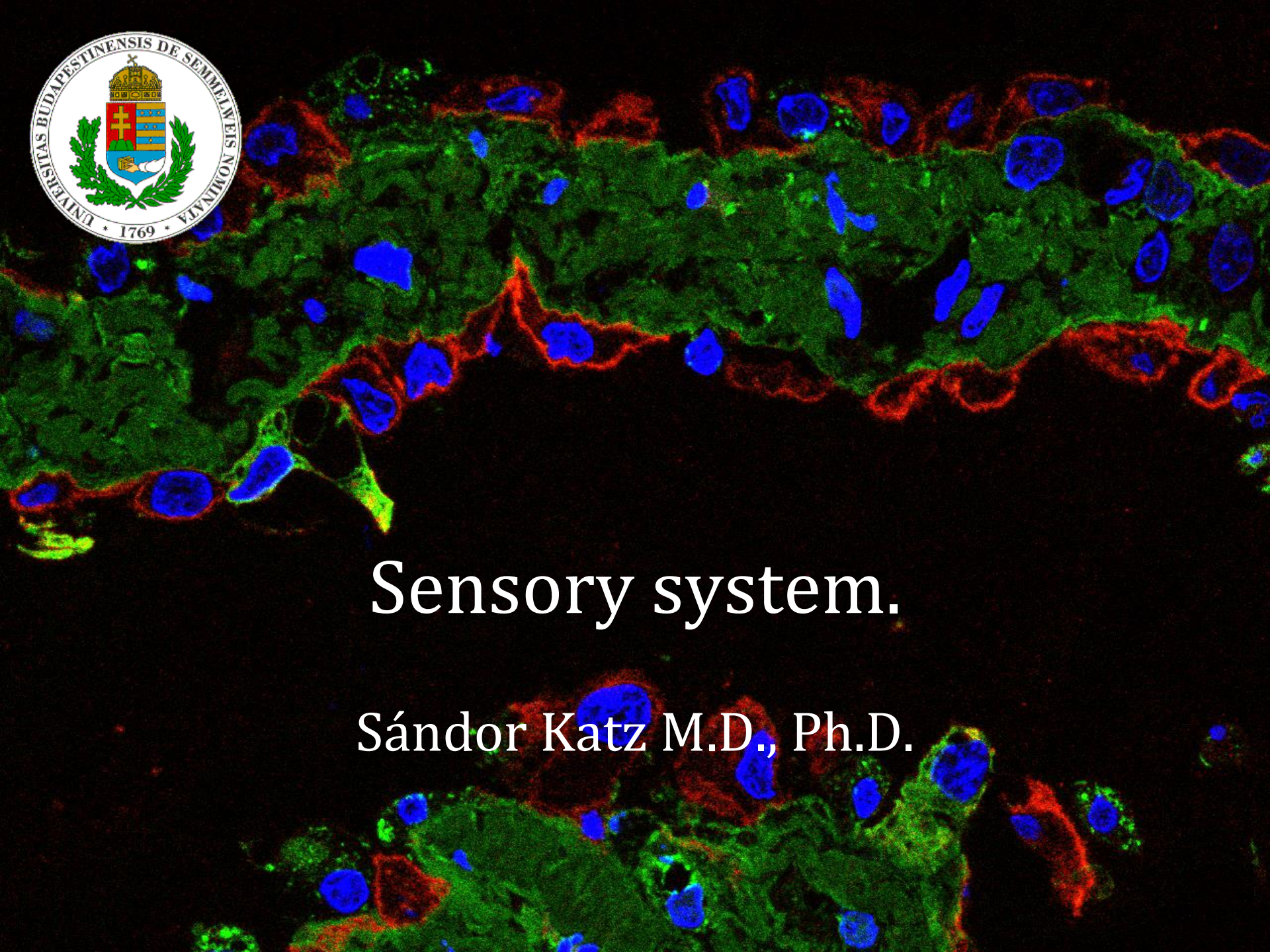
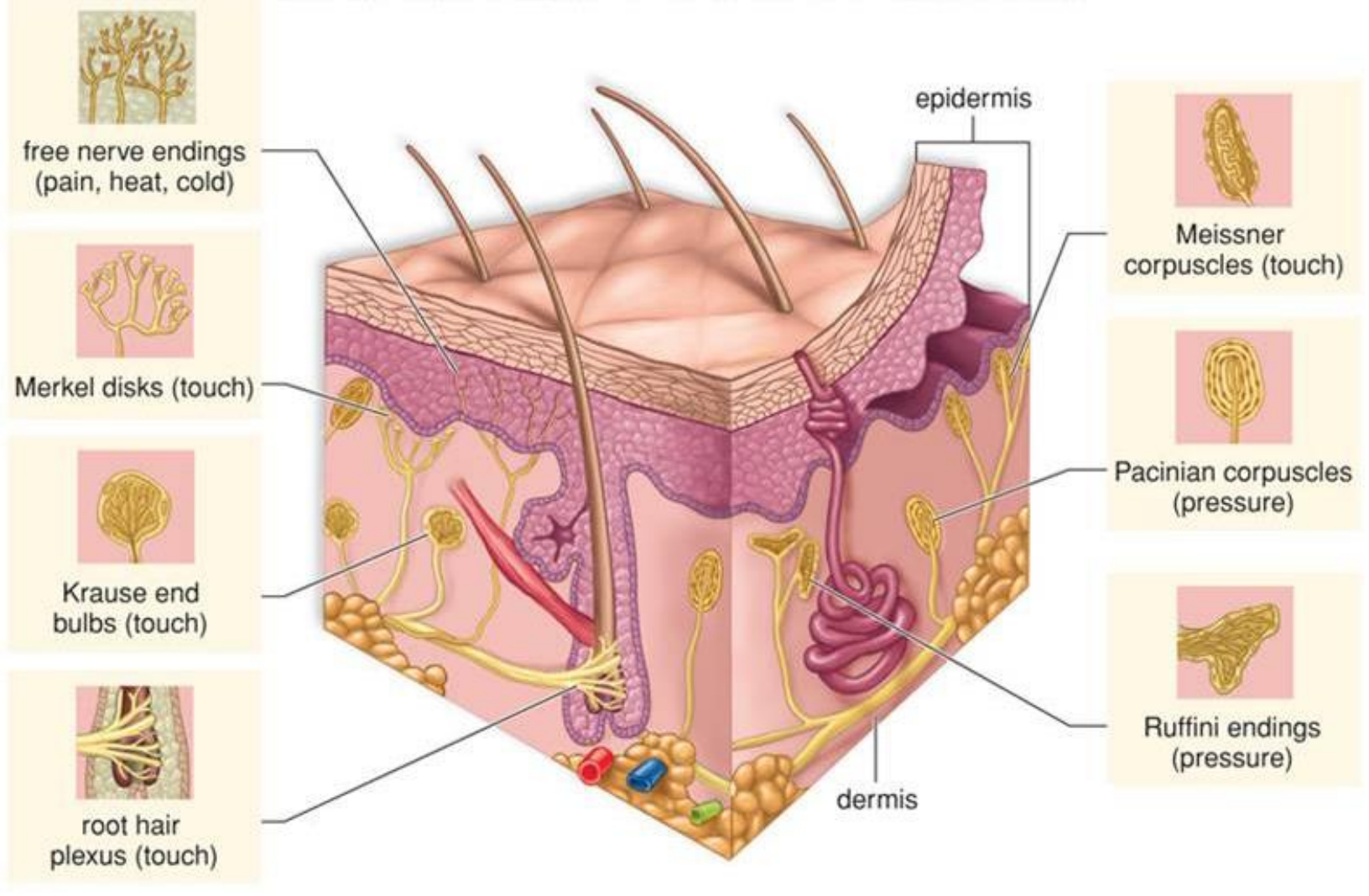


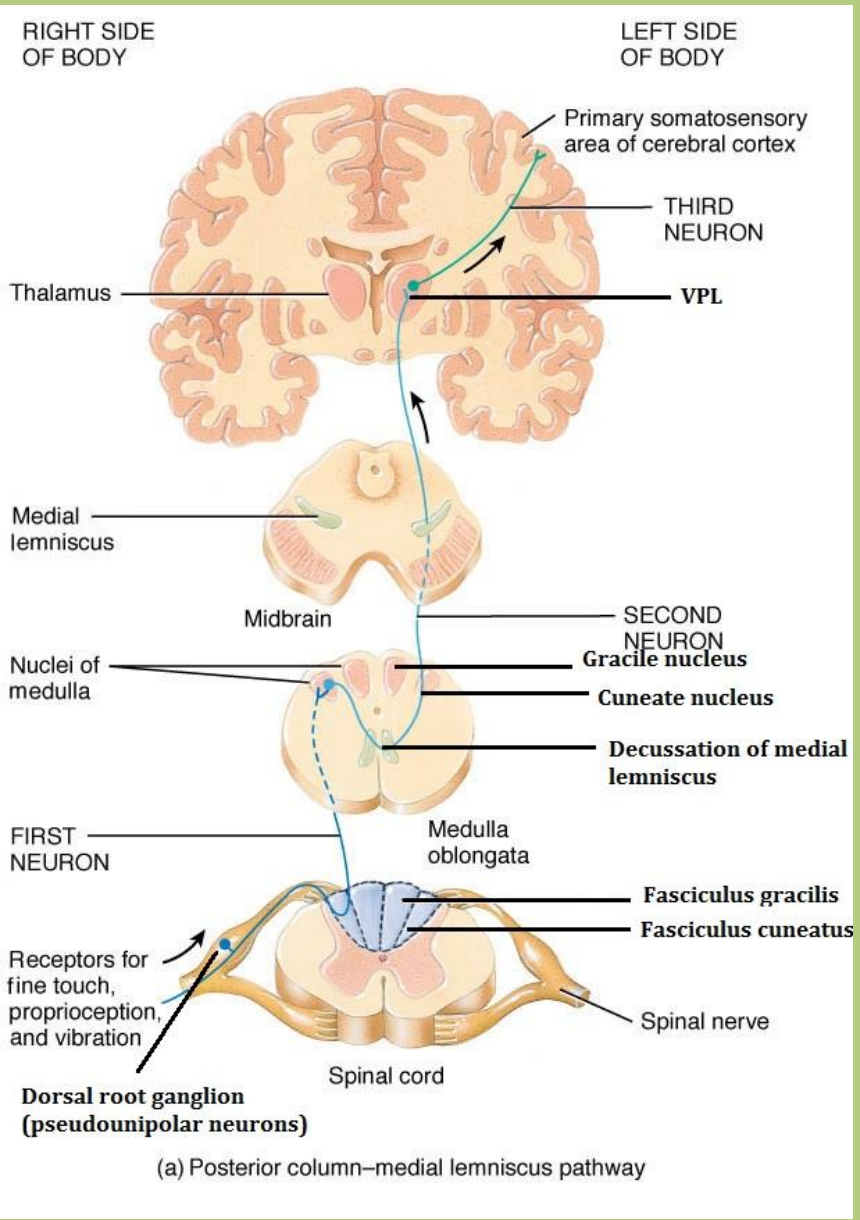
Sensory system.

Sándor Katz M.D., Ph.D.

Sensory pathways - receptors



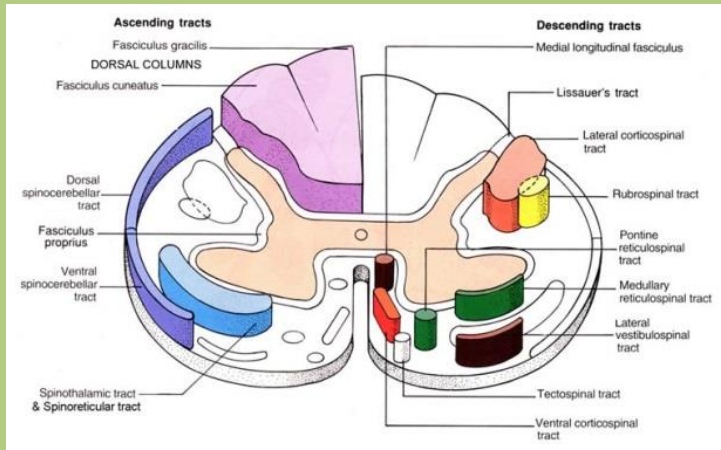
Sensory pathways (ascending tracts)- Fasciculus gracilis (Goll's) and cuneatus (Burdach's)



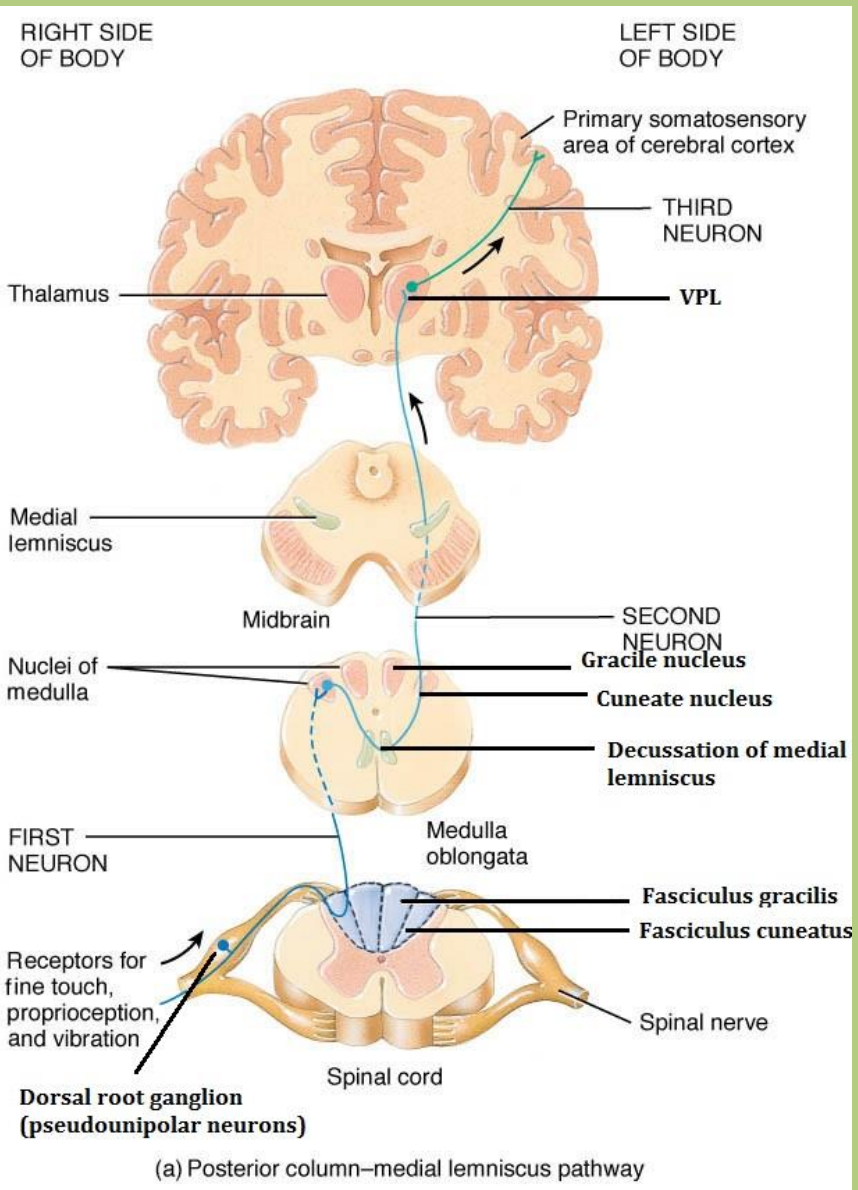
(a) Posterior column–medial lemniscus pathway

- Both tracts convey fibers for **position sense** (conscious proprioception) and **fine cutaneous sensation** (touch, vibration, fine pressure sense, two-point discrimination) =**EPICRITIC SENSATION.**

- The **fasciculus gracilis** carries fibers only from the ***lower limbs***, while the **fasciculus cuneatus** carries fibers only from the ***upper limbs*****,** therefore it is not presented in the spinal cord below the T3-(6) level.



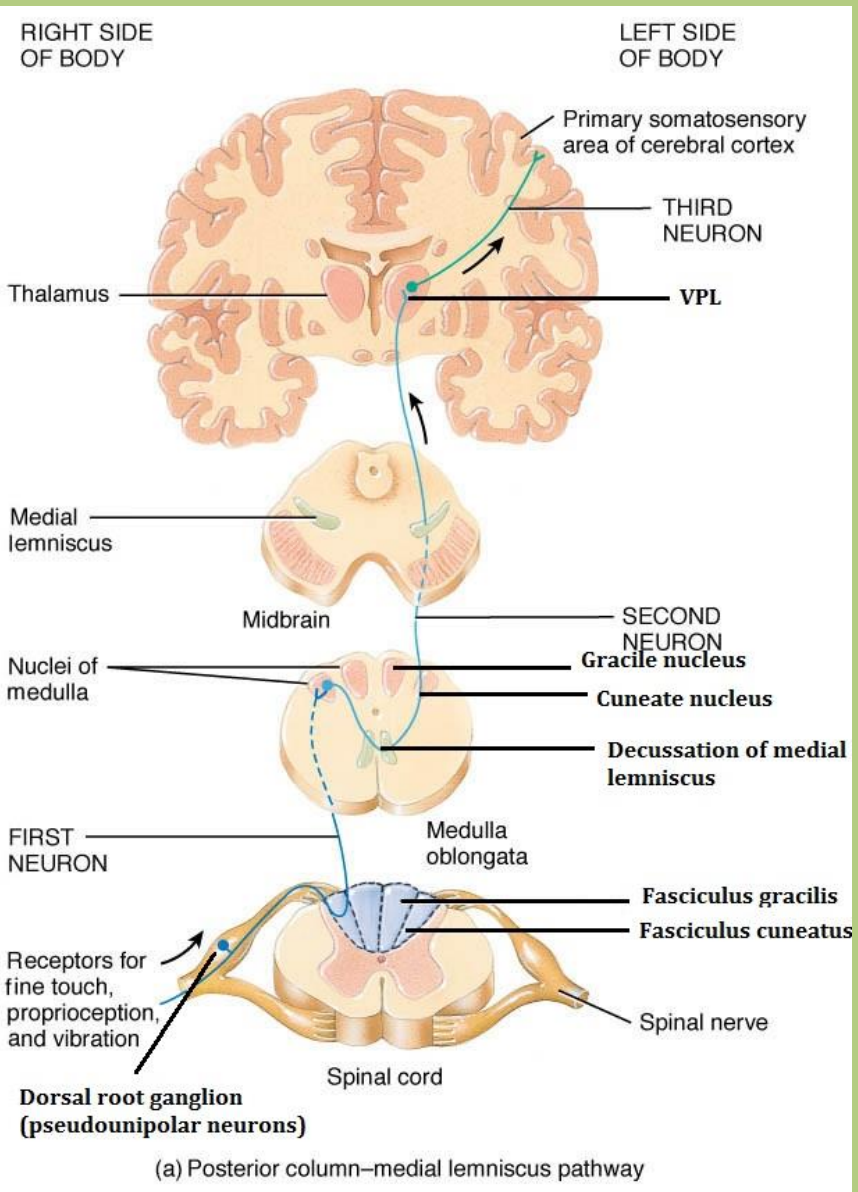
Sensory pathways (ascending tracts)- Fasciculus gracilis and cuneatus



(a) Posterior column–medial lemniscus pathway

- **Receptors:** Meissner's and Pacinian corpuscles. Muscle spindles and tendon organs for the conscious proprioception.
- **1st neuron**: pseudounipolar neurons in the *dorsal root ganglion*. The fibers divide into long ascending and short descending fibers.
- *The descending fibers give off collateral branches (in the cervical region: Schultze's comma tract, in the thoracic and lumbar regions: Flechsig's oval field, in the sacral region: Philippe-Gombault's trigone) that synapse with posterior or anterior horn's neurons. (They are involved with intersegmental reflexes).*
- Many of the long ascending fibers travel ipsilaterally in the posterior funiculi to the *gracile and cuneate nuclei* (**2nd neuron**) in the medulla oblongata.

Sensory pathways (ascending tracts)- Fasciculus gracilis and cuneatus



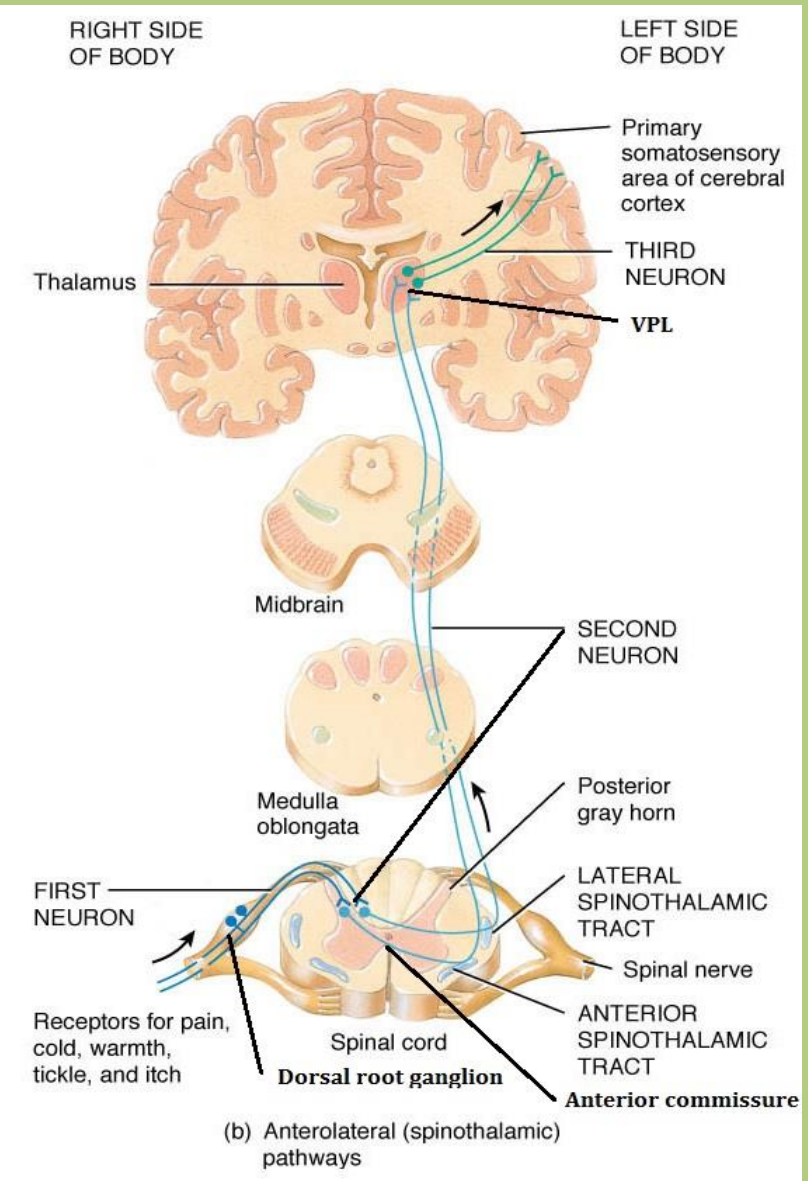
(a) Posterior column–medial lemniscus pathway

- The axons *(called the internal arcuate fibers)* cross in the medulla oblongata and travel as a single bundle ***(medial lemniscus)*** to the *VPL* of thalamus (**3rd neuron**).

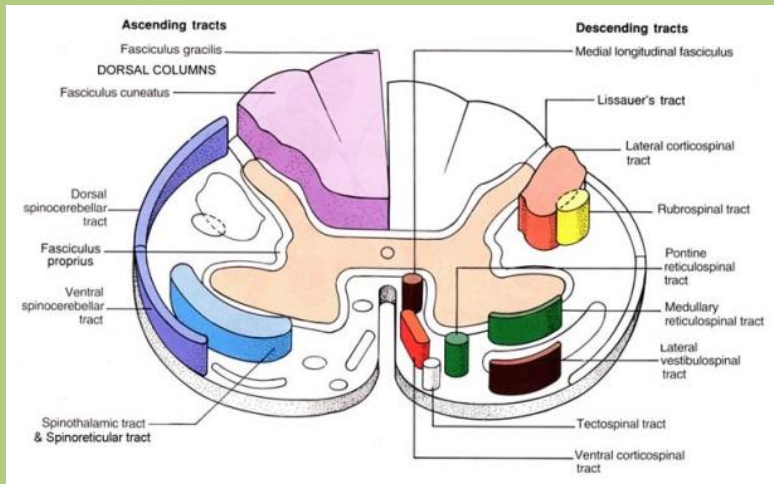
- *(Many axons from the 2nd neurons in the nucleus cuneatus relay to the cerebellum, traveling through the inferior cerebellar peduncle* ***(called cuneocerebellar tract)****, carrying muscle joint sense.)*

- The axons of the third neurons terminate in the *primary somatosensory cortex*, located in the postcentral gyrus.

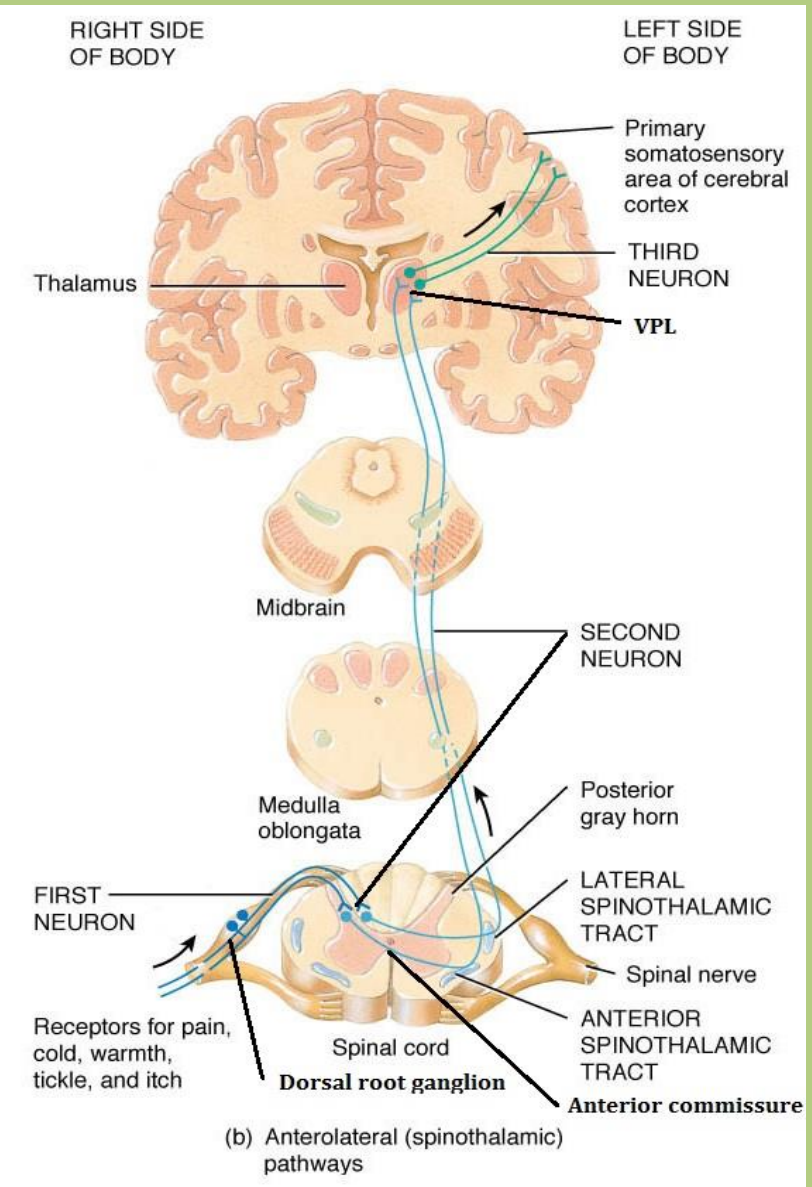
Sensory pathways (ascending tracts)- Spinothalamic tracts



- The **anterior spinothalamic tract** is the pathway for ***crude touch and pressure sensation***, while the **lateral spinothalamic tract** conveys ***pain, temperature, tickle, itch and sexual sensation =PROTOPATHIC SENSATION.***



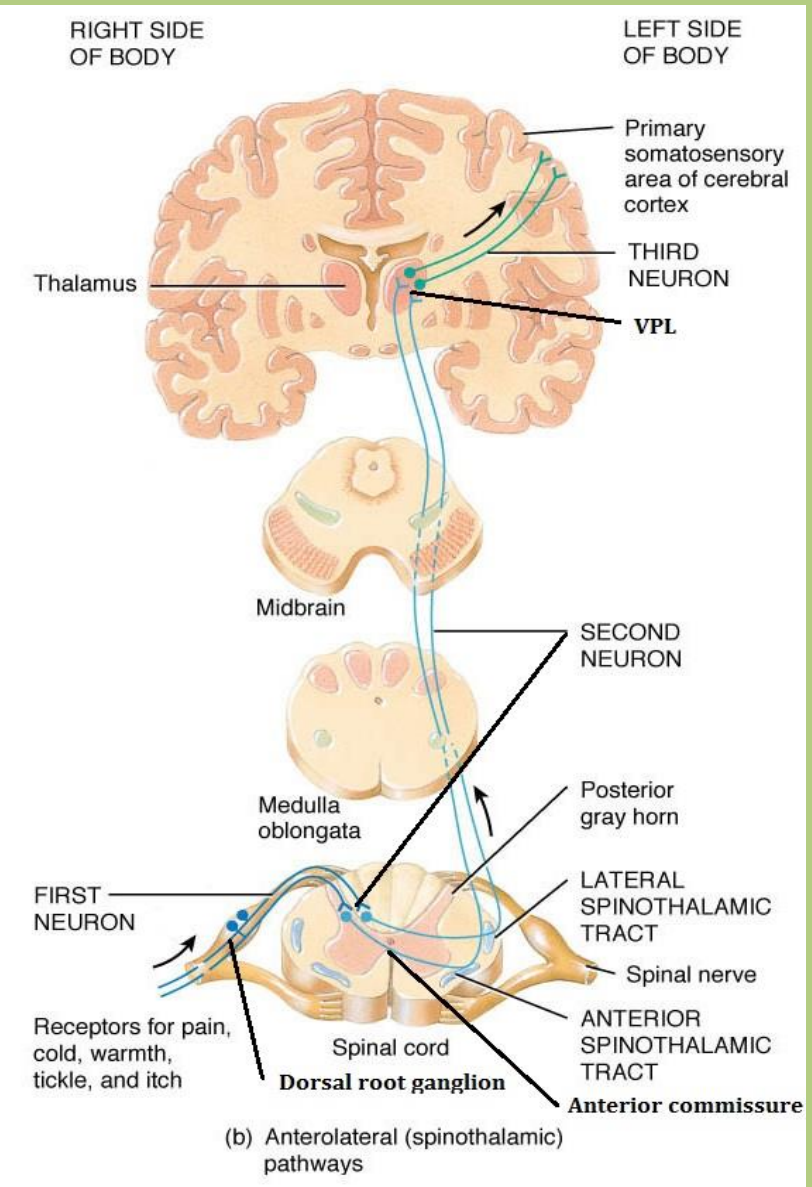
Sensory pathways (ascending tracts)- Lateral spinothalamic tract



(b) Anterolateral (spinothalamic) pathways

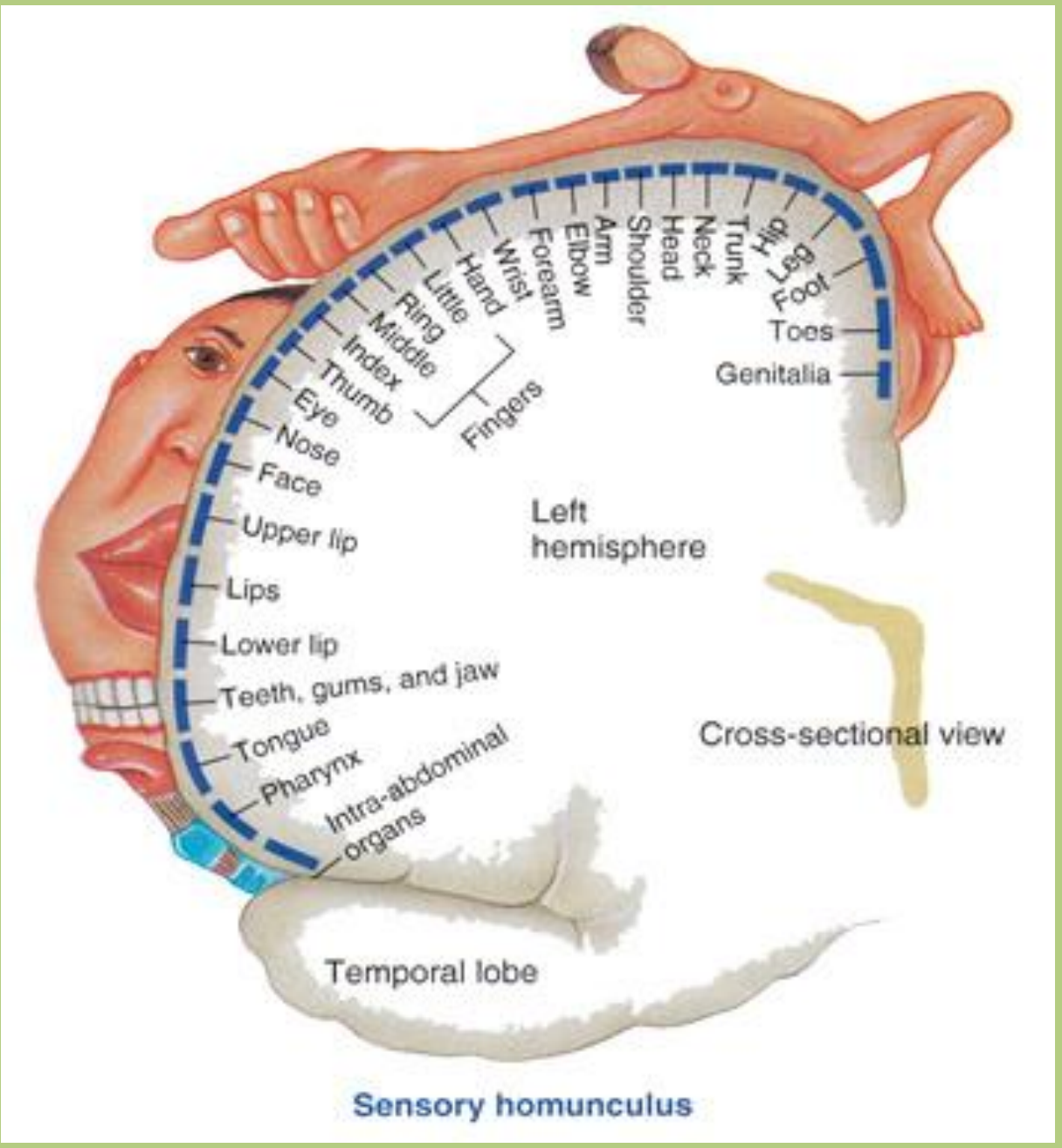
- **Receptors:** Free nerve endings in the skin for **pain and temperature sensation**.
- The pain impulses are transmitted to the spinal cord in fast-conducting delta A-type fibers *(initial sharp pain)* and slow-conducting C-type fibers *(prolonged burning, aching pain)*.
- The cell bodies of these nerve endings are located in the *dorsal root ganglion* (**1st neuron**).
- The central processes of first neurons pass through the dorsal root into the white matter of the spinal cord and divide into descending and ascending branches (*dorsolateral tract of Lissauer*), then they terminate on *secondary sensory neurons* in the posterior horn (including cells of the substantia gelatinosa) (**2nd neuron**).
- The axons of second neurons *cross in the anterior white commissure* in the corresponding spinal segment and ascend in the anterolateral funiculus on the opposite (contralateral) side.

Sensory pathways (ascending tracts)- Lateral spinothalamic tract



(b) Anterolateral (spinothalamic) pathways

- As the ***lateral spinothalamic tract*** ascends through the medulla oblongata, it is accompanied by the ***anterior spinothalamic tract*** and ***spinotectal tract***. Together they form the **spinal lemniscus**.
- In the midbrain, the spinal lemniscus lies in the tegmentum lateral to the medial lemniscus.
- Many of the fibers of lateral spinothalamic tract terminate in the *VPL* of thalamus (**3rd neuron**).
- The axons of third neurons radiate to the *primary somatosensory cortex* in the postcentral gyrus.



The contralateral half of the body is represented as inverted, with the hand and mouth situated inferiorly and the leg situated superiorly, and with the foot and anogenital region on the medial surface of the hemisphere.

Pain control in the CNS

Gate Control Theory

Massage, acupuncture and low frequency electrical stimulation can relieve pain.

Although the precise mechanism for these phenomena is not understood, the theory was proposed in 1965 by Ronald Melzack and Patrick Wall.

It was suggested that at the side where the pain fibers enter the CNS, inhibition could occur by means of connector neurons excited by large, myelinated afferent fibers carrying information of non painful touch and pressure.

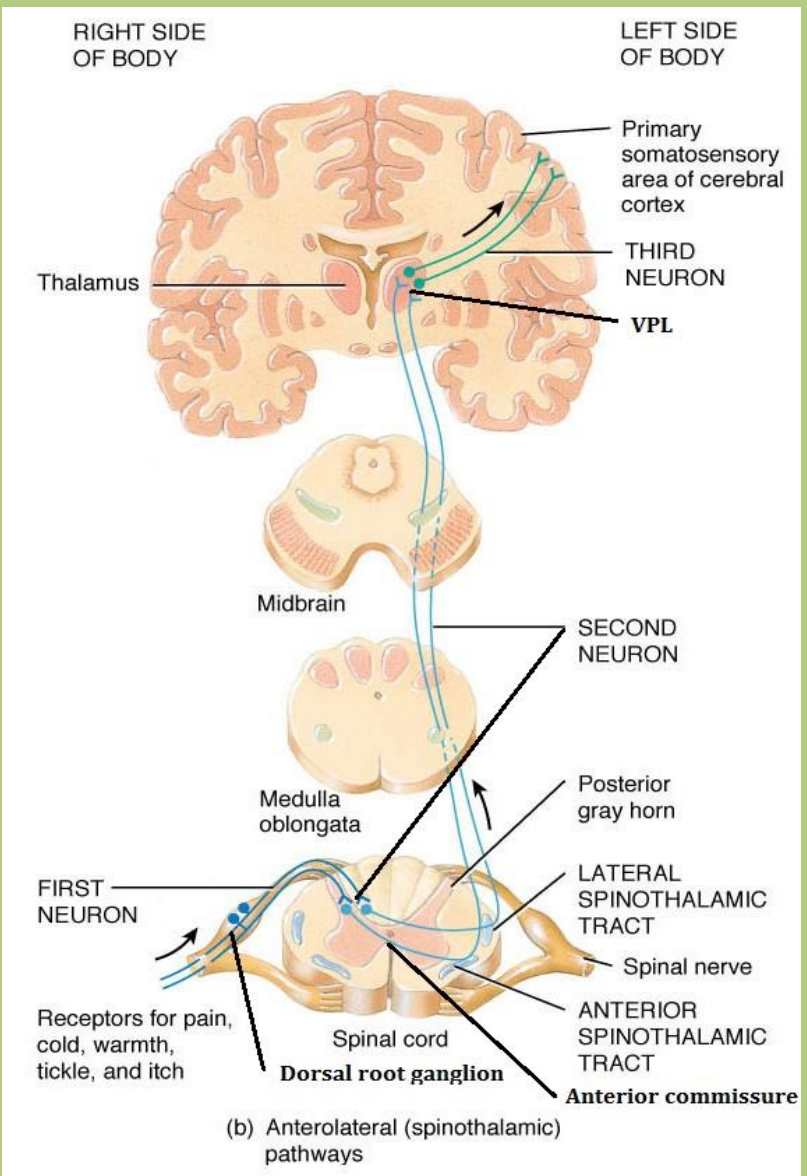
The Analgesia System

Stimulation of certain areas of the brainstem can reduce or block sensations of pain.

These areas include the *periventricular area of the diencephalon, the periaqueductal gray matter of the midbrain, and midline nuclei of the brainstem*. It is believed that fibers of the reticulospinal tract pass down to the spinal cord and synapse on cells concerned with pain sensation in the posterior gray column. The analgesic system can suppress both sharp pricking pain and burning pain sensations.

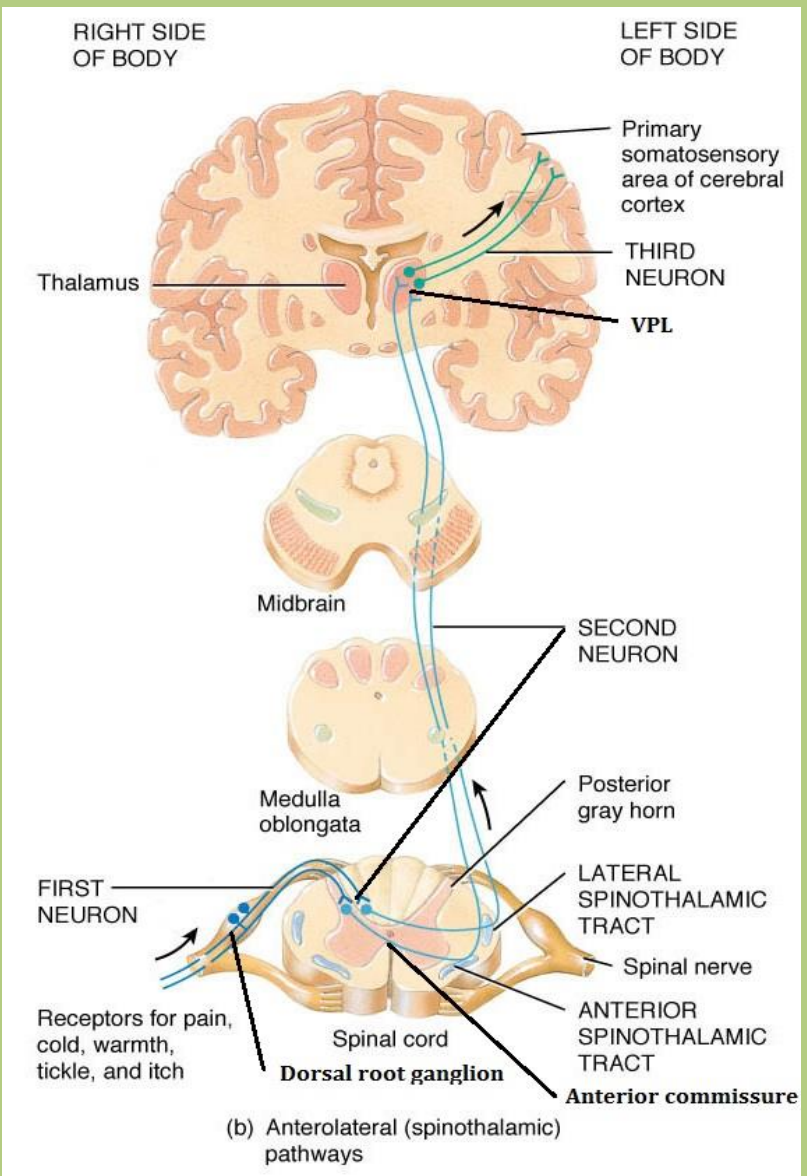
(Related neurotransmitters are *enkephalins, endorphins and serotonin*, inhibiting the release of substance P in the posterior gray column.)

Sensory pathways (ascending tracts)- Anterior spinothalamic tract



- **Receptors:** Impulses from tactile corpuscules and from receptors about the hair follicles.
- **1st neuron**: pseudounipolar neurons in the *dorsal root ganglion*.
- The central processes of first neurons pass through the dorsal root into the white matter and divide into descending and ascending branches (*dorsolateral tract of Lissauer*), then they terminate on *secondary sensory neurons* in the posterior horn (including cells of the substantia gelatinosa) -**2nd neuron**.

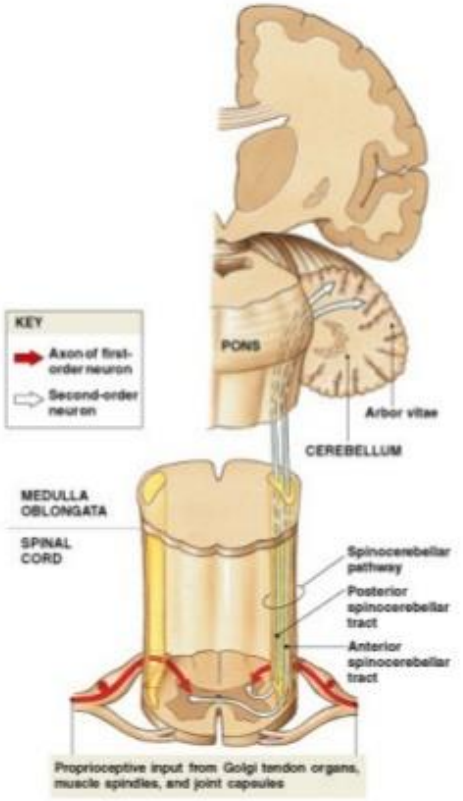
Sensory pathways (ascending tracts)- Anterior spinothalamic tract



- The axons of second neurons *cross in the anterior white commissure* within several spinal segments and ascend in the anterolateral funiculus on the opposite (contralateral) side.
- (As the ***anterior spinothalamic tract*** ascends through the medulla oblongata, it is accompanied by the ***lateral spinothalamic tract*** and ***spinotectal tract***. Together they form the **spinal lemniscus**.)
- The axons terminate in the *VPL* of the thalamus (**3rd neuron**).
- The axons of third neurons radiate to the *primary somatosensory cortex* in the postcentral gyrus.

Sensory pathways (ascending tracts)- Spinocerebellar tracts

The Spinocerebellar Pathway

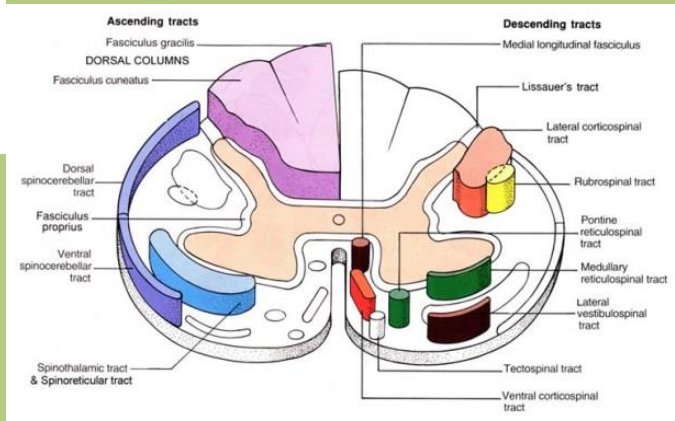


- Proprioceptive information about position of skeletal muscles, tendons, and joints sent to cerebellum

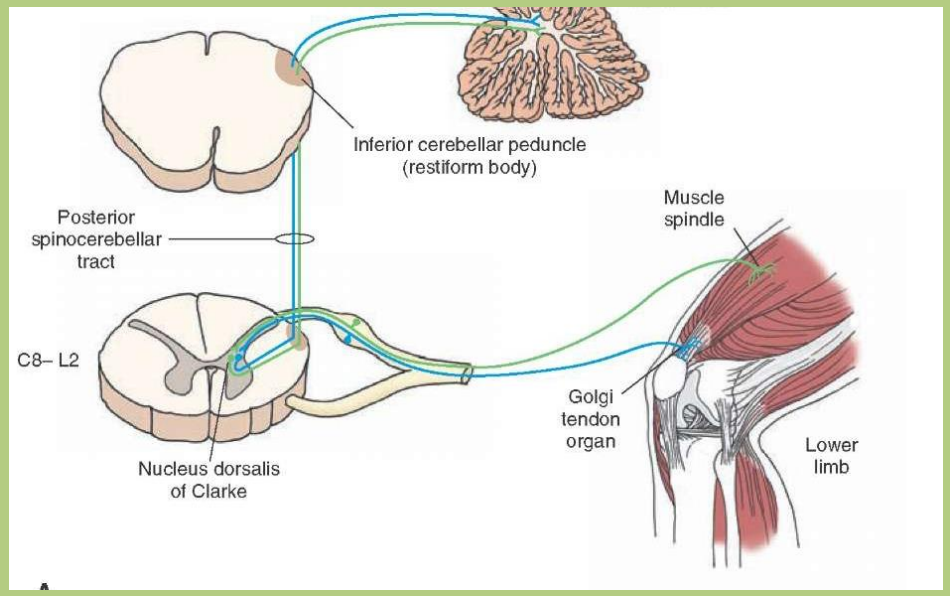
posterior spinocerebellar tracts **do not cross**

Anterior spinocerebellar tracts **do cross**

Receptors: muscle spindles, tendon organs and joint receptors.

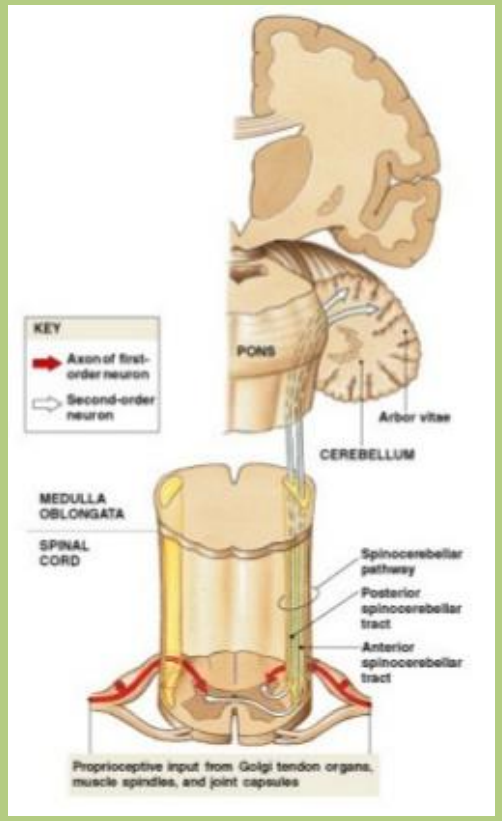


Sensory pathways (ascending tracts)- Posterior spinocerebellar tract



- Muscle spindles and tendon receptors convey proprioceptive information from **lower body part** to pseudounipolar neurons in the *dorsal root ganglion* (**1st neuron**).
- The axons terminate at the dorsal nucleus (*Clark's*) of gray matter (**2nd neuron**), which spans spinal cord segments C8 to L3.
- The axons of the second neurons ascend ipsilaterally to the cerebellum, entering through the inferior cerebellar peduncle.
- The axons terminate with *mossy fibers in the stratum granulosum* of cerebellar cortex.

Sensory pathways (ascending tracts)- Anterior spinocerebellar tract



- Muscle spindles and tendon receptors convey proprioceptive information from **lower body part** to pseudounipolar neurons in the *dorsal root ganglion* (**1st neuron**).
- The axons terminate at the *dorsal gray horn* (**2nd neuron**), which spans spinal cord segments L4 to S3.
- The majority of the axons of second neurons crosses in the anterior commissure and ascends contralaterally to the cerebellum, entering through the superior cerebellar peduncle.
- The axons terminate with *mossy fibers in the stratum granulosum* of cerebellar cortex.
- *(It is believed that those fibers that crossed over to the opposite side in the spinal cord cross back within the cerebellum.)*

Other ascending tracts

Spinotectal tract

It provides afferent information for spinovisual reflexes and brings about movements of the eyes and head toward the source of the stimulation.

- 1st neuron: in the dorsal root ganglia
- 2nd neuron: unknown
- crossing in the median plane
- termination: in the superior colliculi

Spinoreticular tract

It provides afferent information for the reticular formation, which plays an important role in influencing levels of consciousness.

- 1st neuron: in the dorsal root ganglia
- 2nd neuron: unknown
- termination: neurons of the reticular formation in the medulla oblongata, pons and midbrain

Other ascending tracts

Spino-olivary tract

It provides afferent information for the cerebellum from cutaneous and proprioceptive organs.

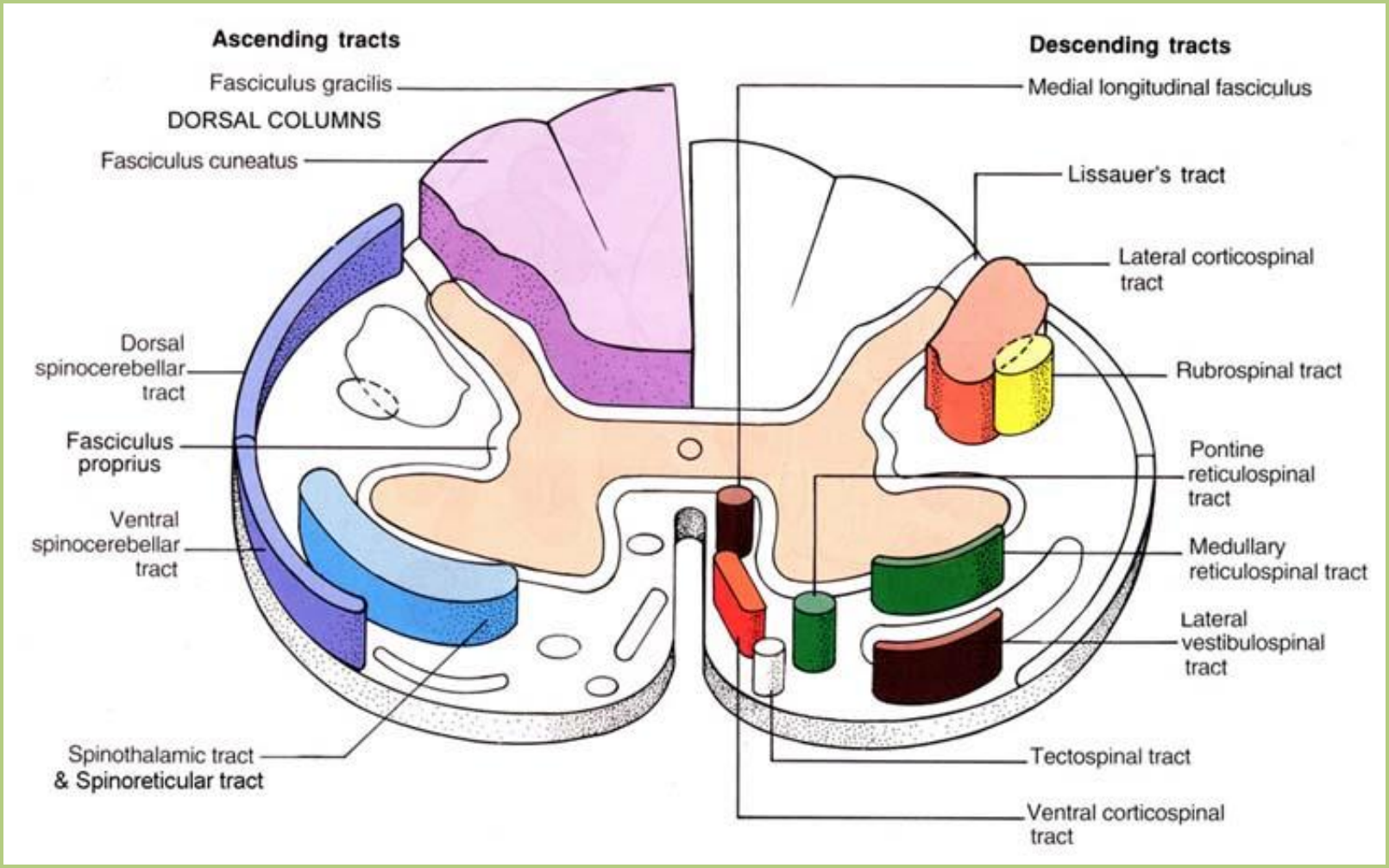
- 1st neuron: in the dorsal root ganglia
- 2nd neuron: unknown
- crossing in the median plane
- 3rd neuron: in the inferior olivary nuclei in the medulla oblongata
- crossing in the midline
- termination: cerebellum via inferior cerebellar peduncle

Visceral sensory tracts

It provides afferent information for the cerebral cortex about visceral pain, including ischemia, chemical damage and spasm of smooth muscle..

- 1st neuron: in the dorsal root ganglia
- 2nd neuron: posterior or lateral gray column
- the axons of 2nd neurons are believed to join the spinothalamic tracts
- 3rd neuron: VPL nucleus of the thalamus
- termination: postcentral gyrus

Ascending and descending tracts - overview



Thank you for your attention.

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