Physiology

Modified no. 3

الكاتب: فرح سائد

المدقق: ميس قشوع وعمر صمادي

الدكتور: فاطمة ريالات

Neurophysiology

Somatic Sensory Pathways

Fatima Ryalat, MD, PhD

Assistant Professor, Department of Physiology and Biochemistry

School of Medicine, University of Jordan

Color code

- Slides
- Doctor
- Additional info
- Important

Welcome to the 3rd physiology lec in the CNS 🎉

PLEASE, watch the anatomy lectures before this one; after that, it will be a piece of cake for you. 🍰

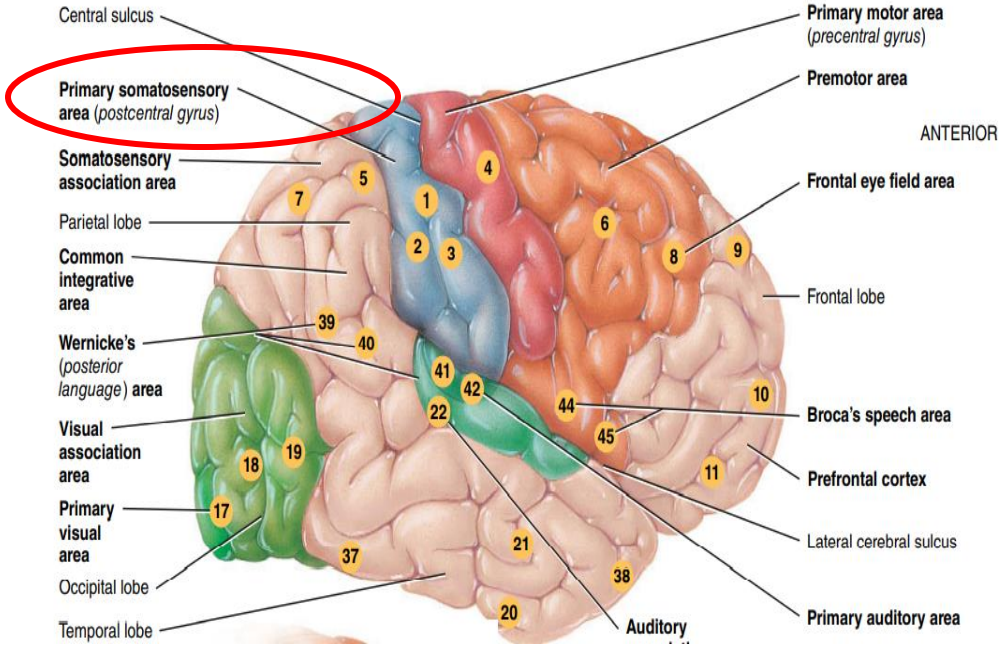
In this lec we will discuss the pathways that transmit somatic sensation, from sensory receptors up to the CNS.
Remember: The Ascending Sensory Tracts.

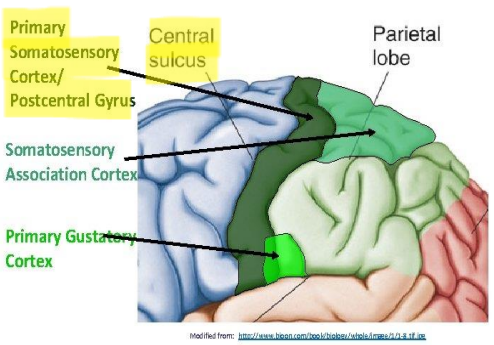
1-Posterior (Dorsal) Column- Medial Lemniscus Pathway.
2-Antero-Lateral Spinothalamic Pathways.
3-Trigeminothalamic Pathway.
4-Anterior and Posterior Spinocerebellar Pathways.(won't be discussed)

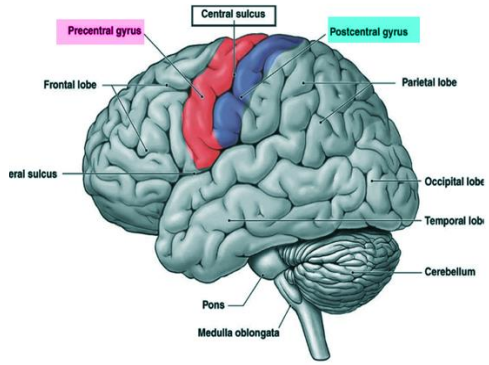
Cerebral cortex

Integration function happens in the CNS, and the most important integrative part of somatic sensation is the cerebral cortex.

The bluish area is called the **primary somatosensory area**, which is in the post-central gyrus of the parietal lobe.
Responsible for Detecting and interpreting sensations.







Extra Pics

1. Posterior (Dorsal) Column- Medial Lemniscus Pathway

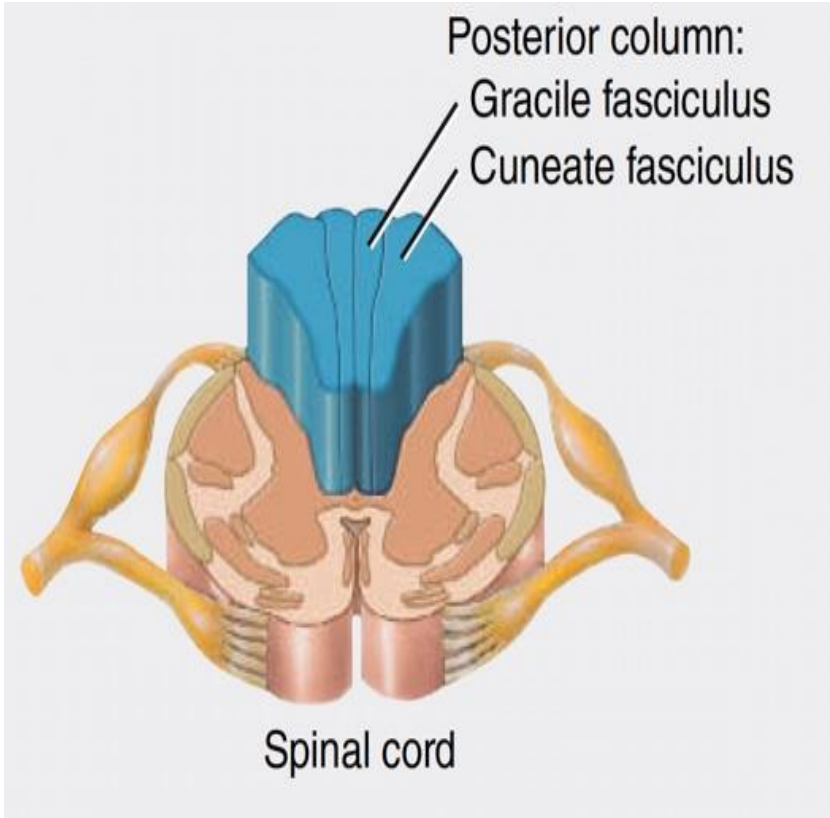
The name will help you make connections

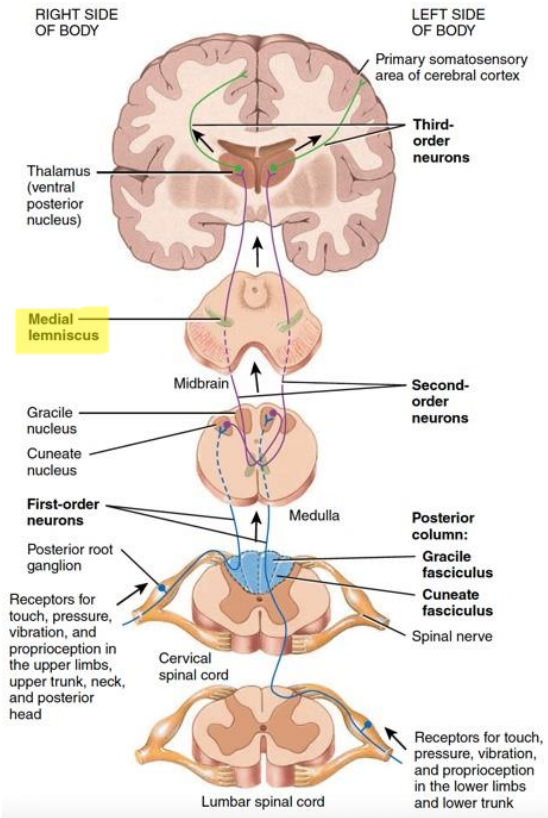
- **Posterior column**: presents in the posterior column of the white spinal matter.
- **Medial lemniscus**: part of the midbrain.

So, the tract will go from the posterior column to the medial lemniscus, meaning it's an **A**scending tract = **S**ensory pathway.

However, the pathway will go through other parts, not just these two.
These two are within the pathway.

The tract will transmit information from peripheral sensory receptors to the cerebral cortex by spinal nerves.



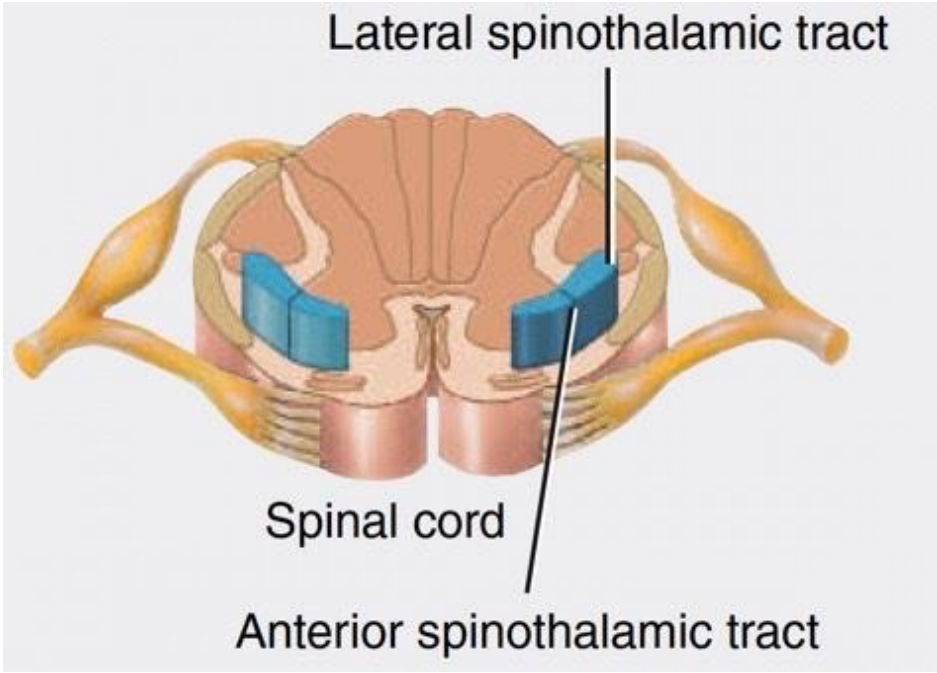


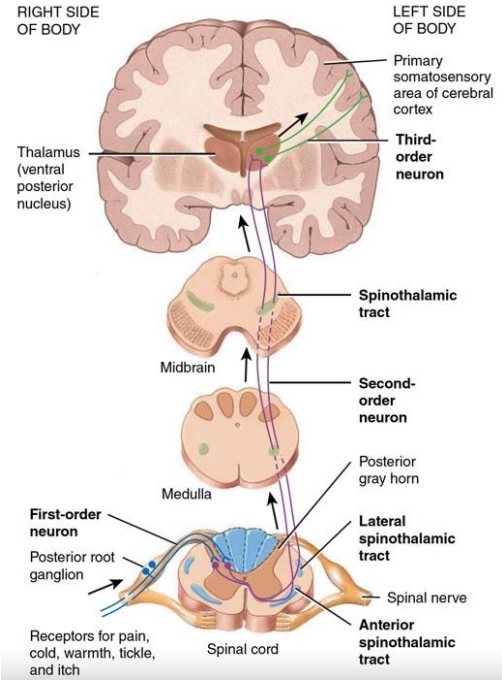
2. Antero-Lateral Spinothalamic Pathways

Antero-lateral: two pathways one anterior and another lateral to the ventral horn of the spinal gray matter.

Spinothalamic: reaches the thalamus through the spinal cord.

Another Ascending tract that gets info from the spinal nerves --> spinal cord --> thalamus --> cerebral cortex.





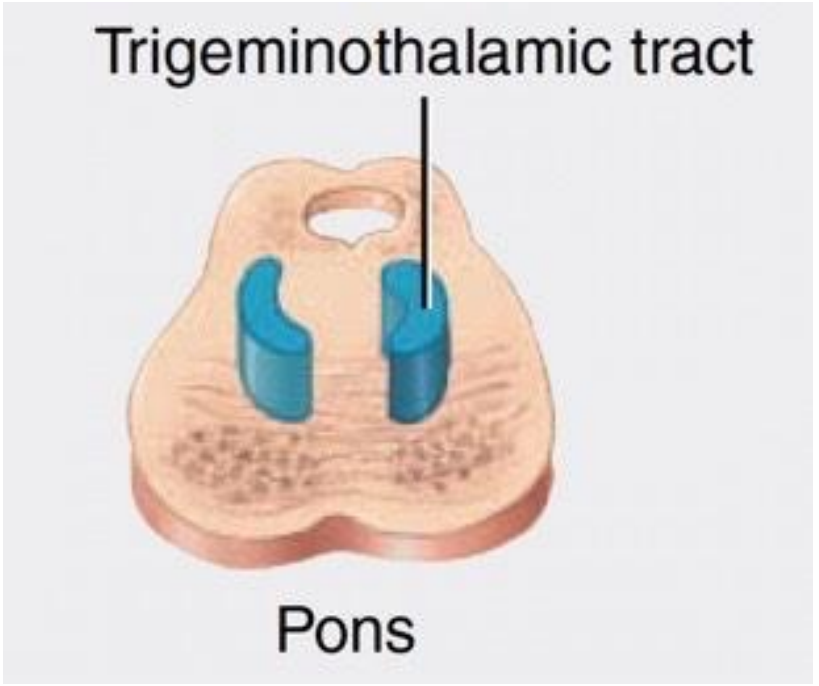
3. Trigeminothalamic Pathway

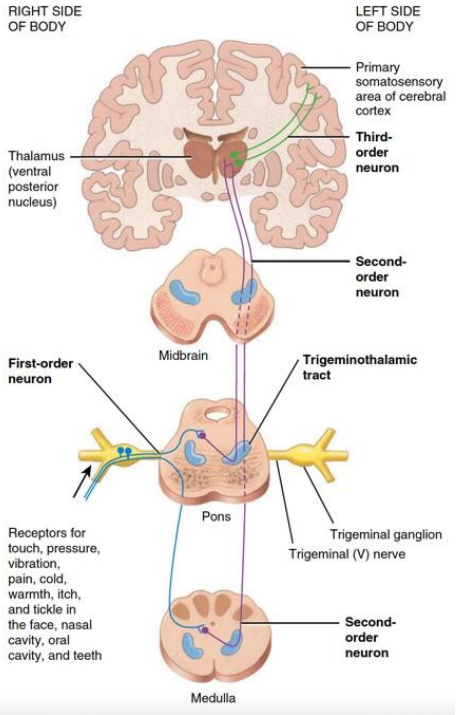
- **Trigeminothalamic**: between the cranial trigeminal nerve and the thalamus.

- Another sensory pathway that transmits sensation through a **cranial nerve**.

- The full pathway:

Trigeminal nerve --> brain stem --> thalamus --> cerebral cortex.





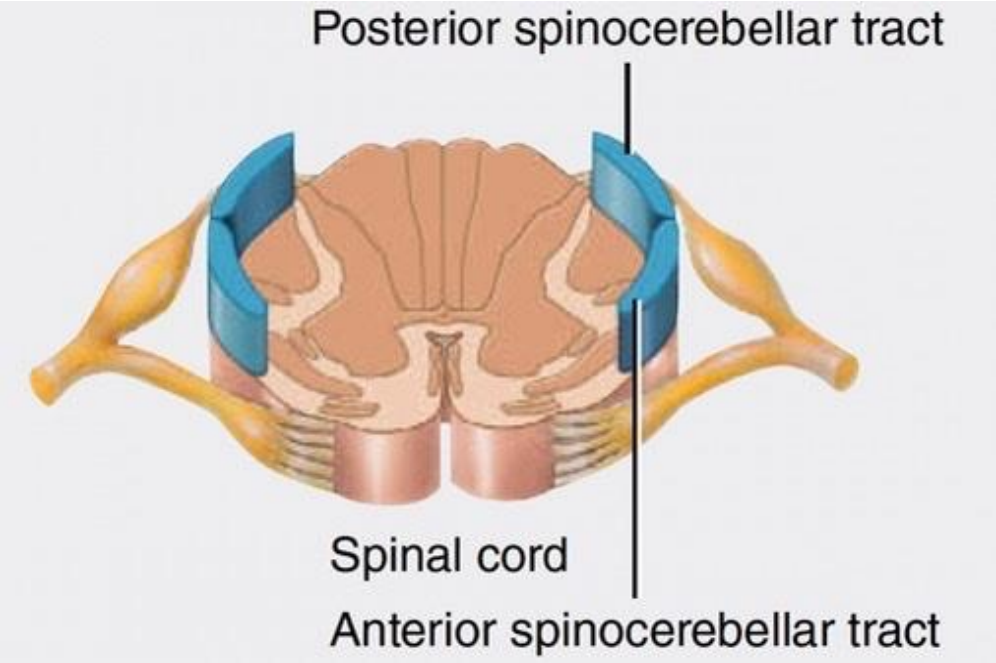
4. Anterior and Posterior Spinocerebellar Pathways

The difference in this tract is that integration happens in the **cerebellum**, so we don't have the perception of it because its subcortical.

- **Anterior and posterior**: two pathways, one anterior and another posterior one, in the lateral column of the white spinal matter.

- **Spinocerebellar**: from the spinal cord to the cerebellum.

Carry proprioception info. and maintain balance, posture and coordination of the skilled movement. [we are **unconsciously** aware of them].



Somatic sensation can also be integrated in the spinal cord for spinal cord reflexes, some fibers will go to the reticular formation.
But in this lec we will focus on the pathways that will be integrated in the somatosensory area of the cerebral cortex.

Somatic sensory pathways

- A somatic sensory pathway to the cerebral cortex consist of thousands of **sets of three neurons**:

- a **first-order neuron** brings information from the receptors, synapses with a **second-order neuron**, and a third-order neuron.

- Integration (processing) of information occurs at each synapse level along the pathway.

First-order (primary) neurons

- Sensory neurons that conduct impulses from somatic sensory receptors into the brainstem [through cranial nerves] or spinal cord [through spinal nerves].

- Somatic sensory impulses propagate along spinal or cranial nerves.

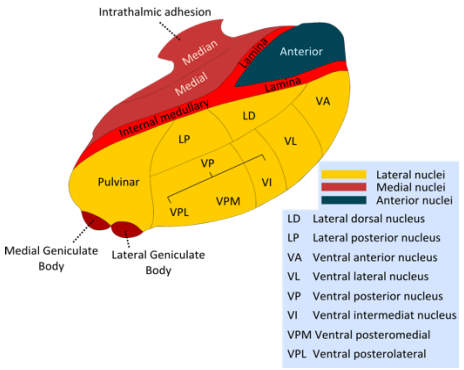
- All other neurons in a somatic sensory pathway are located completely within the CNS, but part of the first order neuron will be in the PNS.

Second-order (secondary) neurons

- Conduct impulses from the brainstem or spinal cord to the **thalamus**.

- Axons of **second-order** neurons **decussate** (cross over to the opposite side) as they course through the brainstem or spinal cord before ascending to the thalamus.

- The thalamus is considered a major relay station for sensory information, because most of the sensory neurons will synapse within the thalamus.
- In somatic sensation the synapse is mainly in the ventrobasal complex.



Third-order (tertiary) neurons

- The second-order neurons will synapse with the third-order neurons in the thalamus.

- Conduct impulses from the thalamus to the primary somatosensory area on the same side.

- Remember: the decussation (crossing) happens once by the second-order neurons that's means that the somatic sensory information on one side of the body is perceived by the primary somatosensory area on the **opposite** side of the brain.

1. Posterior column - medial lemniscus pathway

- The fibers here are large and myelinated, which makes its conduction velocity very high.

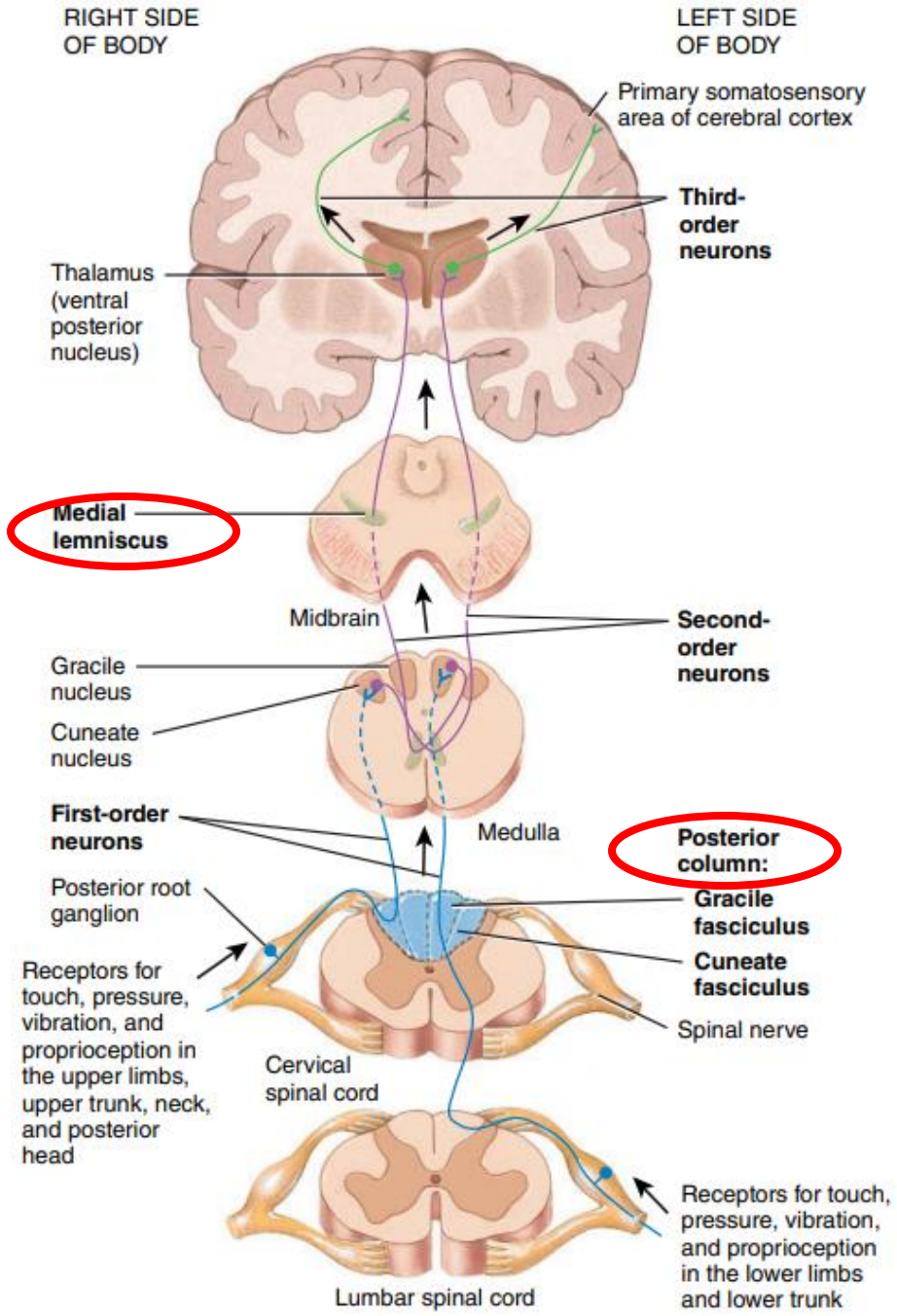
- The information for this pathway comes from:

-Limbs -Trunk -Neck -Posterior head

- Sensory modality:

-Touch -Vibration -Pressure -Proprioception

*Posterior carries TV Programs



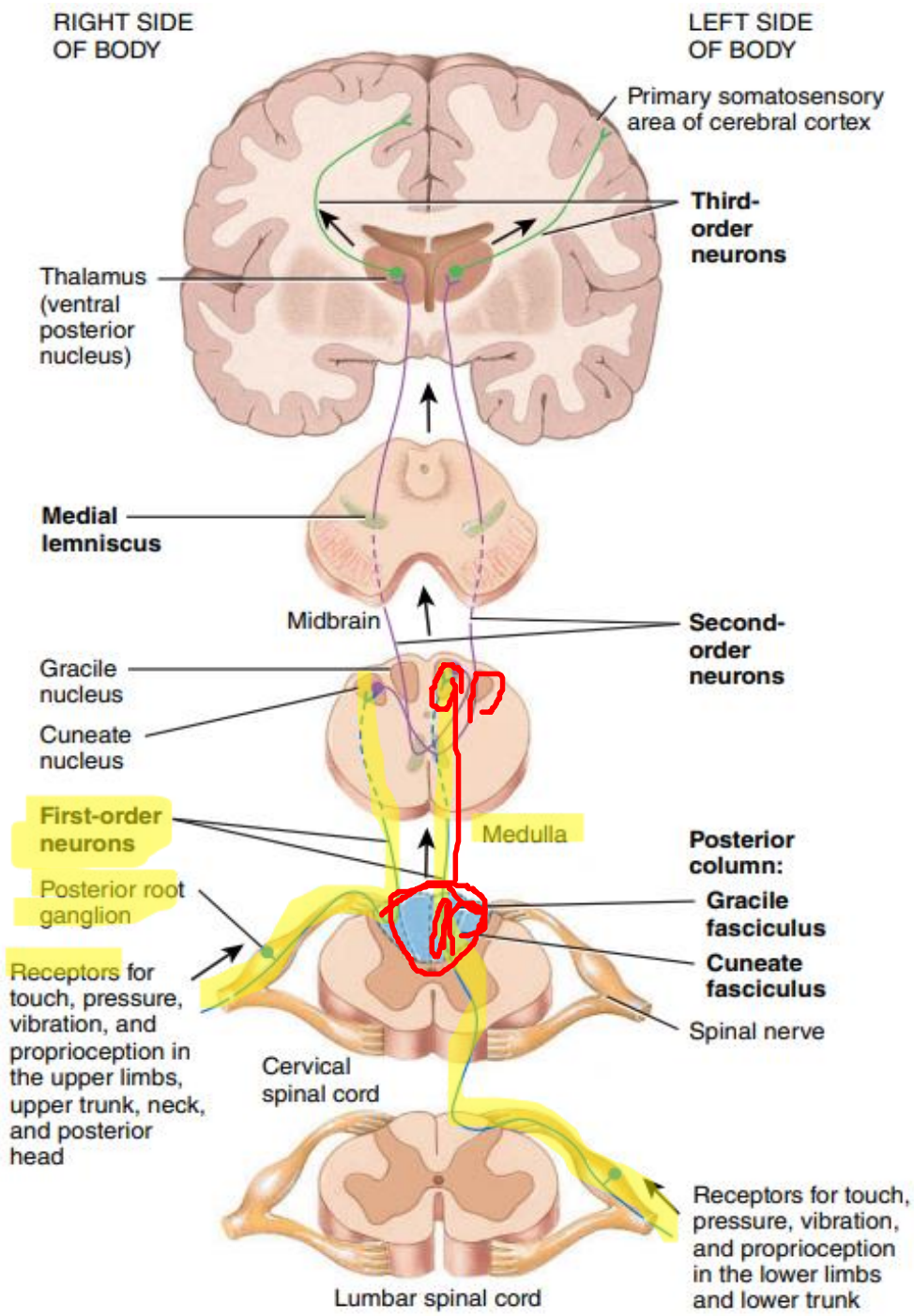
Posterior column - medial lemniscus pathway

Information about these sensory modalities will enter the spinal cord through spinal nerves to the posterior column.

The posterior column is divided into:
1- the **medial** part is called **gracilis fasciculus**.
2- the **lateral** part is called **cuneate fasciculus**.

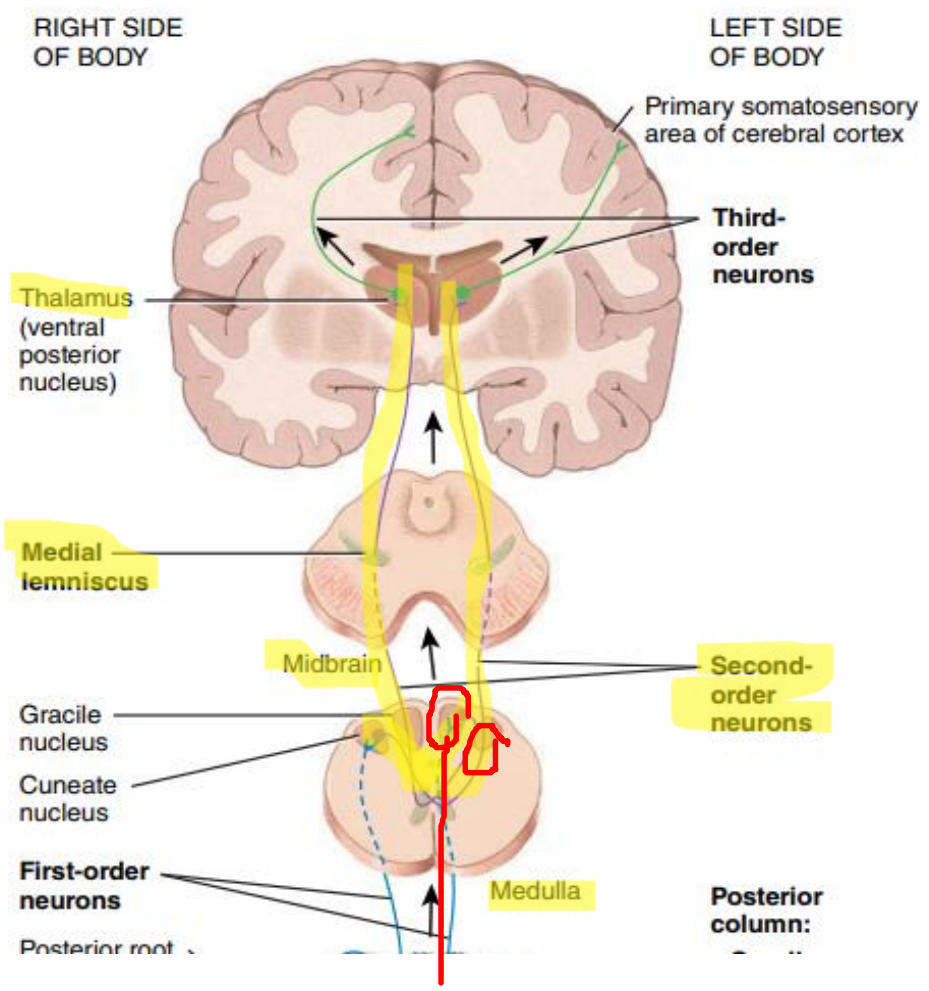
Fasciculus gracilis transmits information coming from the lower parts of the body, while Cuneatus transmits from the upper part of the body. A fiber coming from the foot would be the first to enter, taking place in the most medial part of the column, then the thigh more lateral, the upper limb more lateral, and then the neck the most lateral. This is important for localization.

- 1st order neurons will ascend to the medulla and synapse with the 2nd order neurons within the gracilis and cuneate nuclei.

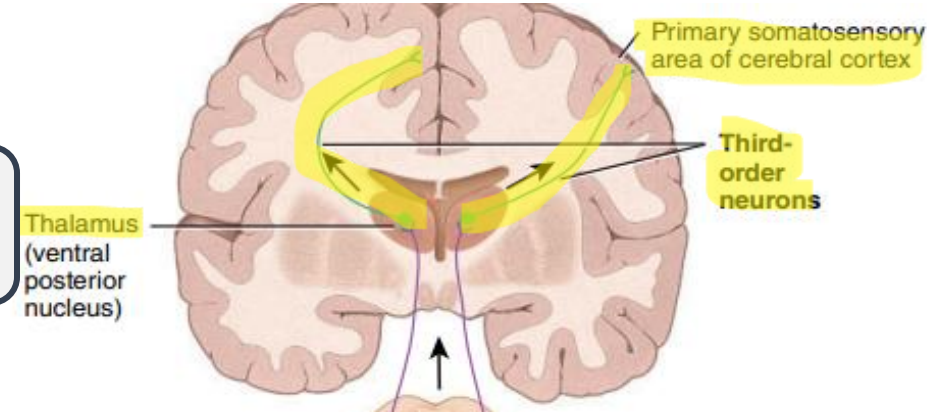


Posterior column - medial lemniscus pathway

- 2nd order neurons **decussate in the medulla**. Then ascend to the medial lemniscus, and then up to the thalamus.



- 3rd order neurons start in the ventrobasal complex of the thalamus and continue to the **primary somatosensory area of the cerebral cortex.**



2. Anterolateral spinothalamic pathway

- The fibers here are small, which makes their conduction velocity slow.

- The information for this pathway comes from:

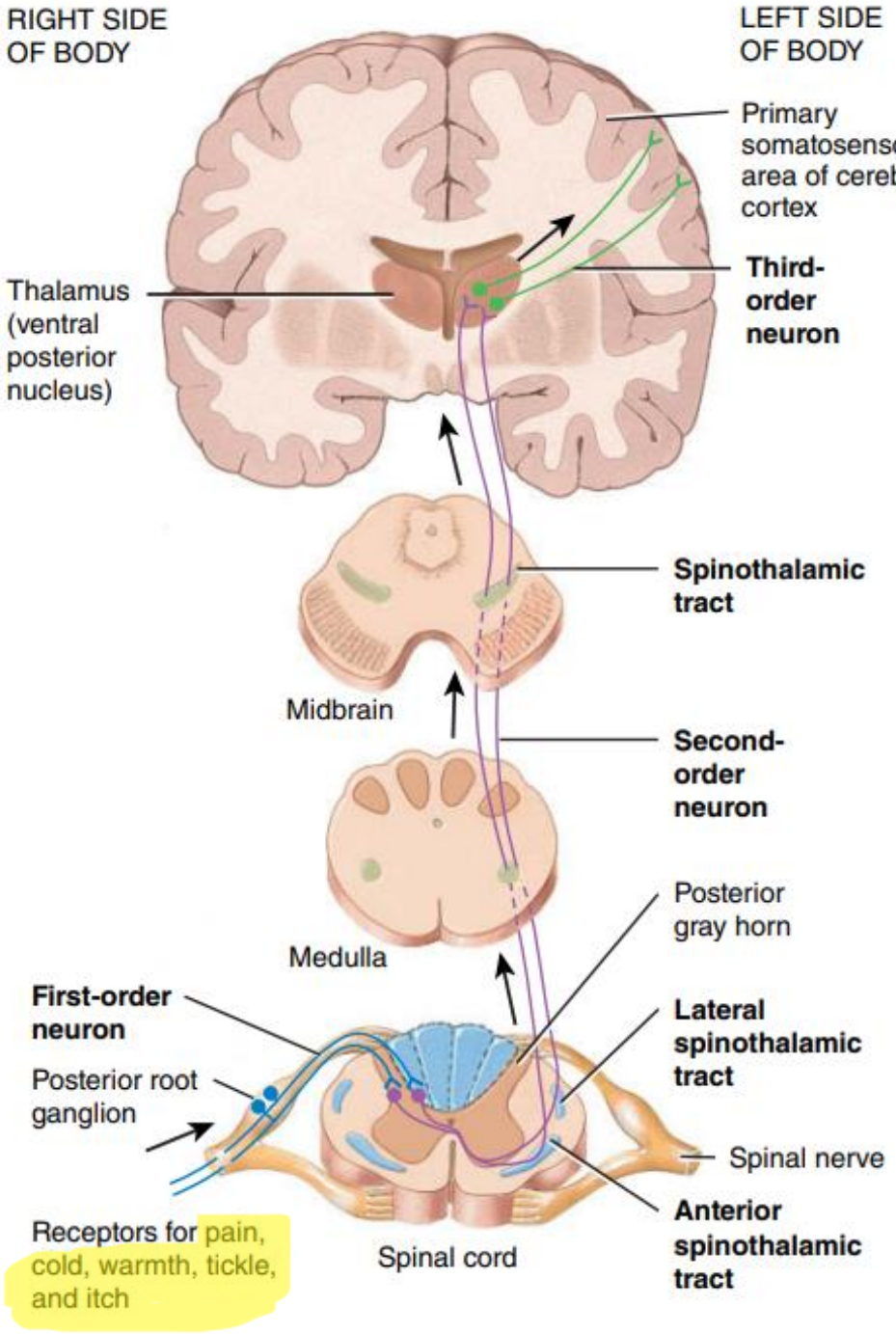
-Limbs -Trunk -Neck -Posterior head

[like the Posterior column pathway]

- Sensory modality:

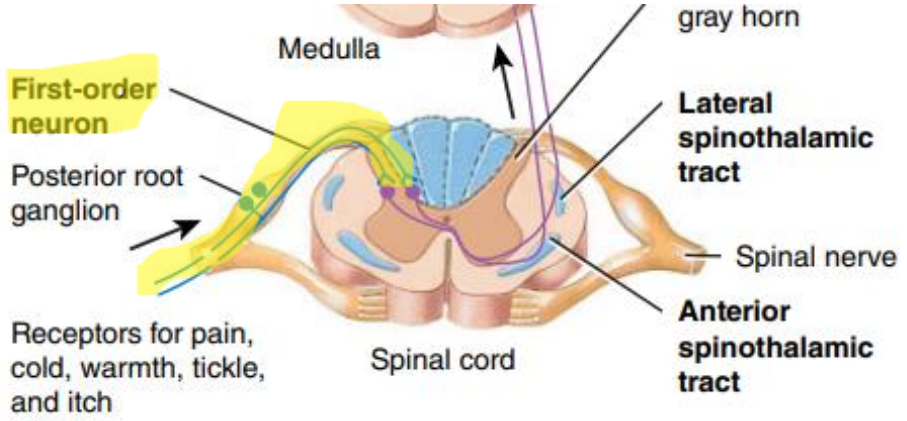
-Pain -Temperature -Itch -Tickle -crude touch -sexual sensation

*The fibers here are small, so it is PTIT (petite)

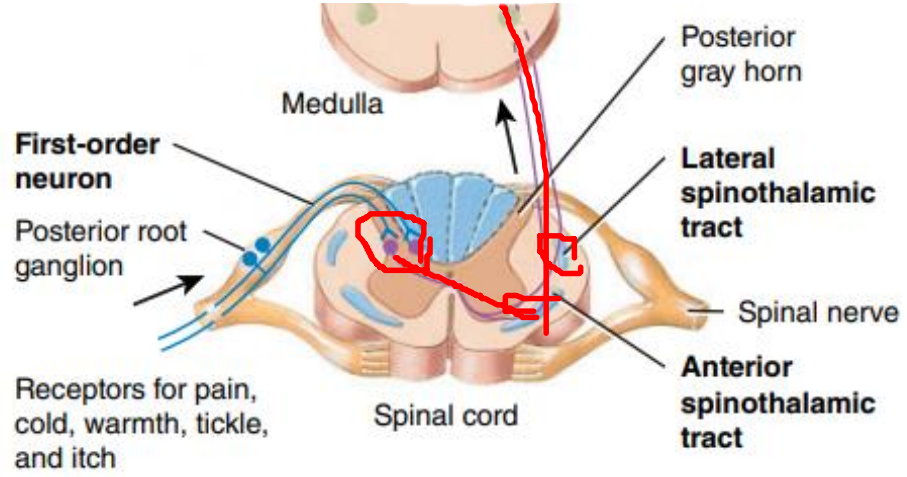


Anterolateral spinothalamic pathway

- 1st order neurons will come through the dorsal root ganglion into the spinal cord.



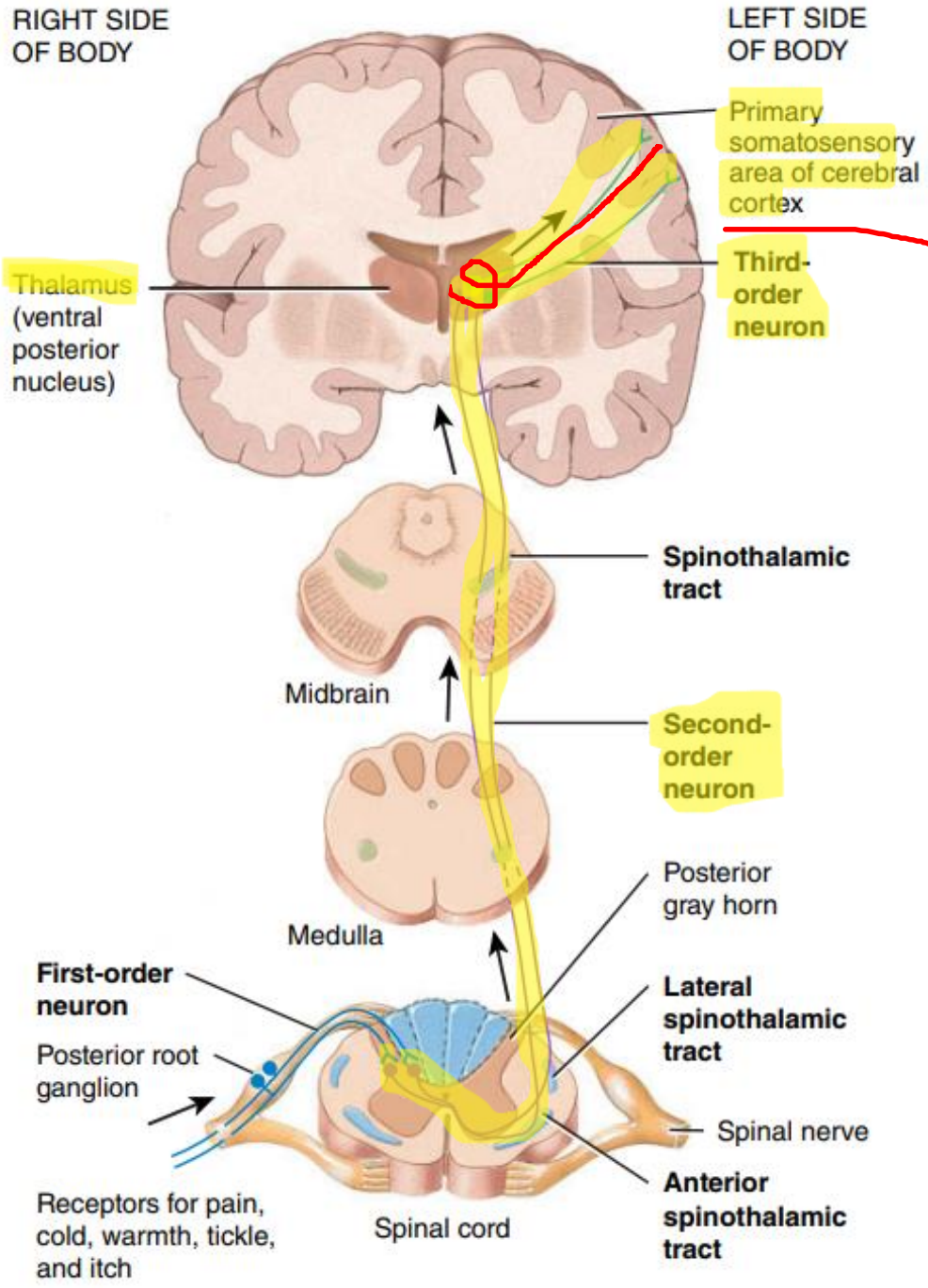
- Shortly, they synapse with the 2nd order neurons in the dorsal horn of the gray spinal matter.



Anterolateral spinothalamic pathway

- The 2nd order neurons [which are very long] will **decussate immediately in the spinal cord** to the other side to join the anterior or lateral pathway of the anterolateral spinothalamic tract up to the thalamus.

- 3rd order neurons start at the thalamus and then to the primary somatosensory area of the cerebral cortex.

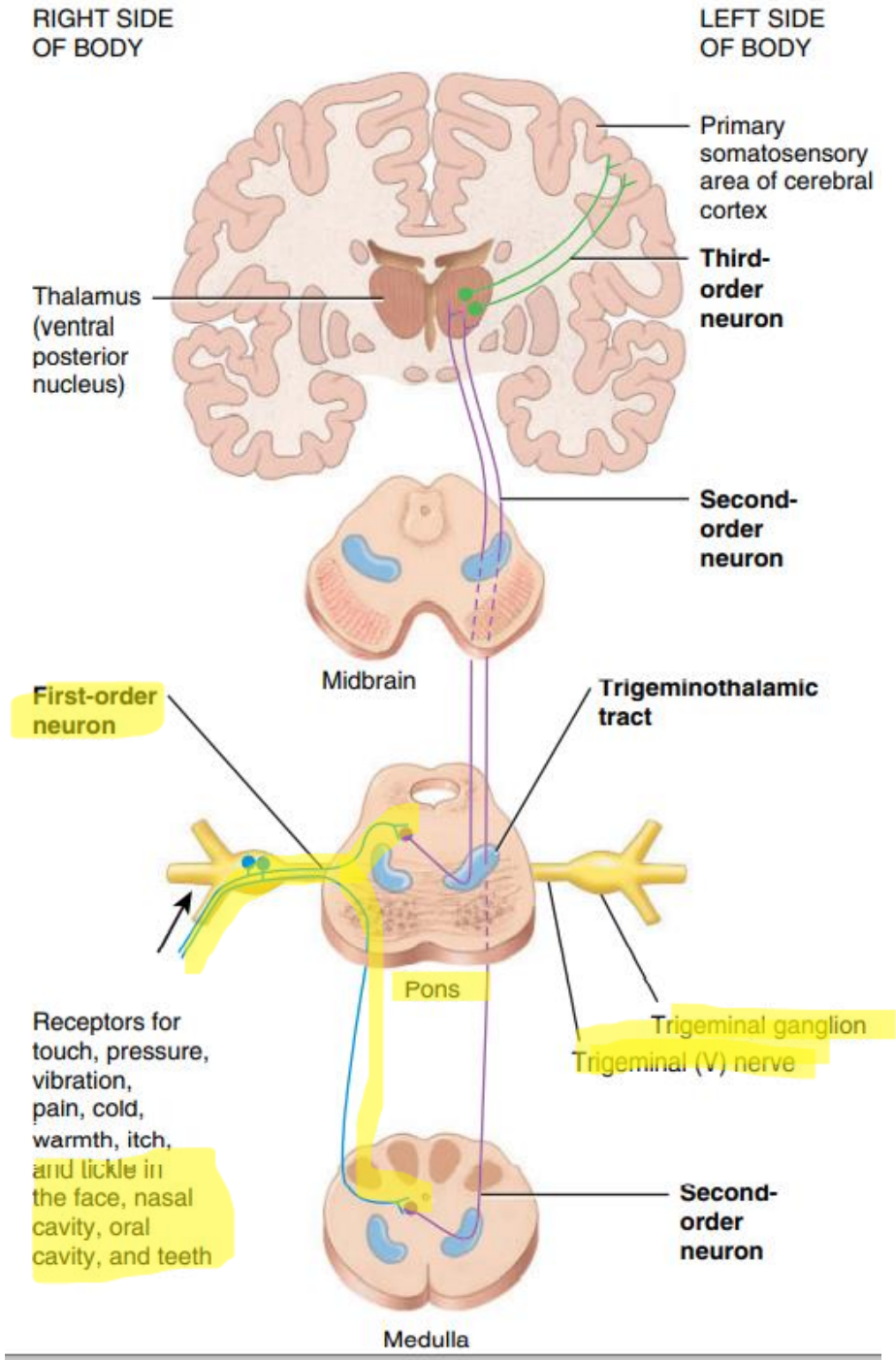


3. Trigeminothalamic pathway

- The information for this pathway comes from:

-Face -Oral cavity -Nasal cavity -Teeth

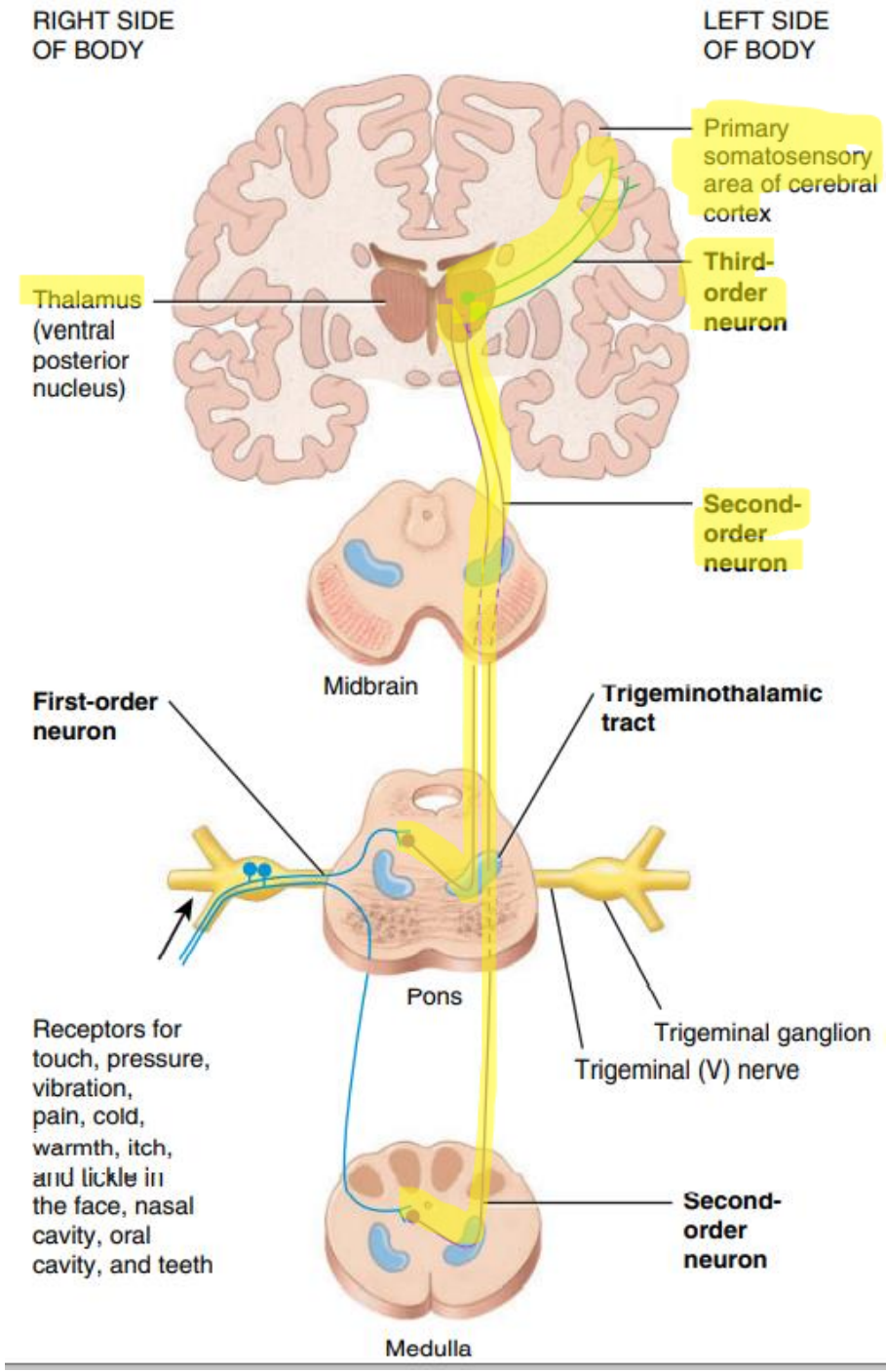
- 1st order neurons will enter through trigeminal ganglion to the brain stem **[at the level of both pons and medulla]** where its synapse with the 2nd order neurons.



Trigeminothalamic pathway

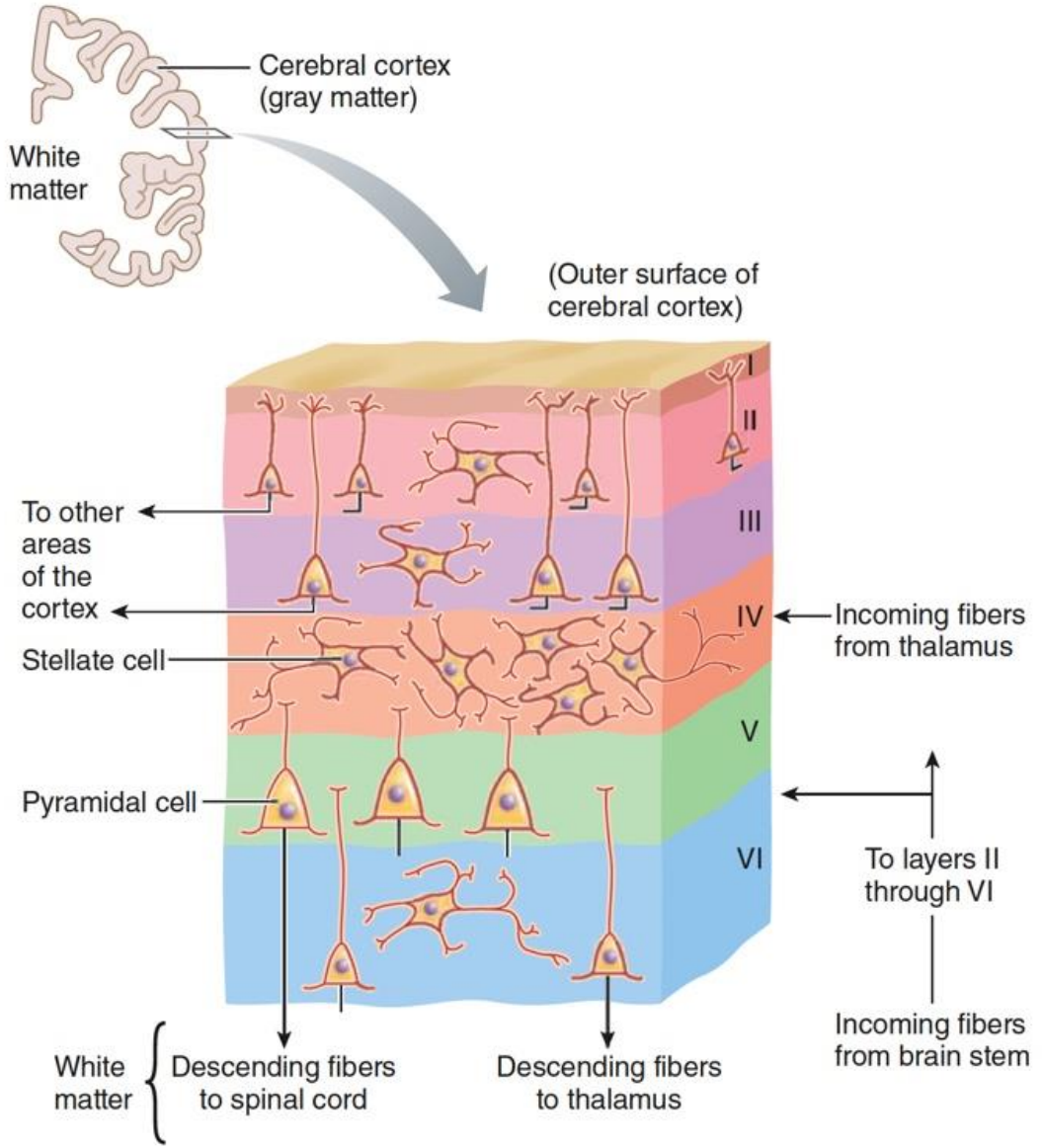
- 2nd order neurons will **decussate at the level of pons and medulla**, then they continue up to the thalamus joining the somatic sensation of the body.

- 3rd order neurons continue from the thalamus up to the primary somatosensory area for perception and integration.



So, the somatosensory information will be Processed in the cerebral cortex which consists of 6 layers according to the histological and functional differences.

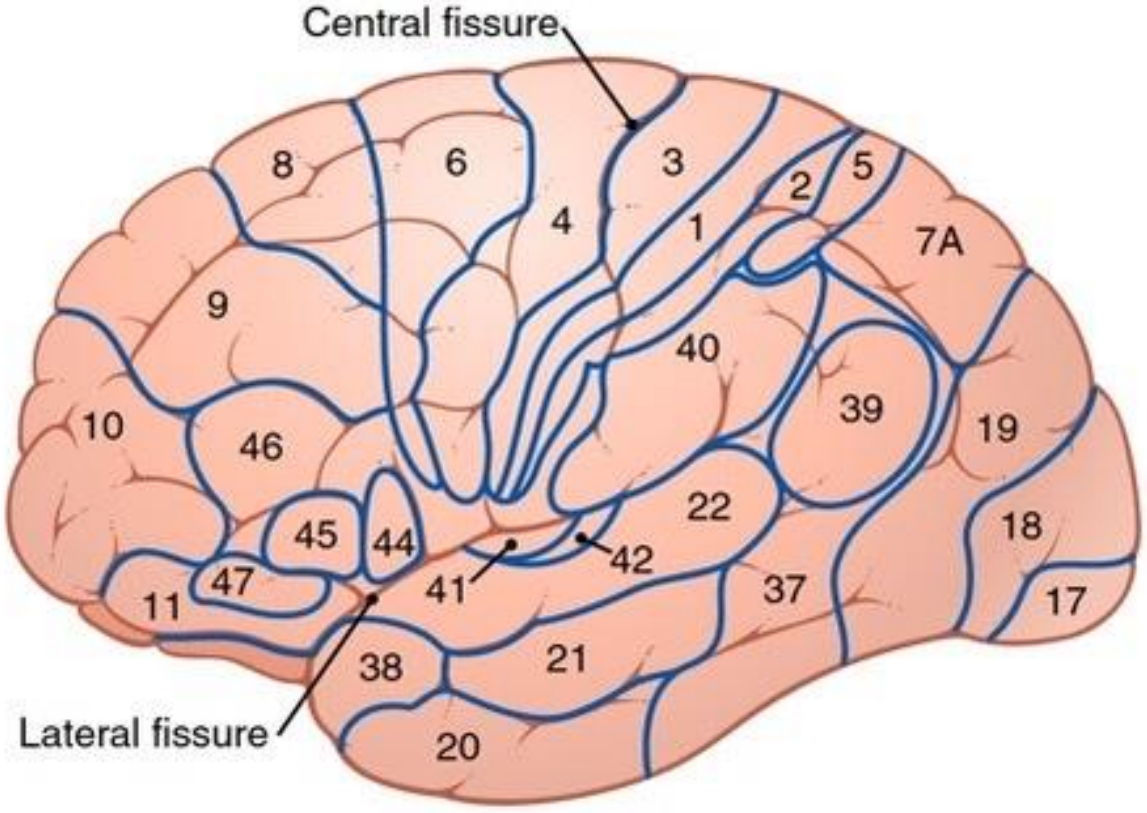
- Layer 4 (IV) : receives incoming fibers and transmits them to the other layers.
- Layers 1&2 (I & II) : receive diffuse and nonspecific information to control the excitability level of the cerebral cortex.
- Layers 2&3 (II & III) : communicate with the opposite side of the brain cortex.
- Layers 5&6 (V & VI) : contain pyramidal cells that send descending/motor fibers to the spinal cord, brain stem and basal nuclei.



The cerebral cortex is subdivided into several areas based on the histological and anatomical differences.

- Areas 1&2&3 called Brodmann Area or Primary somatosensory area.

- layer 4 here (layer not area, referring to the previous slide) seems to be advanced to receive sensory information from the neurons.



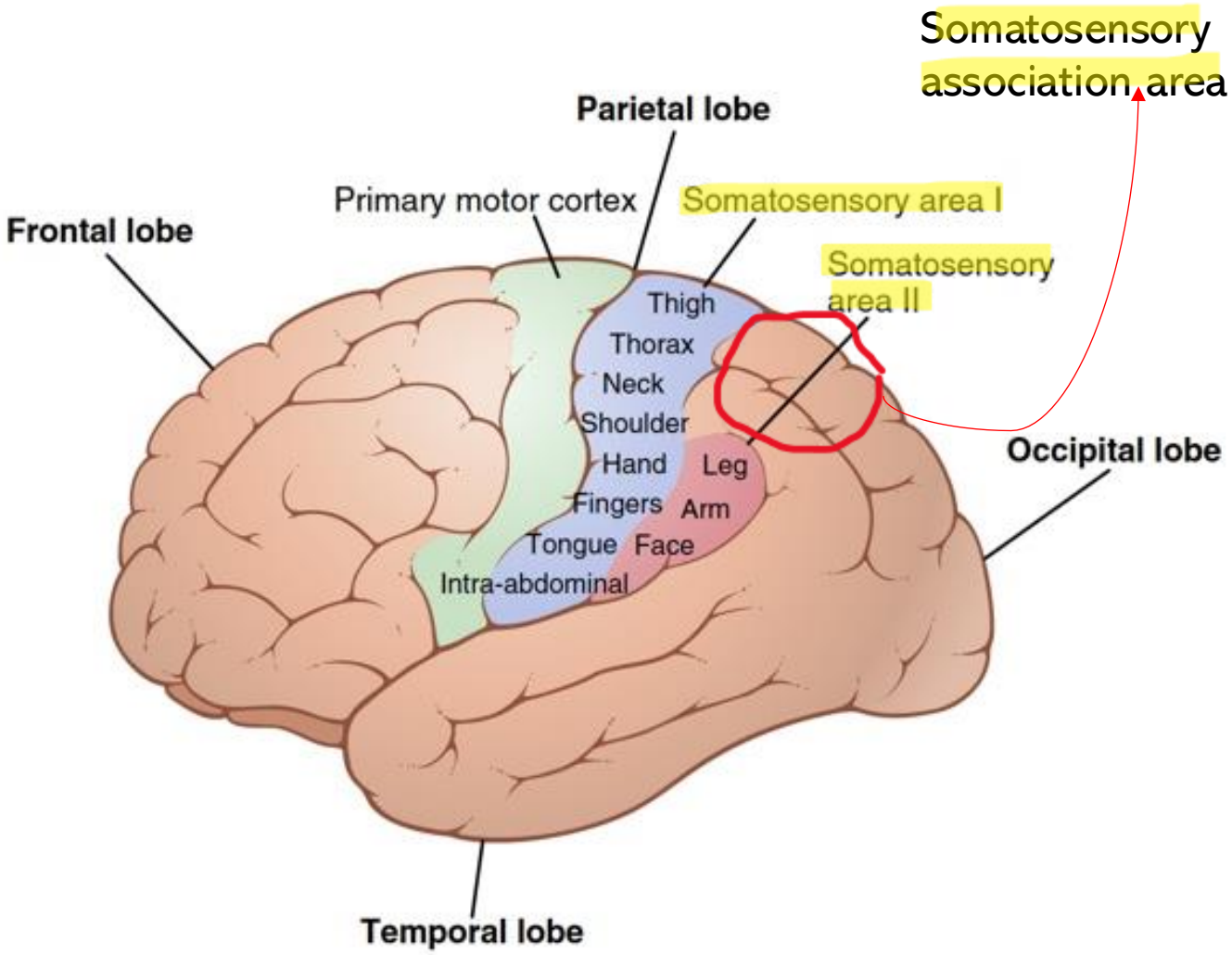
Remember:

The somatosensory area responsible for somatic sensation processing is located in the parietal lobe posterior to the central gyrus, is divided into:

1- somatosensory area I or primary somatosensory area or S1.

2- somatosensory area II or secondary somatosensory area or S2.

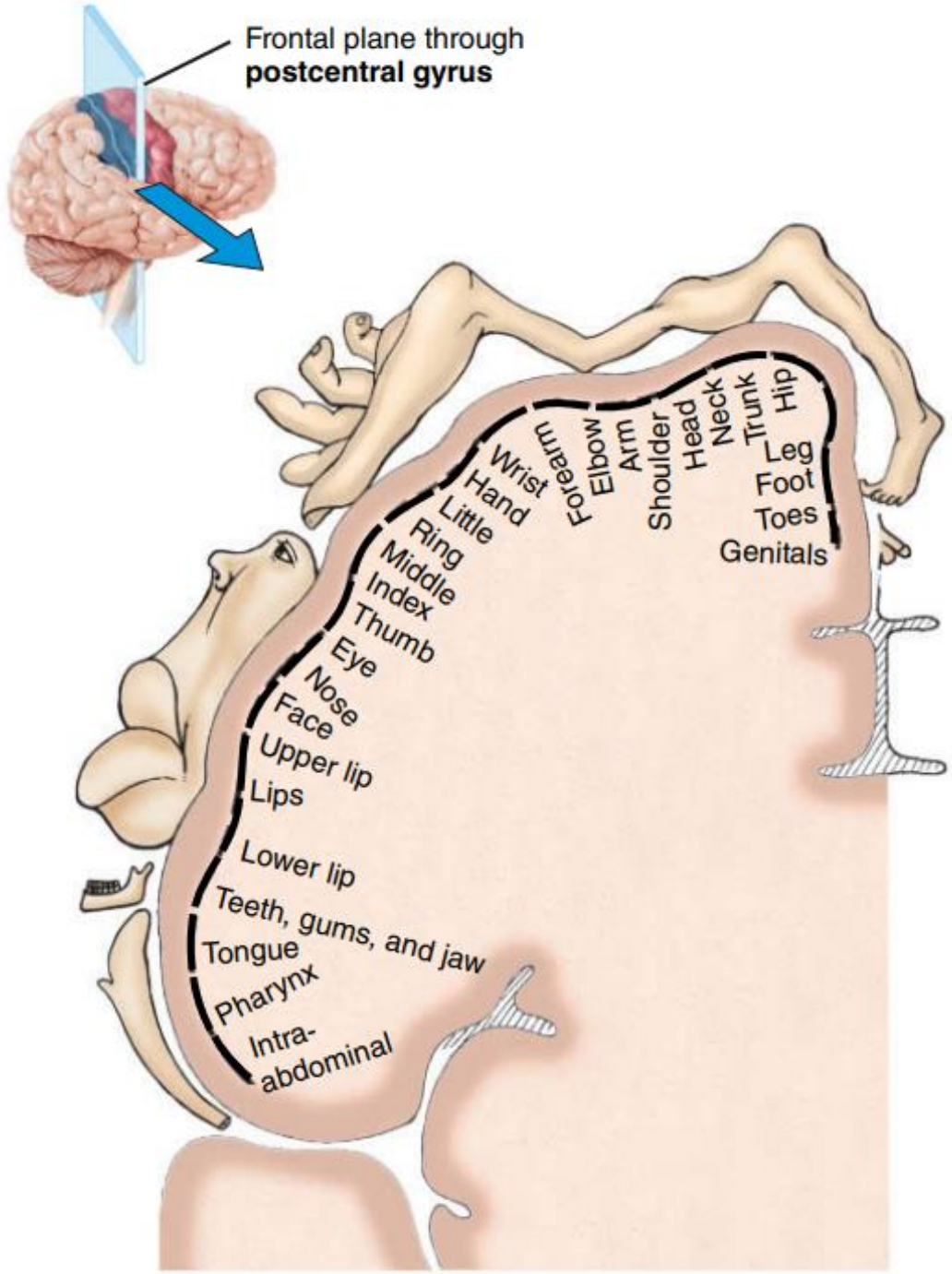
3- somatosensory association area.



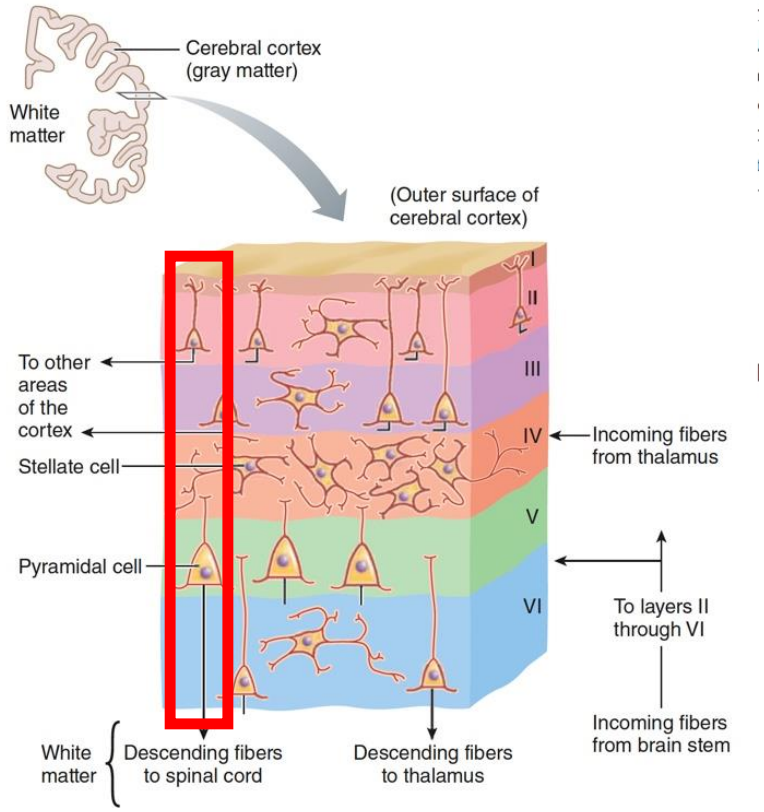
Sensory homunculus

- Detailed presentation of different parts of the body in the primary somatosensory area. (a map of brain areas)
- Kind of distorted (deformed), body parts like the fingers, lips, and face appearing disproportionately large on the homunculus due to their high concentration of sensory receptors and the need for detailed sensory processing.

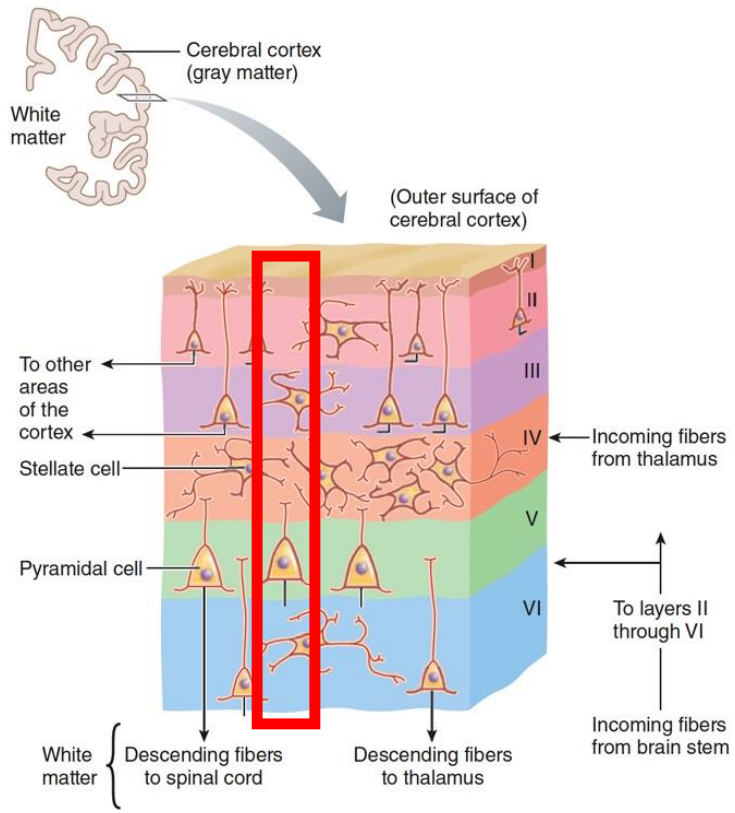
<u>The left cerebral hemisphere receives sensory input from the right side of the body due to decussation</u>



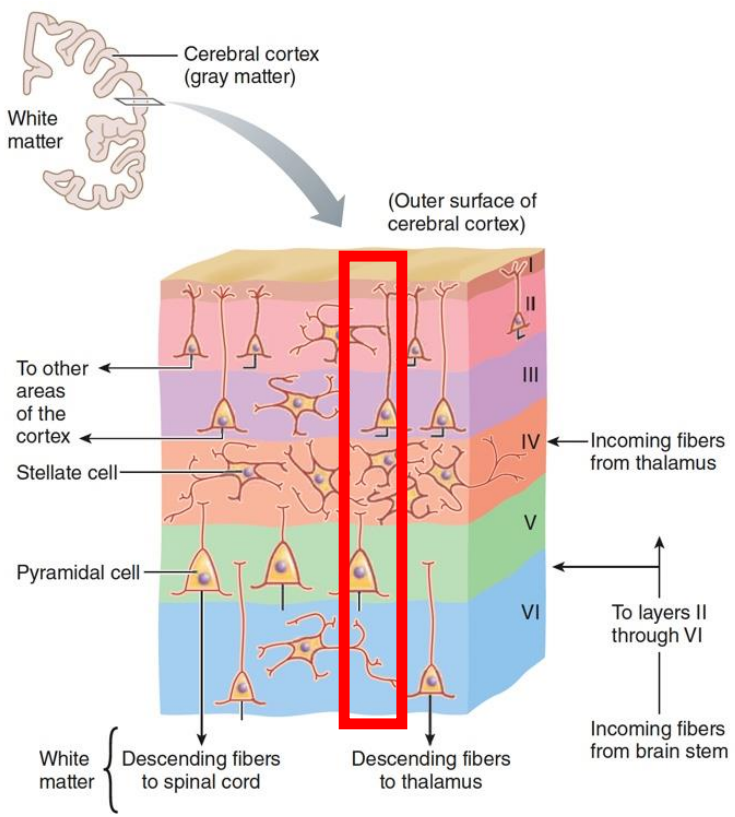
The somatosensory cortex is further divided into columns, each one represents the processing of a certain modality.



For example:
This column only specializes in touch processing.



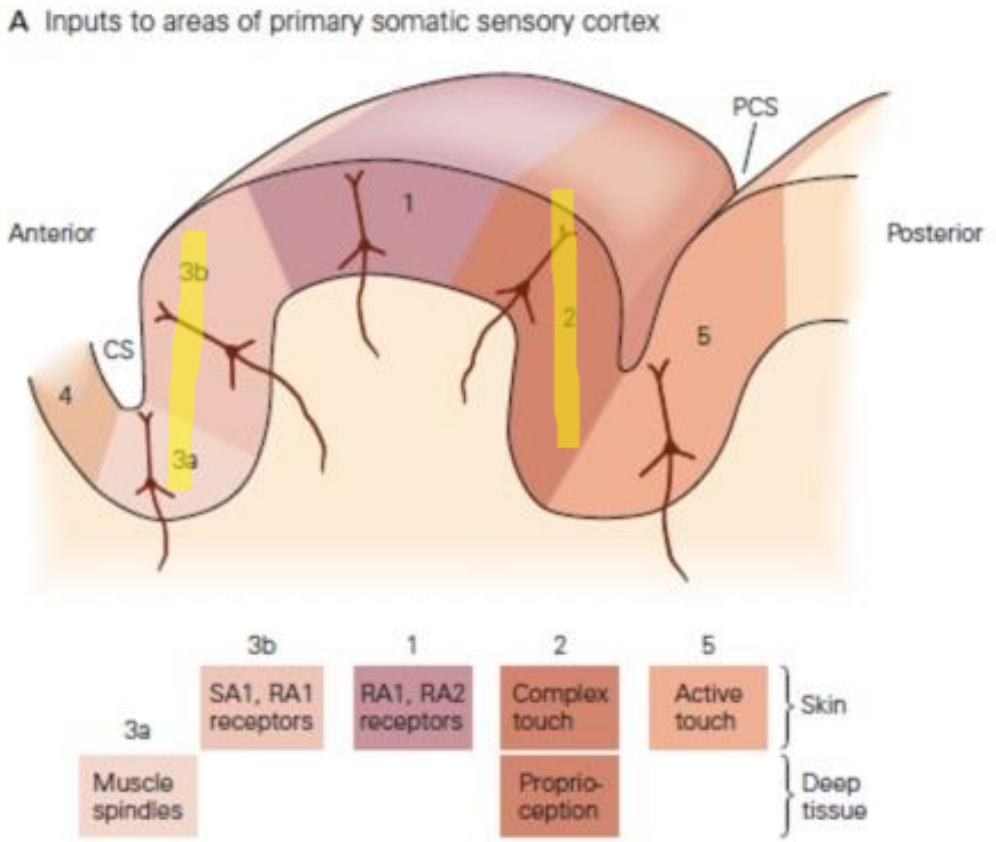
For example:
This column only specializes in vibration processing.



For example:
This column only specializes in pressure processing.

The most **anterior** parts of the primary somatosensory area are primarily responsible for processing information from **muscles**, **joints and tendons**. So, It is **close to the motor cortex** to ensure effective control of the motor function.

The most **posterior** parts are primarily responsible for **light movements** in a specific direction over the skin, so we need a complex processing for it. So, it is close to the **somatosensory association area**.

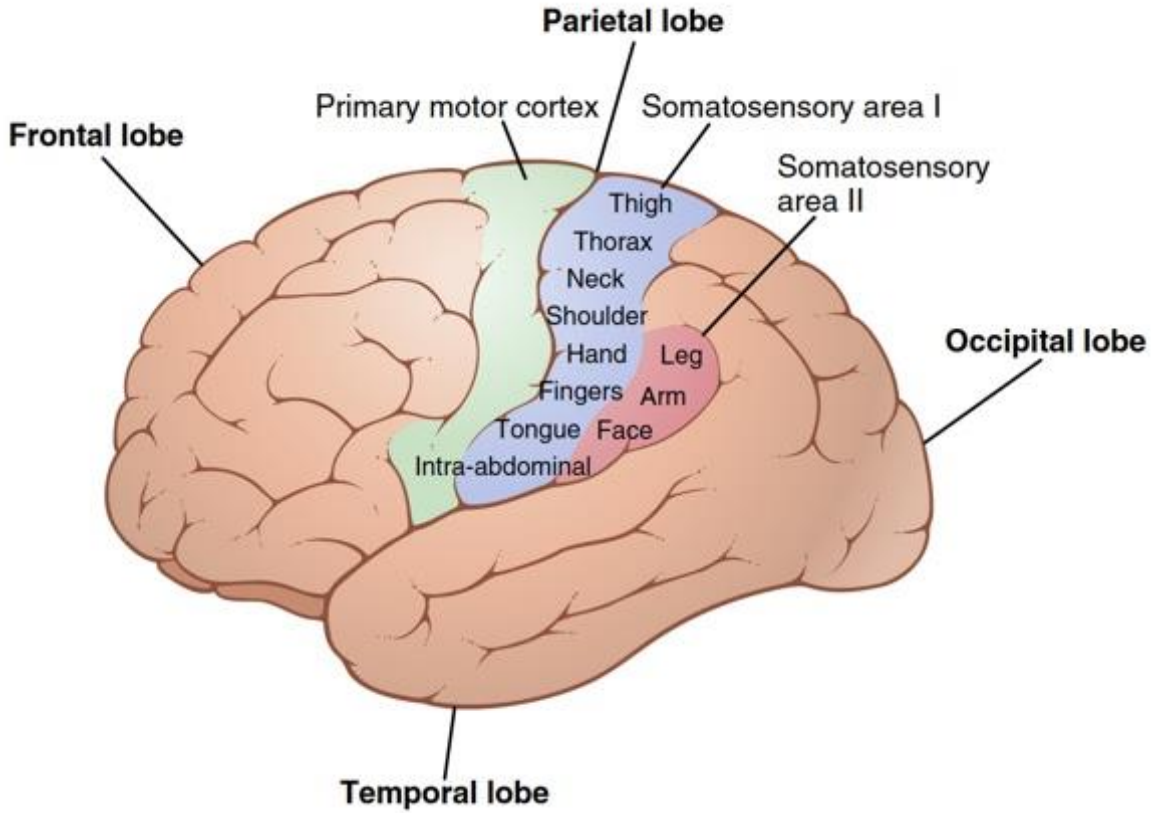


S1 contains a detailed representation of the body region and different types of modalities.

It is easy to pinpoint specific locations for it, such as identifying the location of the touch, the weight of objects, or pressure on muscles.

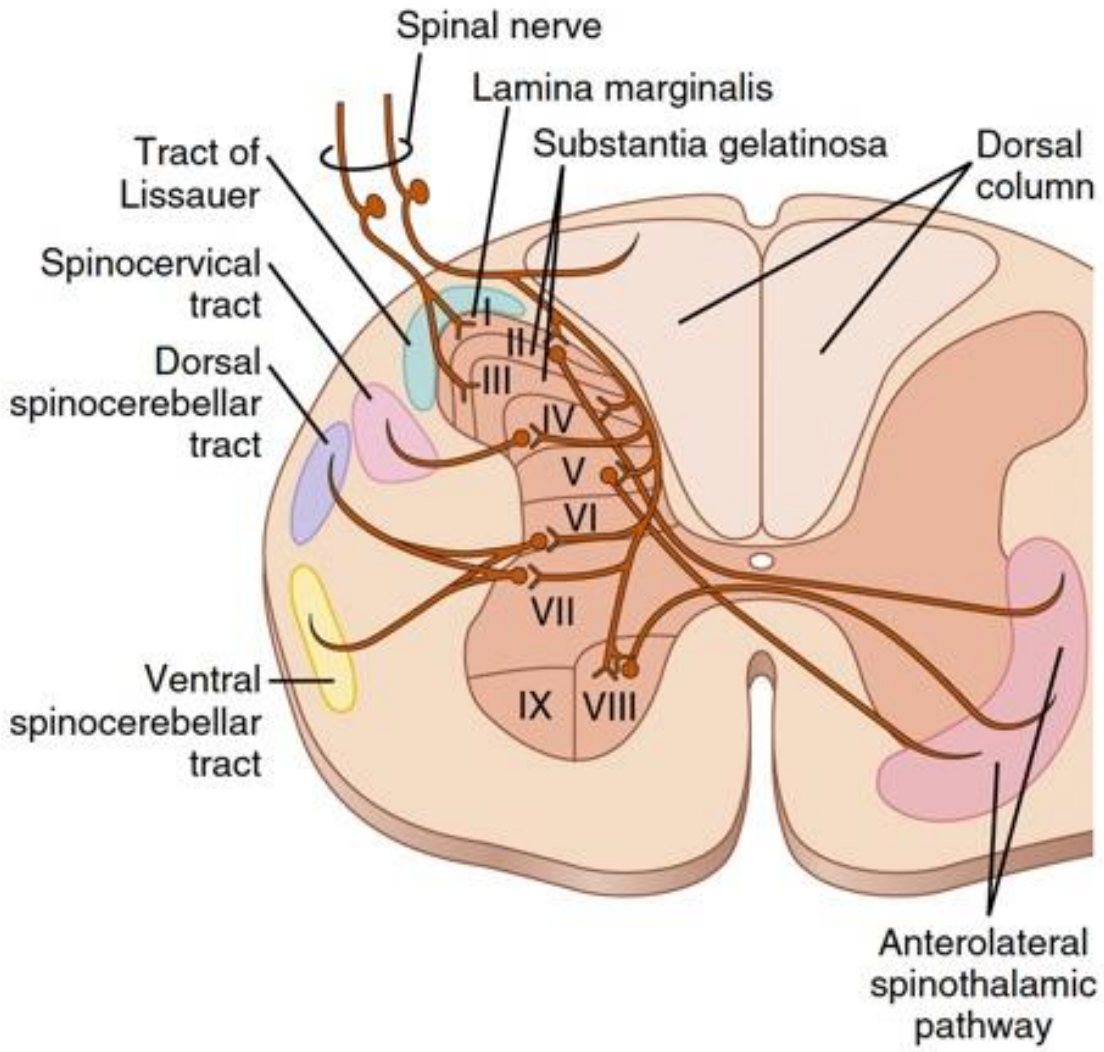
In the S2 there is also a map of body parts, but it is not as detailed as the first area. The function of this area is not very well understood, but it might be related to connecting the two hemispheres or for memorizing specific aspects of somatic sensation, though it is not precisely defined.

The somatosensory association area will give meaning to the sensation. The information comes from all other areas (the first and second areas, as well as the visual, auditory, and memory areas) to provide meaning. For example, you can identify whether you are holding a ball or a knife.



There are some sensory fibers branching into different areas of the spinal cord, for example:

- To control spinal reflexes
- To the spinocerebellar tract, to know the proprioception and tactile sensation.



اللهم اجعل لي فيه إلى مرضاتك دليلاً
ولا تجعل للشيطان فيه علي سبيلاً
واجعل الجنة لي منزلاً ومقيلاً
يا قاضي حوائج الطالبين

VERSIONS	SLIDE #	BEFORE CORRECTION	AFTER CORRECTION
V1→ V2			
V2→V3			

امسح الرمز و شاركنا بأفكارك لتحسين أدائنا !!