

# Sensory Tract

Lecture (3)

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هذا العمل مبني بشكل أساسي على عمل دفعة ٤٣٦ مع المراجعة والتدقيق وإضافة الملاحظات ولا يغني عن المصدر الأساسي للمذاكرة

- **Important**
- **Doctors Notes**
- Notes/Extra explanation

{وَمَنْ يَتَوَكَّلْ عَلَى اللَّهِ فَهُوَ حَسْبُهُ}

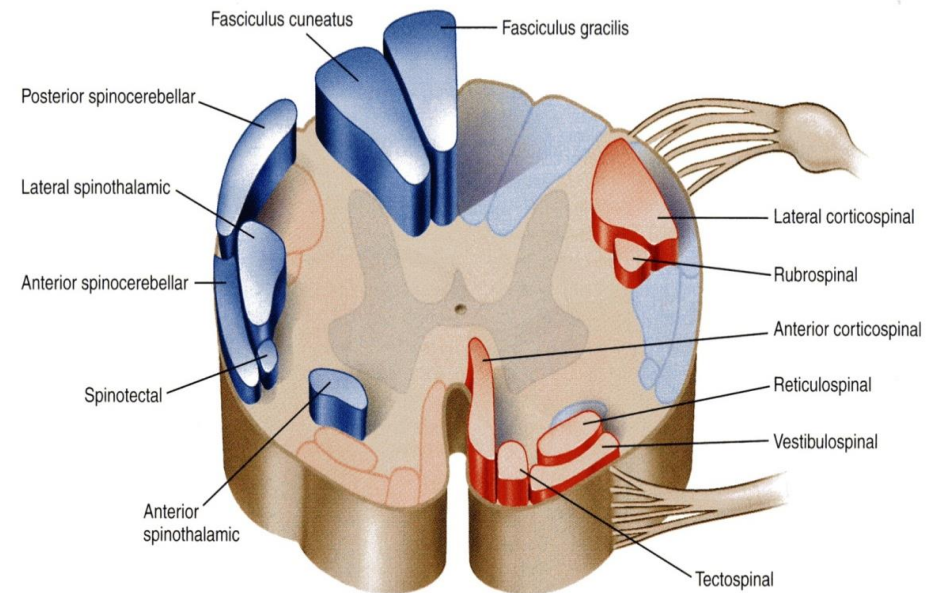
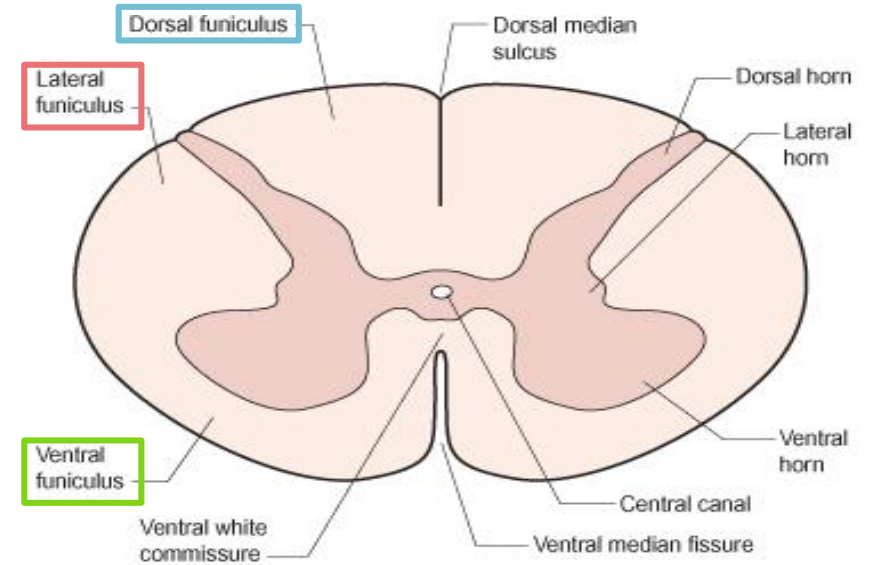
# ■ Objectives

**At the end of the lecture, students should be able to:**

- ✓ Define the meaning of a tract.
- ✓ Distinguish between the different types of tracts.
- ✓ Locate the position of each tract.
- ✓ Describe the sensory pathway.
- ✓ Identify the different sensory spinal tracts and their functions.
- ✓ Identify the course of each of these tracts.
- ✓ Know some associated lesions regarding the main tracts.

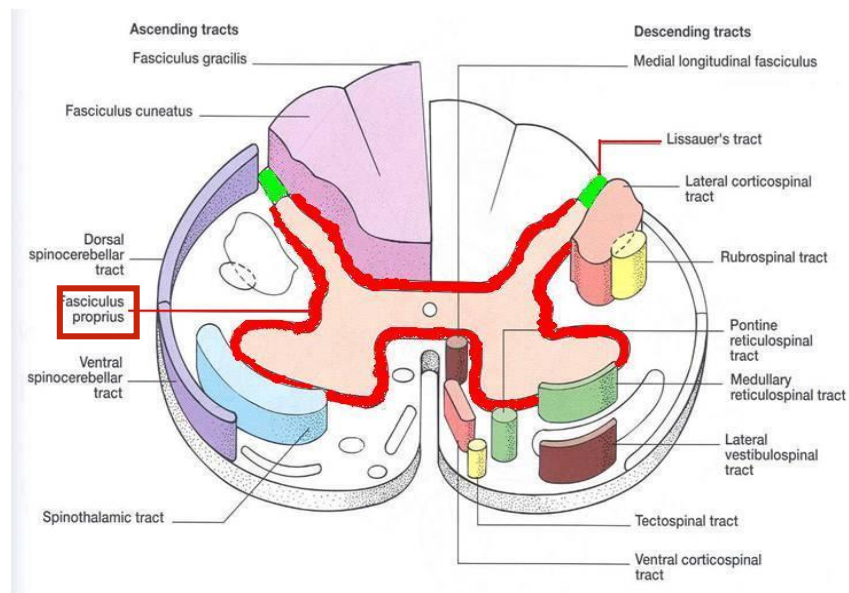
- The **grey matter** of the spinal cord is completely surrounded by the white matter
- The **white matter** of the spinal cord consists of **Ascending** and **Descending** Nerve Fibers.
- It is divided into **Dorsal**, **Lateral** & **Ventral** Columns or Funiculi.
- **White matter tracts:** bundles or fasciculi of fibers that occupy more or less definite positions in the white matter.
- They have the same Origin, Termination and carry the same Function.

Inside CNS → Tract  
 Outside CNS → Nerve



# White matter tracts are classified into: (according to length)

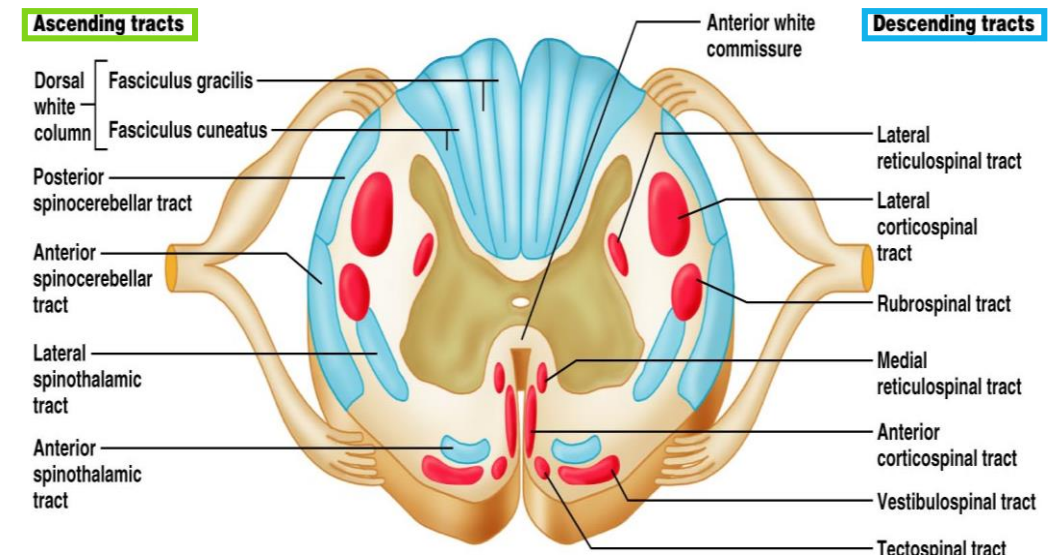
1. Short Tracts; intersegmental or propriospinal.
  - Fibers occupy narrow band immediately peripheral to the grey matter (fasciculus proprius).
  - They interconnect adjacent or distant spinal segments and permit **intersegmental coordination**. (they do not reach the brain)



2. Long Tracts; divided according to function into:
  - (a) Ascending (sensory or afferent).
  - (b) Descending (motor or efferent).

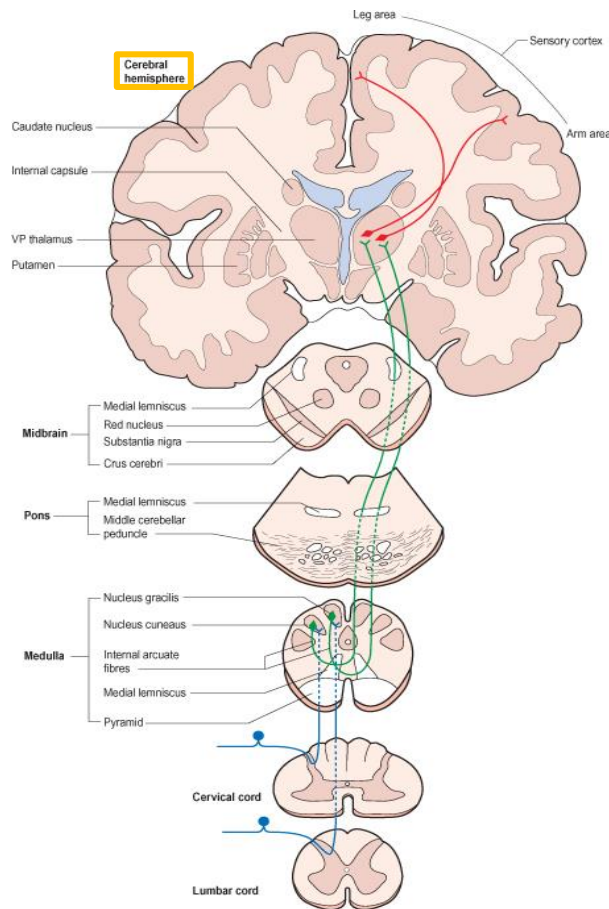
They serve to join the **brain** to the spinal cord.

Note: In this lecture we will only discuss the ascending tracts



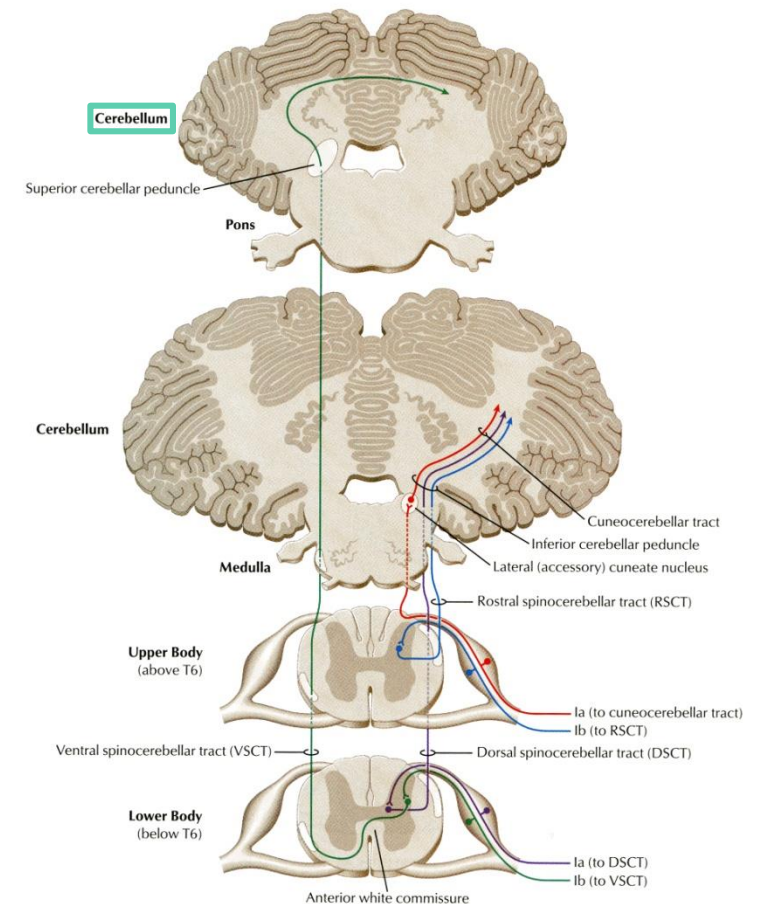
# Ascending Tracts;

- 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** (e.g at the cerebellum).



There are 2 types of sensation:

1. At the **conscious level** (which we feel): these sensations reach the cerebral cortex.
2. At the **subconscious level** (we can't identify): the sensations only reach the cerebellum.





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

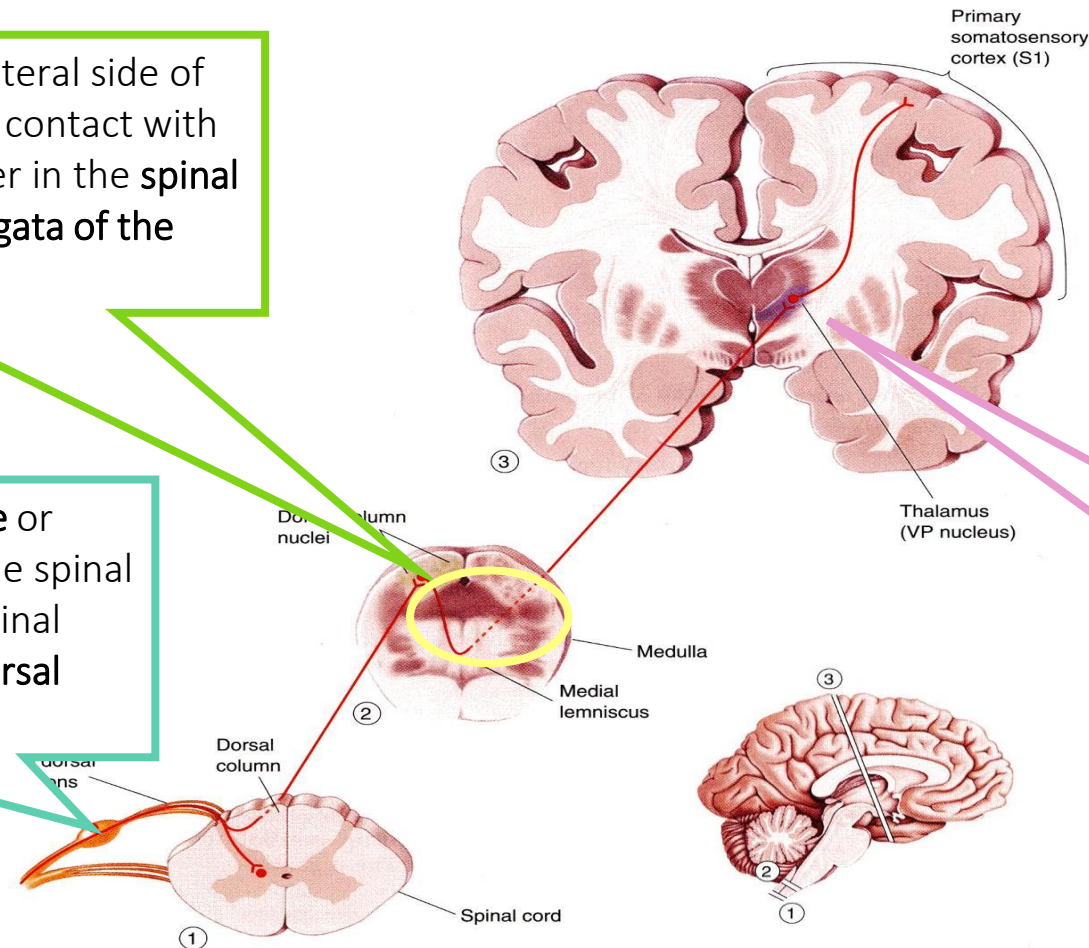
- There is a sequence of **Three Neurones** between the peripheral receptors and the cerebral cortex.  
(for the information/signal to reach the brain it has to relay/synapse in 3 neurons)

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

1 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**.

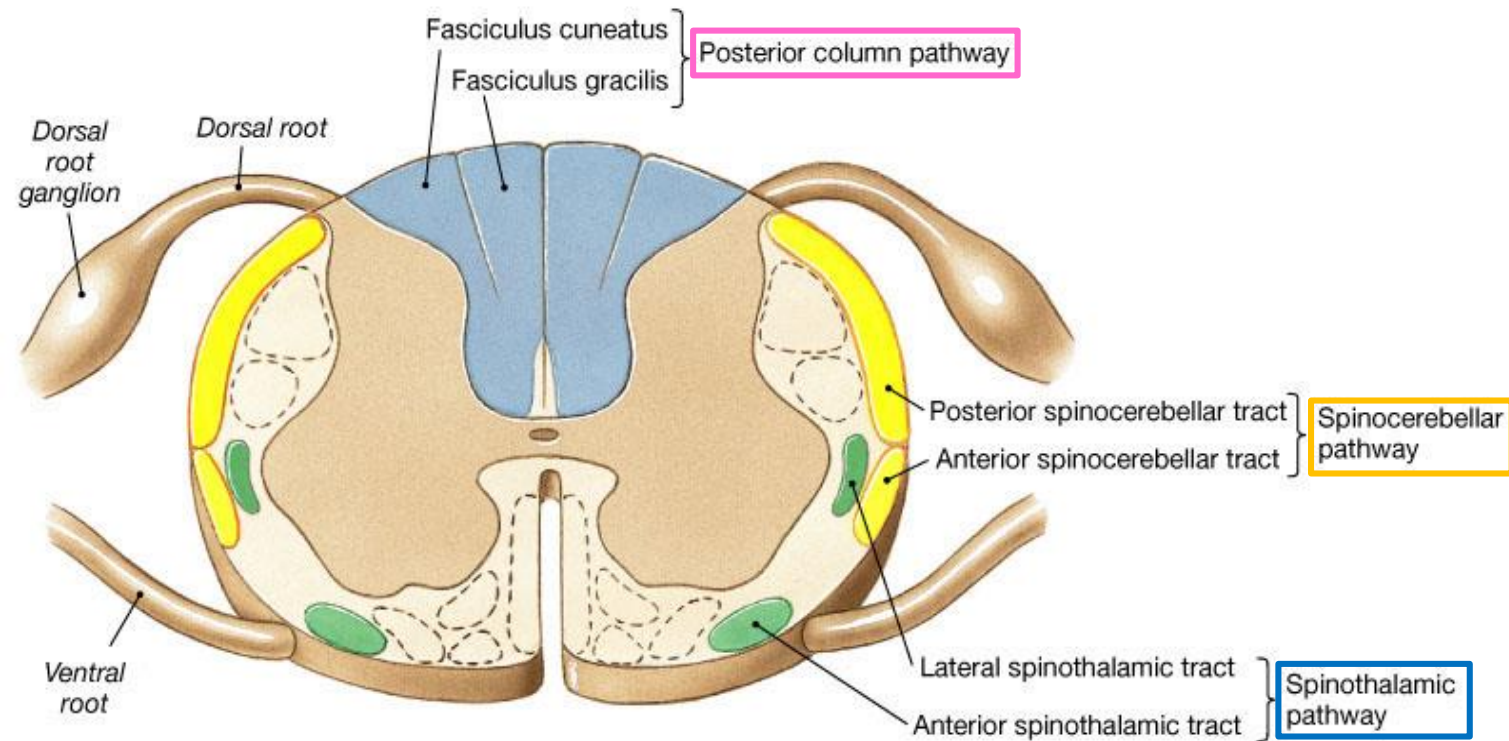
The axon of the **second order neurone** crosses over (**decussates**) to the opposite side of the CNS and ascends to the thalamus, where it terminates.

- 3
- 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.



## Three major\* pathways carry sensory information:

1. Dorsal (Posterior) column (divided into Gracile & Cuneate fasciculi) → Carry **conscious** sensation therefore they will follow the same pathway we discussed in the previous slide
2. Anterolateral pathway (Spinothalamic) **ventral & lateral** →
3. Spinocerebellar pathway **dorsal & ventral** | Carries **subconscious** sensation.



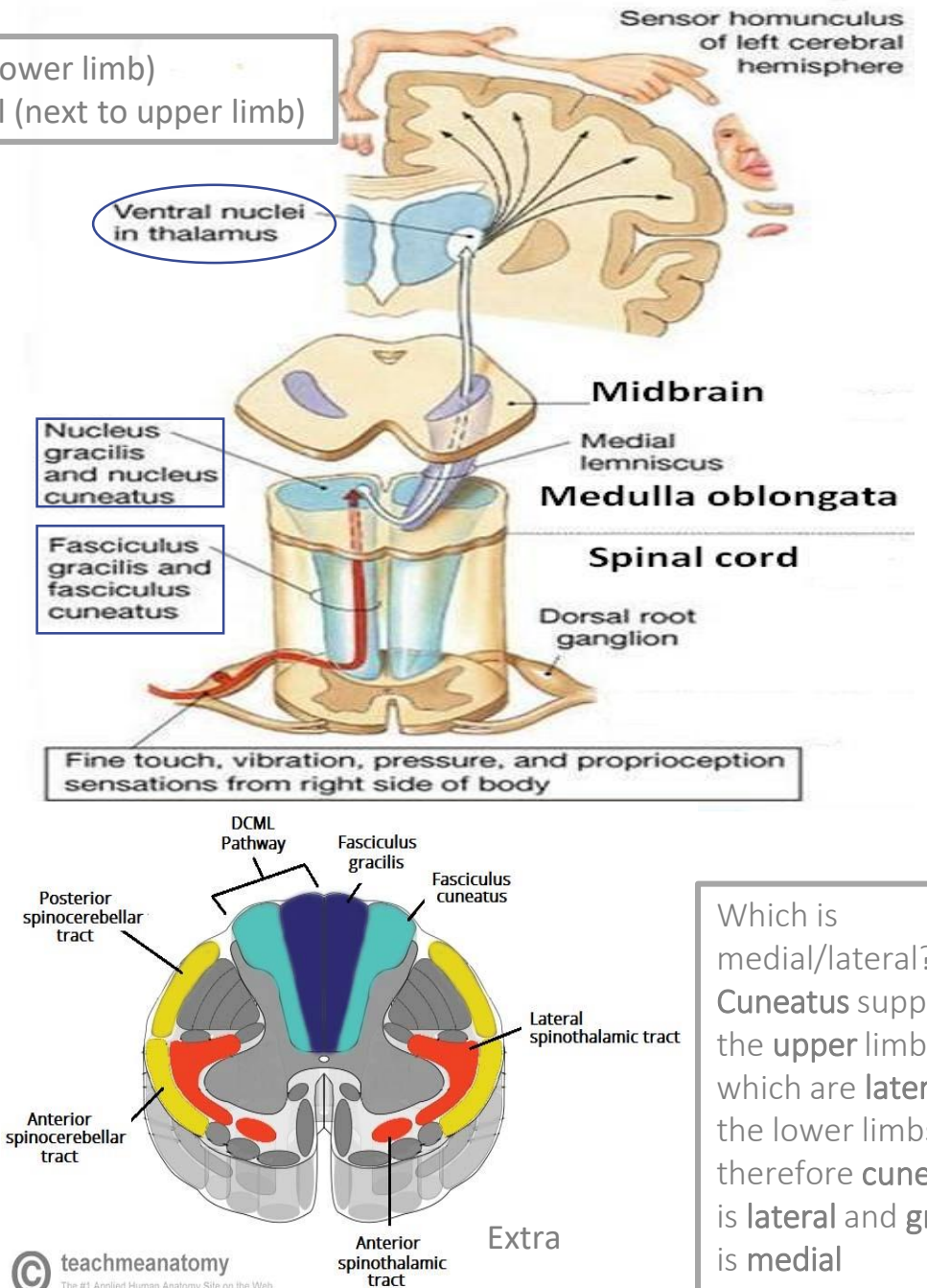
\*We will also discuss 3 minor ways: spinotectal, spino-olivary, and spinoreticular.

# 1. Dorsal Column

- Contains two tracts;
  - Fasciculus Gracilis (FG) &
  - Fasciculus Cuneatus (FC)
- Carry impulses concerned with proprioception (movement and joint position), discriminative touch (fine touch) from **ipsilateral\* side** of the body.\*
- Contain the axons of primary afferent neurons that have entered cord through dorsal roots of spinal nerves.
- Gracilis and cuneate have the same function, and travel in the same pathway but receive fibers from **different segments of the spinal cord**:
  - **Fasciculus Gracilis** contains fibers that are received at sacral, lumbar and lower thoracic levels,
  - **Fasciculus Cuneatus** contains fibers that are received at upper thoracic and cervical levels.

\*There is variation in this point between boys and girls slides, This is the correct information according to Dr. Jameela and Dr. Essam

Gracilis → Ground (lower limb)  
Cuneatus → Cervical (next to upper limb)

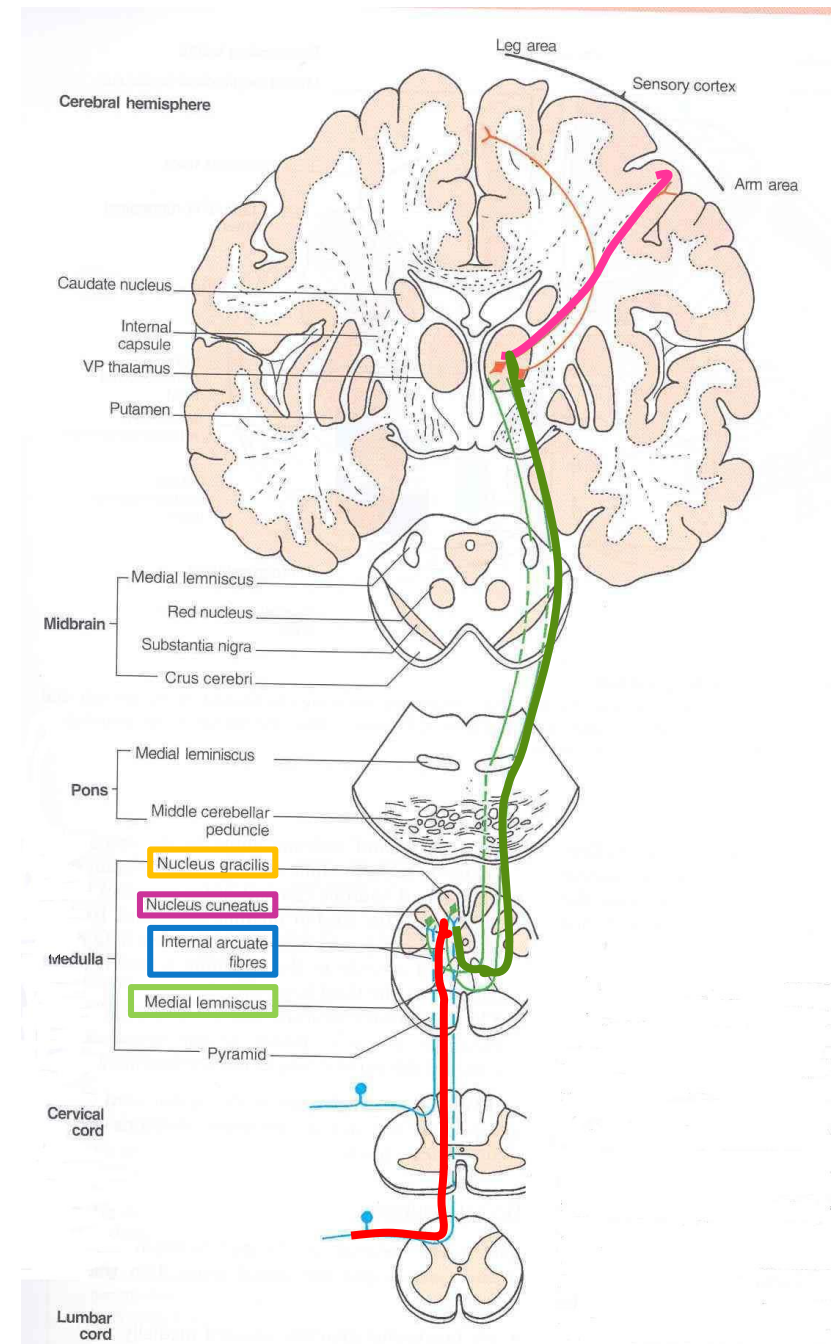


Which is medial/lateral?  
 Cuneatus supplies the upper limbs which are lateral to the lower limbs therefore cuneatus is lateral and gracilis is medial



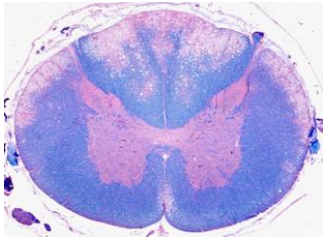
# 1. Dorsal Column

- The primary afferent neurons relayed to the 1<sup>st</sup> order neurons in the dorsal root ganglion.
- Fibers of the first order neurons ascend without interruption where they terminate upon 2nd order neurons in nucleus gracilis and nucleus cuneatus (in the medulla).
- The axons of the 2nd order neurons decussate in the medulla as internal arcuate fibers and ascend through the brain stem as Medial Lemniscus.
- The medial lemniscus terminates in the **ventral posterior nucleus of the thalamus** (3rd order neurons) which project to the somatosensory cortex (thalamocortical fibers)

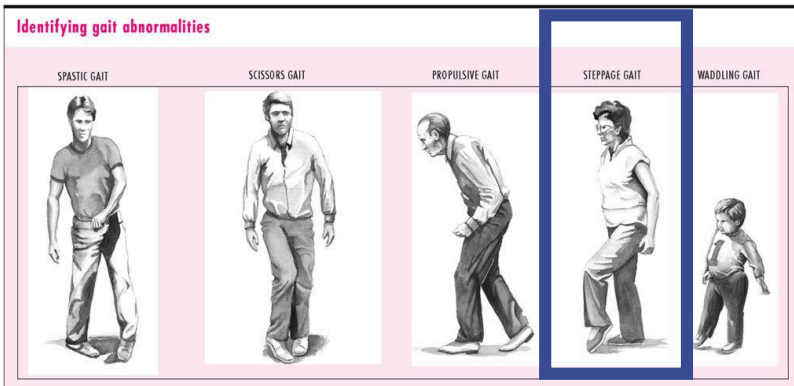


## Tabes Dorsalis

- 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 Page** and **unsteady gait** (Sensory Ataxia). **عدم اتزان بالمشي**



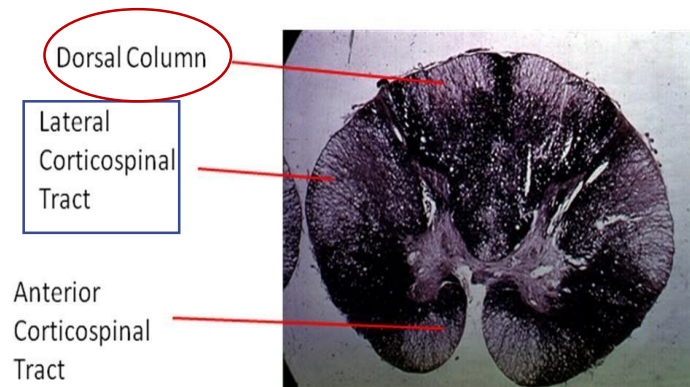
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## Subacute Combined Degeneration of the spinal cord

- A systemic disease results from B12 deficiency
- It produces **Sensory Ataxia**
- **Lateral columns** are also affected (combined) causing **weak and spastic limbs**
- It is completely recovered by proper treatment with B12 .

### Subacute Combined Degeneration



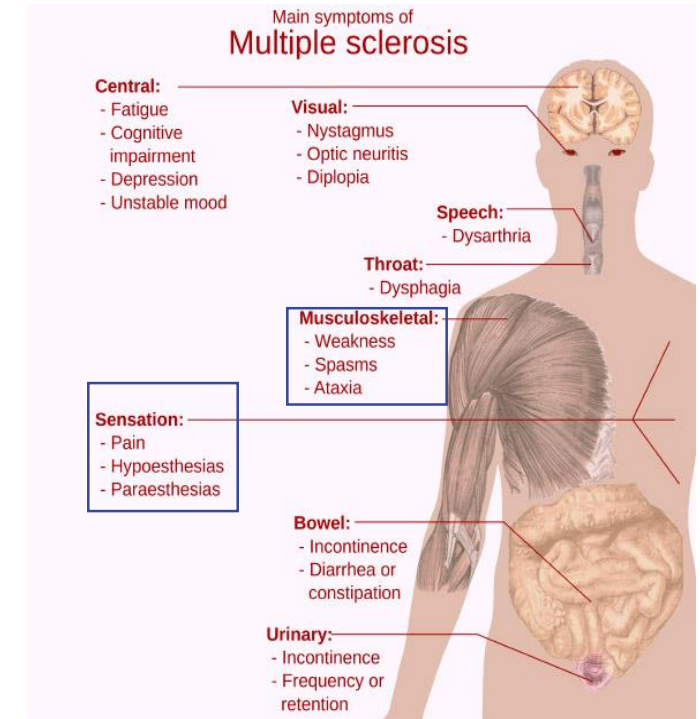
## Multiple Sclerosis

التصلب اللويحي



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- An immune disease affects specifically **fasciculus Cuneatus** of the cervical region. Leads to **loss of proprioception in hands and fingers** (Asteriognosis) **lose of fine touch**



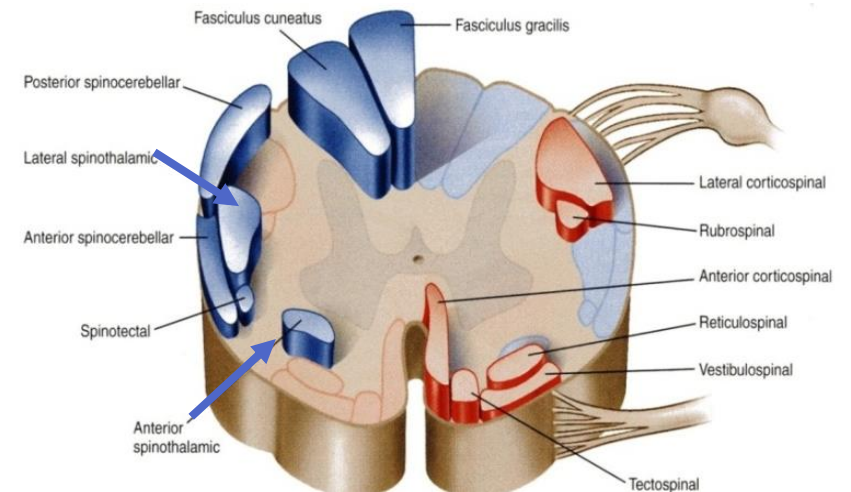
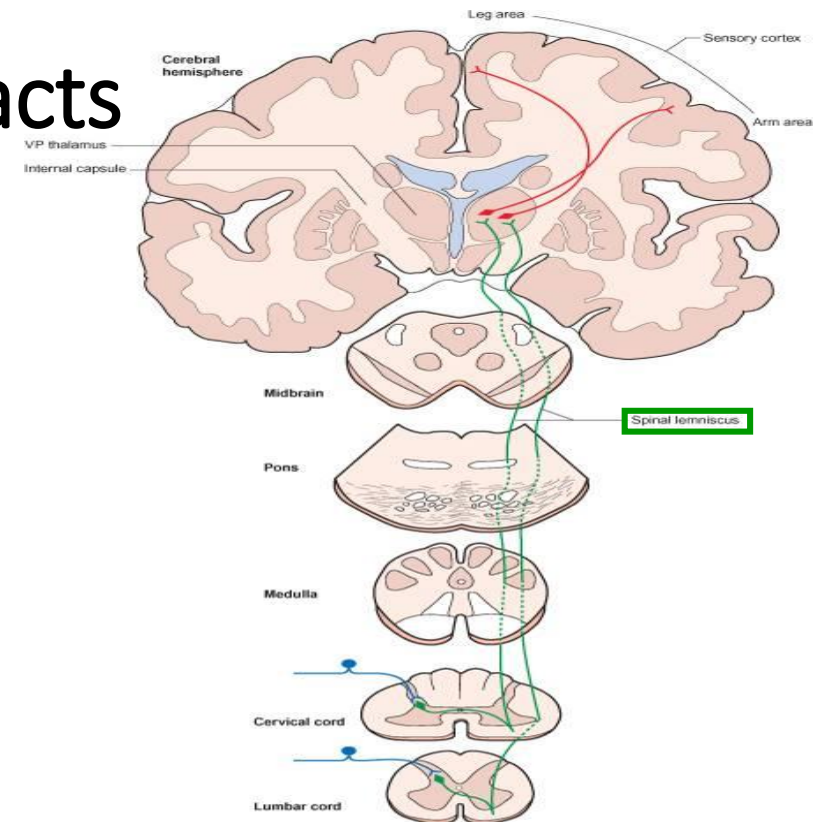
## 2. Spinothalamic (anterolateral) Tracts

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

\***ipsilateral**: on the same side of the body.

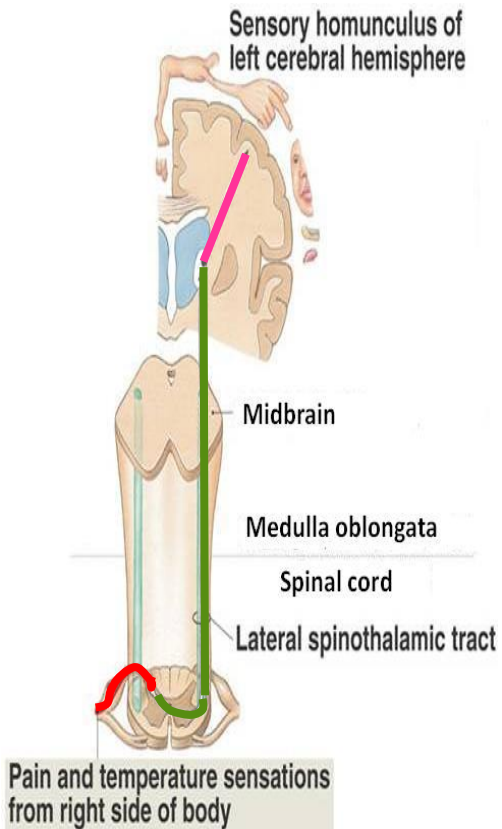
**contralateral**: on the opposite side of the body.

\*There is variation in this point between boys and girls slides, This is the correct information according to Dr. Jameela and Dr. Essam

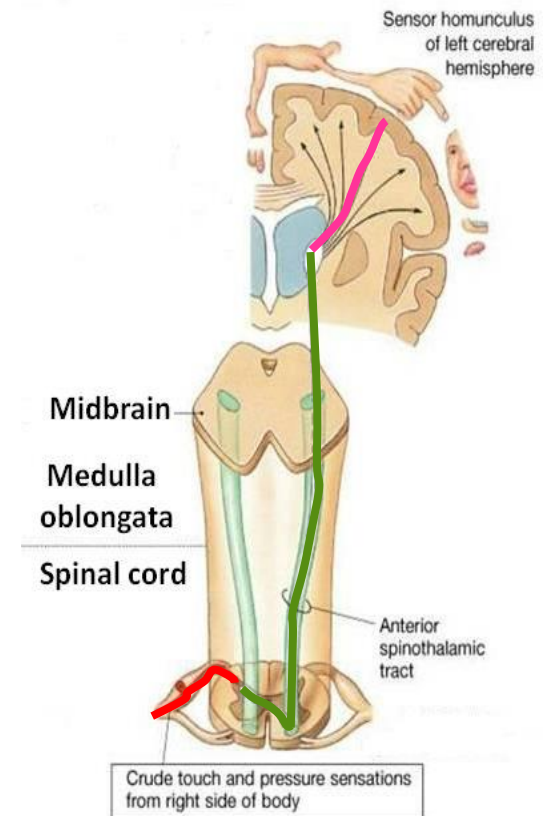




## 2. Spinothalamic (anterolateral) Tracts



Lateral Spinothalamic Tract		Anterior Spinothalamic Tract
Carries pain & Temperature to thalamus and sensory area of the cerebral cortex.	Function	Carries crude touch (non discriminative) & pressure to thalamus and sensory cortex.
<b>Neurone I:</b> Small cells in the dorsal root ganglia.	Neurons: 3 Neurones	<b>Neurone I:</b> Medium sized cells in the dorsal root ganglia.
<b>Neurone II:</b> Cells of substantia gelatinosa of Rolandi in the posterior horn.		<b>Neurone II:</b> Cells of main sensory nucleus or (nucleus proprius).
<b>Neurone III:</b> Cells of (VP*) nucleus of the thalamus.		<b>Neurone III:</b> Cells of VP* nucleus of thalamus.



Fibers arising from Substantia Gelatinosa & Nucleus Proprius decussate in the **Anterior White Commissar** and ascend as **Spinal Lemniscus**

\* The lateral & ventical Spinothalamic tract when they ascend together we call the Spinal lemniscus

\*Ventral Posterior



## 2. Spinothalamic (anterolateral) Tracts Lesions

- It is selectively damaged in **Syringomyelia**
- The central canal becomes enlarged forming a cavity compressing the adjacent nerve fibres
- Fibres 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**)
- Light touch and proprioceptive sensations are retained.
- Joints of the limbs become disorganized without discomfort (**Charcot's joint**). (the joint looks misshapen but does not cause pain)

The ventral commissure is close to the central canal. So when the central canal enlarges it presses on the fibers passing through it.

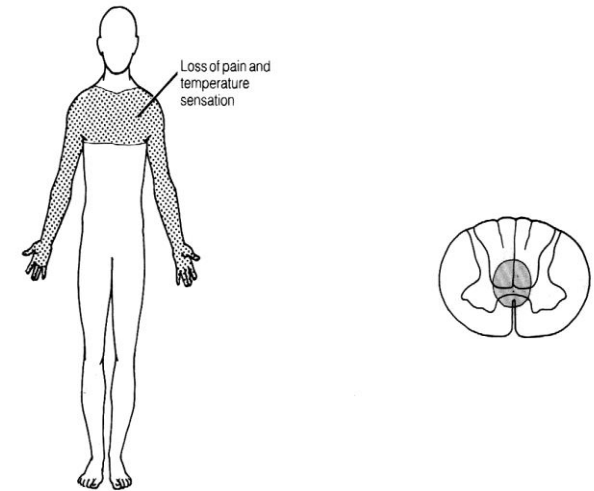
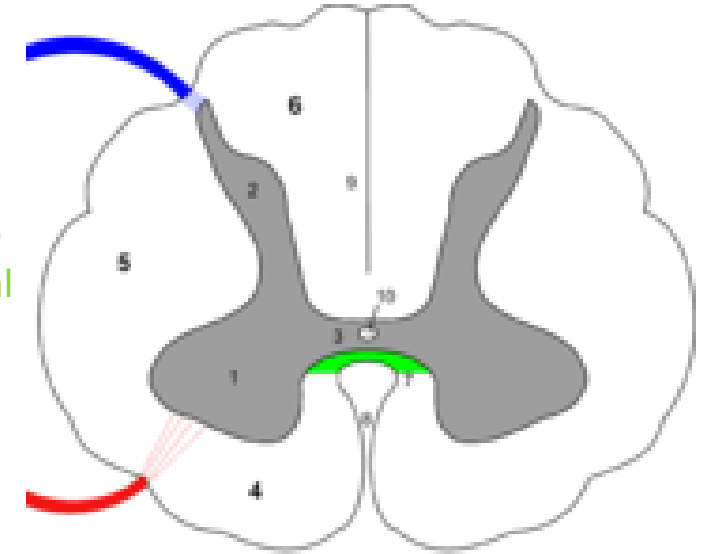
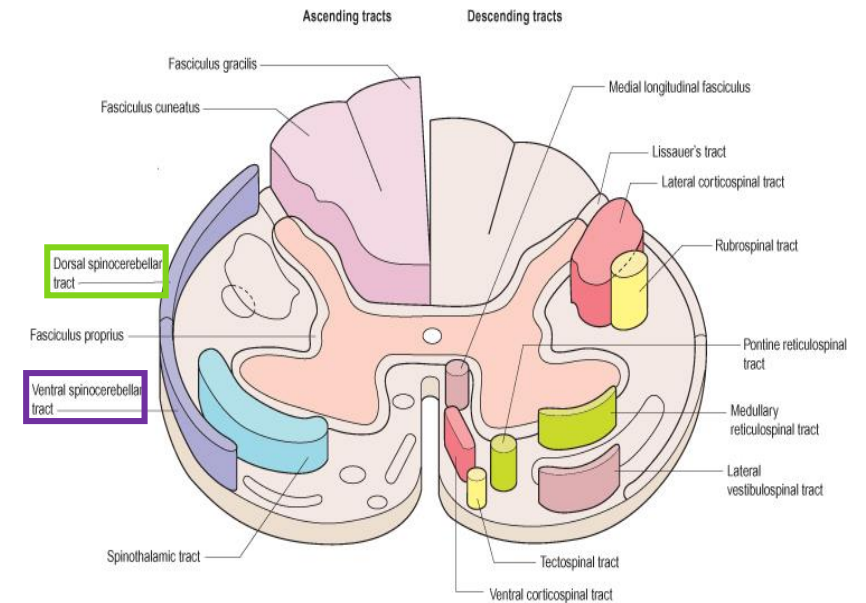


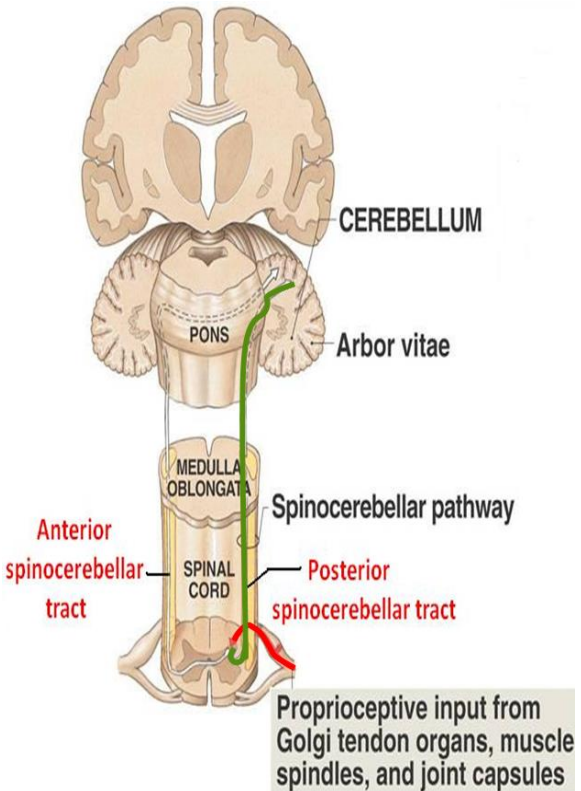
Figure 5-17. Syringomyelia involving the cervicothoracic portion of the spinal cord.

# 3. Spinocerebellar Tracts

- The Spinocerebellar system consists of a sequence of **only two neurons**;
  - **Neurone I:** Large cells of dorsal root ganglia.
  - **Neurone II:** cells of the nucleus dorsalis; **Clark's nucleus** (column) . Carry information to lateral side
- **Two tracts: Dorsal & Ventral**
- Located near the dorsolateral and ventrolateral surfaces of the cord
- Contain axons of the second order neurons
- Carry information derived from muscle spindles, Golgi tendon and tactile receptors to the cerebellum for the control of posture and coordination of movements.  
(it is responsible for subconscious sensations)



# 3. Spinocerebellar Tracts

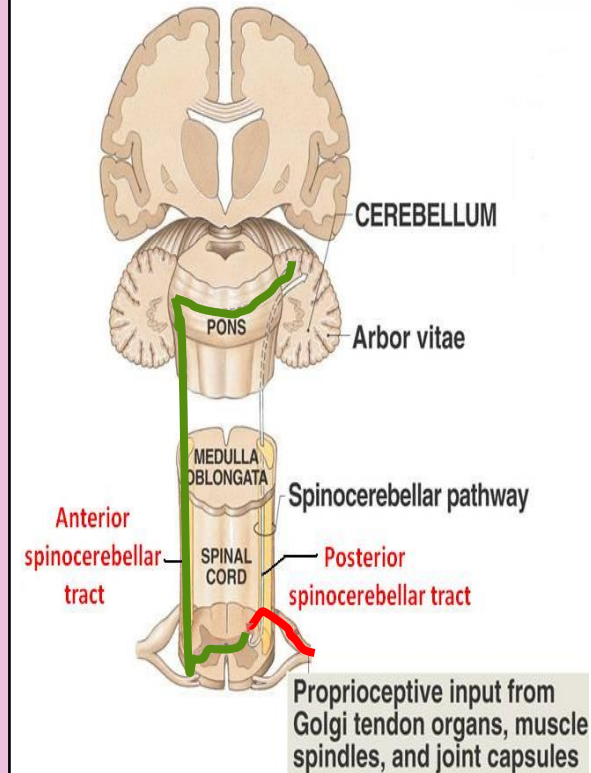


## Posterior (Dorsal) Spinocerebellar Tract

- Present only above level L3
- The cell bodies of 2nd order neuron lie in **Clark's column**
- Axons of 2nd order neuron terminate **ipsilaterally (uncrossed)** in the cerebellar cortex by entering through the **inferior cerebellar peduncle**.
- **Posterior spinocerebellar tract convey sensory information to the same side of the cerebellum**

## Ventral (Anterior) Spinocerebellar Tract

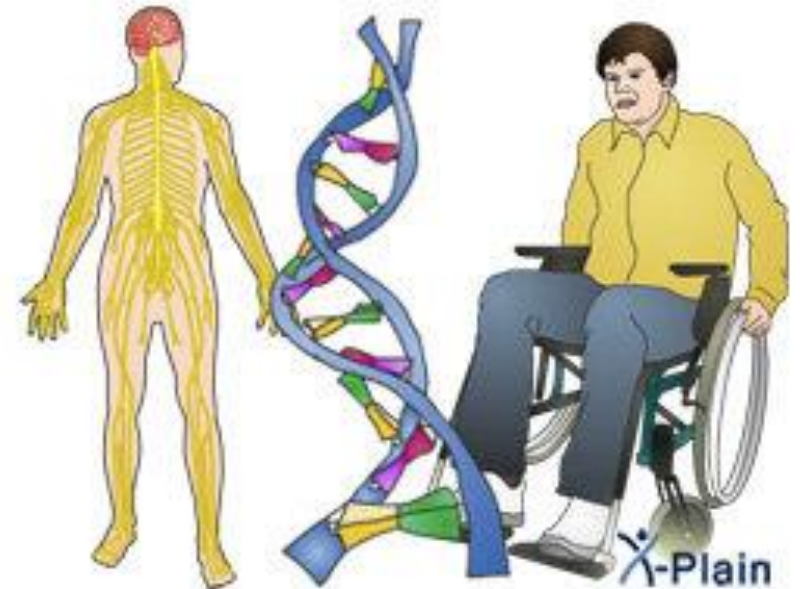
- The cell bodies of 2nd order neuron lie in base of the dorsal horn of the **lumbosacral** segments
- Axons of 2nd order neuron **cross to opposite side**, ascend as far as the midbrain, and then make a sharp turn caudally (the fibers **cross the midline for the second time**) and enter the **superior cerebellar peduncle** to terminate in the cerebellar cortex
- So Ventral spinocerebellar tract conveys sensory information to the **same side** of the cerebellum



# 3. Spinocerebellar Tracts Lesions

Friedrichs ataxia = (ataxia = gait)

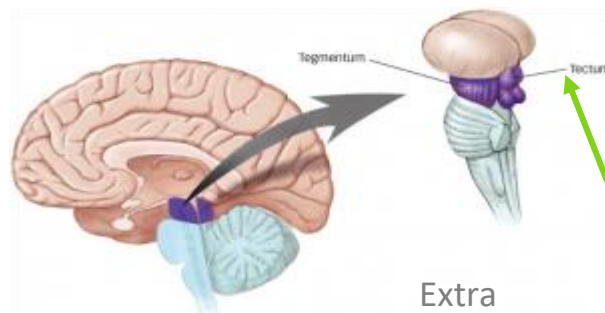
- An inherited degenerated disease
- Affecting the spinocerebellar tracts
- Leading to **incoordination of arms, intense tremor, wide base reeling gait ataxia**
- It begins in child hood
- Wheelchair is bound by 20 years of age



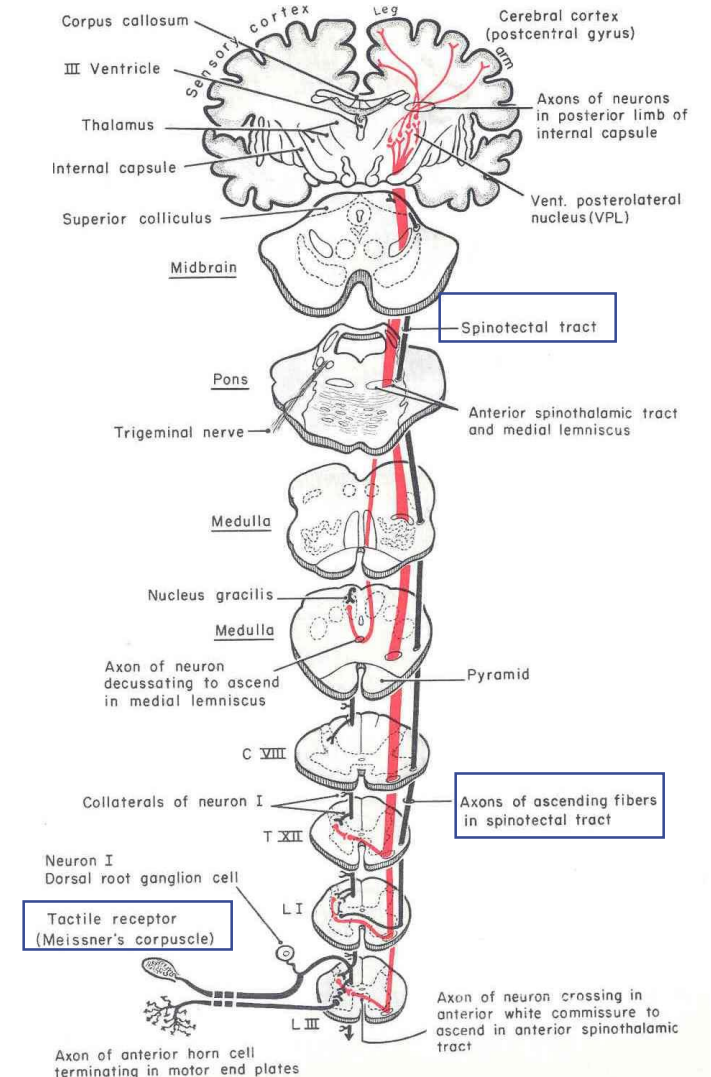


# Spinotectal Tract

- Ascends in the **anterolateral** part, in close association with spinothalamic system.
- 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 **periaquiductal gray matter** and **superior colliculus** in the midbrain.
- Involved in reflexive turning of the head and eyes toward a point of cutaneous stimulation.

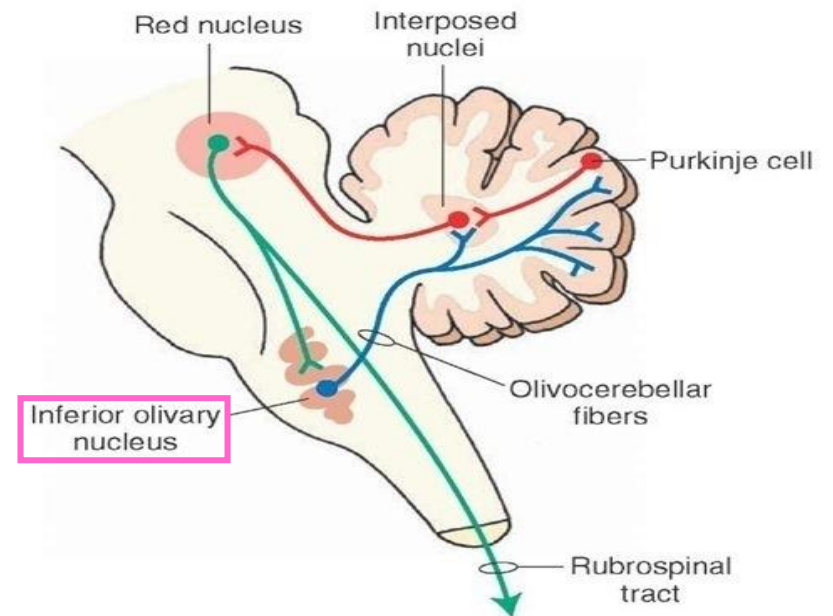
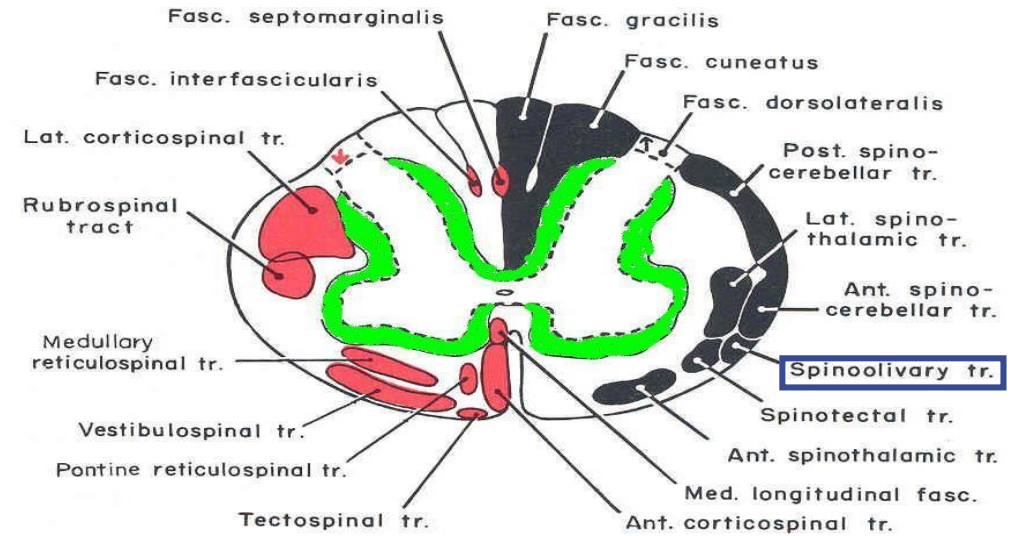


Spinotectal: the fibers travel from the spine (spino-) to a region in the midbrain called tectum (-tectal)



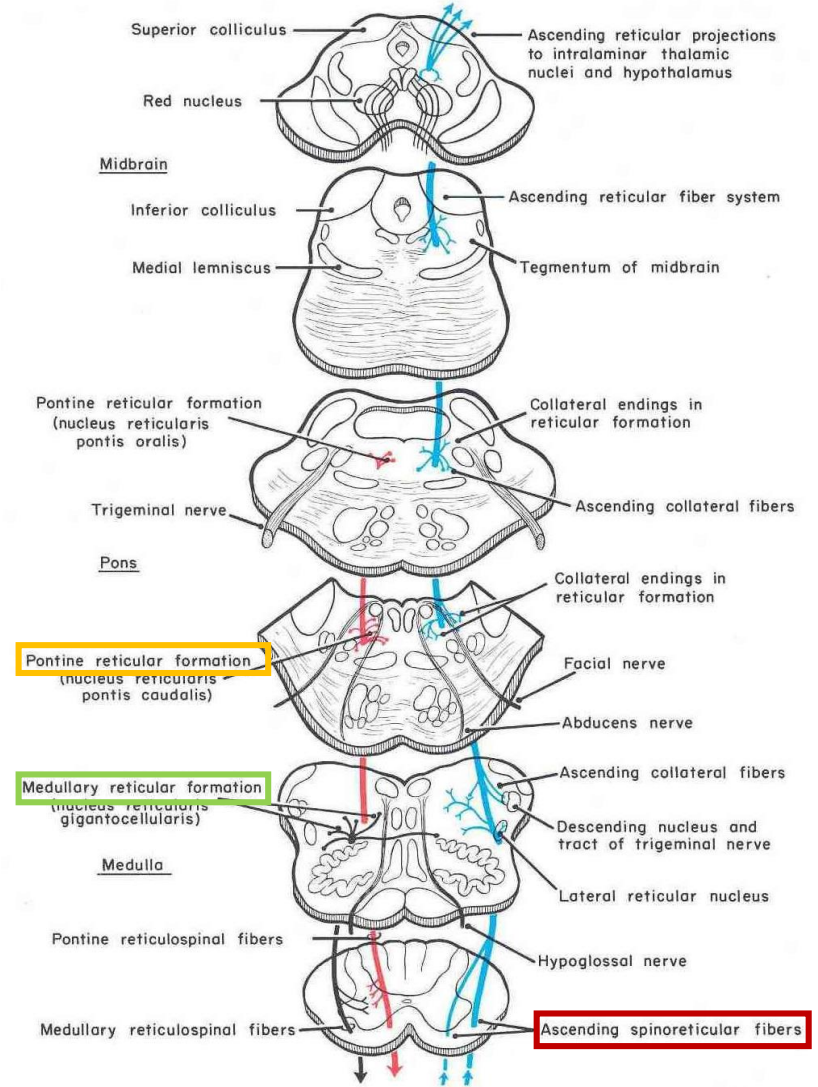
# Spino-olivary Tract

- Indirect spinocerebellar pathway (spino-olivo-cerebellar) meaning it connects the spinal cord with the cerebellum but indirectly through the olivary nucleus
- Impulses from the spinal cord are relayed to the cerebellum via inferior olivary nucleus.
- Conveys sensory information to the cerebellum.
- Fibers arise at all levels of the spinal cord.
- Contribute to movement coordination associated primarily with **balance**.



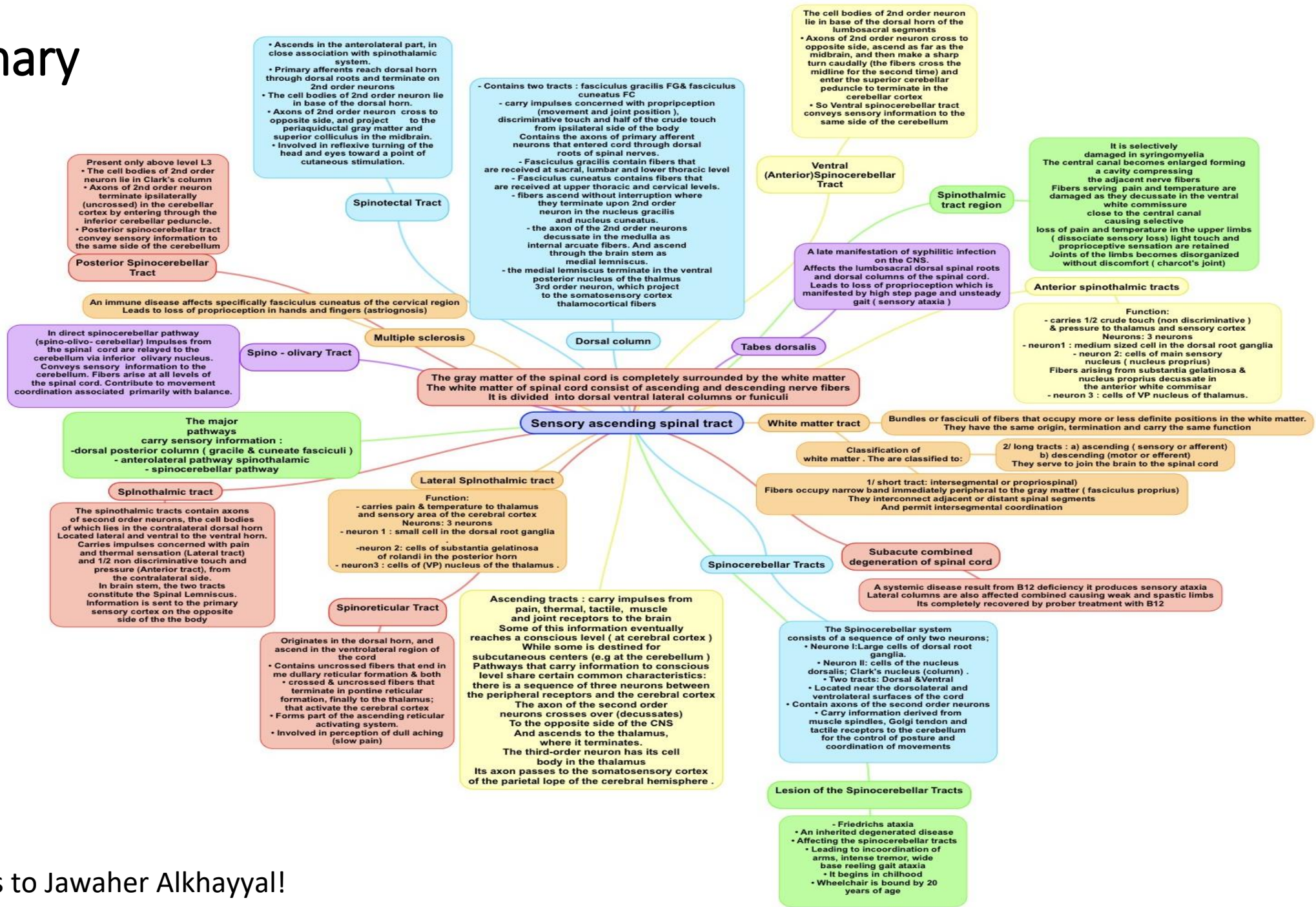
# Spinoreticular Tract

- Originates in the dorsal horn, and ascend in the ventrolateral region of the cord
- Contains uncrossed fibers that end in medullary reticular formation & both crossed & uncrossed fibers that terminate in pontine reticular formation, finally to the thalamus; that activate the cerebral cortex
- Forms part of the ascending reticular activating system (*waking up*).
- Involved in perception of dull aching (slow pain)





# Summary



Special thanks to Jawaher Alkhayyal!



# MCQs

**(1) Which of the following is a short white matter tract?**

- A) fasciculus proprius
- B) fasciculus gracilis
- C) fasciculus cuneatus
- D) fasciculus thalamus

**(2) Pathways that carry information to a conscious level have?**

- A) 1 order neurons
- B) 2 order neurons
- C) 3 order neurons
- D) 4 order neurons

**(3) The internal arcuate fibers ascend through the brain stem as?**

- A) Lateral lemniscus
- B) Medial lemniscus
- C) Spinal lemniscus
- D) Dorsal lemniscus

**(4) Tabes dorsalis is a late manifestation of which infection?**

- A) Meningitis
- B) Syphilis
- C) Syringomyelia
- D) Non of them

**(5) Spinoreticular Tract Originates in \_\_\_\_\_ & ascend in \_\_\_\_\_ ?**

- A) The ventral horn, the ventrolateral region of the cord
- B) The dorsal horn, the dorsolateral region of the cord
- C) The dorsal horn, the ventrolateral region of the cord
- D) The ventral horn, the dorsolateral region of the cord

**(6) Spinothalamic tracts send information to primary sensory cortex on the \_\_\_\_\_ of the body?**

- A) Same side
- B) Opposite side

**(7) The posterior spinocerebellar tract passes through?**

- A) Superior cerebellar peduncle
- B) Middle cerebellar peduncle
- C) Inferior cerebellar peduncle
- D) Lateral cerebellar peduncle

**(8) Which of the following is involved in the perception of dull aching pain?**

- A) Spinotectal tract
- B) Spino-olivary tract
- C) Spinoreticular tract
- D) Spinothalamic


**(9) Subacute Combined Degeneration of the spinal cord results from?**

- A) B12 deficiency
- B) B9 deficiency
- C) B6 deficiency
- D) B7 deficiency

**(10) Multiple sclerosis affects which tract?**

- A) fasciculus proprius
- B) fasciculus gracilis
- C) fasciculus cuneatus
- D) fasciculus thalamus

# Answers



(1) A

(2) C

(3) B

(4) B

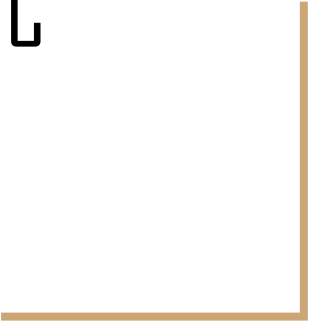
(5) C

(6) B

(7) C

(8) C

(9) A



(10) C

# SAQ

## **(1) Write down the location of the three order neurons between the peripheral receptors and the cerebral cortex?**

1. First-order neuron
  - Delivers sensations to the CNS
  - The cell body is in the dorsal or cranial root ganglion
2. Second-order neuron
  - An interneuron with the cell body in the spinal cord (grey matter) or brain stem (medulla oblongata)
3. Third-order neuron
  - Transmits information from the thalamus to the cerebral cortex

## **(2) The three major pathways carry sensory information are?**

1. Dorsal (Posterior) column (divided into Gracile & Cuneate fasciculi)
2. Spinocerebellar pathway "dorsal & ventral"
3. Anterolateral pathway (Spinothalamic) "ventral & lateral"

## **(3) An immune disease affects specifically fasciculus Cuneatus of the cervical region. Leads to Astereognosis Is ?**

Multiple Sclerosis

## Major sensory pathway

This is one of the objective that will be discuss in next lectures in physiology but it's important to study it with anatomy lecture  
“sensory tract”

Use the skitch and follow Dr.Najeeb  
Wish you best of luck ...



Done by :

- ❖ **Team leaders:** Abdulelah Aldossari, Ali Alammari, Fatima Balsharaf, Rahaf Alshammari.
- ❖ **Special thanks to:** Sara Altowirb - Lubna aloufi
- ❖ **Team member:** Renad alsuelmi



# 1- Dorsal column

First of all you can start from 45:10 minutes if you already you know these basic concepts :

**Tract** : Bundle of axons in the CNS with common origin and common termination and serve same function.

White matter ( have ascending and descending tract ) they organized like :

- 1- vertical fibers ( up & down ) like Tracts
- 2- commissar fibers ( right- left ) like corpus callosum
- 3- association fiber ( ant-pos)

- **Ascending tract How it works?**

Stimulus > convert electrochemistry reaction > by receptor > move through sensory nerve > CNS

- **Descending How it works?**

From high center > descending tract > motor nerve > effector system ( muscle/ gland )

**White matter divided into:**

Dorsal column > ascending tract

Lateral column > ascending & descending Tract

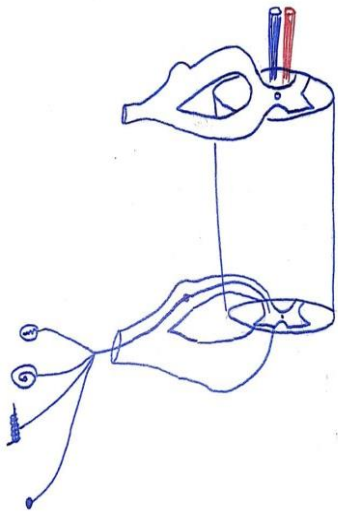
Ventral column > ascending & descending Tract

Dorsal column = highly myelinated > fast conduction. Ex: fine touch , proprioception , vibration.

Give better localization of the sensation + gradations.

Ventrolateral = less myelinated > slow condition > pain , temperature , tickling, itchy, sexual.

Less localization + lesser gradation



## 1- Dorsal column

now we will start dealing with individual Tract Dorsal column- 45:10 minutes

First to understand the system we have to start with receptors that will receive the ( fine touch , pressure, vibration, and proprioception ) all these have to take up to the cerebral cortex through:

**1- First order neurons** = Dorsal root ganglion

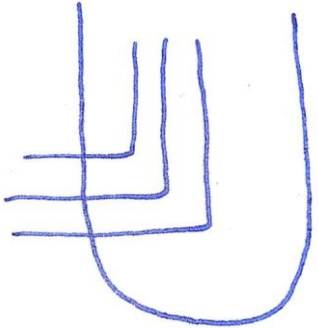
Then these root will divided medially and laterally. Medial one going upward and start ascending as dorsal column

Sensations that carried from **Lower limb** they will deposit **medially** (fasciculus gracilis ) and from **upper limb** they will be deposited **laterally** ( fasciculus cuneatus ) because sensation are added So , in the dorsal column fibers that are more laterally are coming from upper limb and and the fiber that are more medially are coming from Lower limb.

**- What the importance to know this point?**

Because if there is tumor compress the lateral fibers then upper part of the body sensation will be lost.

They are arranged in topographical



## 1- Dorsal column

Ascending fibers continue to reach in the medulla oblongata

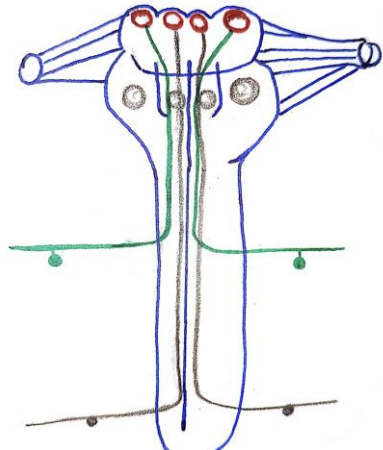
( we have special nucleus called **fasciculus gracilis + fasciculus cuneatus** ) = 2nd order neurons.

Here we have that right nucleus of cuneatus and right nucleus of gracilis their axons emerge out and **cross the opposite side** and after this crossing these fibers is going upward and making a very special system called ( **internal arcuate fibers** )

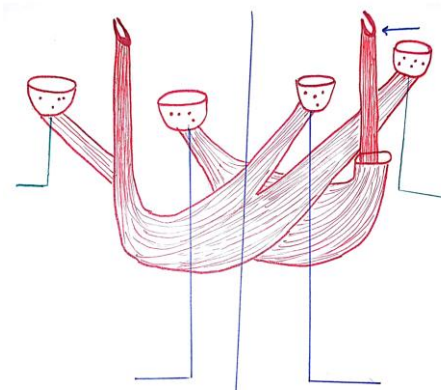
\* notice here right fibers are taking the information from the left nuclei

These information going to 3rd nucleus by **medial lemniscus** )

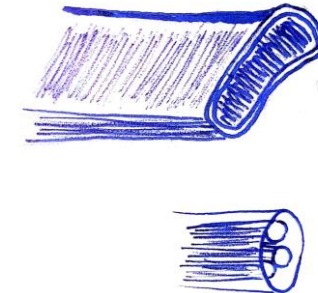
(Inferior cerebral peduncle)



(Medial lemniscus)



(lemniscus)



Until 10 minutes

❖ Identify the major sensory pathways Najeeb Explanation

# 1- Dorsal column

Medial lemniscus going to the Third order neuron thalamus specifically in the **VPL** (ventroposterior lateral ) then fibers move laterally in the posterior limb of the **internal capsule** then fan out to cerebral cortex as corona radiata

Thalamus view divided into :

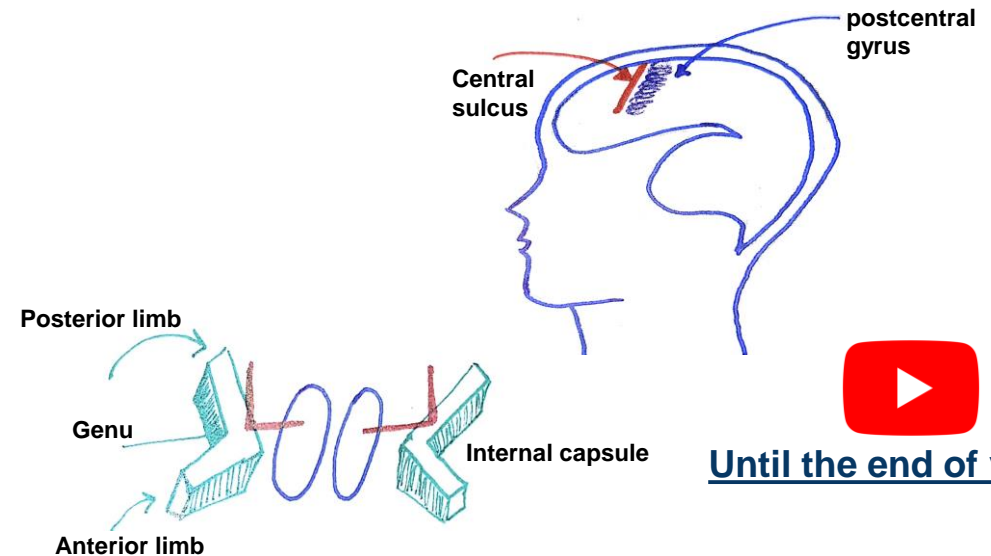
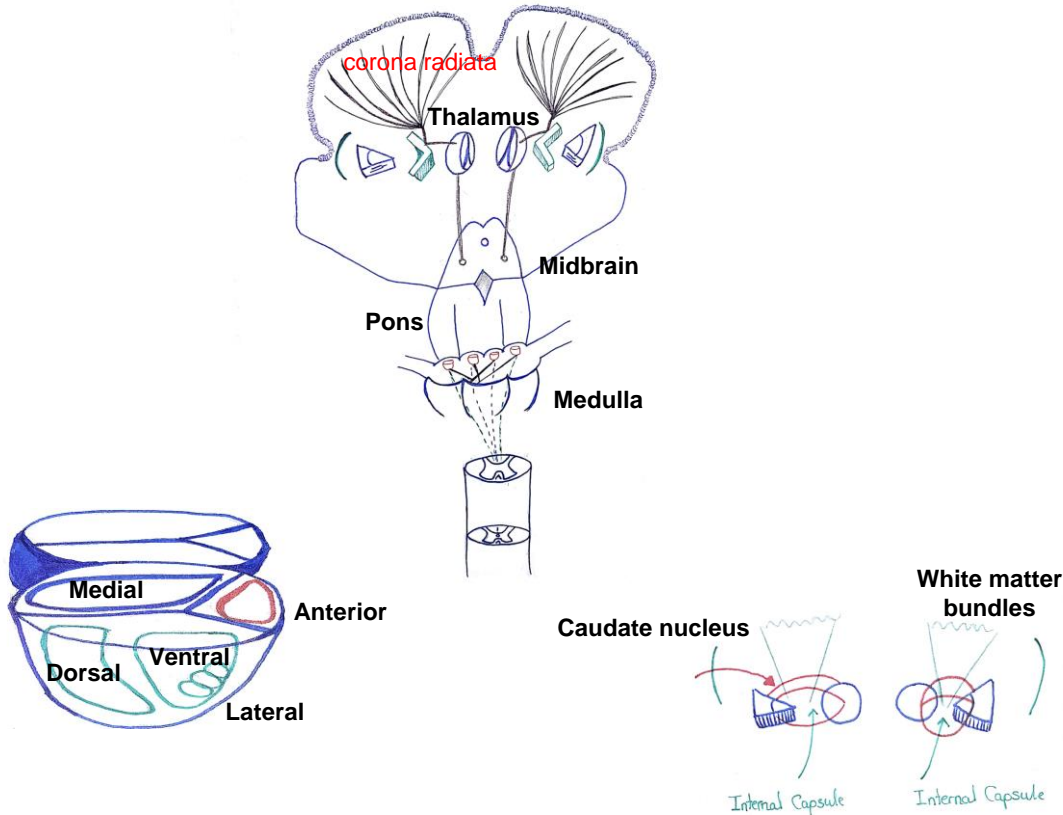
- 1- Anterior
- 2- Medial
- 3- Lateral divided into :
  - 1- **Ventral**

A- ventral anterior nucleus

B- Ventral Intermediate

C- Ventral posterior have (1- **ventroposterior lateral** ) -receive most of the sensation - and medial to it we have ventroposterior medial ) - receive fibers from head & neck fibers

2- **Dorsal**



Until the end of video

## 2-Anterolateral tract

Receptors : 1- free nerve ending

2- temperature receptor

Pain pathway :

1- Fast pin prick A-Delta pathway 0.1 sec , Mechanical stimulus or thermal

2- Slow dull- fibers pathway 1hr or longer Mechanical , thermal , chemicals stimulus

Why Sometimes you notice that one of your hand is painful and the other isn't?

Because we have chemical mediator responsible for stimulation of pain receptor like : 5ht , histamine , bradykinin, acids , K+

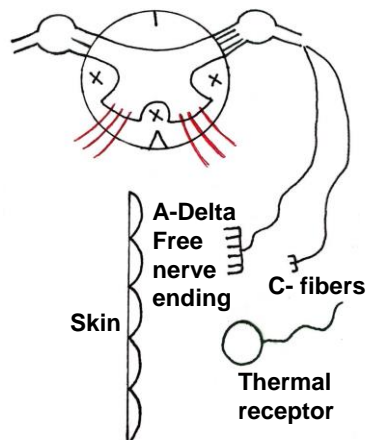
What are the substance that decrease the threshold of the pain ? PGs-substance p (peptide)

\* Red circle : First neuron = Dorsal root ganglion second neuron :substantia gelatinosa then it's crossed to contralateral to the third neuron .

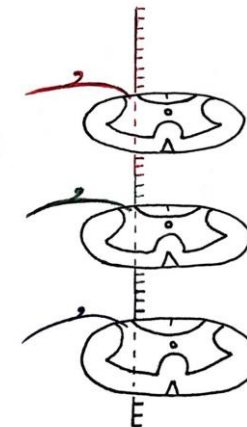
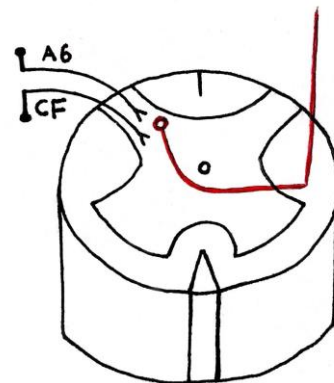
This called Dorsolateral tract of "LISSAURE"

It means this tract made of ascending and descending branches of the **first neuron** as it enter to the spinal cord then connect with second neuron in the subtisa gelatinosa **in the same level**

\*notice here the first neuron not like dorsal column that enter medially then ascend to nucleus because it is not at the same level



Until 11:05 min



Until 17:52 min

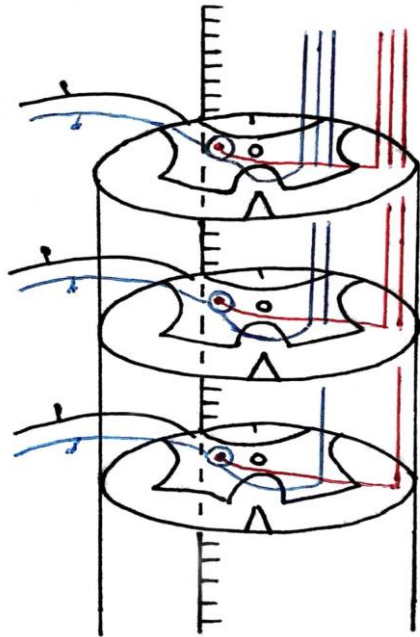


Dr.Najeeb lecture 57 min  
Follow him & use the sketch



❖ Identify the major sensory pathways Najeeb Explanation

## 2-Anterolateral tract



Until 31:00 min

### Blue tract:

Ventral spinothalamic tract ( crude touch )

### Red tract:

Lateral spinothalamic tract  
( pain and temperature )

Between Ventral and lateral spinothalamic tract we find **spinotectal pathway** and going to the tectum(superior colliculus + inferior colliculus ) which is responsible for for spinovisual response

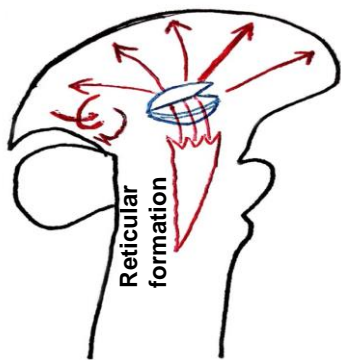
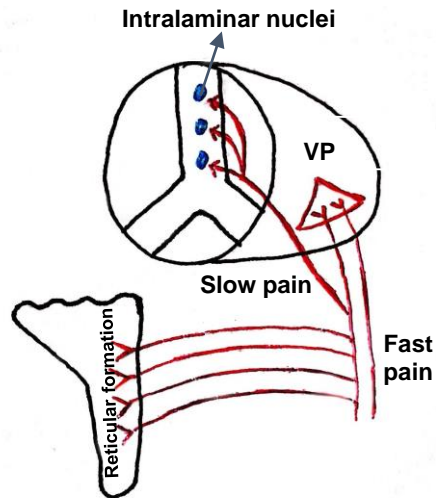
All these tract when reach to the medulla fuse together and called **spinal lemniscus**

All of them -3- will pass pons & midbrain but only 2 ( ventral spinothalamic and lateral spinothalamic will get connect to the ventroposterior lateral **VPLnucleus** of the thalamus.



Dr.Najeeb lecture 57 min  
Follow him & use the sketch

## 2-Anterolateral tract



Until 31:00 min

Fast pain information reach VP nucleus

Slow pain information reach Intralaminar nuclei and stimulate the reticular formation so all the brain is alert

Reticular formation :

is mixed between gray matter and white matter and its function is switch on\off cerebral cortex activity

Pain pathway pass through VP nucleus then into internal capsule posterior limb and reach to area of cortex (postcentral gyrus)

Connections of the pain tract :

1-(postcentral gyrus): tell you exactly where is the pain if it fast - localized - if it slow poorly localized also the graduation and quality of the pain

2- cingulate gyrus special connection from posterior limb of the internal capsule is considered with emotional

3- Insula

Is considered with Autonomic reaction like tachycardia , sweating



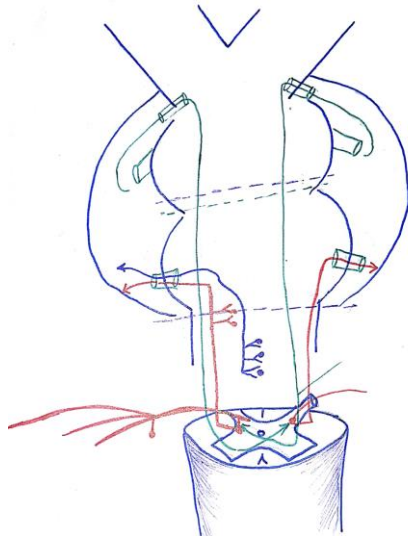
**Dr.Najeeb lecture 57 min**  
**Follow him & use the sketch**

- ❖ Identify the major sensory pathways Najeeb Explanation

## 3-Spinocerebellar Pathway

Dorsal Spinocerebellar Tract

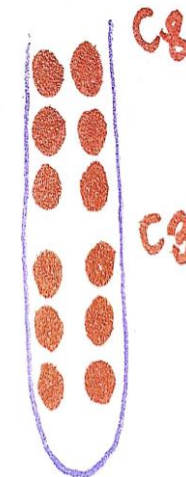
Fibers take information from spinal cord to cerebellum. **First order neuron** has their cell bodies in dorsal root ganglion and terminates in **CLARKE nucleus** in dorsal Grey horn. Second order neuron ascends through **ipsilateral** white lateral column and connects with **cerebellar cortex** of same side via inferior cerebellar peduncle




**Clarke nucleus** ; This is a large column of neurons which is located in the dorsal Grey horn of the spinal cord, extending from C8 to L3. It receives information from **lower limbs** and **trunk**.

**Accessory Cuneate Nucleus** ; Spinocerebellar tract fiber, above the C8 level enters into the nucleus then ascends and pass through inferior cerebellar peduncle. It receives information from **Upper limbs**

**Cerebellar peduncles** ; These are specialized bundles of white matter which connect brainstem with cerebellum.



Good luck  
Special thank for team436  
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