بسم الله الرحمن الرحيم

Spinal cord (pt.2)

MID | Lecture 3

﴿إِنِّي تَوَكَّلْتُ عَلَى اللَّهِ رَبِّي وَرَبِّكُمْ ۚ مَا مِن دَابَّةٍ إِلَّا هُوَ آخِذٌ بِنَاصِيَتِهَا ۚ إِنَّ رَبِّي عَلَىٰ صِرَاطٍ مُّسْتَقِيمٍ﴾

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ANATOMY

رحلة اليقين مع سورة يس

بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

لِتُنذِرَ قَوْمًا مَّآ أُنذِرَ ءَابَآؤُهُمْ فَهُمْ غَٰفِلُونَ (٦) لَقَدْ حَقَّ ٱلْقَوْلُ عَلَىٰٓ أَكْثَرِهِمْ فَهُمْ لَا يُؤْمِنُونَ (٧)

فلما أقسم تعالى على رسالته وأقام الأدلة عليها، ذكر شدة الحاجة إليها واقتضاء الضرورة لها فقال: { لِتُنْذِرَ قَوْمًا مَا أُنْذِرَ آبَاؤُهُمْ فَهُمْ غَافِلُونَ } وهم العرب الأميون، الذين لم يزالوا خالين من الكتب، عادمين الرسل، قد عمتهم الجهالة، وغمرتهم الضلالة، وأضحكوا عليهم وعلى سفههم عقول العالمين، فأرسل الله إليهم رسولا من أنفسهم، يزكيهم ويعلمهم الكتاب والحكمة، وإن كانوا من قبل لفي ضلال مبين، فينذر العرب الأميين، ومن لحق بهم من كل أمي، ويذكر أهل الكتب بما عندهم من الكتب، فنعمة الله به على العرب خصوصا، وعلى غيرهم عموما. ولكن هؤلاء الذين بعثت فيهم لإنذارهم بعدما أنذرتهم،انقسموا قسمين: قسم رد لما جئت به، ولم يقبل النذارة، وهم الذين قال الله فيهم { لَقَدْ حَقَّ الْقَوْلُ عَلَى أَكْثَرِهِمْ فَهُمْ لَا يُؤْمِنُونَ }

Posterior White Column-Medial Lemniscal Pathway

- Modality: Discriminative Touch Sensation (include Vibration) and Conscious Proprioception
- Receptor: Most receptors except free nerve endings

- Ist Neuron: Dorsal Root ganglion and

Will ascend in the spinal cord epsilaterally.

- 2nd Neuron: Dorsal Column Nuclei

(Nucleus Gracilis and Cuneatus) the first

Part of medulla oblongata where the 1st order synapse with the 2nd order neuron (the location of cell body of second order neuron).

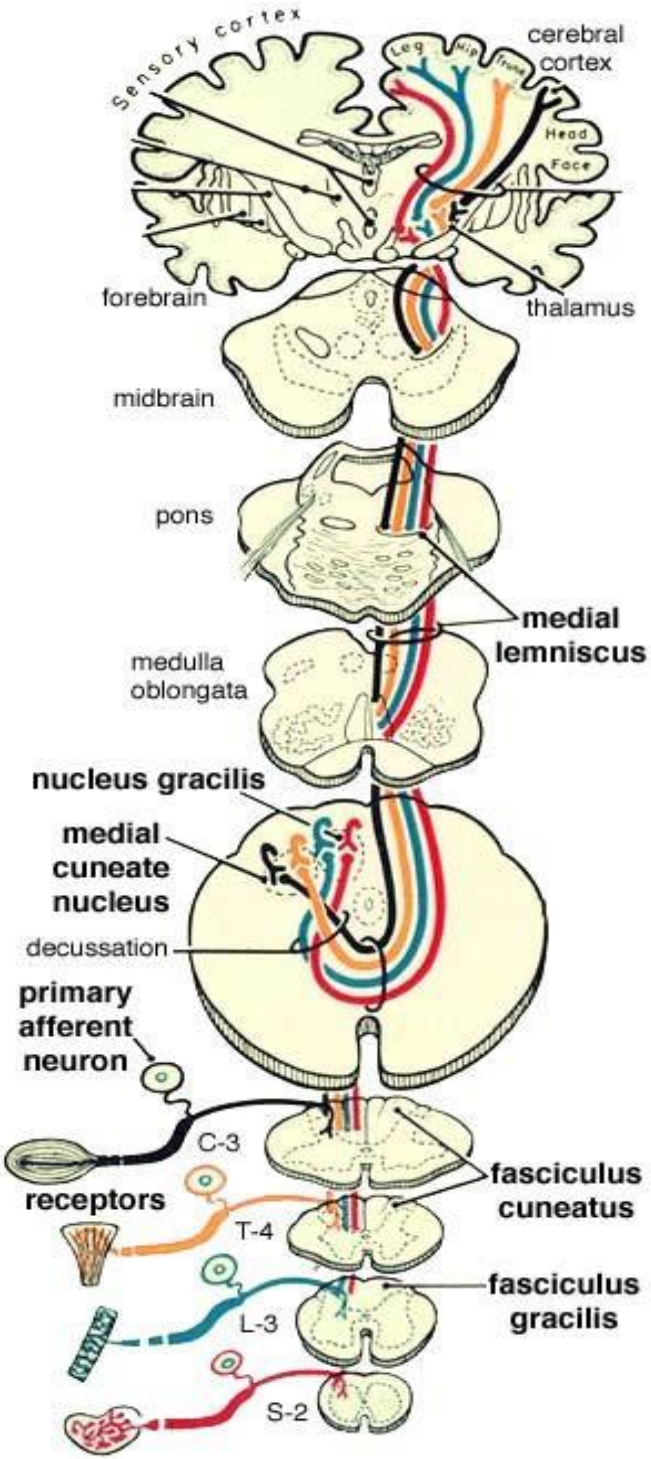
---Internal Arcuate Fiber is the fibers that

cross the midline during Decussation - Lemniscal

Decussation the leminiscus is band of white matter its shape is elongated , the fasciculus is the same But rounded.

---Medial Lemniscus medial because its near

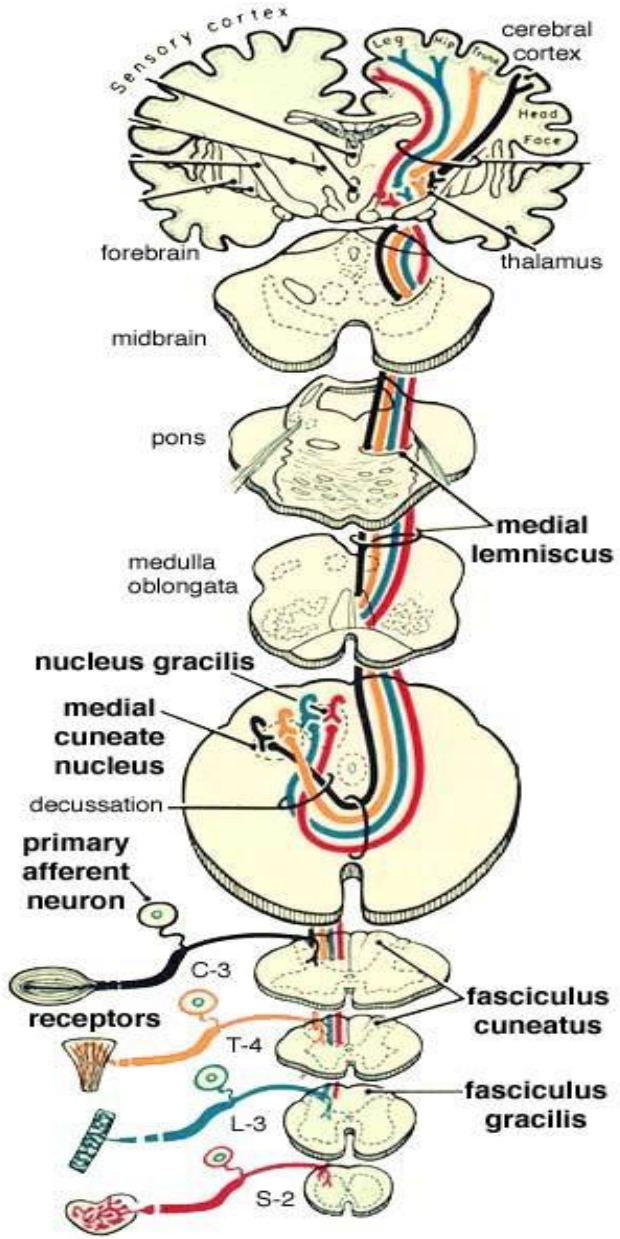
the midline ... then it will ascends all the way of mid brain reaching thalamus.



- 3rd Neuron: Thalamus (VPL)

Internal Capsule ----- Corona Radiata

- Termination: Primary Somesthetic Area (S I)



- The thalamus is part of forebrain diencephalon and it's egg in shape and consists of group of nuclei , one of these nuclei is VPL (ventral postolateral nucleus), this where 2nd neuron synapse with 3rd neuron (VPL is the site of cell bodies of 3rd order neuron).

- 3rd neurons project from the thalamus towards the cortex (the outer aspect of the cerebrum (telencephalon)).

- The thalamus is the secretary of the cortex. All fiber except olfactory will go to the cortex but first should go to the thalamus **(Thalamus then cortex).**

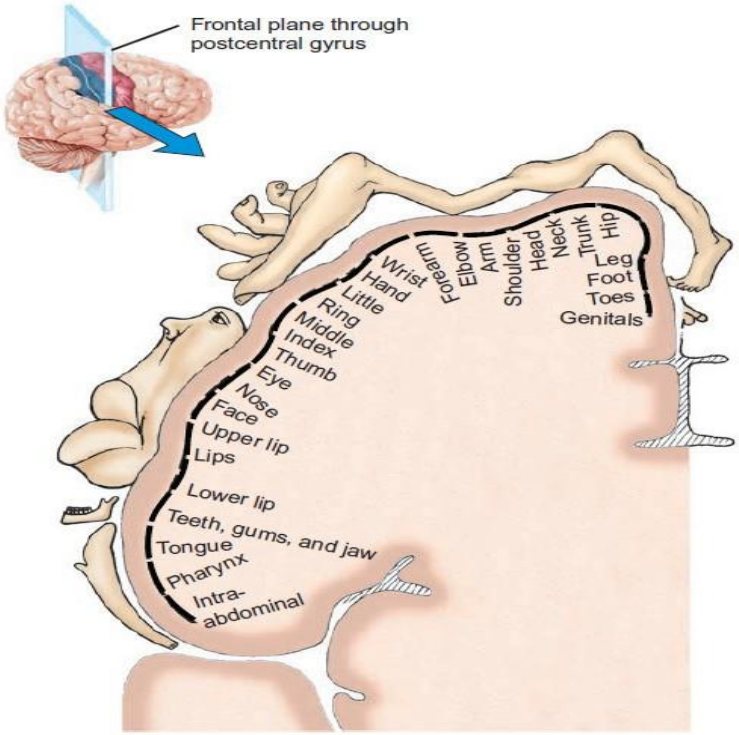
- As the fibers head towards the cortex, they pass through a critical narrow area between multiple nuclei (caudate nucleus, the thalamus, and the lentiform nucleus) and this area is called internal capsule. Capsule here **isn't** connective tissue.

- As they approach the cortex, the fibers spread out forming corona radiata, here they show localization as each body part is represented by these fibers on a specific area.

- Now to complete the pathway we should know the outer surface of the brain:
- The brain is divided into two hemispheres right and left, separated by longitudinal fissure.
- Each sphere is subdivided into lobes: Frontal lobe, parietal lobe, temporal lobe and occipital
- The outer surface of cerebrum is characterized by presence of sulci and gyri , the prominent area is called gyrus and the internal is sulcus

- The nickname of frontal lobe is motor lobe, parietal lobe is sensory lobe, temporal lobe auditory lobe, occipital lobe is visual lobe. (Each nickname represents the **function** of the lobes).
- The sulcus between frontal lobe and parietal lobe is called **central sulcus**

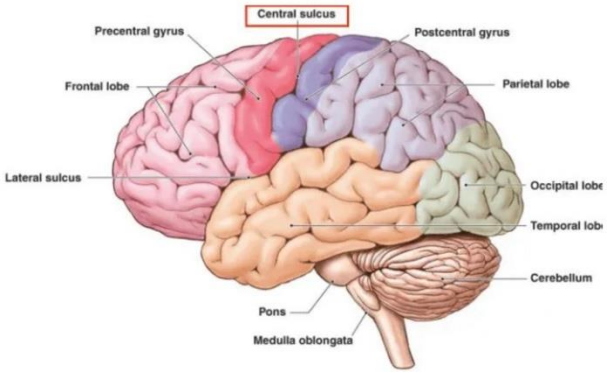
- The body is represented as a map/ homunculus (a tiny human representation) on the cortex which helps our CNS localize the body parts.
- For example the fibers that come from the hand will project specifically on the area of the hand (localization)... if we have a patient and we start to stimulate parts of the cortex using electrodes and making activation of specific area for example the area that is specific for the sensation come from the thumb, the patient will sense something in his thumb even though there is nothing in his thumb
- The figure isn't proportionate to the site (the presentation of hand is larger than thigh even it's larger in reality) it's proportionate to the number of receptors.



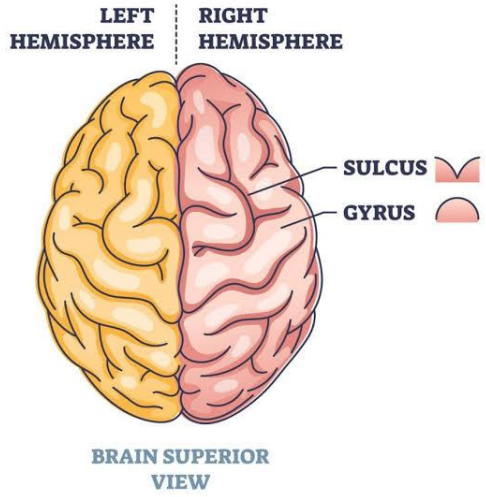
- The first gyrus in parietal lobe after central sulcus is called **postcentral gyrus**
- The gyrus before central sulcus is called **precentral gyrus**

- The termination of Posterior White Column-Medial Lemniscal Pathway is postcentral gyrus

- The part of the cortex the sensory fibers terminate into is known as primary somatosensory (Somesthetic) Area (SI), a part of the parietal lobe



Extra figures to clear the idea

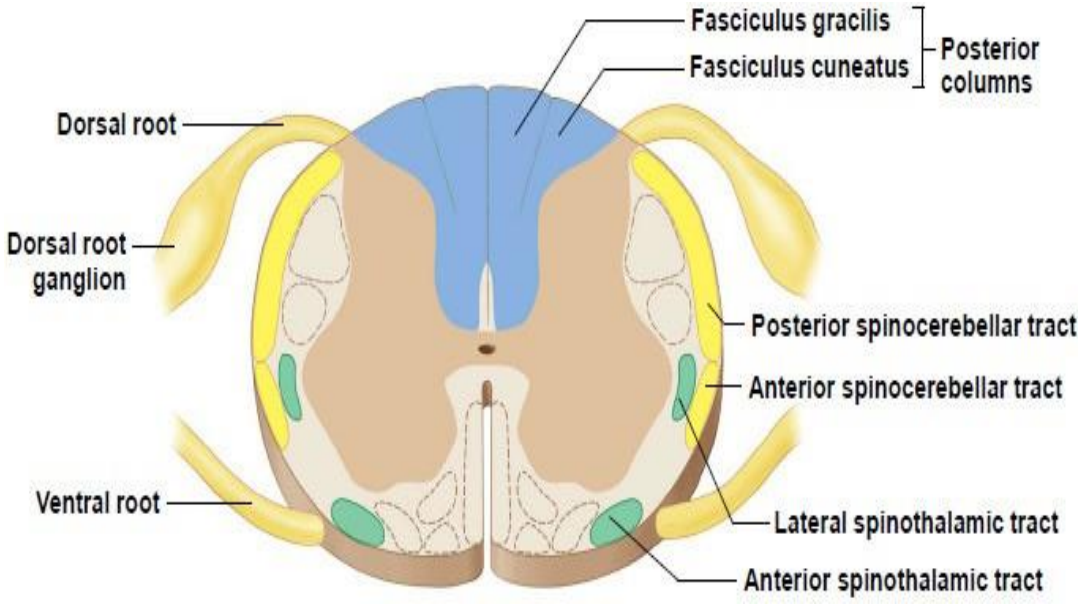


Fasciculus means white matter

Posterior White Column-Medial Lemniscal Pathway

Discriminative touch, vibratory sense, and conscious muscle-joint sense

- **Posterior Column tract consists of:**
- **Fasciculus gracilis** near the midline
- Transmits information coming from areas inferior to T6 the lower part of the body
- **Fasciculus cuneatus** away from the midline
- Transmits information coming from areas superior to T6 the upper part of the body

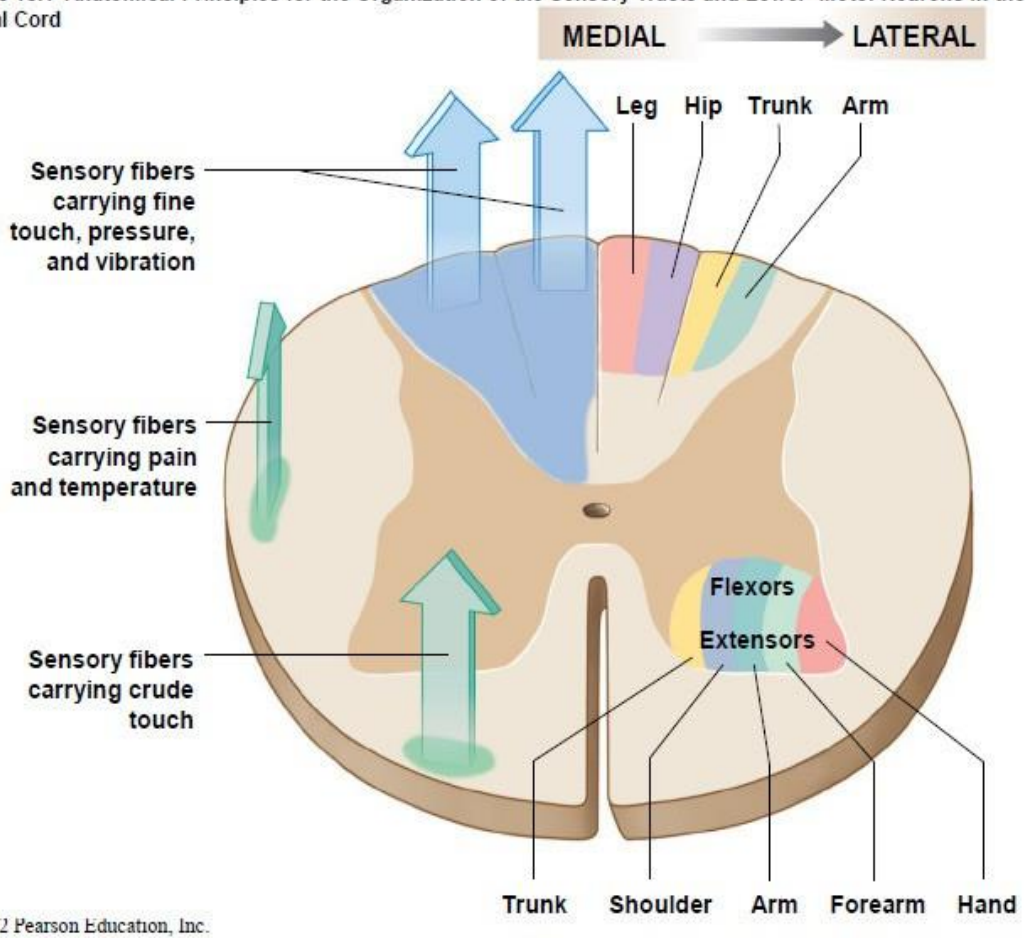


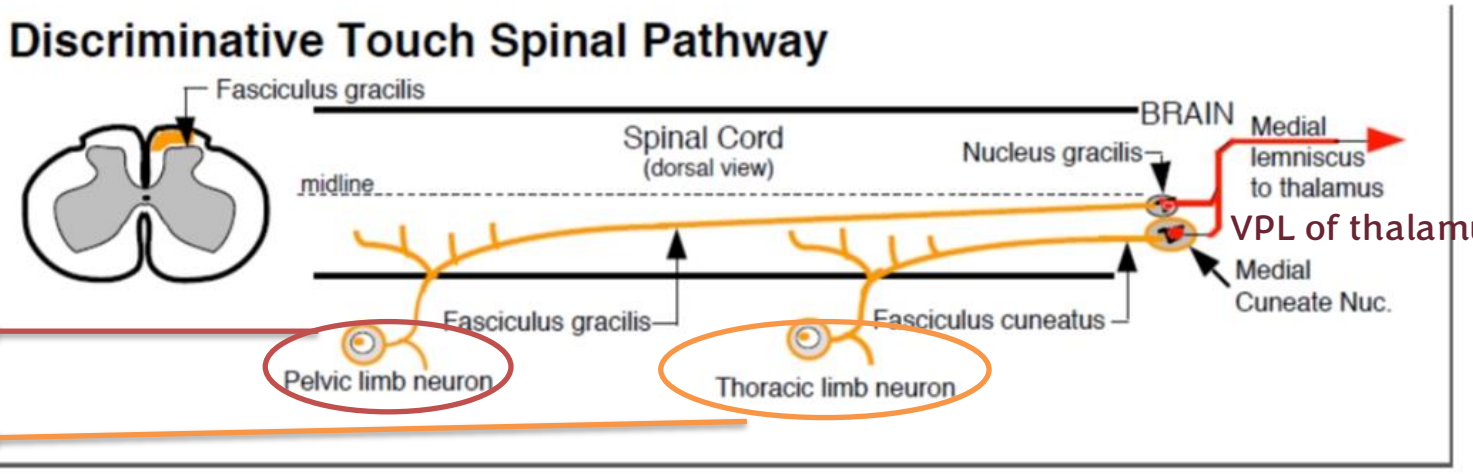
- In the posterior WC-ML pathway, the fibers come ipsilaterally. Now, let's take a look at the lowest part of the body 'THE FOOT'. A fiber coming from the foot to the dorsal root ganglion, would be the first to enter to the posterior column , taking place in the first-row seats which happen to be the most medial part of the column. The fibers that come afterwards would the sit next to them and more laterally. Thus, the lower part is most medial, and the upper part is most lateral.
- So the presentation of the body in the cortex from the lower parts to the upper parts has a similar copy in the posterior column
- The borderline between fasciculus Gracilis and Cuneatus is T6

Inferior to T6 → gracilis above T6 → Cuneatus

Example : if we take a cross section at level L4 what we will see Gracilis or Cuneatus or both ? Because L4 is inferior to T6 the active part will be fasciculus Gracilis because Cuneatus is not formed yet

Figure 15.1 Anatomical Principles for the Organization of the Sensory Tracts and Lower–Motor Neurons in the Spinal Cord



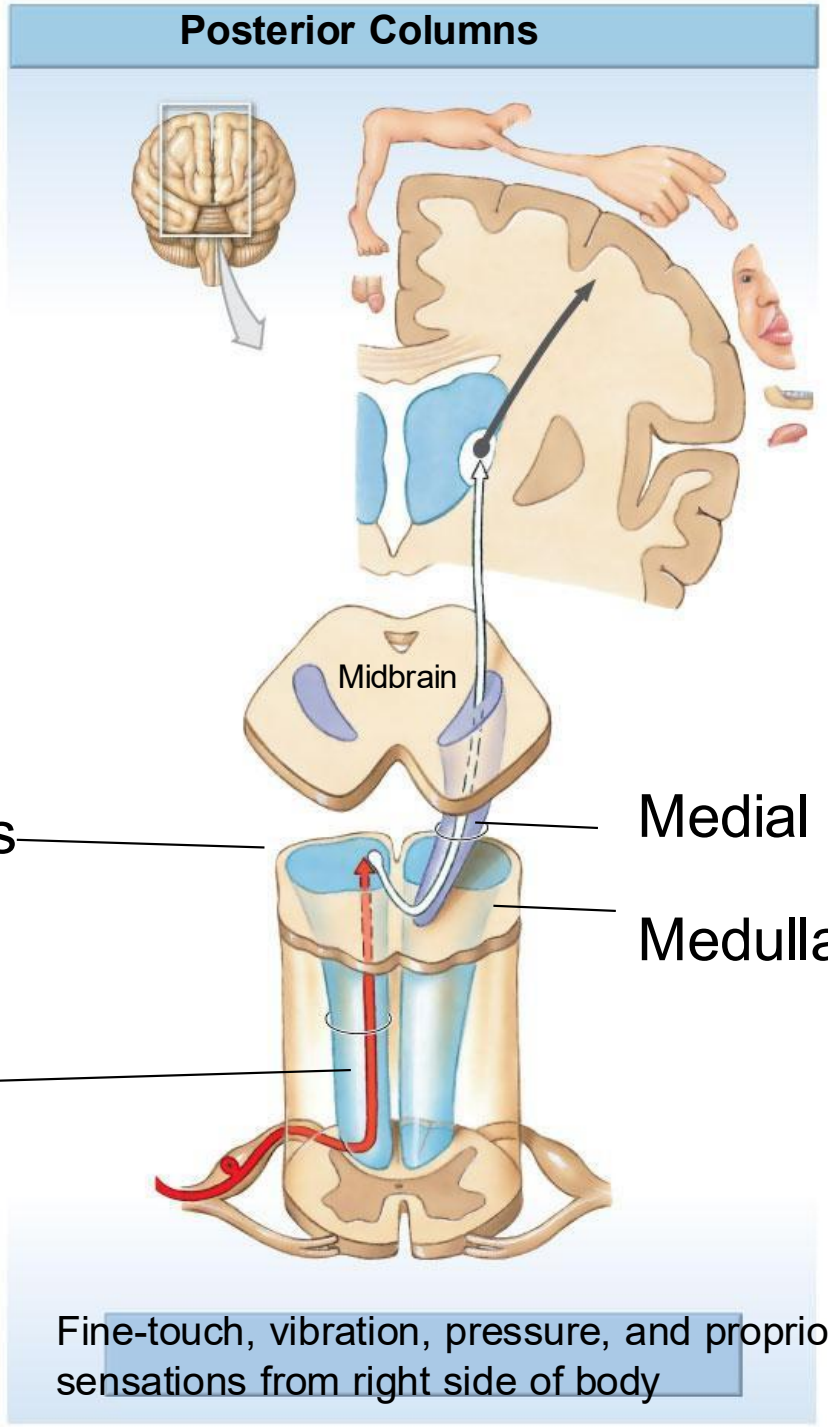


The lower comes first

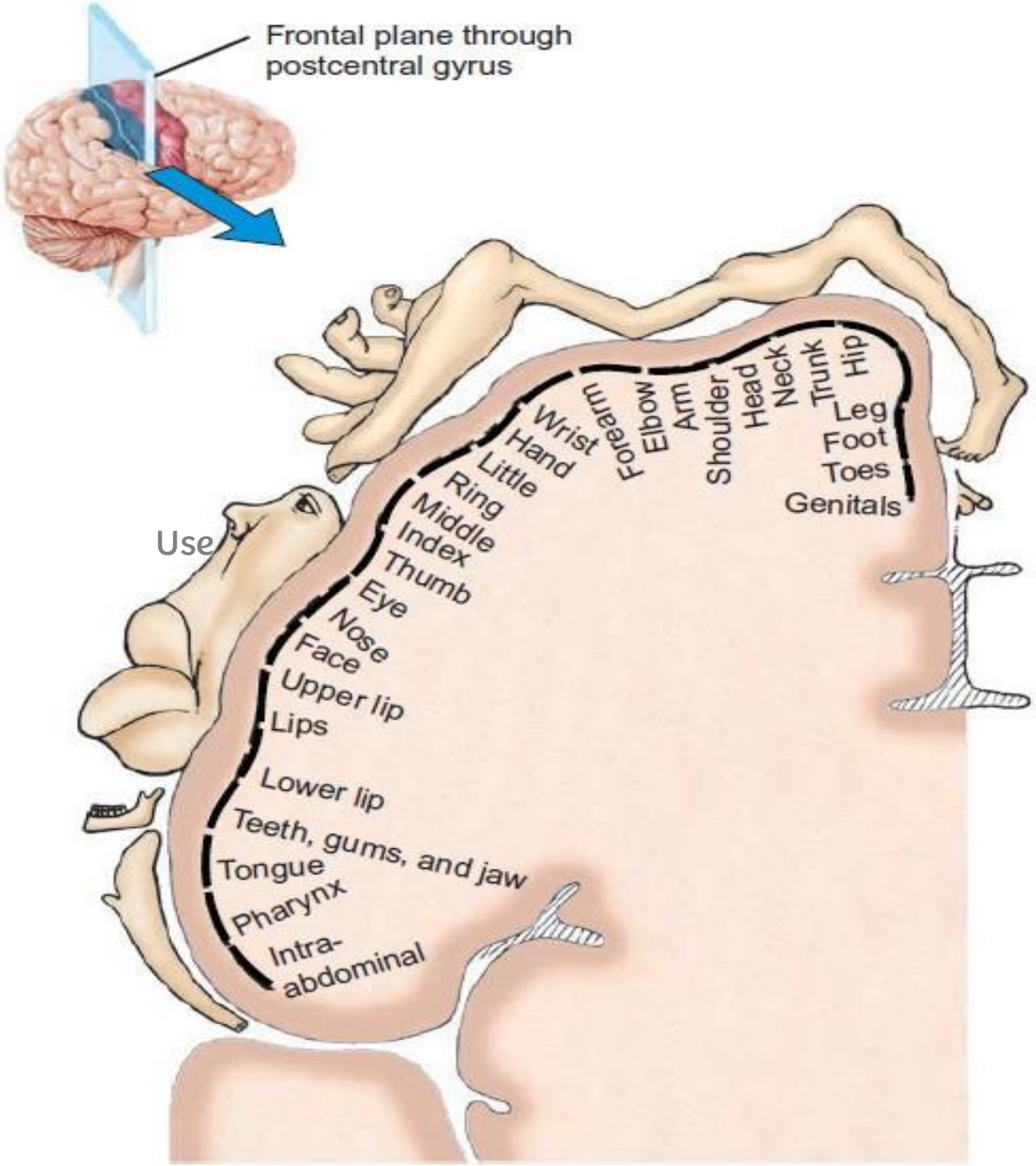
Fasciculus Gracilis

The upper comes after

Fasciculus Cuneatus



The doctor said he will focus on these points: where the fibers enter, how they are arranged internally vs externally, and their relation to the lesion. He emphasized that the internal structure is especially important, particularly the order of the fibers, because the orientation (outside → inside vs inside → outside) makes a difference.


Frontal plane through postcentral gyrus
Wrist
Hand
Little
Ring
Middle
Index
Thumb
Eye
Nose
Face
Upper lip
Lips
Lower lip
Teeth, gums, and jaw
Tongue
Pharynx
Intra-abdominal
Forearm
Elbow
Arm
Shoulder
Head
Neck
Trunk
Hip
Leg
Foot
Toes
Genitals

Primary Somatosensory (SI) Cortex

A scientist named Brodmann divided the cortex into functional areas by numbers:

This region (postcentral gyrus) is subdivided by types of receptors into four distinct areas: from anterior to posterior, Brodmann areas 3a, 3b, 1, and 2.

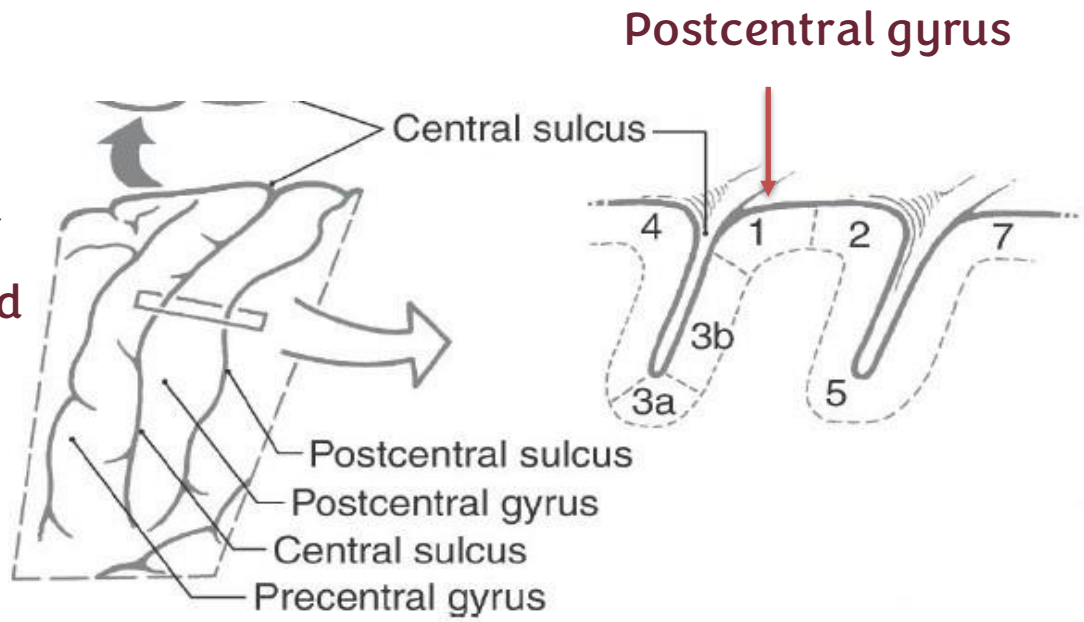
- Explanation from the doctor simpler than the net slide

How do you know that what you sense is temperature or touch ?

Depending on the receptor that can transform the energy from mechanical to electrical signals called mechanoreceptors, or receptors that transform the energy from thermal to electrical called thermoreceptors.

If all the signals are electrical how can we distinguish between the forms of energy ?

The labeled line theory , which means every single fiber has just one type of receptors and after the signal is detected by the receptor and go through specific pathway it will reach certain area so when these area is stimulated the body will sense heat for example.



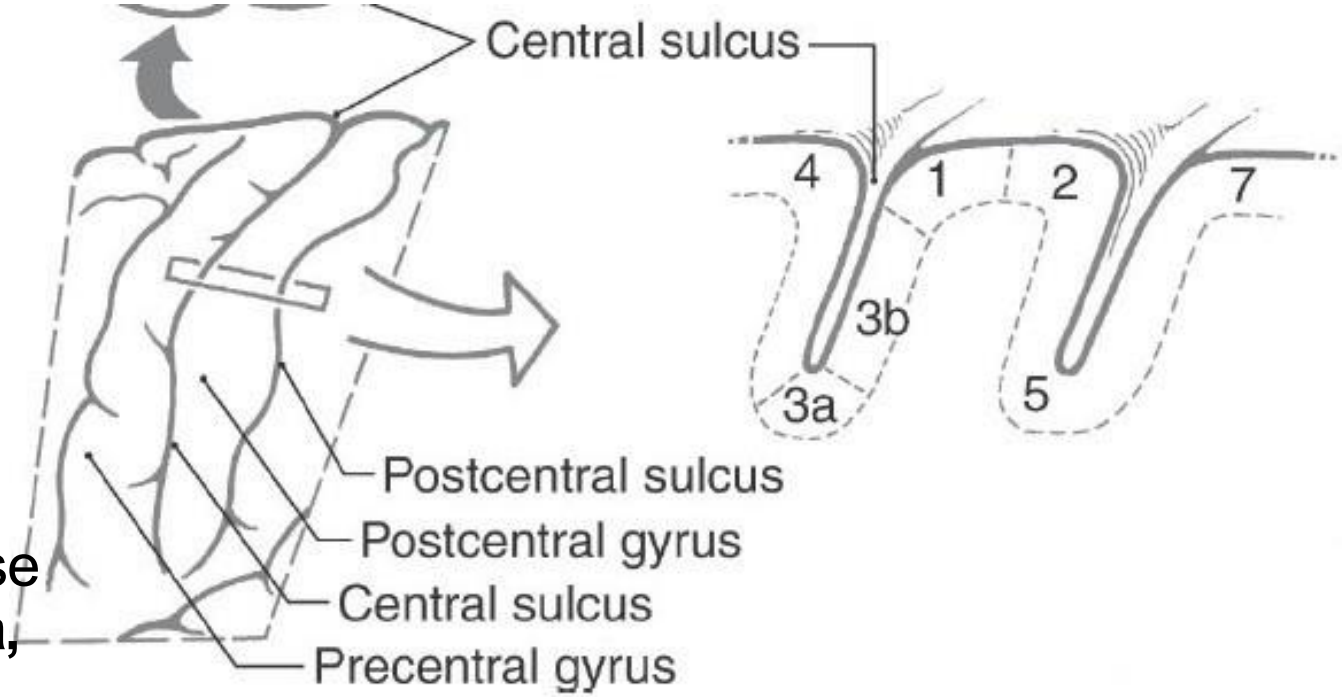
- Neuroscience looks exactly like computer science, although it uses only one language in its CPU : 1 &0 (opened or closed circuit)
- ✓ It has several outputs: colors, words, & numbers

- Suppose we don't have a language to communicate with, rather we use electrical lines to communicate:
- Line 1: the microphone is not working
- Line 2: we are hearing you but not understanding what you're saying
- And Line 3 with a third meaning and so on

- Going back to the CNS all the input are electric signals but they are labeled (each with specific meaning)
- ✓ So we have three numbers (Brodmann area) each one is responsible for the reception of a specific type of data

Primary Somatosensory (SI) Cortex

- Axons from third-order thalamic neurons terminate in the **primary somatosensory (SI)cortex**
- subdivided into four distinct areas; from anterior to posterior, these are **Brodmann areas 3a, 3b, 1, and 2**



- **Area 3a:** muscle spindle afferents (mainly)
- **Area 2:** Golgi tendon organs, and joint afferents (mainly).
- **Areas 3b and 1:** They receive cutaneous afferents from receptors such as Meissner corpuscles and Merkel cells). also receive input from cutaneous receptors that transmit pain and temperature

lateral spinothalamic tract

- The **spinothalamic tract** is divided into: **lateral** and **anterior**
- The general modalities for it include: **pain, temperature, and crude touch** (less precise- not discriminative)
- ✓ ***The lateral spinothalamic tract*** is responsible for **pain** and **temperature**

While ***the anterior*** is responsible for **crude touch**

- ✓ Although these tracts are described as separate pathways, there is significant anatomical overlap within the anterolateral system.

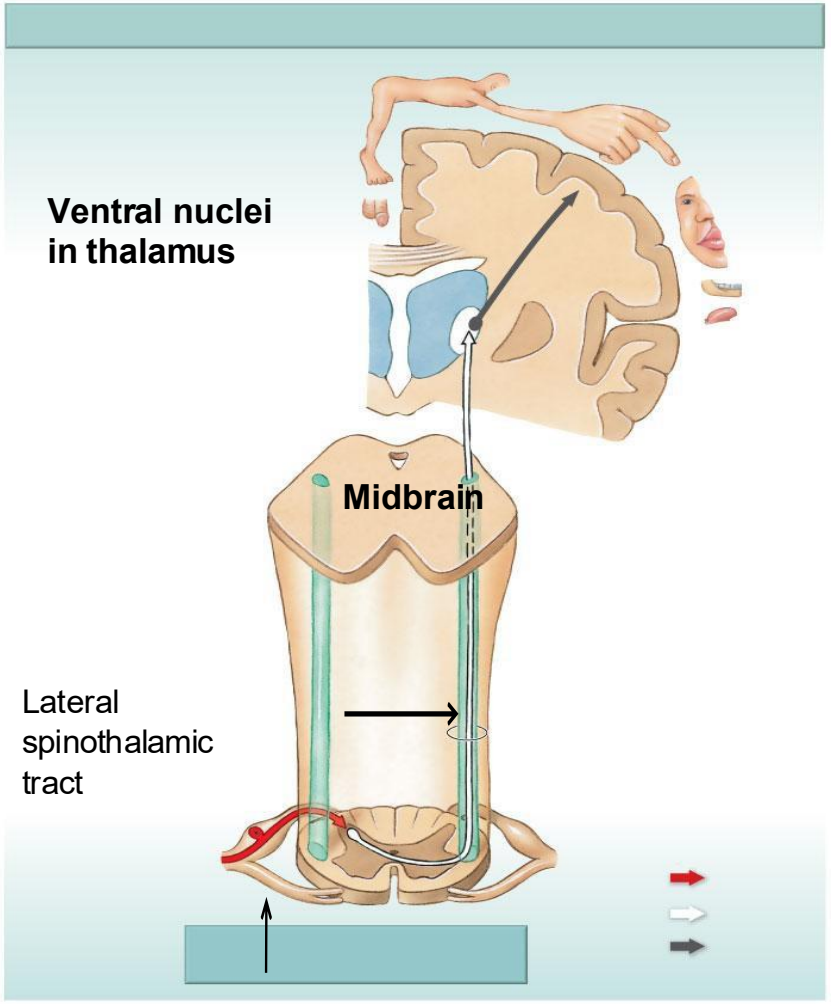
Note: Anterior and lateral are related to the cross section in the spinal cord .

	Receptors	**First order neuron cell body**	**First synapse**	**Fibers ascendance**	**decussation**	**Fibers of the lower part of the body**	**Localization (on the cortex)**
Spinothalamic system	Free nerve ending (they are slower-smaller diameter)	Dorsal root ganglia	Dorsal horn of grey matter (sensory function)	Contralaterally: right to left or left to right (2nd order neuron)	Spinal cord (at the same level of entrance, above, or below)	More lateral	primary somesthetic and the widespread cortical region
Posterior column system	All receptors except free nerve ending	Dorsal root ganglia	The lower part of medulla oblongata	Ipsilaterally (in the white column)	The lower part of medulla oblongata	More medial	Primary somesthetic

lateral spinothalamic tract

- Modality: pain and temperature
- Receptors: free nerve endings
- 1st Neuron: Dorsal root ganglia
- 2nd Neuron: the posterior gray column (substantia gelatinosa) 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 lateral spinothalamic tract

another formulation



Pain and temperature sensations from right side of body

The second-order neuron has its cell body in the dorsal horn of the spinal cord. Its axon crosses the midline anterior to the central canal through a structure known as the anterior white commissure.

✓ Therefore, the decussation in this pathway occurs early.

Due to this early decussation, fibers originating from the lower parts of the body are positioned more laterally within the ascending tract. This anatomical organization is clinically important, as it helps determine the consequences of spinal cord lesions, such as tumors or vascular injuries.
The second-order neuron then ascends until it reaches the same nucleus.

lateral spinothalamic tract

- 3rd Neuron: Thalamus (VPL) Internal Capsule ----- Corona Radiata(**one of the thalamic nuclei)then it projects to the cortex**

✓ The rest are all the same.

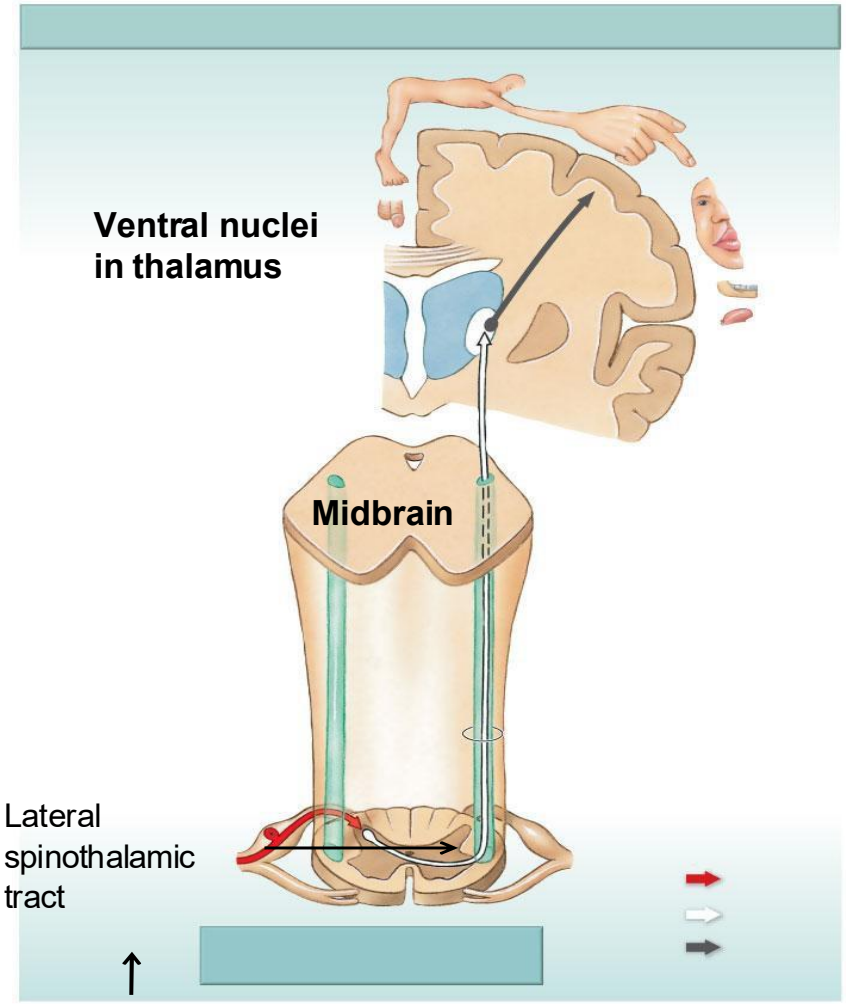
➢ It goes through the thin area in the internal capsule, which lies between the thalamus and caudate medially and the lentiform nucleus laterally.

➢ Then it continues as the corona radiata and reaches the cortex, where localization occurs.

- In the posterior column system, localization occurs in one area only: the primary somesthetic area S1 (Brodmann areas 3,1, &2).
- The lateral system has localization in both...

Termination: Primary Somesthetic Area (S I) **and Widespread Cortical Region**

Because the sensation of pain is a complex sensory experience, it has emotional & autonomic components



Rexed laminae

The grey matter is divided into 10 laminae (7 divisions are in the dorsal horn).

- **Lamina I:** tip of the dorsal horn, most posterior.
- ✓ *The most important divisions in the lateral system are I, 2, and5 , which are related to pain and temperature.*
- **Laminae I & 2:** substantia gelatinosa (an old name; now we use the laminae numbering). This represents the cell bodies of the second-order neurons, which then cross the midline and ascend.
- ✓ **There is a difference between laminae in function and structure.**

Types of pain:

➢ **Fast pain**

- Sharp, specific, and well-localized (e.g., needle stick)
- Considered "good pain"; it becomes a problem when it is not felt.

➢ **Slow pain**

- Dull, non-specific, and diffuse
- Example: if injured by a dirty knife, infection and inflammation with edema and tenderness develop.
- Requires time to heal; it is inflammatory pain and a type of slow pain.

✓ Other types include **neuropathic pain** and **cancer pain.**

✓ The chronicity of slow pain bothers patients the most and often forces them to visit the doctor.

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

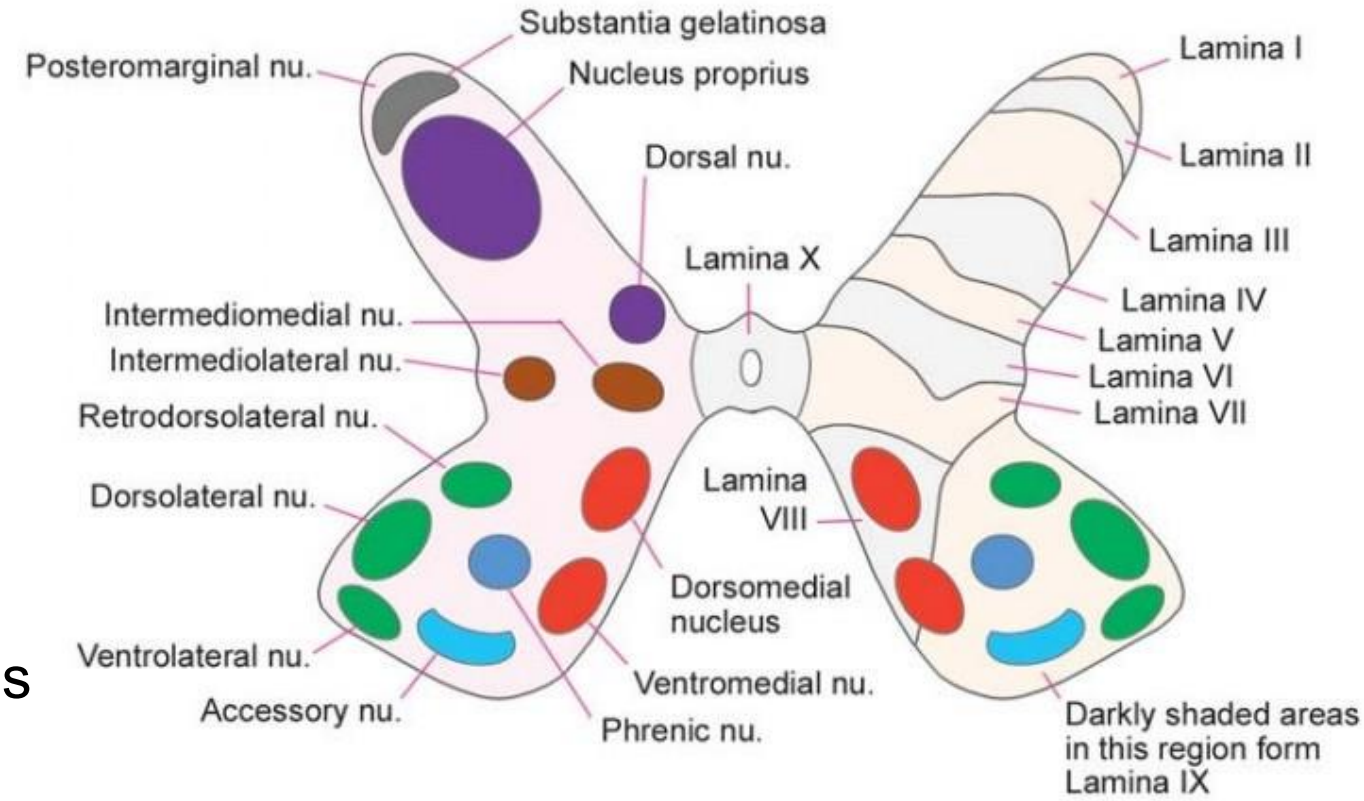
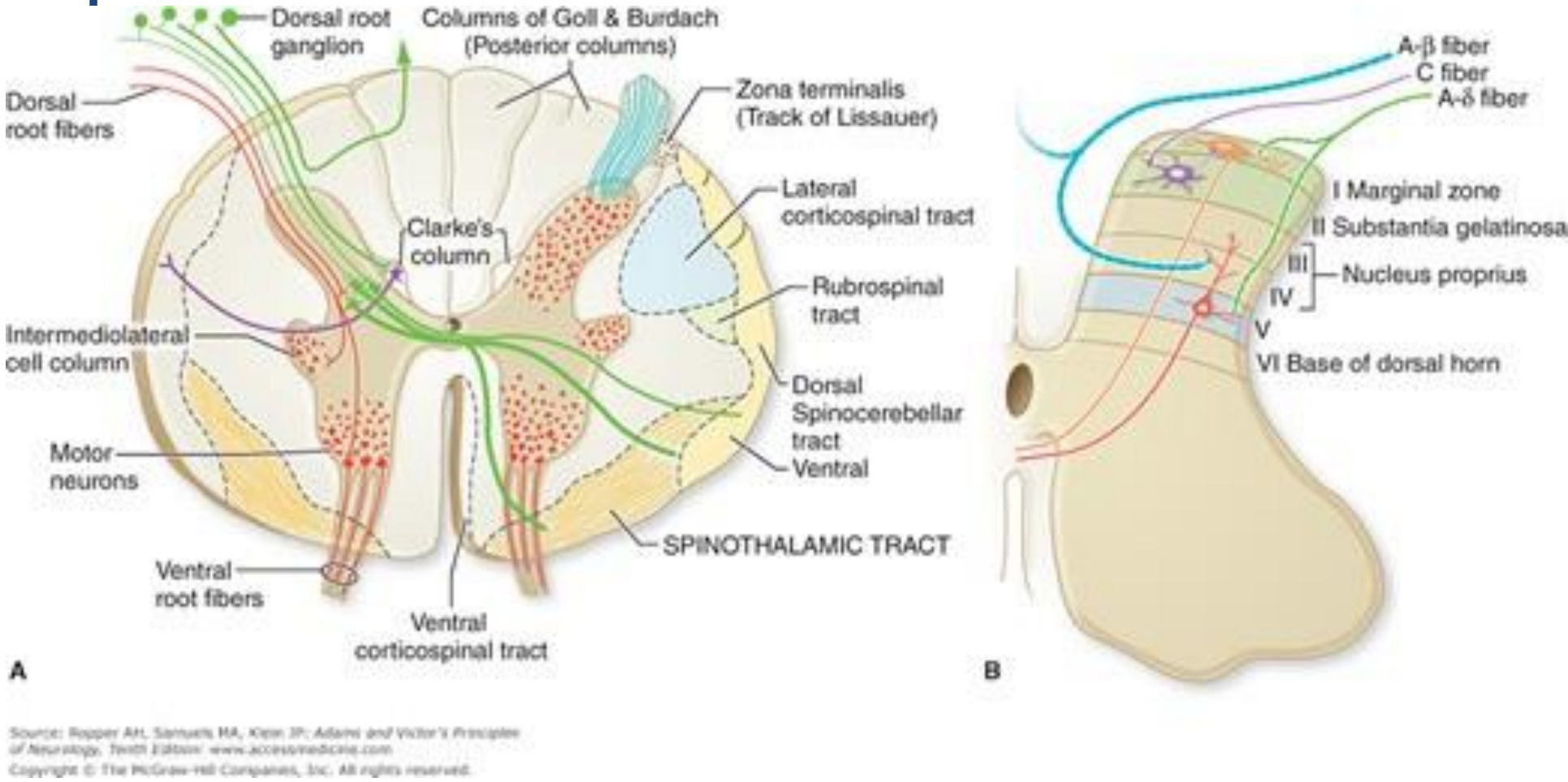


Fig. 5.2. Subdivisions of the grey matter of the spinal cord. The left half of the figure shows the cell groups usually described. The right half shows the newer concept of laminae.

- **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**

lateral spinothalamic tract

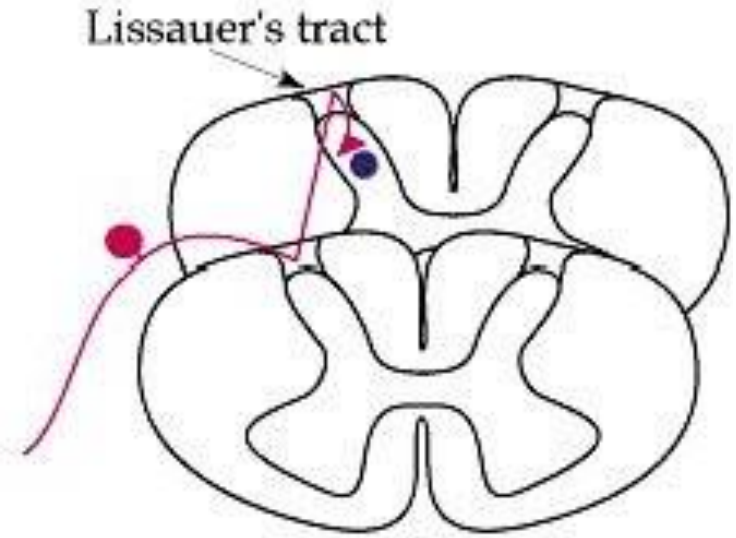


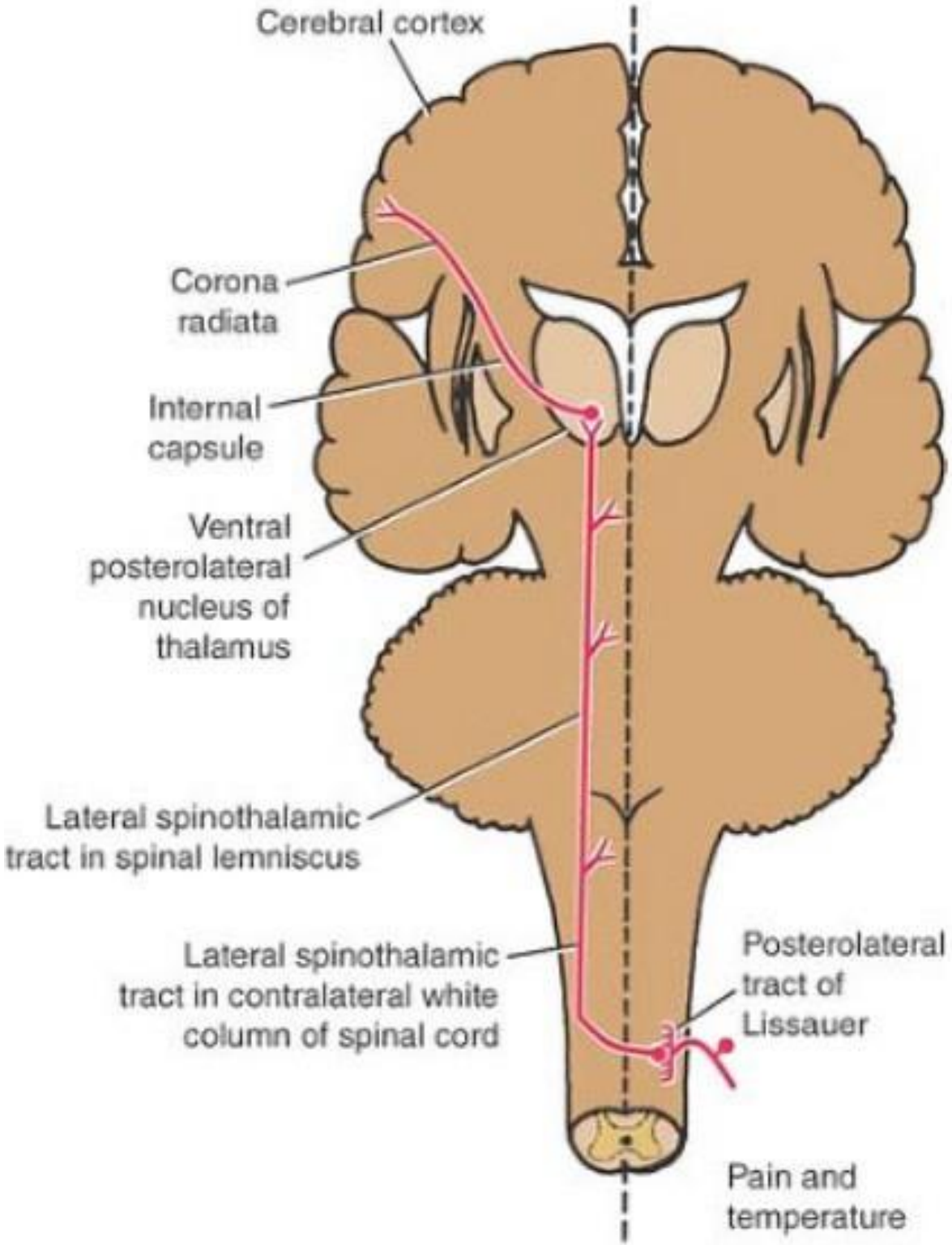
- Lamina 1+ 5: the spinothalamic tract ascend which transmit pain, temperature and touch. (A delta fibers)
- Lamina 1+ 2: the spinothalamic tract ascend (C fibers).

Anatomically: fast and slow pain are conducted by different fibers:
•Aδ fibers (faster than C fibers) → synapse in laminae I & 5 → fast pain
•C fibers → synapse in laminae I & 2 → slow pain

Posterolateral tract of Lissauer

- located between the posterior white column and the lateral white column





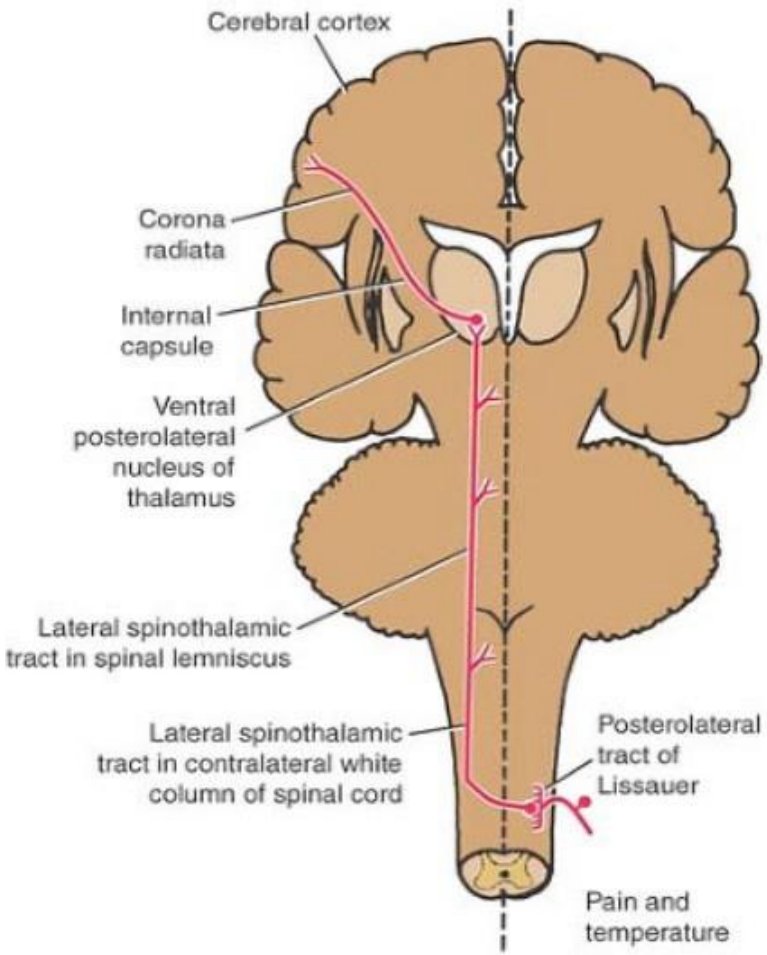
Lissauers tract

- We said that the first order neuron enters through the dorsal root ganglia and synapses with the second order neuron in the substantial gelatinosa and then it ascends.

- The idea here is that it's not necessarily for the fiber to synapse in the same segment which it had entered.

✓ Eg: a fiber entered through the segment T4 it can synapse in the same segment or in one or two segments above, so the fibers while they are ascending they create a local tract (from T4 to T3 which is a short distance) that ascends between the posterior white column and the lateral white column .

✓ According to the picture taken from snells book the fibers can synapse below or above the entrance site.



Pain (widespread cortical region)

Pain is a complex experience. Usually, when suffering from pain, a feeling of depression accompanies it, and some types of severe pain trigger an autonomic response (increased heart rate, sweating, vomiting).

This is explained by:
•The connections of this tract to other areas while ascending
•The widespread cortical termination

➢ Examples of other connections (terminations):

1. Reticular (شبكي) formation : A group of neurons in the core of the brainstem, has many functions (motor functions will be discussed later)

- Main function for now: regulating sleep-awake cycles
- Acts as a switch for the cortex

✓ How it works:

- During sleep, quiet noises may occur but won't wake you up, even though your body is still functioning (tympanic membrane vibrating, cochlear nerve firing) – the cortex is switched off.
- If a massive sensory input occurs (e.g., spilling water on the face), you wake up because the reticular formation activates the cortex.
- Accordingly, the spinothalamic pathway activates the reticular formation, keeping you aware of pain – this has survival value.

Clinical relevance:
•When taking history, it is important to ask: Does the pain wake the patient up?

2. **Cingulate gyrus**

- Not a surface gyrus (like frontal or parietal gyrus).
- A deep gyrus in the longitudinal fissure, part of the limbic system (emotional mind – related to memories and emotions).
- Receives the emotional component of pain from the lateral spinothalamic tract.

✓ **Example (experiment): Conditioned place paradigm in rats**

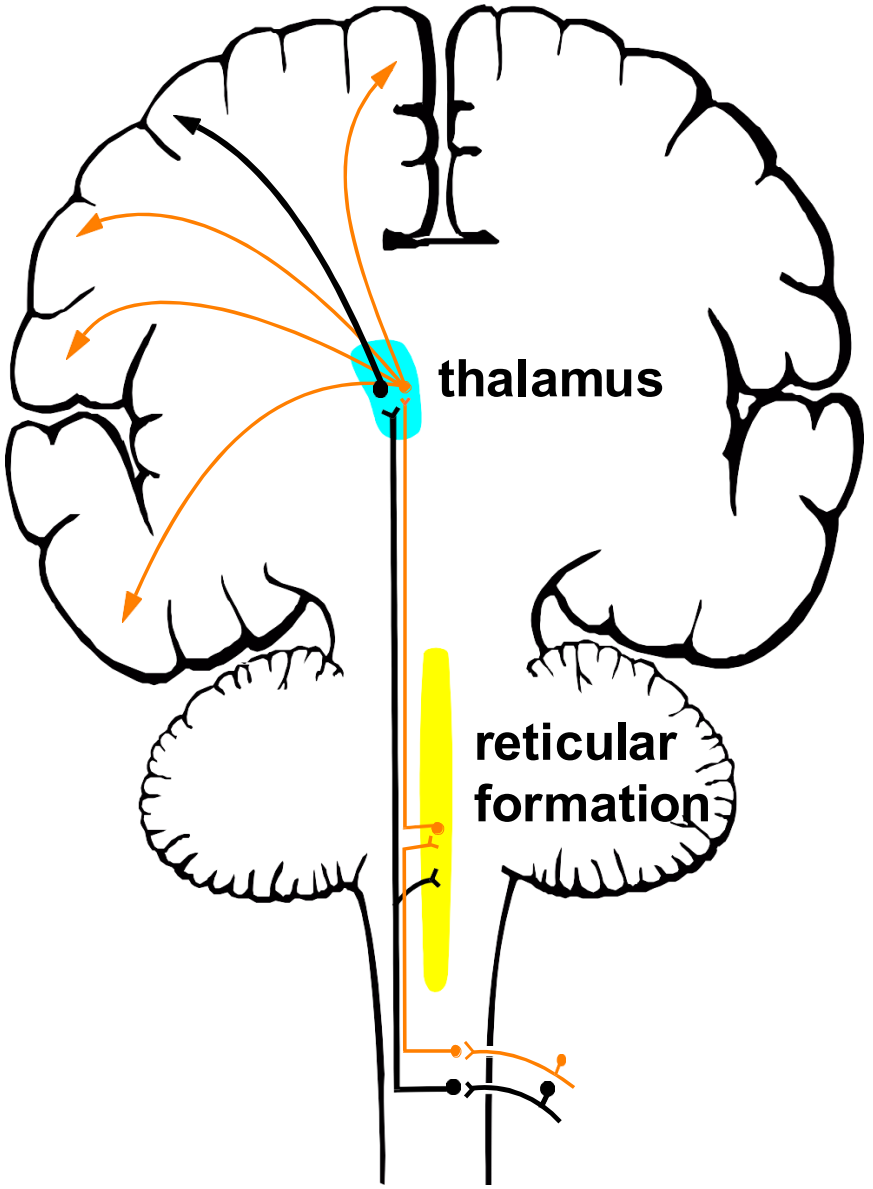
- Cage with 3 rooms: **right, middle, left.**
- **Right room:** always associated with pain (electric shock or injection).
- **Left room:** no pain.
- After one month, if given a choice, the rat chooses the **left room.**
  - If the anterior cingulate gyrus is damaged, the rat cannot choose correctly.
  - The rat still remembers things, but pain-related connections are lost.

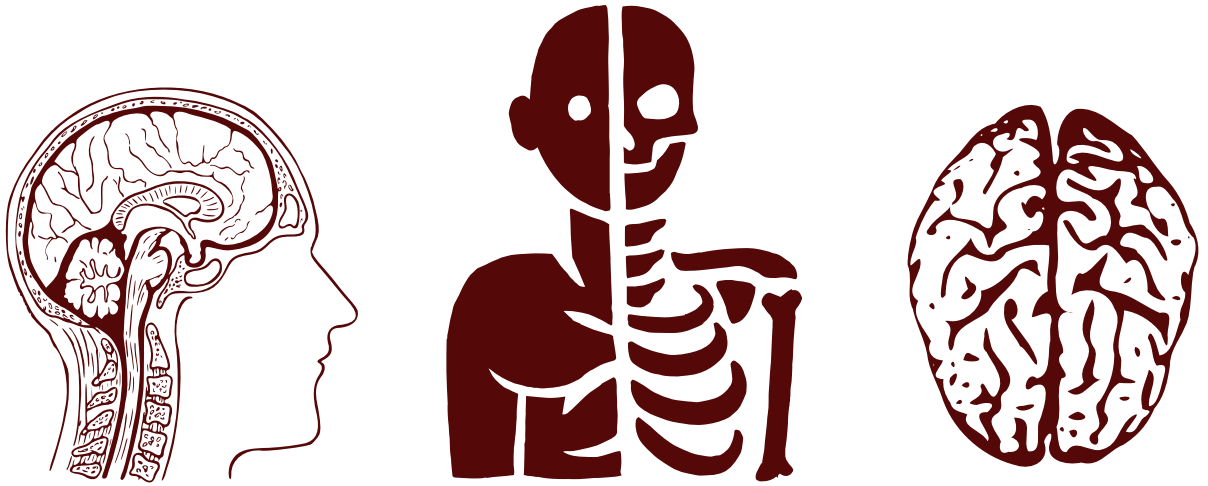
3. Insular (insulate) gyrus

- A deep gyrus in the lateral fissure.
- Related to interpretation of visceral pain (e.g., peptic ulcers, myocardial infarction) through C fibers.
- Also related to the autonomic response of pain (tachycardia, sweating, vomiting).

Other Terminations of the Lateral Spinothalamic Tract

- **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





ANATOMY QUIZ LECTURE 3

رسالة من الفريق العلمي

اللهم إن عمر عطية في ذمتك وحبل جوارك، فقِه من فتنة القبر وعذاب النار،
أنت أهل الوفاء والحق، فاغفر له وارحمه إنك أنت الغفور الرحيم.

Click on the picture

For any feedback, scan the code or click on

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1			
V1 → V2			