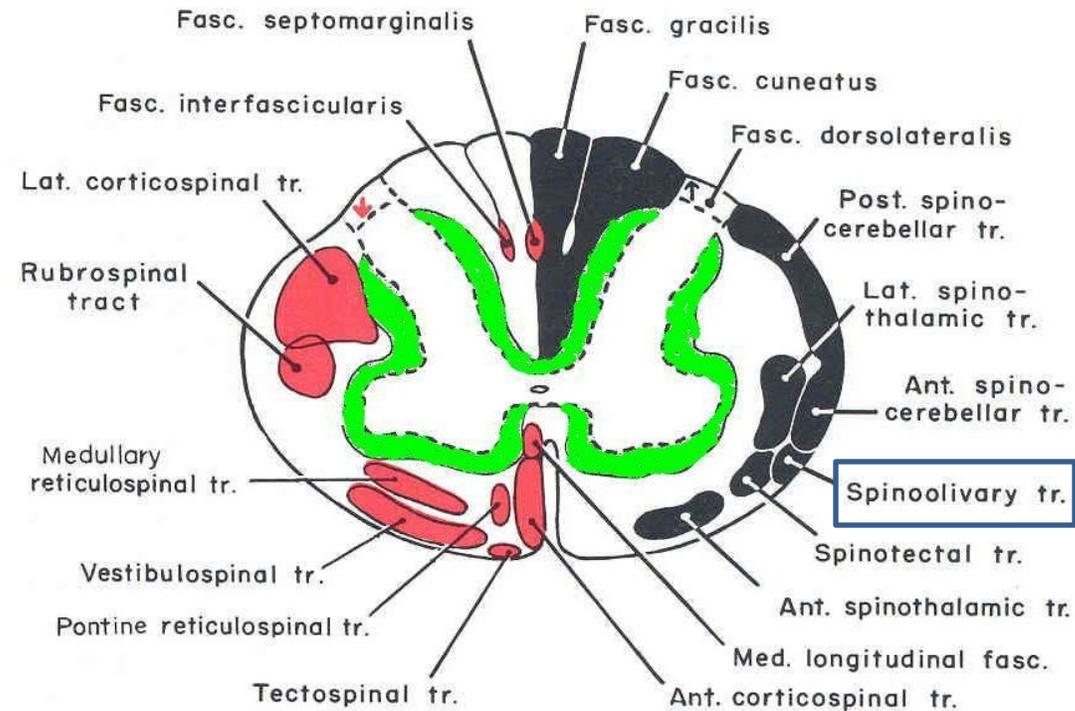
Impulses from the spinal cord are relayed to the cerebellum via inferior olivary nucleus.

Conveys sensory information to the cerebellum.

Contribute to movement coordination associated primarily with **balance**.

# Spino - olivary Tract

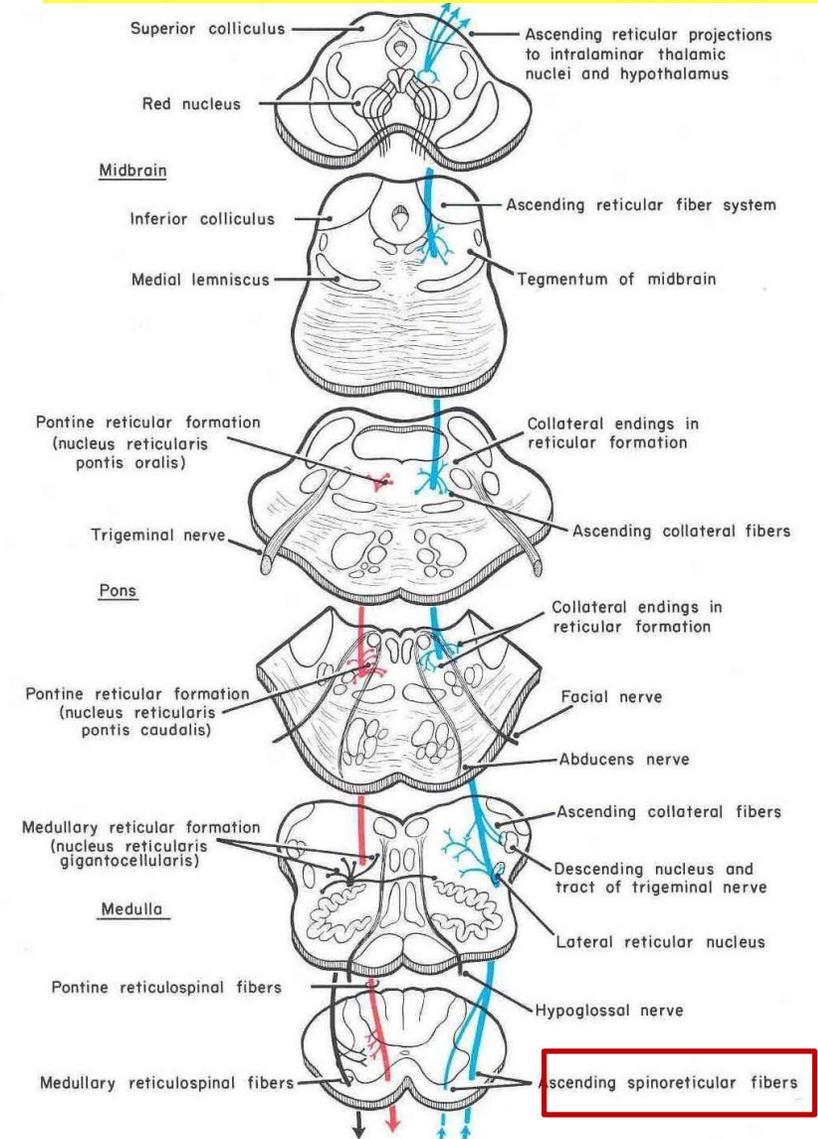
# مش جاي في الامتحان .. سكيب 🙄



# Spino-reticular Tract

😊 مش جاي في الامتحان .. سكيب #

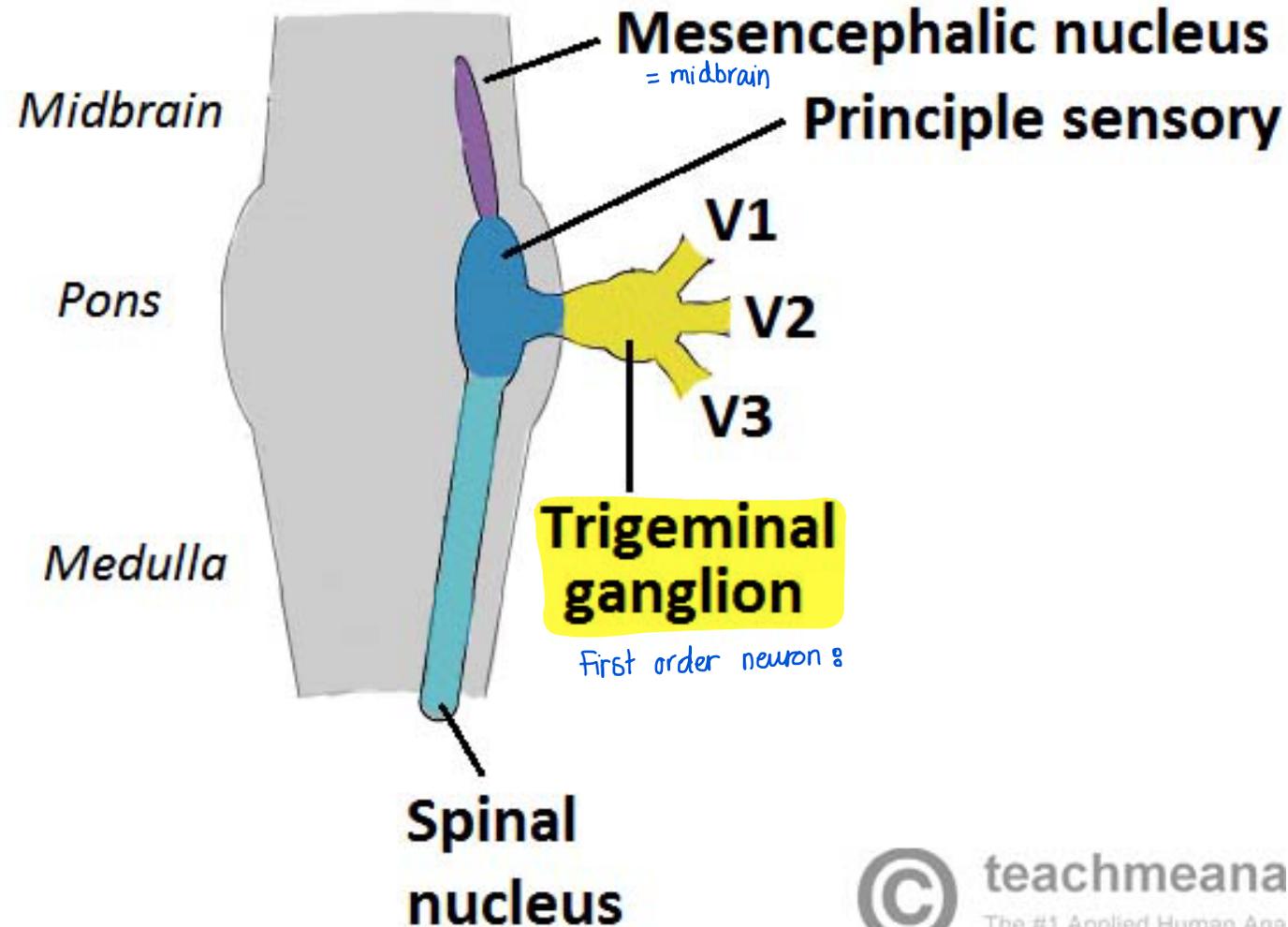
- Originates in the dorsal horn and ascend in the ventrolateral region of the cord.
- End in **medullary reticular formation** ----- > **pontine reticular formation**, finally to the thalamus; that activate the cerebral cortex
- Forms part of the ascending reticular activating system (RAS).
- Involved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

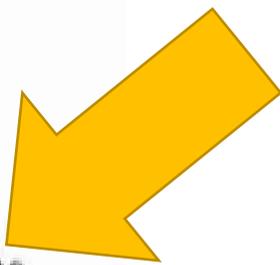
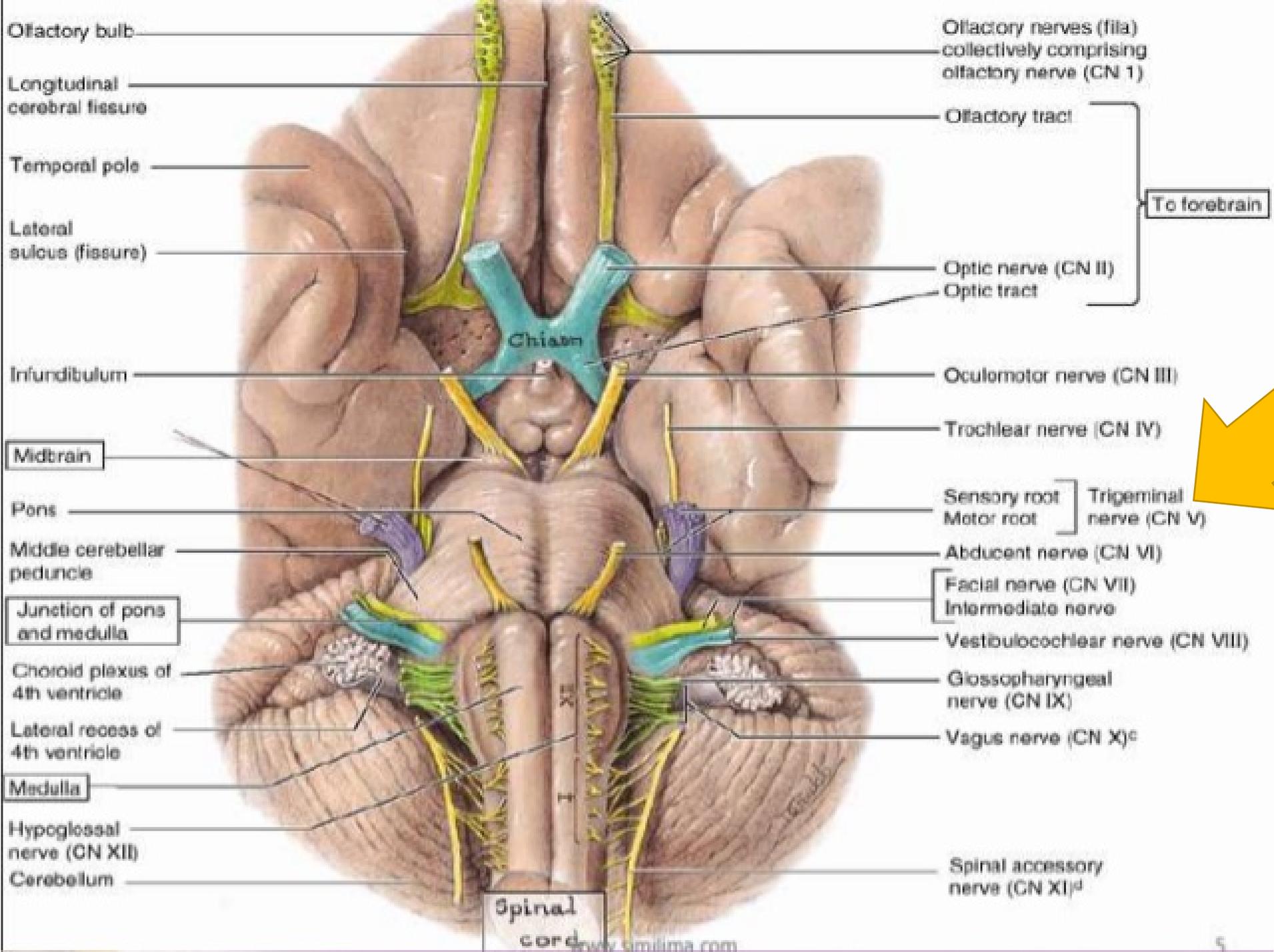


# Nuclei of trigeminal nerve

It has got 4 nuclei :

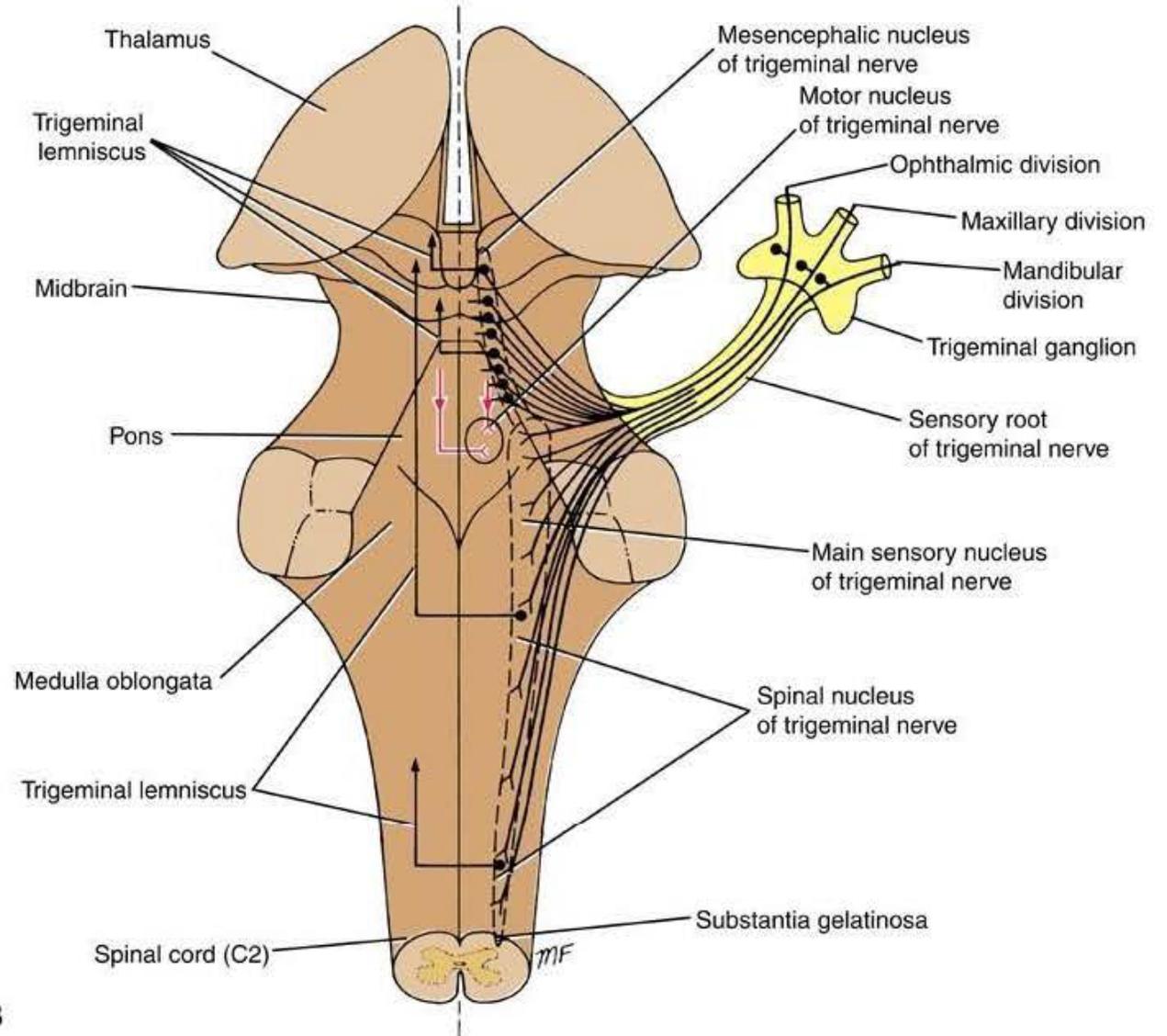
1. **Mesencephalic** nucleus: in midbrain.  
(proprioception)
2. **Main sensory** nucleus: in upper pons.  
(touch and pressure)
3. **Spinal nucleus**: in upper pons to C2  
segment of spinal cord.  
(pain and temperature)
4. **Motor** nucleus: in upper pons.





# Trigeminal Nerve Sensory Nuclei

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



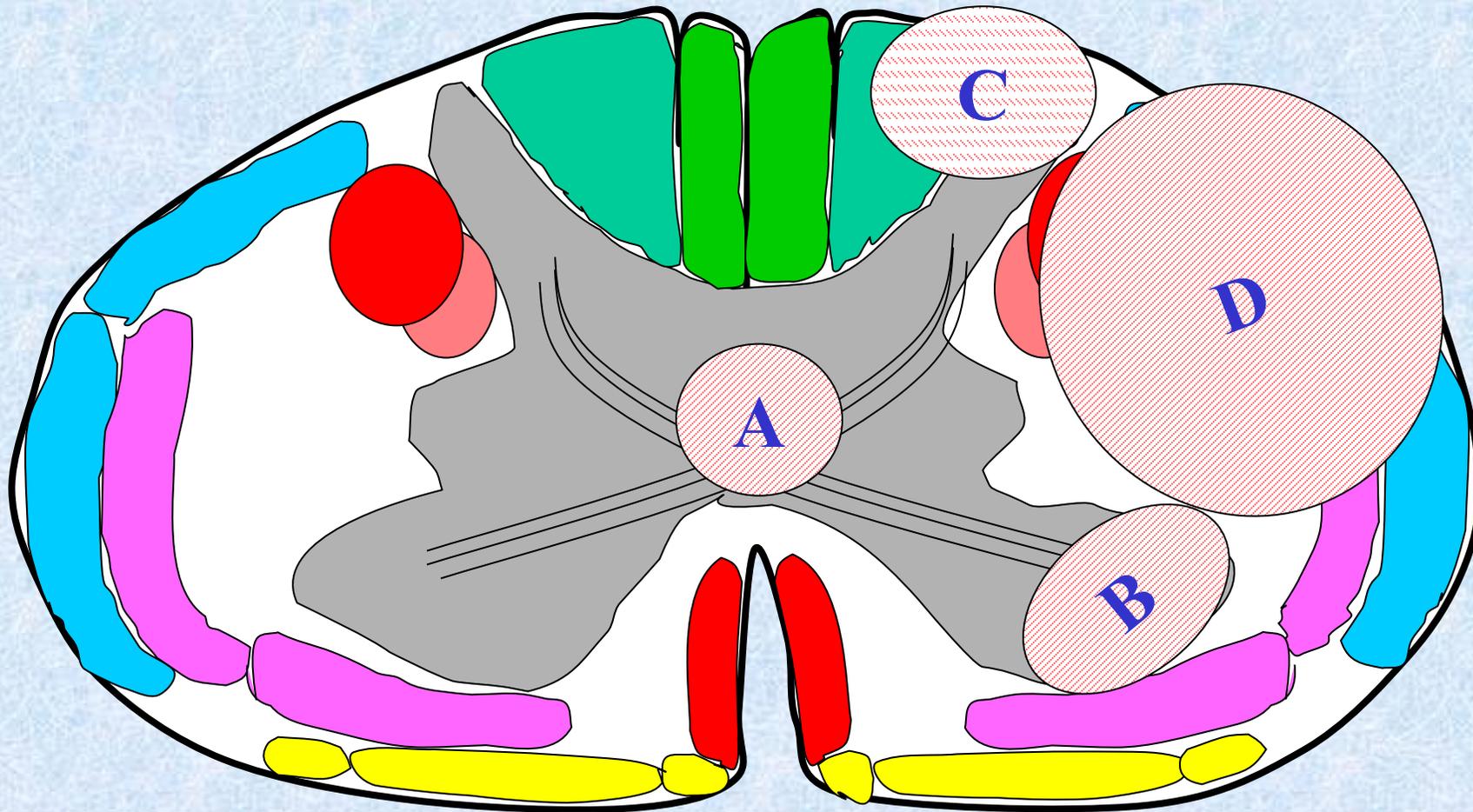
B

# Spinal cord lesions

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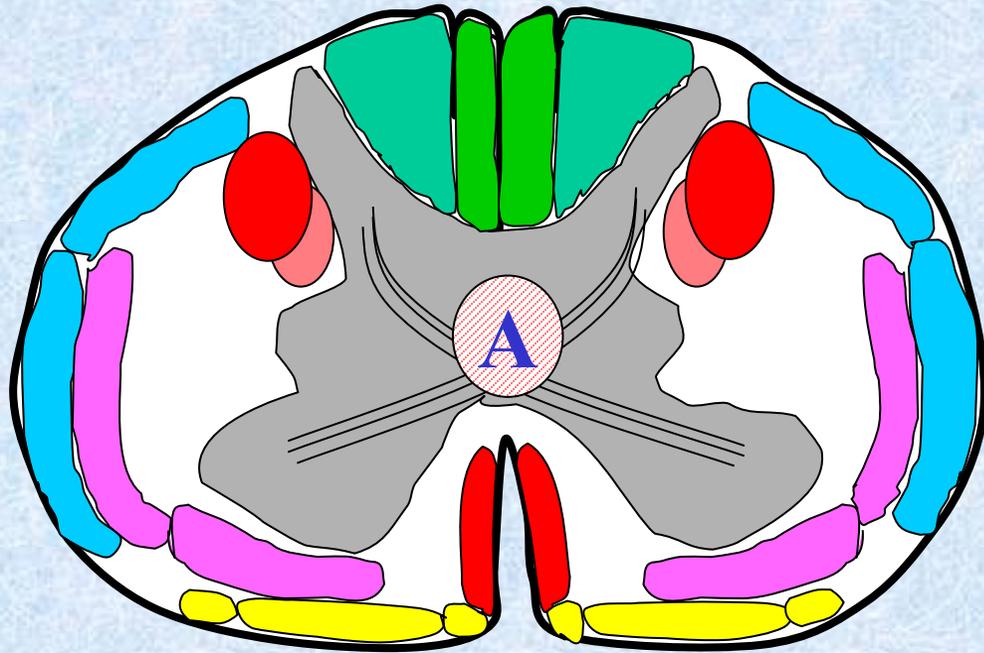


# Spinal cord lesions



Refer Clinical Medicine by Kumar & Clark's

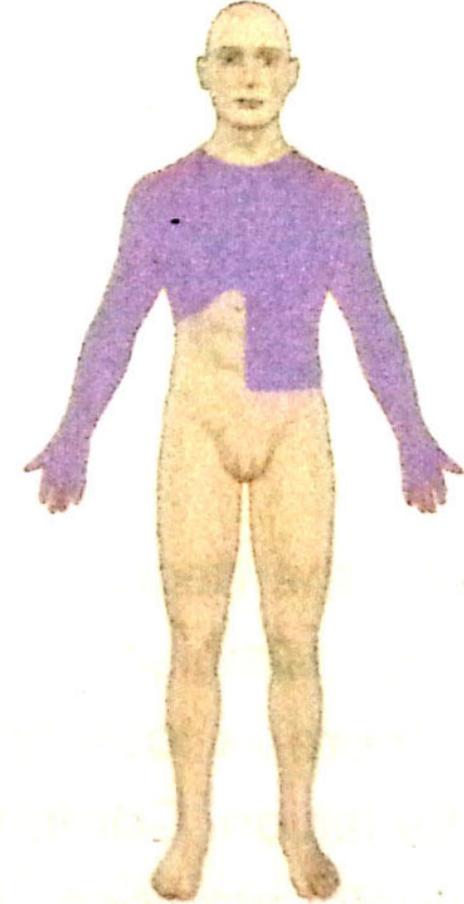
# A – Syringomyelia



## A – Syringomyelia

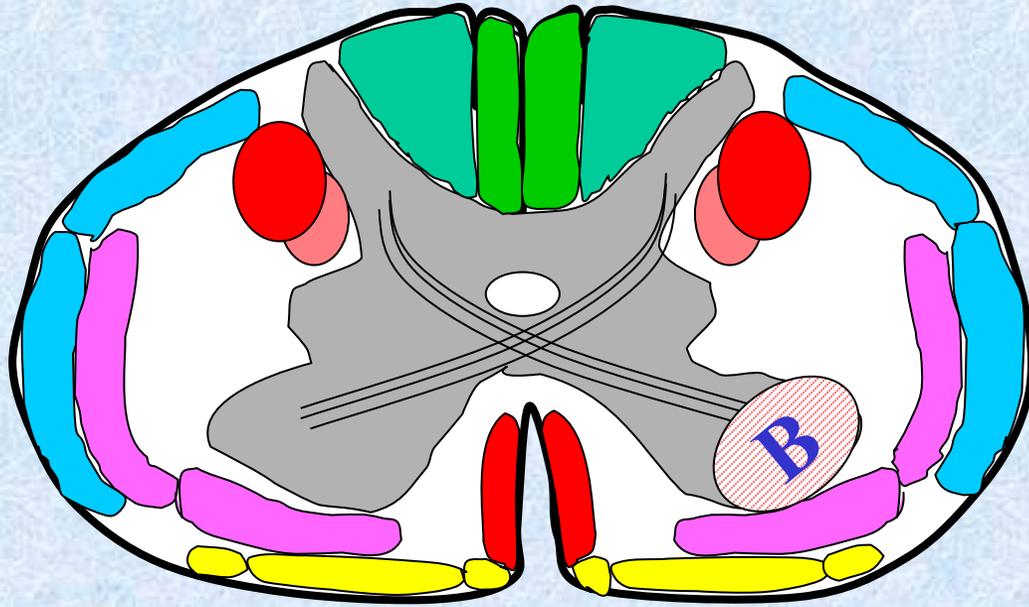
- The central canal becomes enlarged forming a cavity compressing the adjacent nerve fibers.
- Fibers serving pain and temperature are damaged as they decussate in the ventral white commissure close to the central canal causing selective loss of pain and temperature in the upper limbs (**dissociate sensory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

(c) Central cord



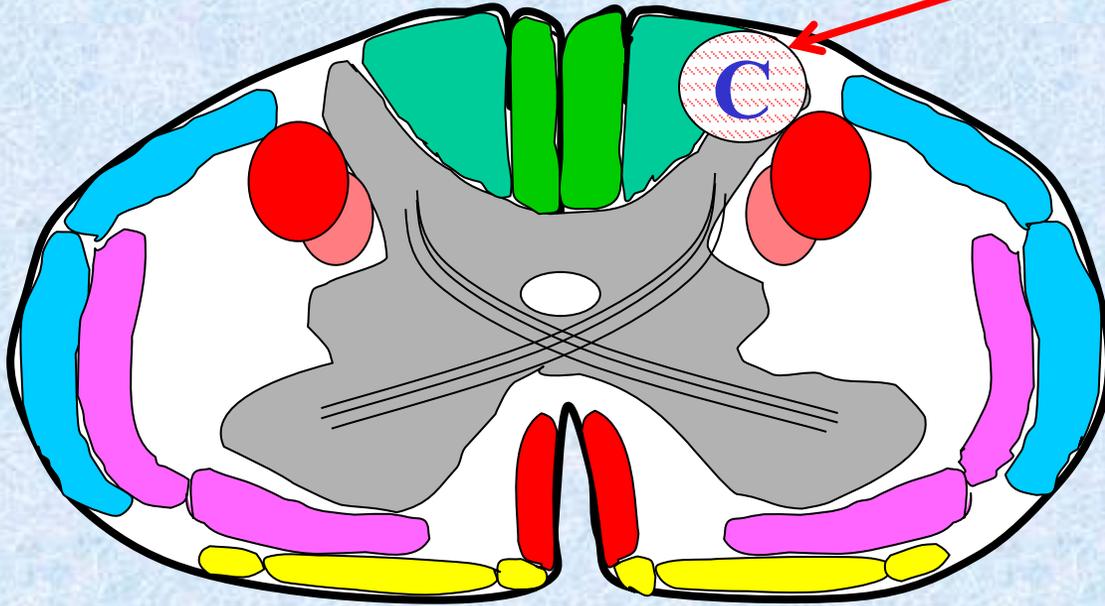
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## B – Poliomyelitis



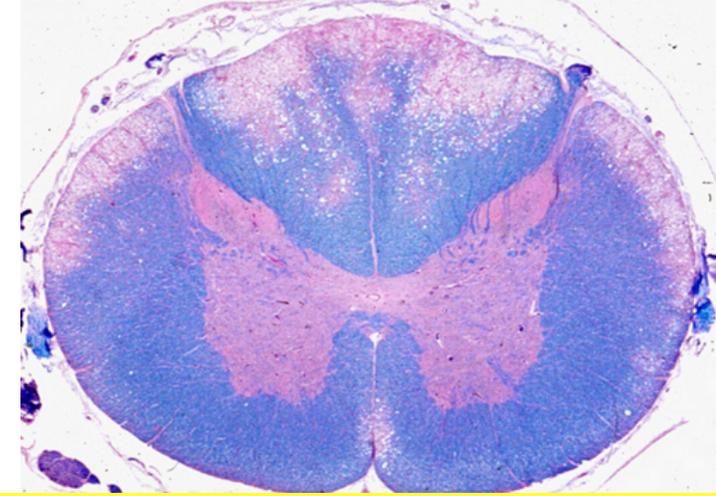
# C – Tabes dorsalis

Demyelination

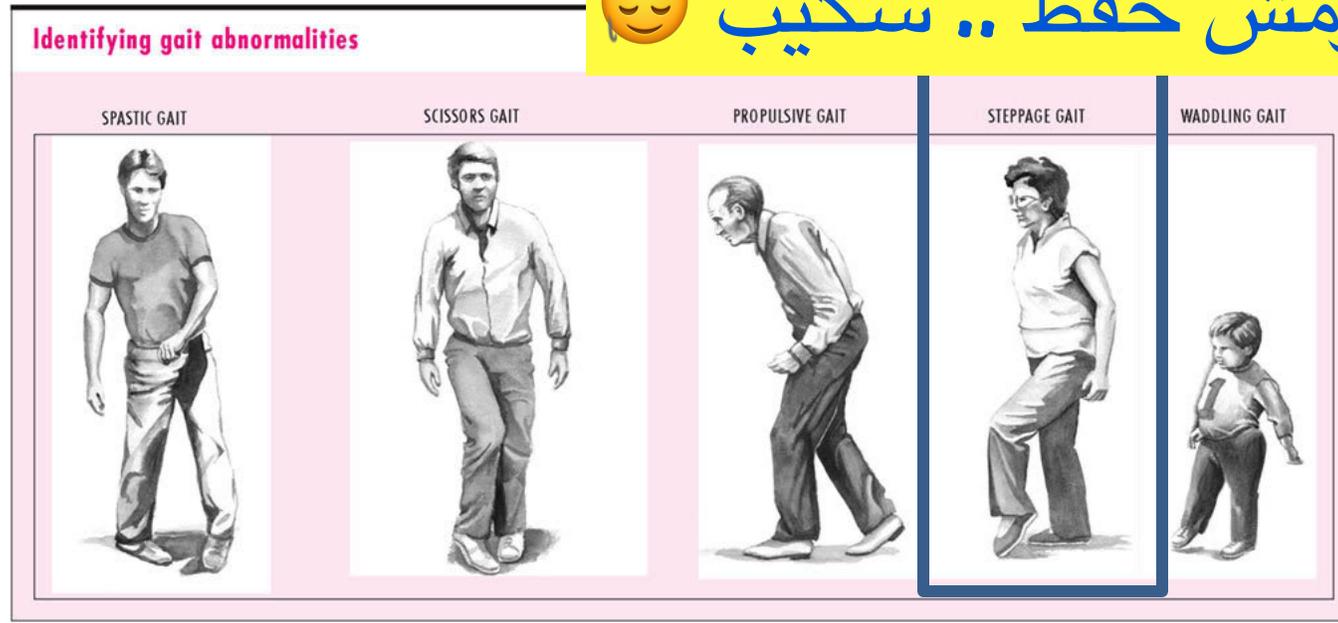


# Tabes Dorsalis

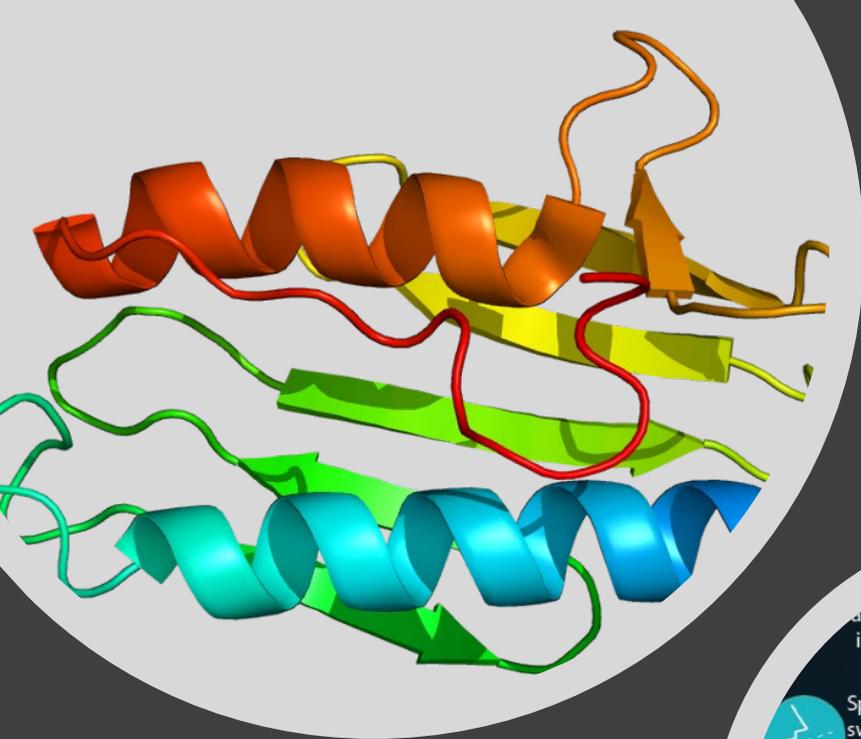
- A late manifestation of **syphilitic infection** on the CNS.
- Affects the **lumbosacral dorsal spinal roots and dorsal columns of the spinal cord**.
- Leads to **loss of proprioception** which is manifested by a **high Step** and **unsteady gait (stamping) (Sensory Ataxia)**



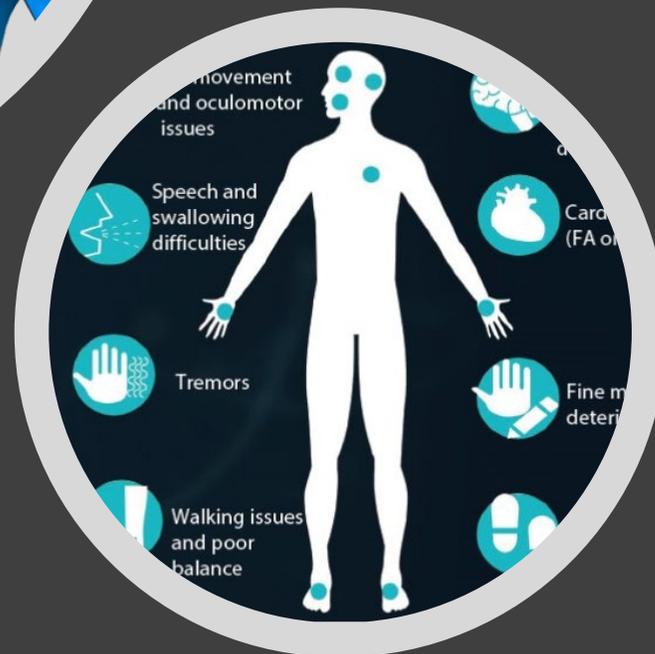
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## Lesion of the **Spino-cerebellar Tracts**



### **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



1- أي tract في المحاضرة مهم نعرف فيها:

- First order neuron
- Second order neuron
- Third order neuron
- Function

◆ MCQ : Which of the following tracts carrying proprioception from big toe?

◆ MCQ : Which of the following tracts carrying crude touch ?

2- بالنسبة لل Spinocerebellar tract:

• مش هيجي في الامتحان يسألك مين فيهم ال crossed ومين لا فيها.

◆ MCQ: Posterior (dorsal) spinocerebellum enter the cerebellum via: inferior cerebellar peduncle

◆ MCQ: Ventral (anterior) spinocerebellum enter the cerebellum via: superior cerebellar peduncle

◆ Spinocerebellar system consists of only two neurons ومهم نعرف هما مين

◆ MCQ: Unconscious proprioception reach: cerebellum and carried by: spinocerebellar tract

◆ MCQ: Conscious proprioception reach: cerebrum and carried by: gracile and cuneate tract

3- بالنسبة لل Spinotectal, Spinoolivary and spinoreticular مش جايين في الامتحان

4- ال Spinal cord lesions للاطلاع بس ومش حفظ

