

Neurophysiology

Sensation 2

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Labeled Line Principle

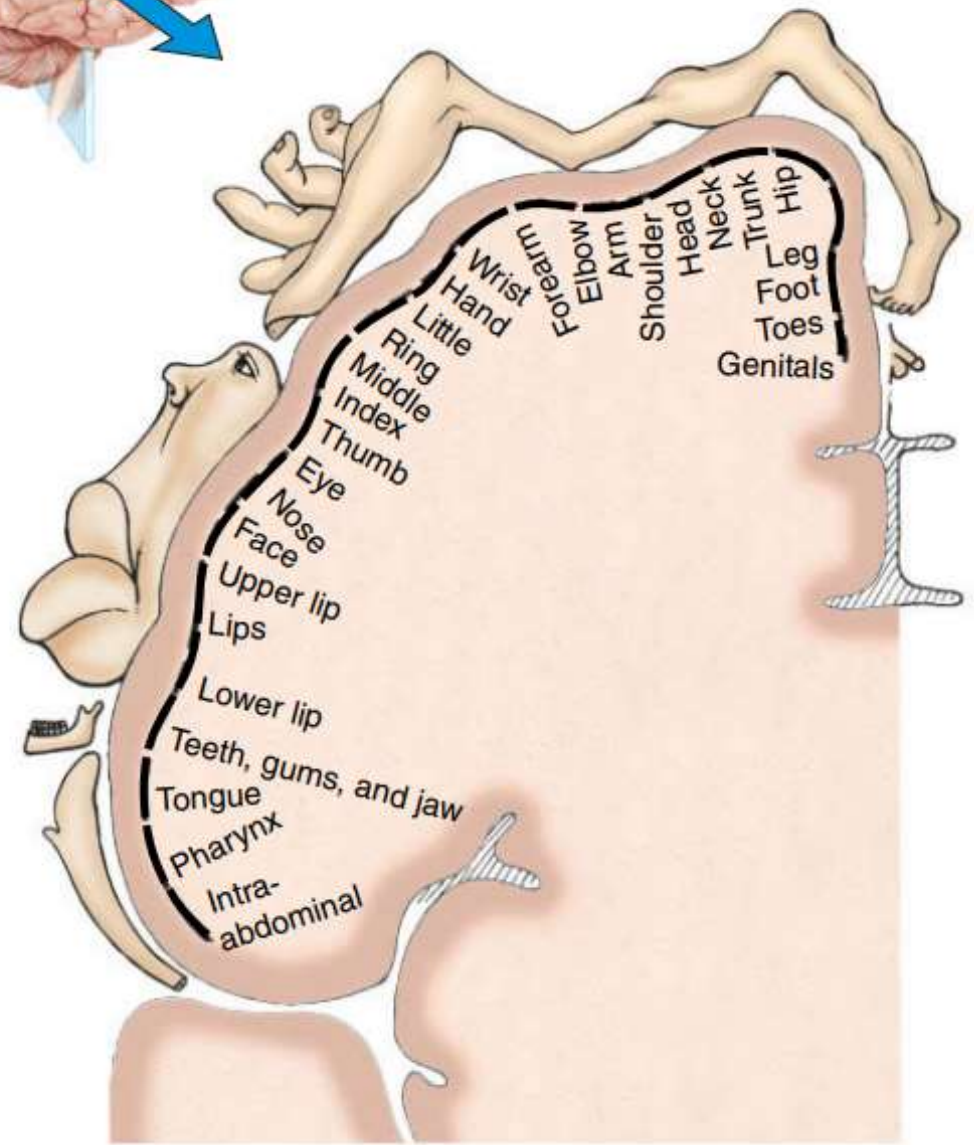
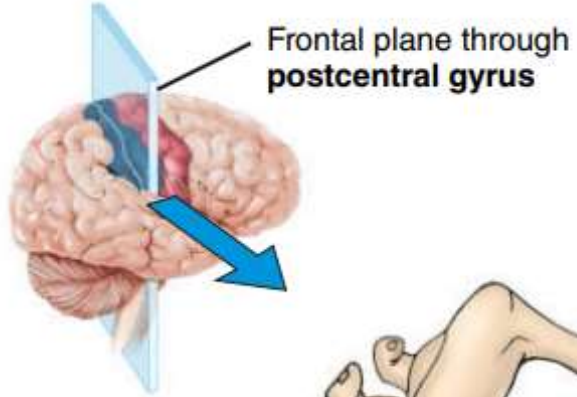
- Even though all information is propagated to the CNS via the same type of signal (action potentials), the brain can **decode** the type and location of the stimulus.
- A particular sensory modality detected by a specialized receptor type is sent over a specific afferent and ascending pathway to excite a defined area in the somatosensory cortex.
- Thus, different types of incoming information are kept separated within specific labeled lines between the periphery and the cortex.

Stimulus intensity

- The intensity of the stimulus is reflected by the magnitude of the receptor potential.
- The larger the receptor potential, the greater the frequency of action potentials generated in the afferent neuron.

Stimulus intensity

- Stimulus strength is also reflected by the size of the area stimulated: Stronger stimuli usually affect larger areas, so correspondingly more receptors respond.
- **Temporal and spatial summation.**

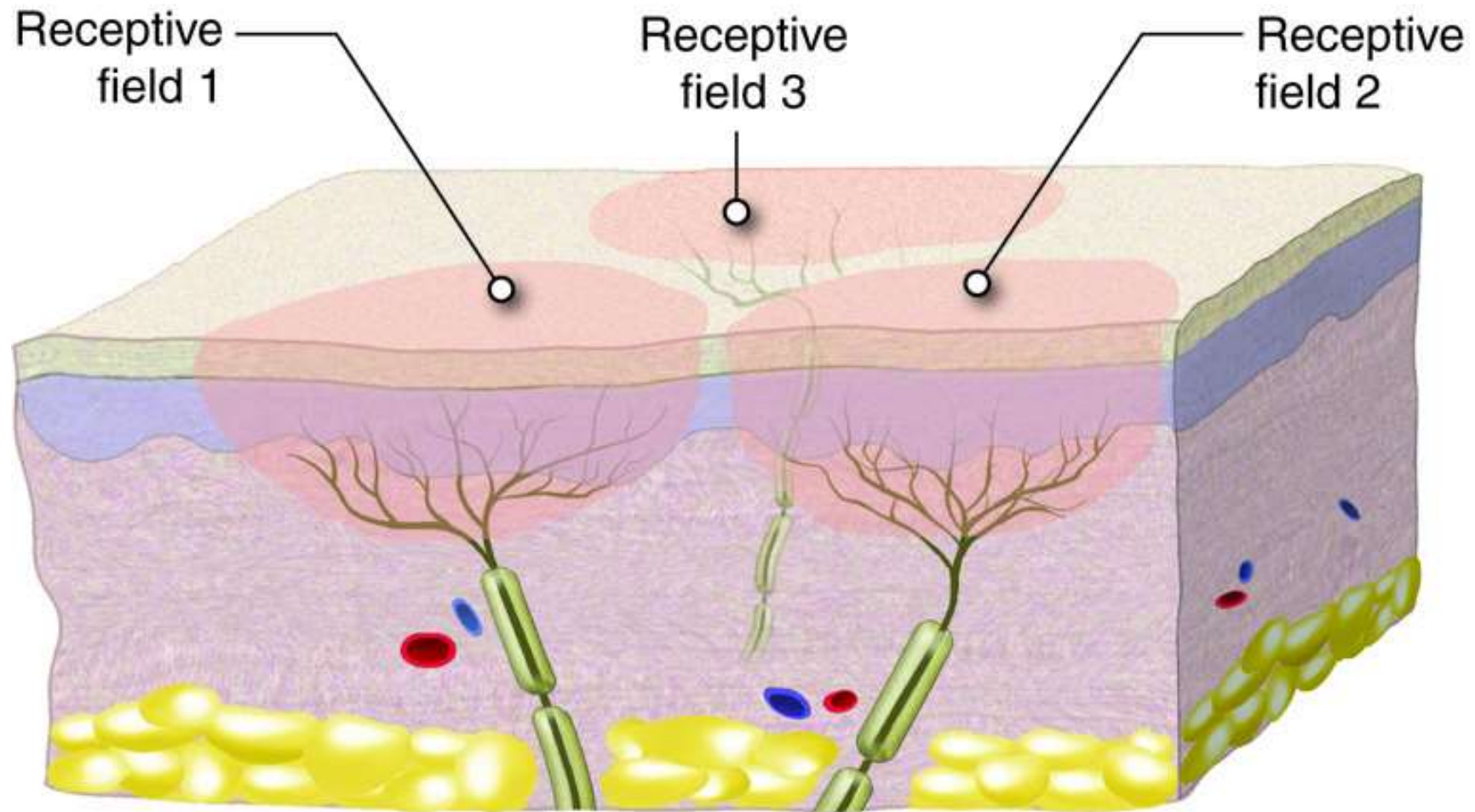


Somatic sensory receptors distribution

- Receptors are **distributed unevenly**.
- The areas with the highest density of somatic sensory receptors are the tip of the tongue, the lips, and the fingertips.

Receptive Field

- Each sensory neuron responds to a stimulus only within a specific region surrounding it, this region is called its **receptive field**.
- The size of a receptive field varies inversely with the density of receptors in the region.
- The smaller the receptive field is in a region, the greater its acuity or discriminative ability: **2 point discrimination**



Lateral Inhibition

- Blockage of further transmission in the weaker inputs increases the contrast between wanted and unwanted information so that the stimulus is precisely localized.
- With lateral inhibition, each activated signal pathway inhibits the pathways next to it by stimulating inhibitory interneurons that pass laterally between ascending fibers serving neighboring receptive fields.
- The extent of lateral inhibitory connections within sensory pathways varies for different modalities. Those with the most lateral inhibition: touch and vision

True or false

- Stimuli of the same intensity always result in receptor potentials of the same magnitude in the same receptor.

Adaptation in sensory receptors

- A characteristic of most sensory receptors is **adaptation**, in which the receptor potential decreases in amplitude during a maintained, constant stimulus.
- Because of adaptation, the perception of a sensation may fade or disappear even though the stimulus persists.
- Receptors vary in **how they adapt and how quickly they adapt** (tonic vs phasic).

Position sensory receptors

- The Pacinian corpuscles and muscle spindles are especially adapted for detecting rapid rates of change.
- It is likely that these are the receptors most responsible for detecting rate of movement.

Transmission of tactile signals in peripheral nerve fibers

- Almost all specialized sensory receptors, such as Meissner's corpuscles, transmit their signals in type **A β** nerve fibers.
- Free nerve ending tactile receptors transmit signals mainly via the small type **A δ** myelinated fibers.
- Some tactile free nerve endings transmit via type **C** unmyelinated fibers such as in itch and tickle senses.

Thermoreceptors

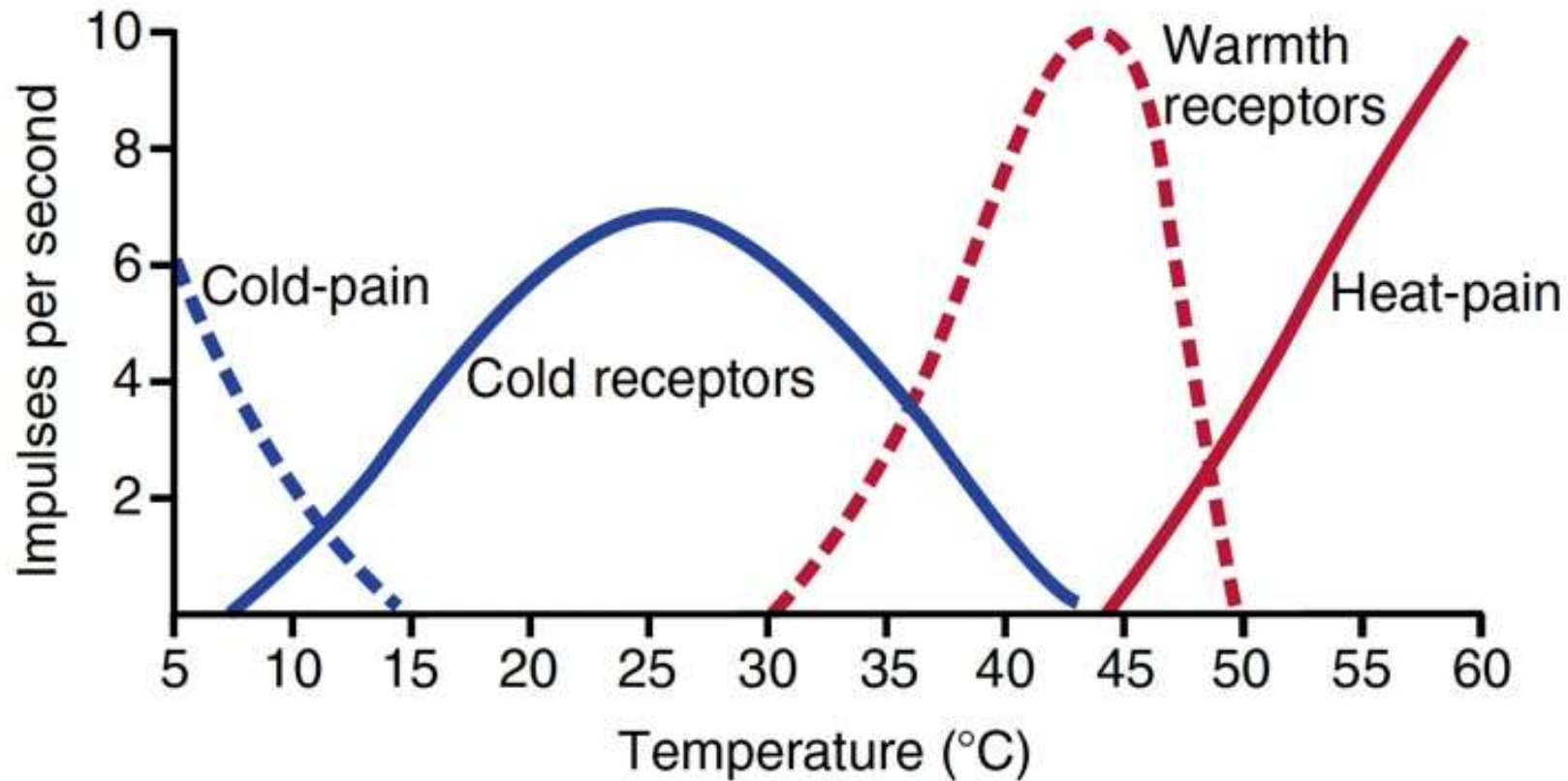
- Cold receptors
- Warmth receptors
- Pain receptors (stimulated only by extreme degrees of heat or cold).

- They are located immediately under the skin at discrete separated spots.
- Most areas of the body have more cold receptors than warmth.
- The number of receptors in different areas of the body varies.

Thermoreceptors

- Free nerve endings.
- Warmth signals are transmitted mainly over type C nerve fibers.
- Cold signals are transmitted mainly via type A δ nerve fibers.
- In general, thermal signals are transmitted in pathways parallel to those for pain signals.

Thermal sensations



Thermal sensations

- The different gradations of thermal sensations can be determined by the relative degrees of stimulation of the different types of thermoreceptors and nociceptors.
- Because the number of cold or warmth endings in any one surface area of the body is slight, It is difficult to judge gradations of temperature when small skin areas are stimulated.
- However, when a large skin area is stimulated all at once, the thermal signals from the entire area are cumulative.

Adaptation in thermal receptors

- Thermal senses respond markedly to changes in temperature than to steady states of temperature.
- This means that when the temperature of the skin is actively falling, a person feels much colder than when the temperature remains cold at the same level.

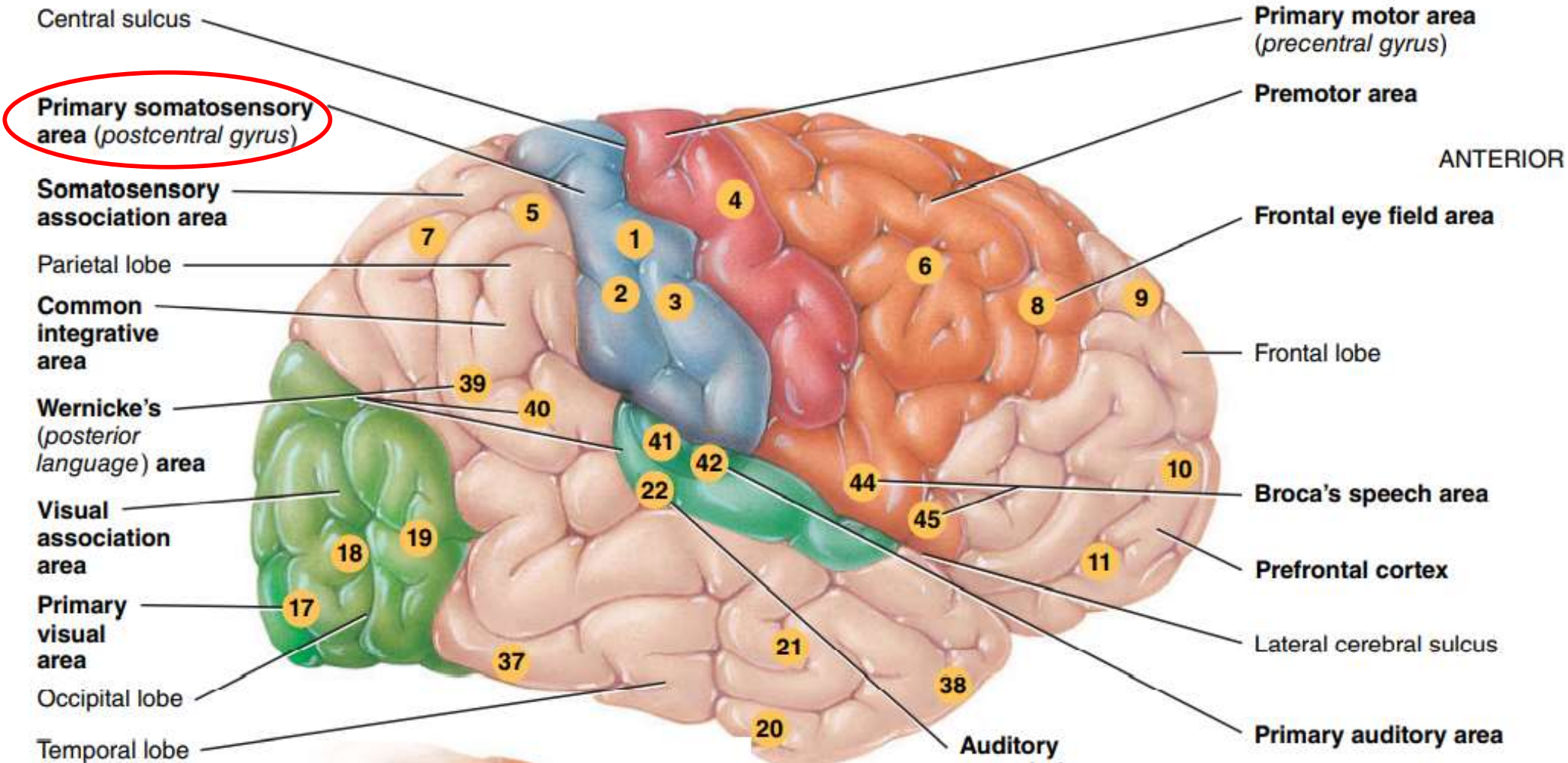
Thermal receptors

- Transduction of warm temperatures involves transient receptor potential (TRP) channels in the family of vanilloid receptors (TRPV).
- These channels are activated by compounds in the vanilloid class, which includes capsaicin, an ingredient in spicy foods. (This phenomenon explains why people describe the taste of chili peppers as “hot.”)

Thermal receptors

- Transduction of cold temperatures involves a different TRP channel, TRPM8, which is also opened by compounds like menthol (which gives a cold sensation).

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, a second-order neuron, and a third-order neuron.
- Integration (processing) of information occurs at each synapse along the pathway.

First-order (primary) neurons

- Sensory neurons that conduct impulses from somatic sensory receptors into the brainstem or spinal cord.
- Somatic sensory impulses propagate along spinal or cranial nerves.
- All other neurons in a somatic sensory pathway are located completely within the CNS.

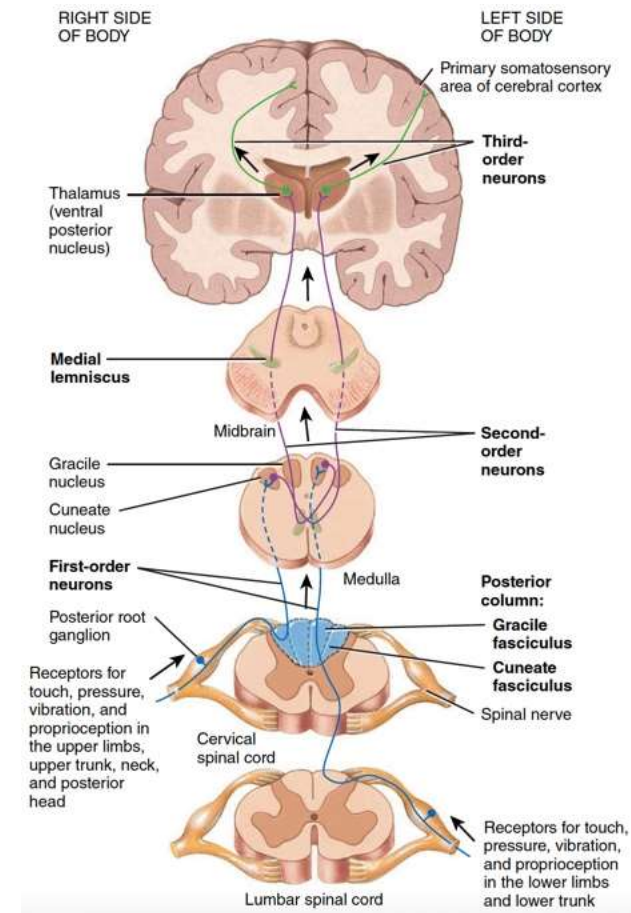
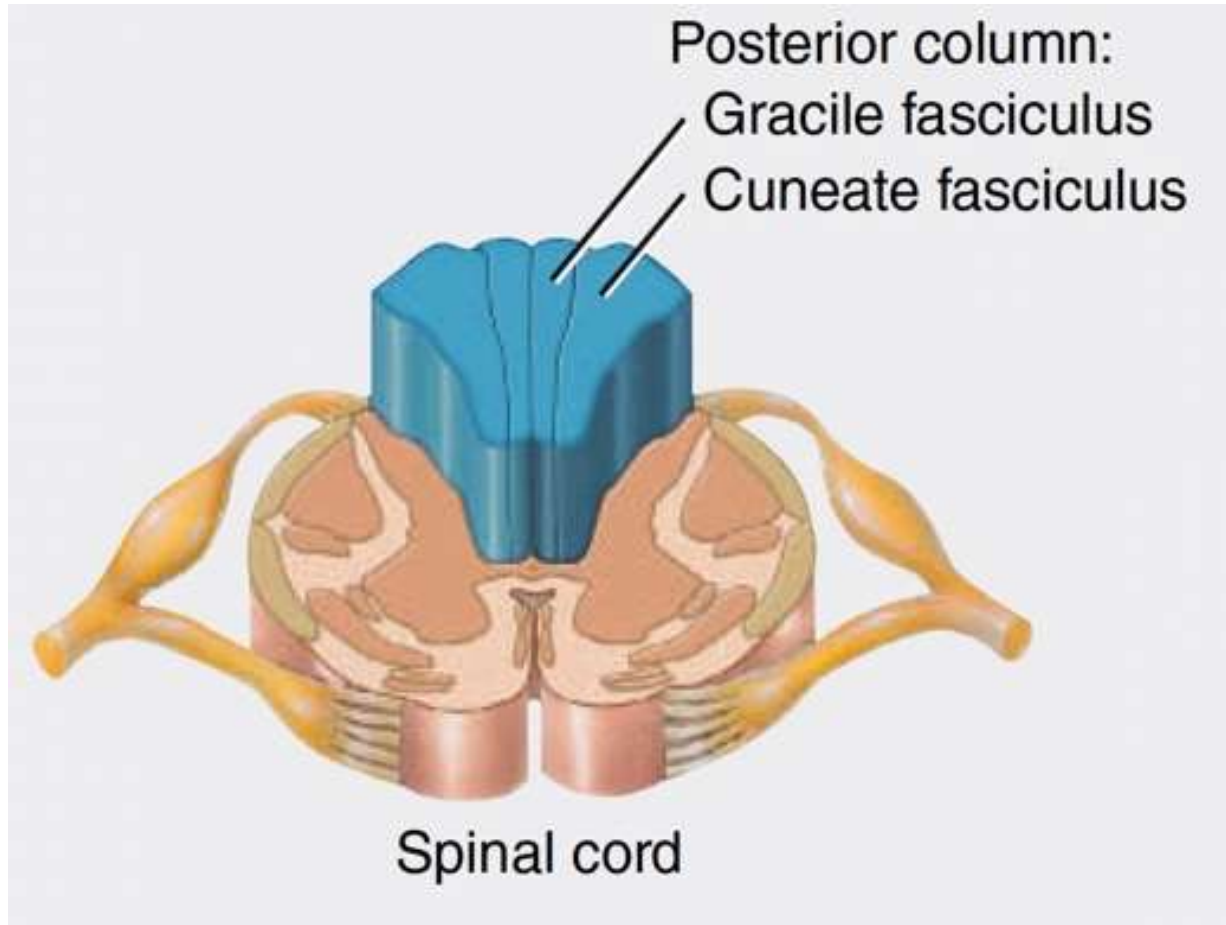
Second-order (secondary) neurons

- 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.

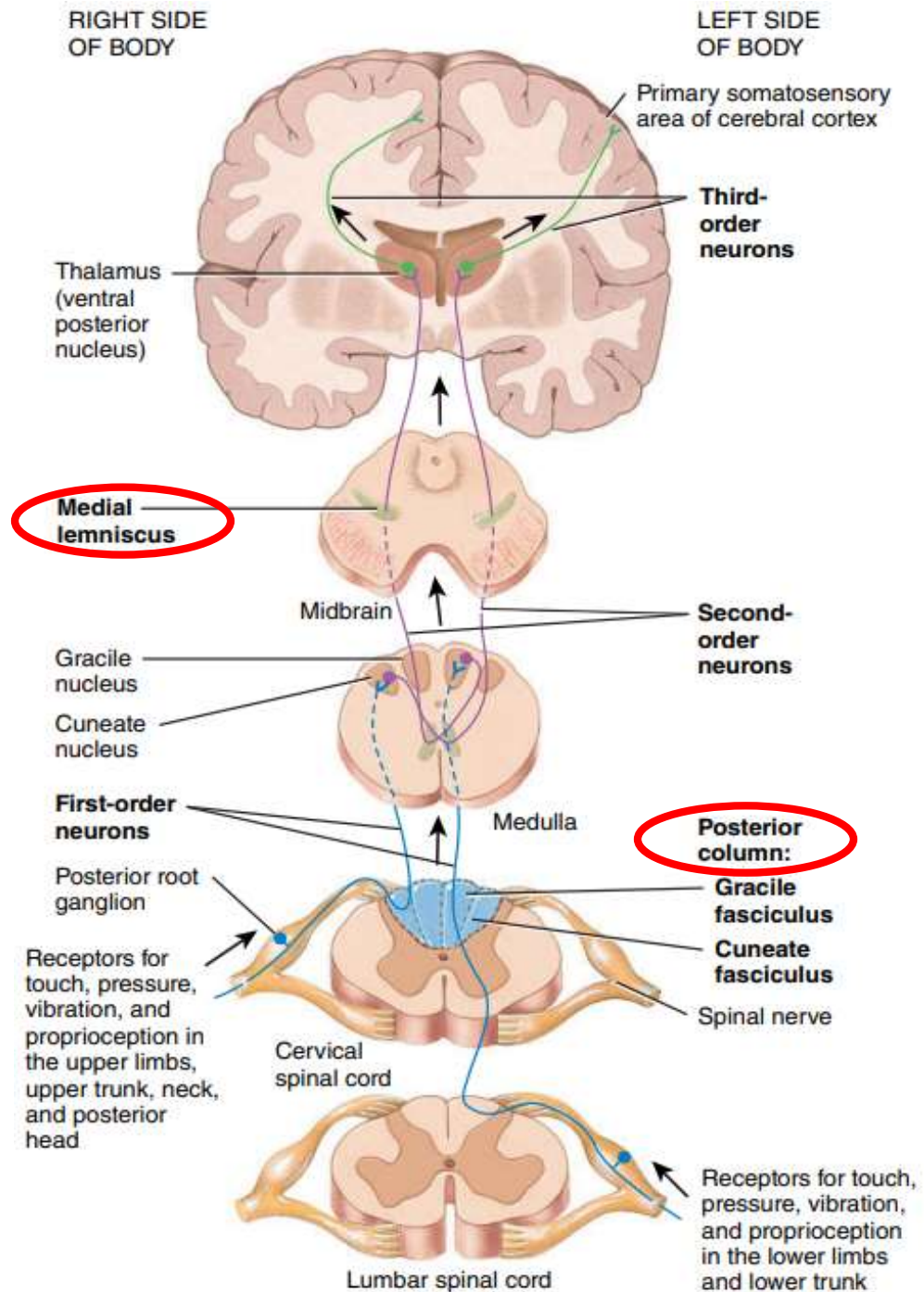
Third-order (tertiary) neurons

- Conduct impulses from the thalamus to the primary somatosensory area on the same side.
- Somatic sensory information on one side of the body is perceived by the primary somatosensory area on the opposite side of the brain.

Posterior (Dorsal) Column- Medial Lemniscus Pathway

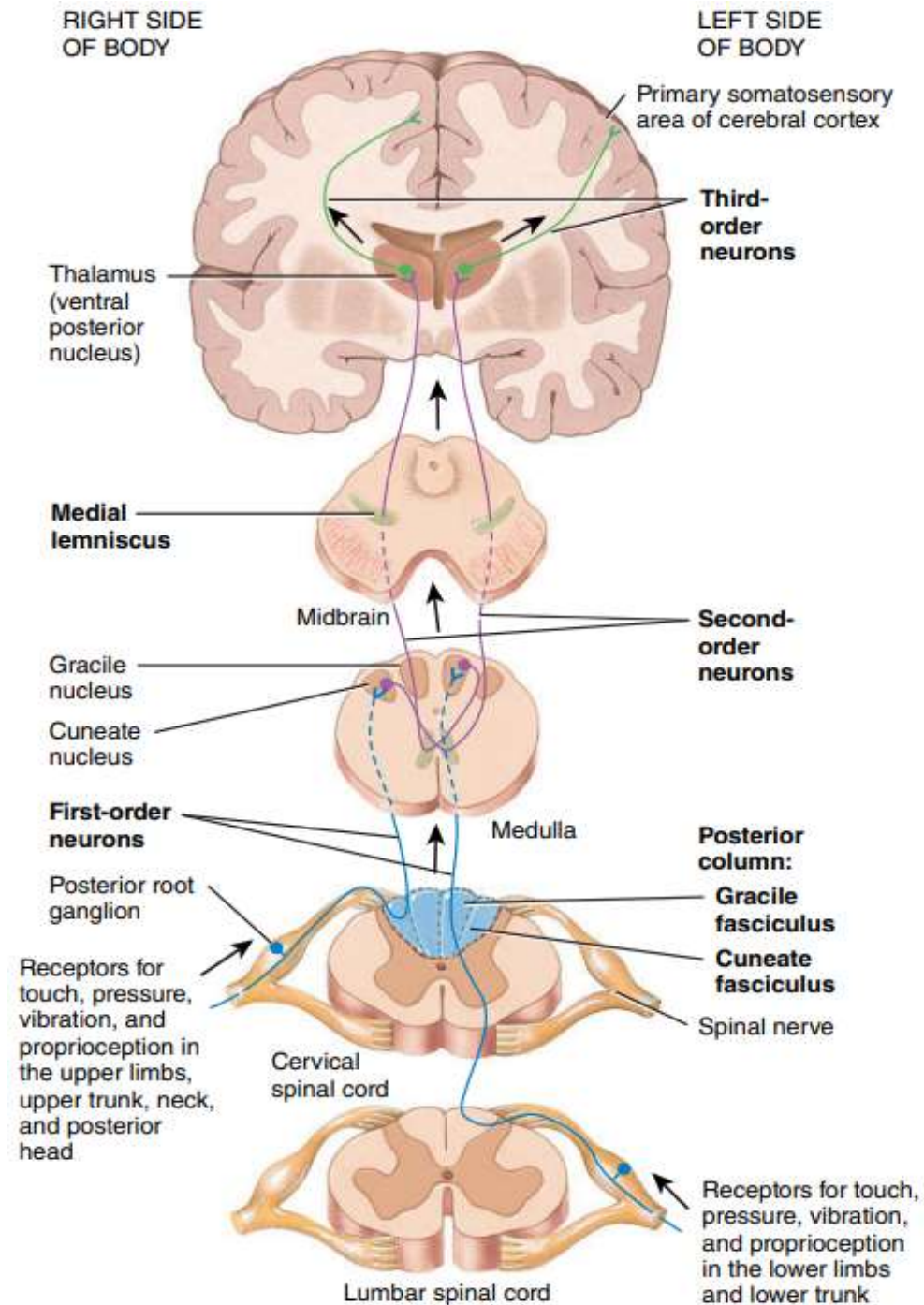


Posterior column - medial lemniscus pathway



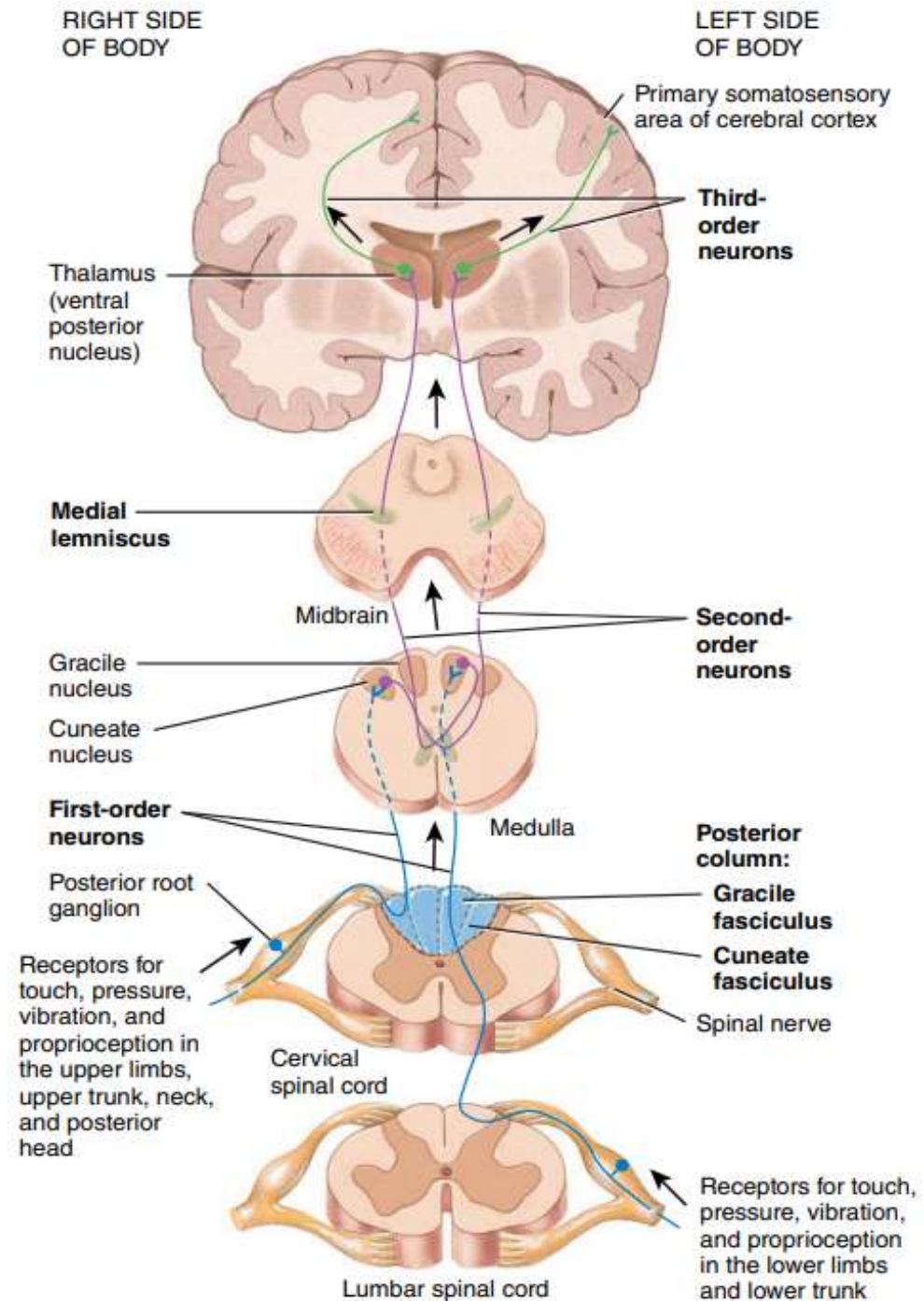
Posterior column - medial lemniscus pathway

Touch (fine)
Vibration
Pressure
Proprioception

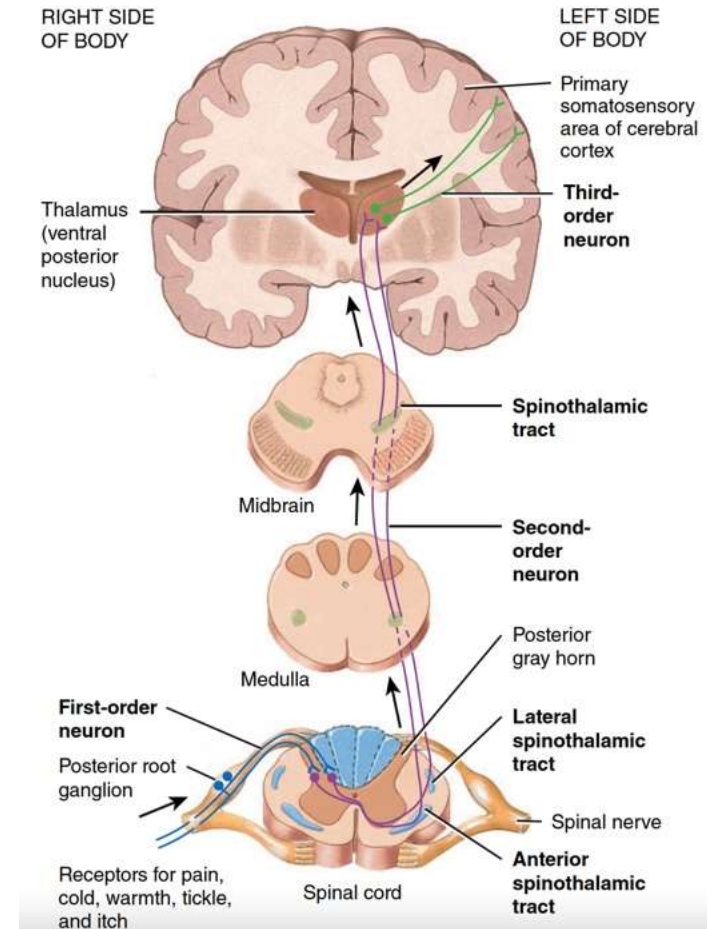
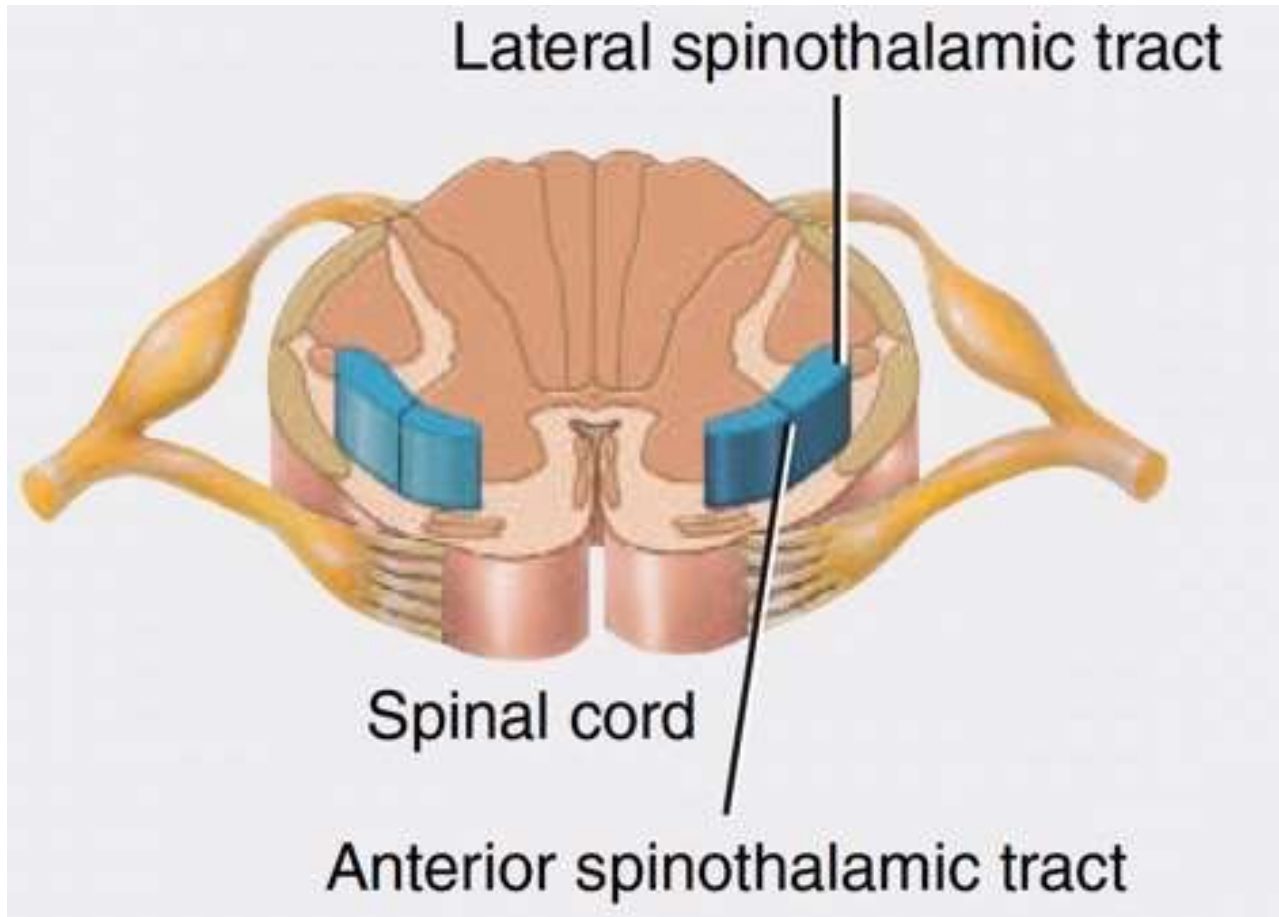


Posterior column - medial lemniscus pathway

Decussation in
the medulla

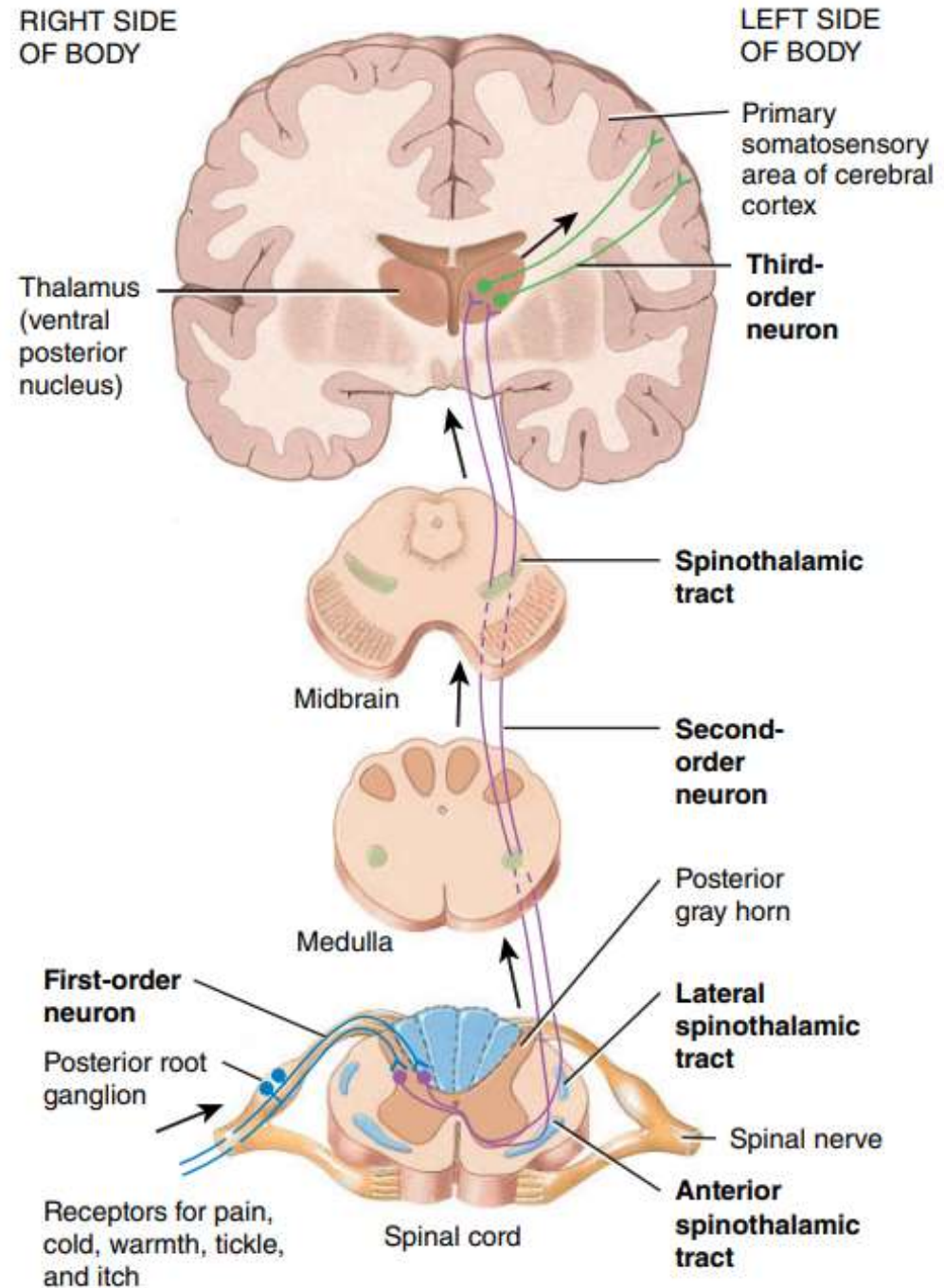


Antero-Lateral Spinothalamic Pathways



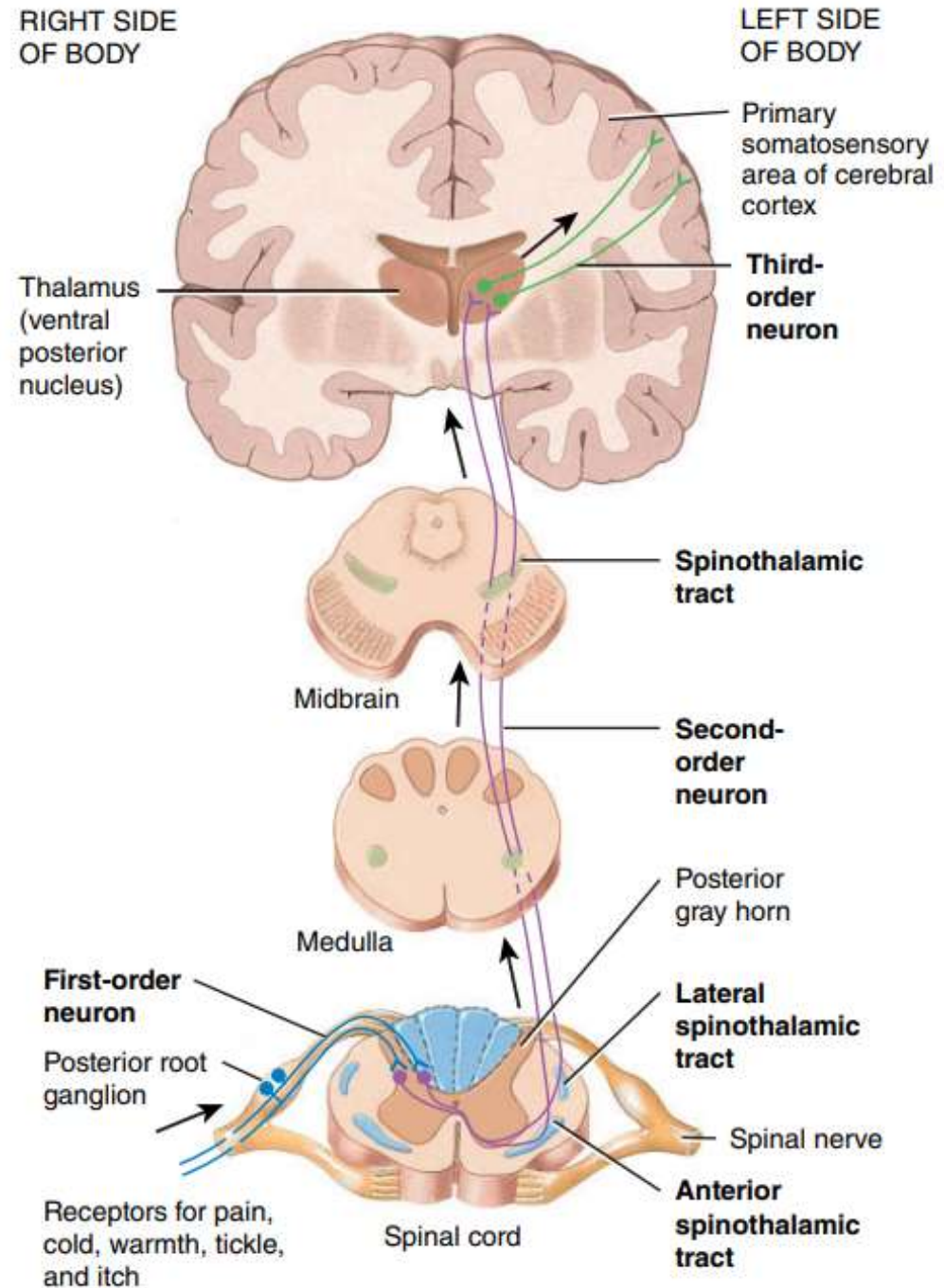
Anterolateral spinothalamic pathway

Pain
Temperature
Itch
Tickle

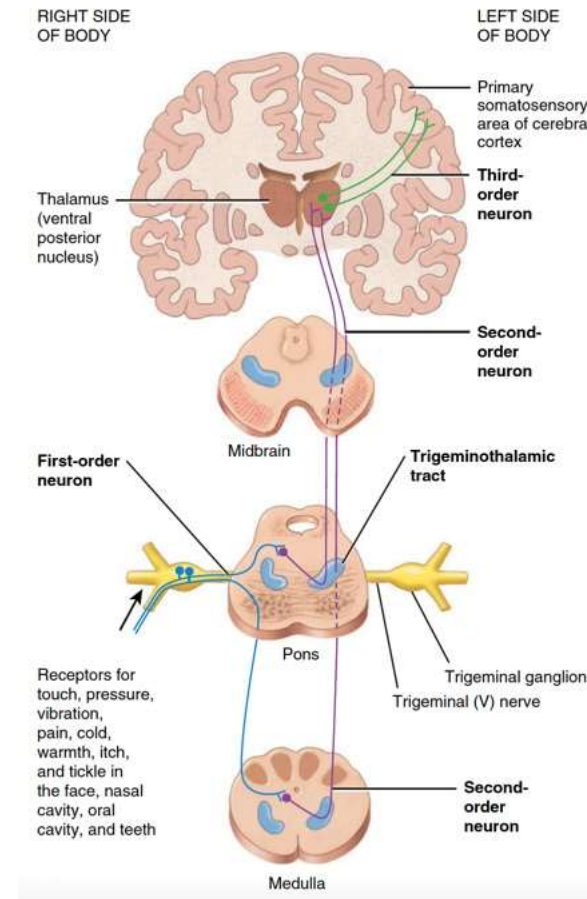
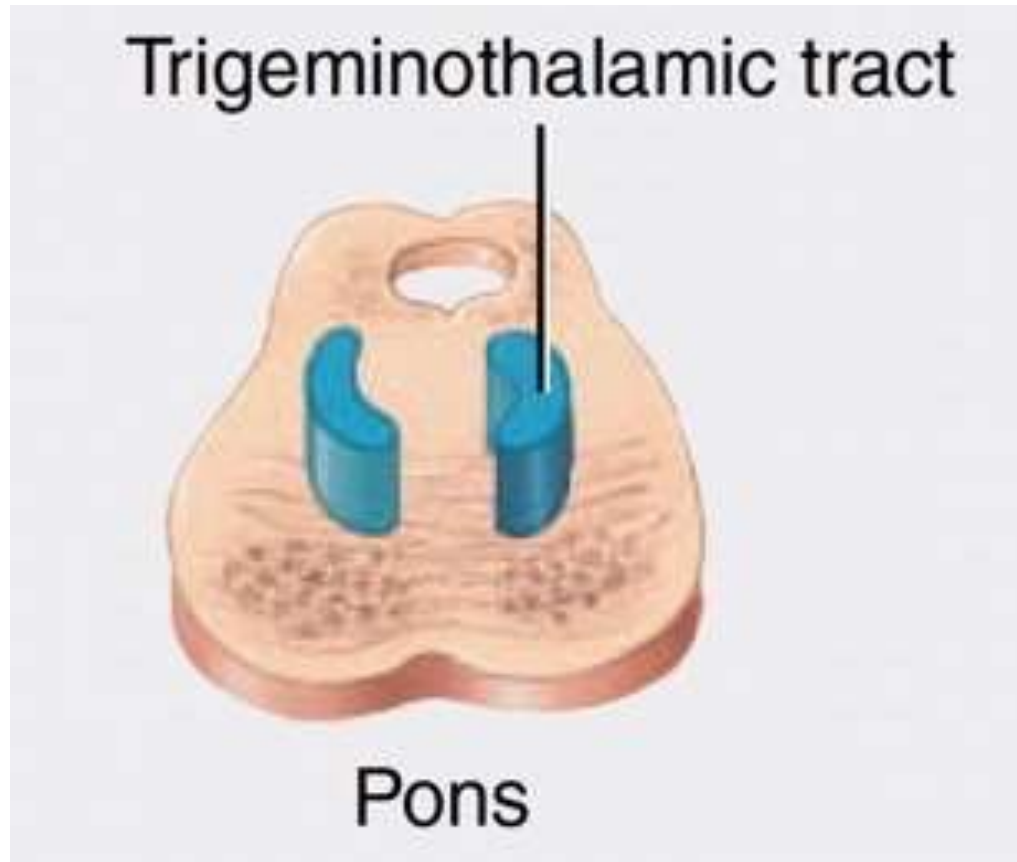


Anterolateral spinothalamic pathway

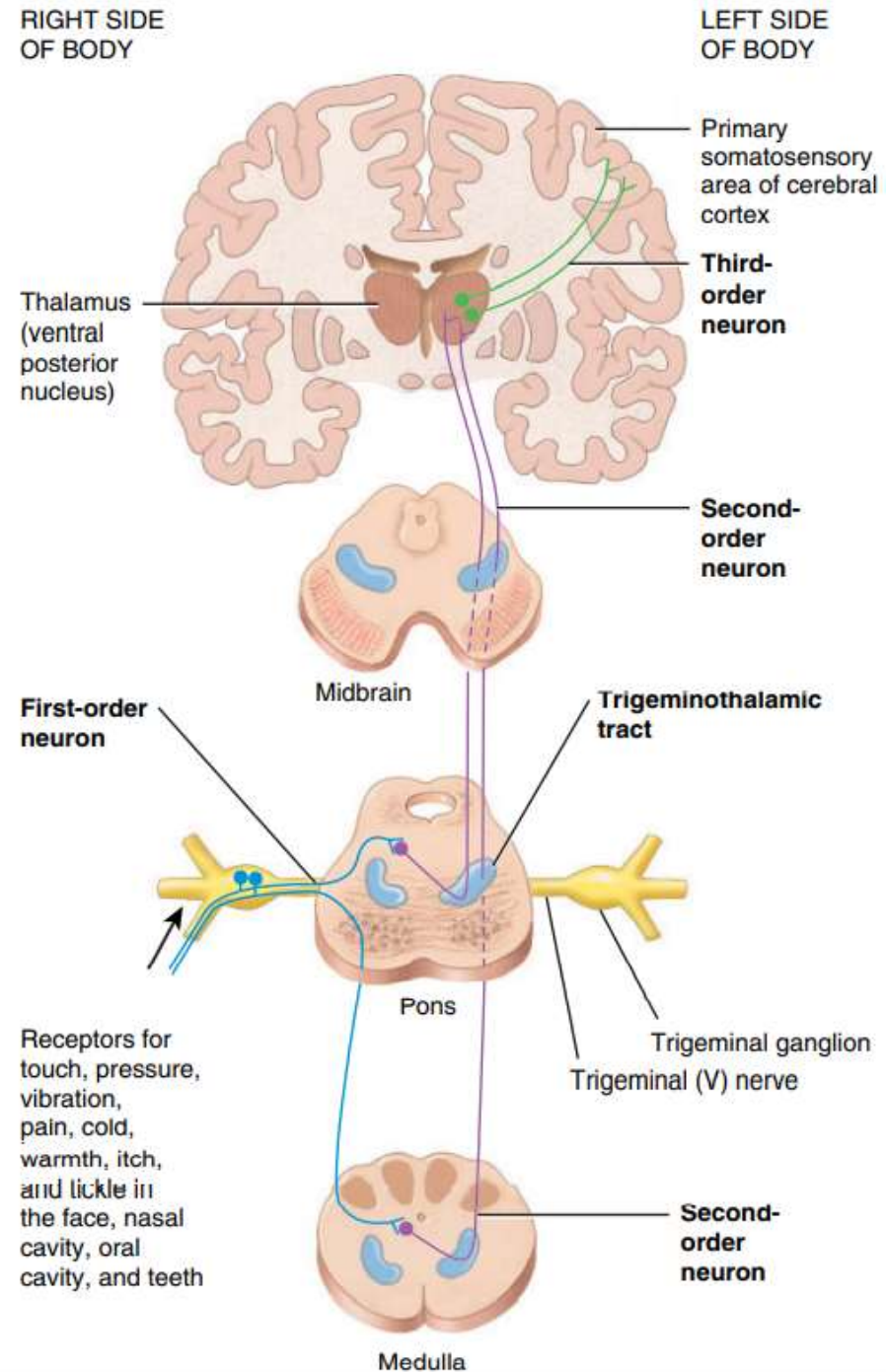
Decussation in spinal cord



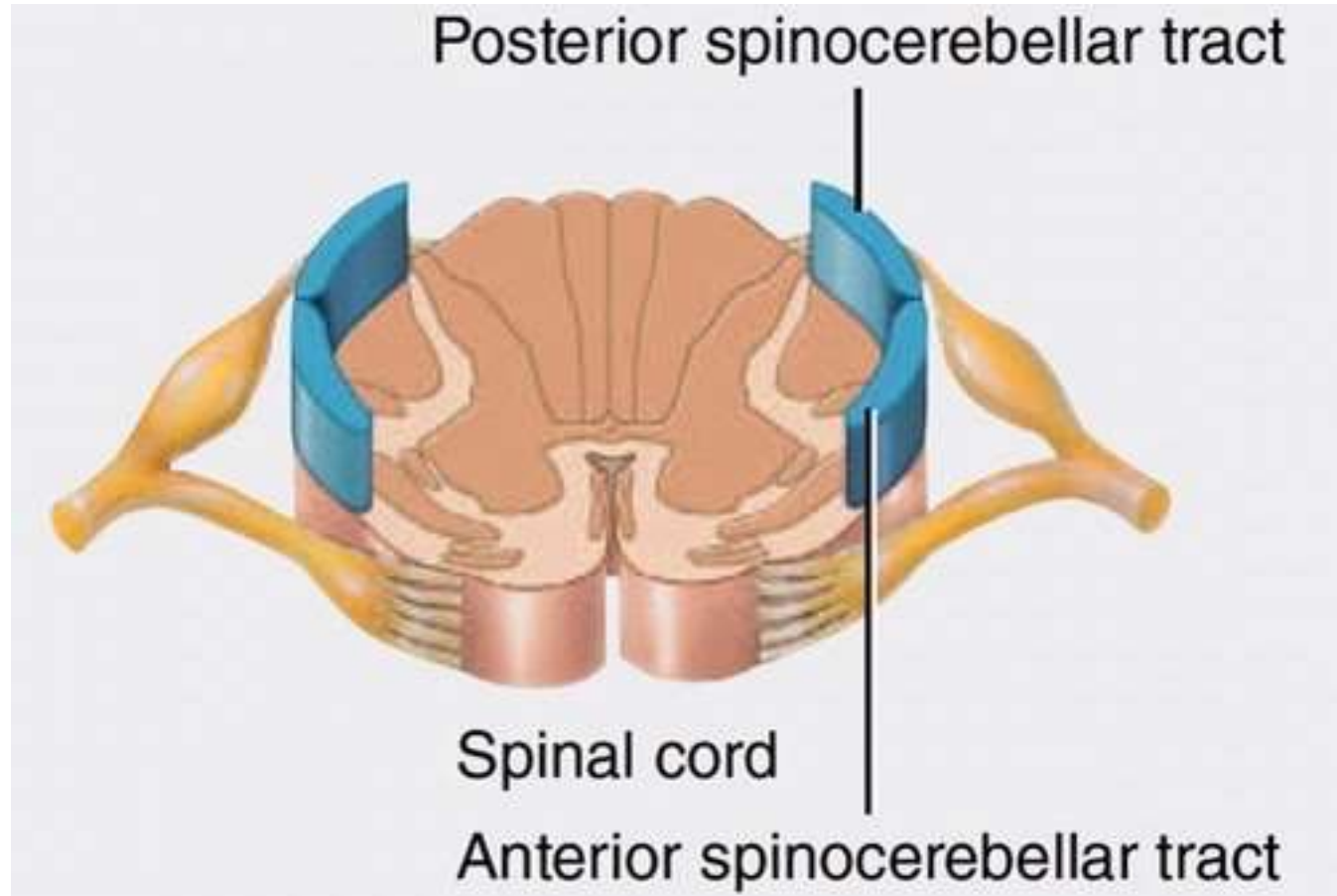
Trigeminothalamic Pathway



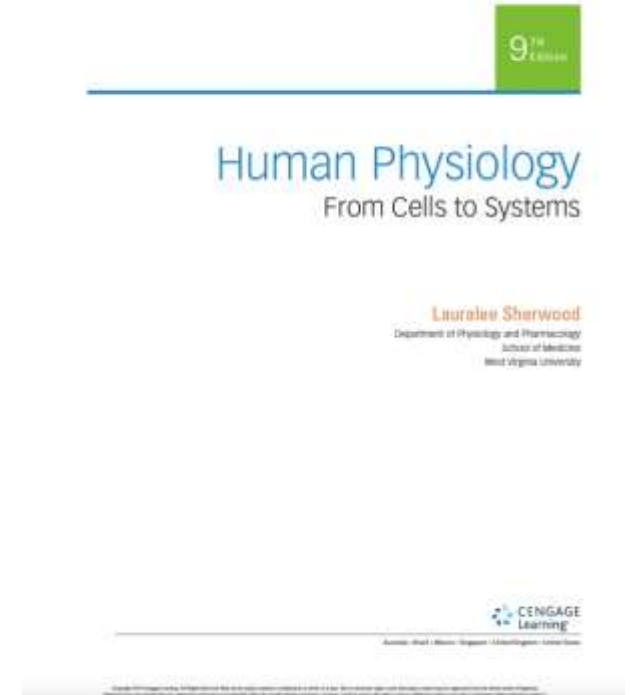
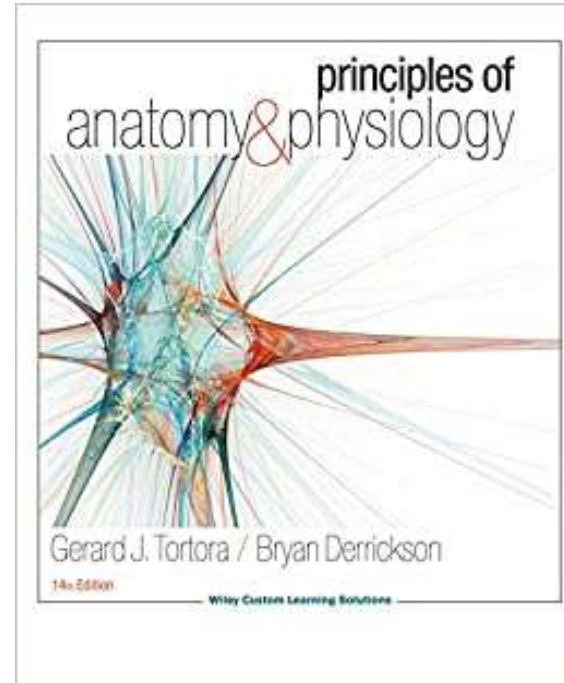
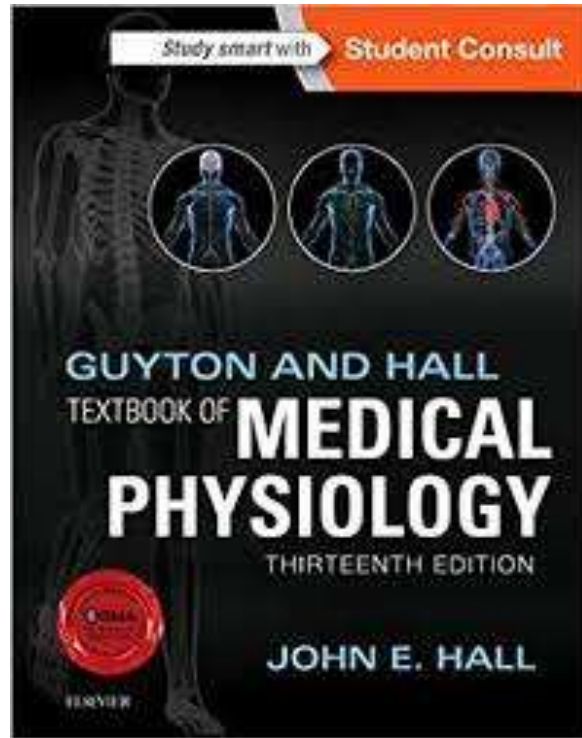
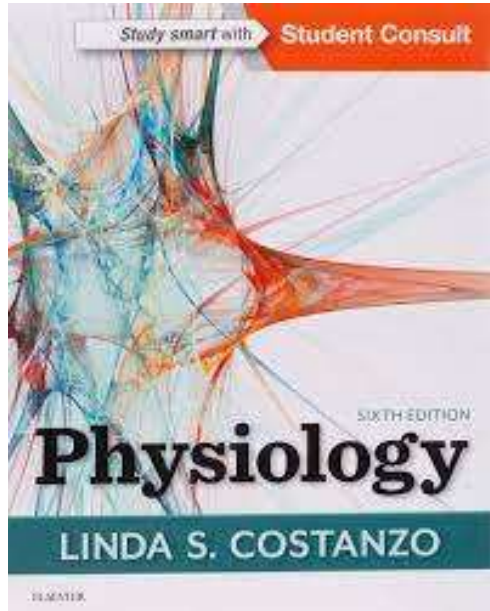
Trigeminothalamic pathway



Anterior and Posterior Spinocerebellar Pathways



References



Thank you