CNS
ANATOMY

4

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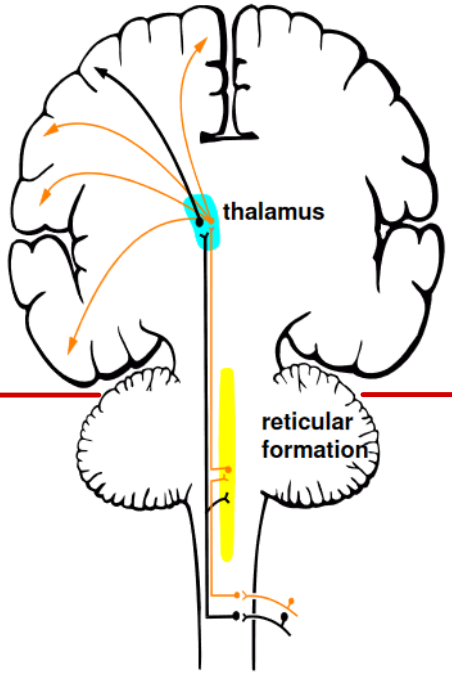
Doctor:

Last lecture, we discussed the lateral spinothalamic tract which is the main route for pain and temperature.

Lateral spinothalamic tract terminates in many sites and it is not limited to the somatosensory cortex (it has a widespread cortical termination):

- **Reticular formation**: (majority of the slow pain fibers) individual becomes aware of the pain.
- **Cingulate gyrus**: interpretation of the emotional aspect of pain.
- **Insular gyrus**: concerned with the interpretation of pain stimuli from the internal organs of the body and brings about an autonomic response.



Pain classifications:-

Read only

❖ **According to type:**

1. Fast pain (initial pain): pain within seconds or minutes, e.g. Knife cut
2. Slow pain (chronic pain): e.g. due to inflammation of that cut wound (infection).

Fast Pain	Slow Pain
Sharp, pricking	Dull, burning
(Aδ) fiber	(C) fiber
Short latency	Slower onset
Well localized	Diffuse
Short duration	Long duration
Less emotional	Emotional, autonomic response
Mostly from superficial structures	Superficial & deep structures
Spinothalamic	Spinoreticular
lamina I & V	lamina I & II
VPL nucleus	VPL & intraluminar nucleus

A question arises: why is slow pain poorly localized compared to fast pain? Because the fibers of fast pain (Aδ) tend to synapse with one 2nd order neuron, this will lead to activation of a very precise area in the cortex unlike the C fibers of slow pain which tend to diverge and synapse to more than one 2nd order neuron which leads to activation of wider area in the cortex resulting in poor localization.

Read only

❖ According to origin:

1. **Cutaneous pain**: originates from the **skin** and is felt on it.

2. **Deep somatic pain:** originates in a relatively large area representing the affected muscles, bones, joints & ligaments, dull diffuse.

- one of the most important examples of deep somatic pain is what we call **Intermittent claudication**: a muscle pain which occurs during exercise classically in the calf muscles due to peripheral artery disease (blood supply is not enough to remove the metabolites esp. lactic acid) common in an uncontrolled diabetic patient.

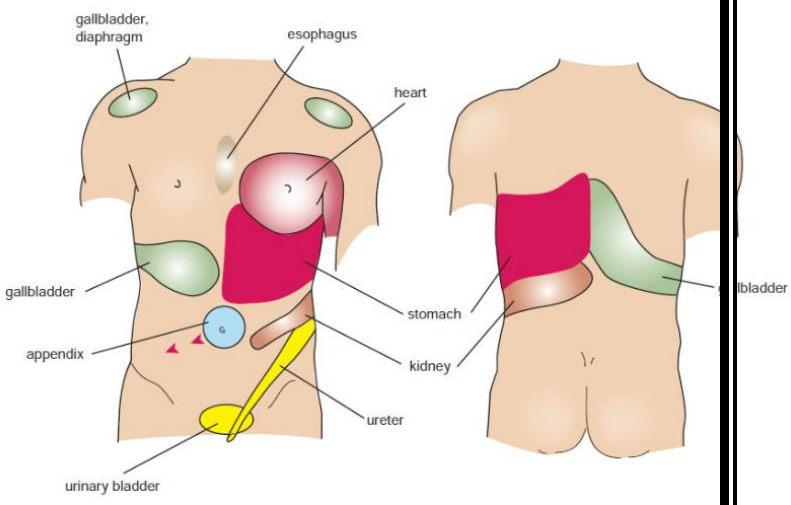
3. **Visceral pain**: the origin for this type of pain is the internal organs, it's poorly localized & transmitted via C fibers (slow pain).

- The internal organs are sensitive to ischemia, chemical damage and stretch, these sensations are detected by chemoreceptors, baroreceptors, osmoreceptors and stretch receptors.
- **Examples of visceral pain:**

✓ Distention of bladder and abdominal viscera (cause stretch and activates C-fibers)
✓ Ischemia e.g. angina pectoris (this pain is commonly referred to the L. arm)
✓ Spasm: leads to blood vessels compressions and accumulation of metabolites.
✓ Chemical damage: HCl from perforated ulcer (e.g. peptic ulcer)

Note: The mechanisms (or stimuli) that cause somatic pain are different from those that cause visceral pain. For instance, a mechanical injury, such as a knife wound, can cause somatic pain from the skin. But the same knife cut to the viscera will not cause pain, because its pain fibers do not respond to this type of stimuli. However, other types of stimuli may cause visceral pain, such as distension and ischemia.

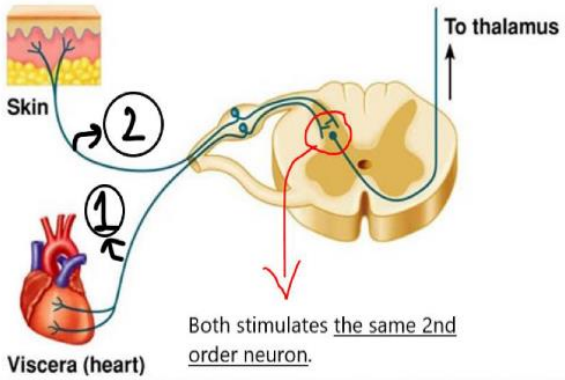
- **Visceral pain is often referred.**
  <u>What is referred pain ?</u> *Referred pain* is when the *pain* you feel in one part of your body is actually caused by *pain* or injury in another part of your body. For example, an injured pancreas could be causing *pain* in your back, or a heart attack could be triggering *pain* in your jaw and left arm.



<u>Note: doctor said that the location of each referred pain for the internal organs in the pic to right is for memorization.</u>

Referred pain mechanism: (13:00)

- **convergence theory**:
  - Referred pain is presumed to occur because the information from multiple nociceptor afferents converges into individual spinothalamic tract neurons.
  - The brain therefore interprets the information coming from visceral nociceptors as having arisen from nociceptors on the body surface, since this is where nociceptive stimuli originate more frequently.

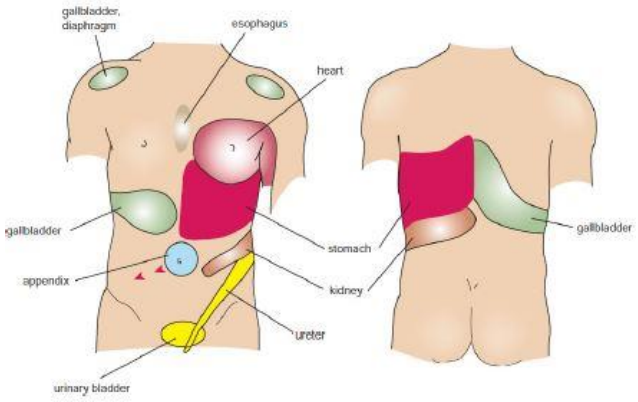


- **More explanation**: two types of fibers reach each segment of the spinal cord: (they are much more than 2 but for simplicity)

1. Autonomic visceral fibers: these fibers need to conduct a signal from the viscera to **insular gyrus** through a 2nd order neuron, so it brings back an autonomic response.
2. Somatosensory fibers: these fibers need to conduct a signal from skin **to postcentral gyrus** through a 2nd order neuron **(different than that for the viscera),** so it brings back a motor response.

What happens is that the visceral fibers might stimulate **the 2nd order neuron that reaches to postcentral gyrus**, this stimulus then is translated in the brain as if it's coming from the skin not from the viscera. This is how referred pain occur.

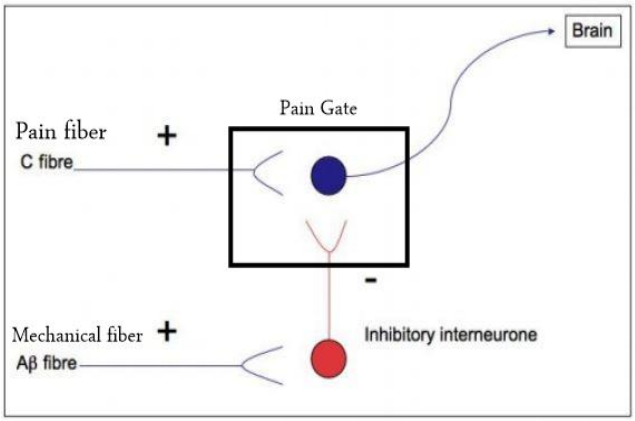
Note: the location in this pic is for memorization



Pain control in the CNS:

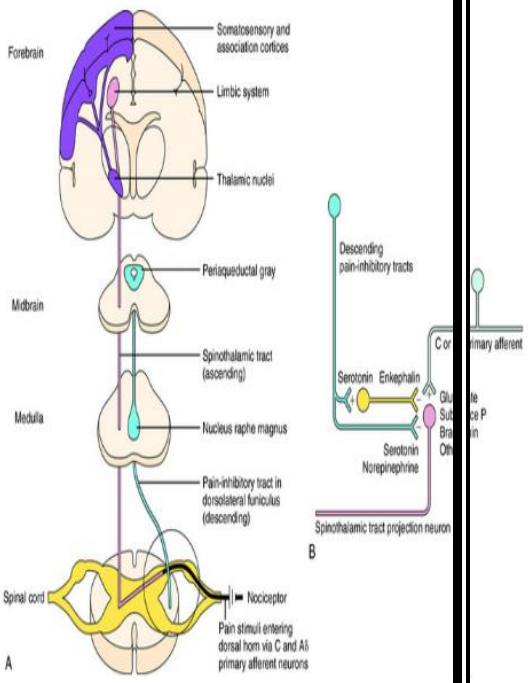
1. **Gating theory:** (inhibition of the pain by another mechanical stimulus).

- At the site where the pain fiber enters the central nervous system, inhibition could occur by means of connector neurons excited by large, myelinated afferent fibers carrying information of **nonpainful touch and pressure.** Note: if the Aβ fibers activated the pain gate is closed.



2. **Descending control (VIP):**

- **Spinoreticular fibers** (coming from spinothalamic fiber (pain fiber)) stimulates **periaqueductal gray in mid brain (PAG)**
- Excitatory neurons of PAG projects to **Nucleus raphe magnus** (NRM)
- (NRM) neurons produces serotonin which activates **inhibitory neurons** that secretes **enkephalins** and the **endorphins** (morphine like actions) in substantia gelatinosa. This leads to termination of pain.
  Note: Locus coeruleus (in Pons) is thought to directly inhibit substantia gelatinosa neurons **(not scientifically confirmed).**
- **Extra Info:**



✓ Periaqueductal gray is the gray matter surrounding cerebral aqueduct.

✓ Cerebral aqueduct is within the midbrain, it contains cerebrospinal fluid (CSF) and connects the third ventricle to the fourth ventricle.

✓ Nucleus raphe magnus is located in medulla oblongata

We are done with the lateral spinothalamic tract.

Anterior spinothalamic tract: (ALS: Anteriolateral system)

❖ Modality: crude touch and pressure.
The most important difference between the anterior and lateral components of ALS is the modality, modality of the lateral part is "pain and temperature" whereas the anterior part's modality is "crude touch and pressure".
When we say ALS, the modality will be "crude touch, pressure, pain and temperature".

❖ Receptors: free nerve endings

❖ 1st Neuron: **Dorsal root ganglia**

❖ 2nd Neuron: the **posterior horn of gray column** specifically in **nucleus proprius** which represents **laminae 3 and 4** of the gray matter and is associated with touch sensation. The axons of 2nd order neurons cross obliquely to the opposite side in the anterior gray and **white commissures**, ascending in the contralateral white column as the Anterior spinothalamic tract.

❖ 3rd Neuron: **Thalamus (VPL) Internal Capsule** ----- **Corona Radiata**.

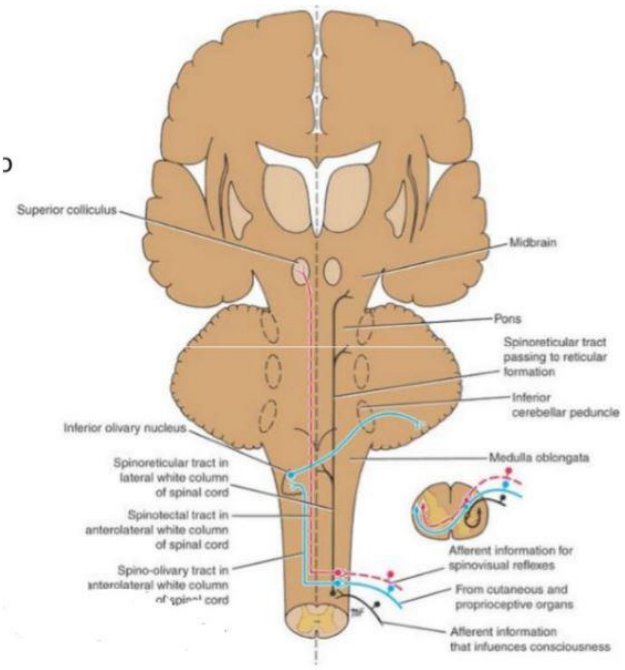
❖ Termination: **Primary Somesthetic Area (SI)**

Spinotectal Tract:

- This is a sensory tract that relays information from the spinal cord (spino) to the tectum (tectal). Hence the name Spinotectal
- The *tectum* (Latin for roof) is the dorsal side of the midbrain and is composed of four colliculi (2 superior and 2 inferior).
- The 4 colliculi collectively form a structure known as corpora quadrigemina
- The 2 superior colliculi have visual functions and are involved in visual reflexes, whereas the 2 inferior colliculi have auditory functions and are involved in auditory reflexes.

❖ **Organization of Spinotectal tract**

- Ascend in the anterolateral white column lying close to the lateral spinothalamic tract
- Terminate: **superior colliculus**
- Provides afferent information for **spinovisual reflexes**.
- Explanation: the 1st order neurons start at the organs involved in the collection of information for the spinovisual reflexes, the cell bodies for them is, again, in the dorsal root ganglia. The 2nd order neurons synapses with the 1st order neurons early in the spinal cord, and then the axons of the 2nd order neurons cross the midline and ascend contra-laterally in the anterolateral white column of the spinal cord, lying close to the lateral spinothalamic tract. This tract terminates in the superior colliculus.

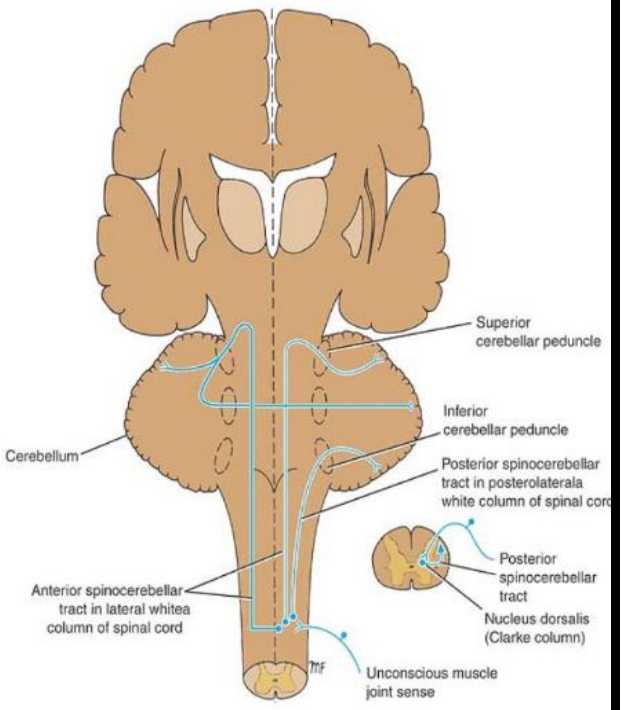


- **Note: In Medulla**: anterior spinothalamic tract + spinotectal + lateral spinothalamic = spinal leminiscus which ends in VPL

- **What are spinovisual reflexes?** The act of movement of the eyes, head and neck spontaneously towards the source of the stimulation. Happens at the level of spinal cord (no need for higher centers).
  Example: if you are walking and you step on a piece of glass, you unconsciously raise your leg away from the glass (withdrawal reflex) and then you immediately look toward the injury site (spinovisual reflex).
  Note: Remember that medial leminiscus was related to the dorsal column system.

Posterior and Anterior spinocerebellar: (from the spinal cord to the cerebellum)

- These two tracts are located in the anterolateral columns of the white matter. They don't reach the cortex, instead, they terminate at the cerebellum



Posterior spinocerebellar

- **Modality**: muscle and joint sensation (unconscious proprioception)
- **Receptors**: same as dorsal column system (Most receptors except free nerve endings)
- 1st order neuron axons terminate at the base of post gray column (**nucleus dorsalis or Clarks nucleus** in lamina 7)
- the axons of 2nd order neurons enter posterolateral part of the **lateral white matter column** on **the same side**.
- **ascend ipsilaterally** as the posterior spinocerebellar tract to medulla oblongata.
- Terminates in **cerebellar cortex** (through **inferior cerebellar peduncle**).

➢ *note: axons of lower lumbar and sacral spinal nerves ascend in the posterior white column until they reach L3 or L4 segments where they synapse with nucleus dorsalis*

Extra info:

- **Peduncle**= bundle of white matter.
- **superior cerebellar peduncle**: connect midbrain to cerebellum.
- **middle cerebellar peduncle**: connect pons to cerebellum.
- **inferior cerebellar peduncle**: connect medulla to cerebellum.

Note 1: in **dorsal column system and anterolateral system** eventually sensation from right side of the body will reach to the left cortex (no matter of the decussation site) and vice versa.

Note 2: in **spinocerebellar tracts** whether anterior or posterior, sensation from right side of the body will reach the right cerebellar cortex and vice versa.

Rexed laminae

- **Lamina 1** relay information related to pain and temperature
- **Lamina 2:** relay information related to pain and temperature **(pain modulation)**
- **Lamina 3 and 4:** nucleus proprius; these laminae have many interneurons

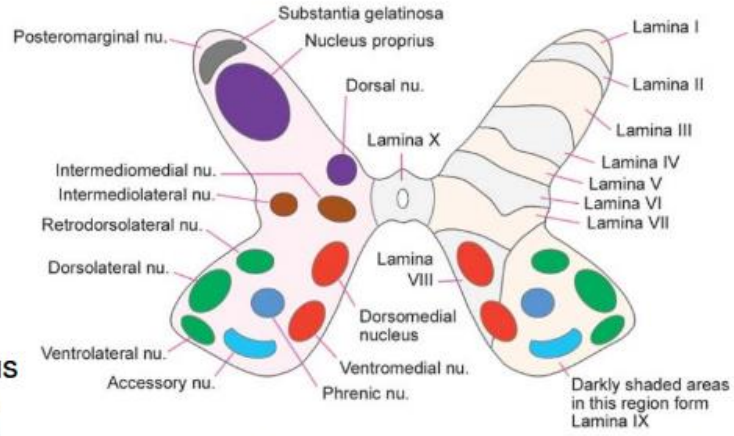


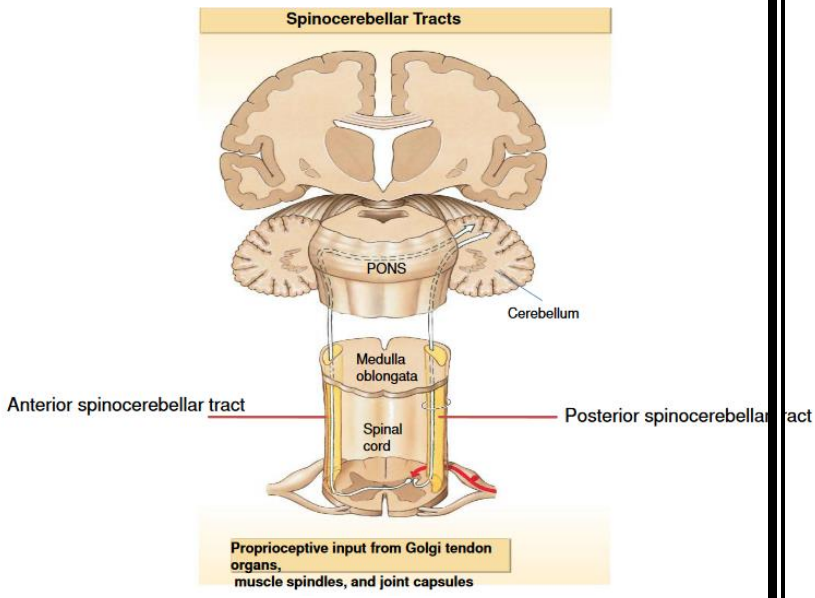
Fig. 5.2. Subdivisions of the grey matter of the spinal cord. The left half of the figure shows the cell groups usually described. The right half shows the newer concept of laminae.

- **Lamina 5:** relay information related to pain and temperature
- **Lamina 6:** presents only at the cervical and lumbar enlargements and receives proprioception
- **Lamina 7: Intermedio-lateral** nucleus, contains preganglionic fibers of sympathetic (T1 -L2). **Intermedio-medial nucleus** ,all over the spinal cord, receive visceral pain. **Dorsal nucleus of Clark's** presents at (C8 – L2 or T1-L4) , relay center for **unconscious proprioception**

Note : the type of sensation that reaches cerebellum (unconscious level) is proprioception.

Anterior spinocerebellar tract:

- **Muscle and joint sensation (unconscious proprioception).**
- 1st order neuron axons terminate at the base of post gray column **(nucleus dorsalis)**
- **Two pathways for the axons:**
  1- **the majority** of axons of 2nd order neurons cross to opposite side and ascend as anterior spinocerebellar tract in the contralateral white column.
  2- **the minority** of axons ascend as anterior spinocerebellar tract in the lateral white column of the same side.
- Ascend as anterior spinocerebellar tract to medulla oblongata and pons.
- Terminates in cerebellar cortex, (through superior cerebellar peduncle).
  the fibers that crossed over in spinal cord **cross back** within cerebellum.



don't panic, these two figures are explained in the video (15:00 – 19:00) for more explanation about referred pain. Please refer to the video.