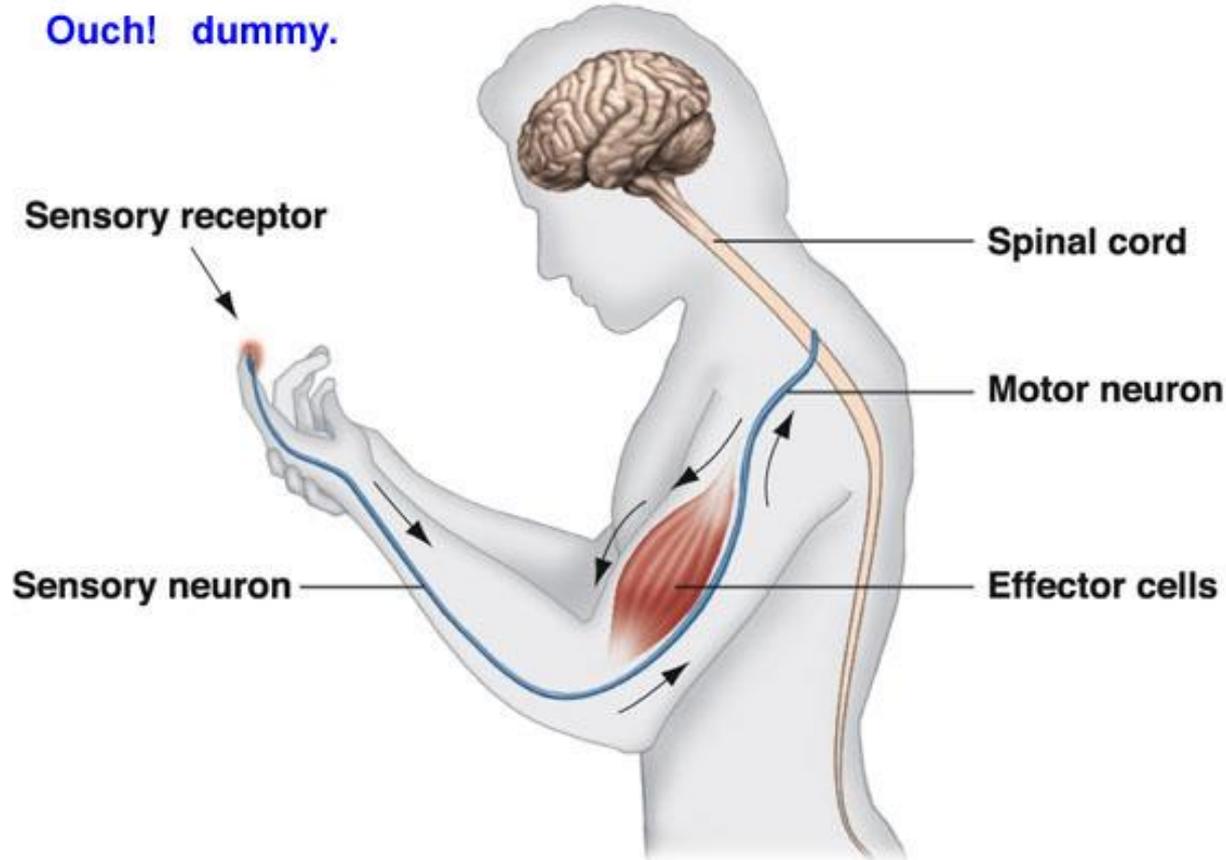


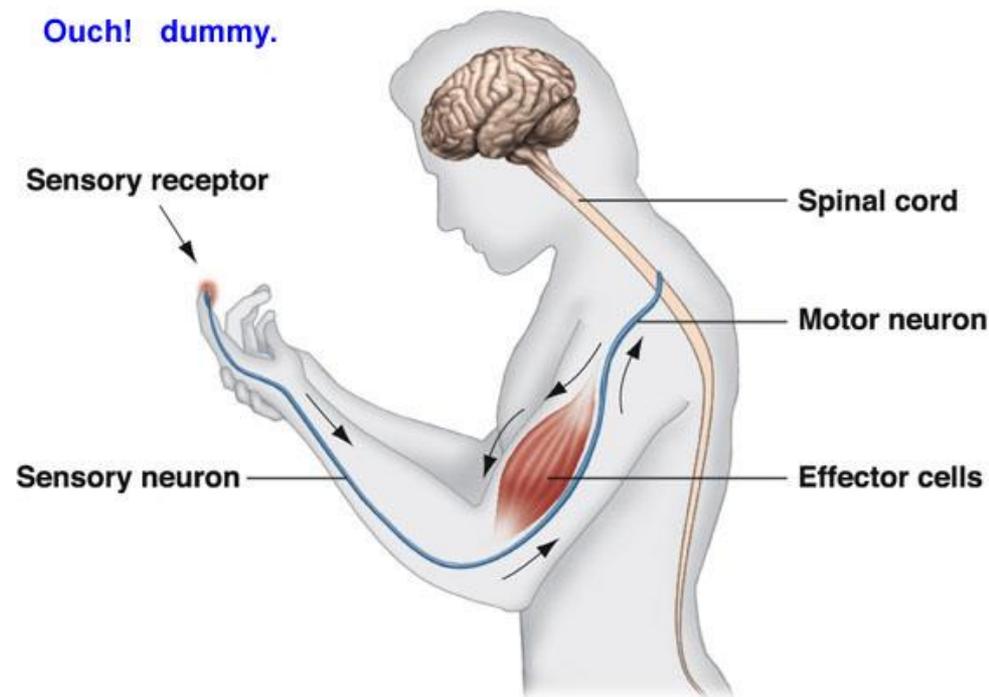
# SENSORY, MOTOR, AND INTEGRATIVE SYSTEMS



- The components of the brain interact
  - to receive sensory input,
  - integrate and store the information,
  - transmit motor responses.

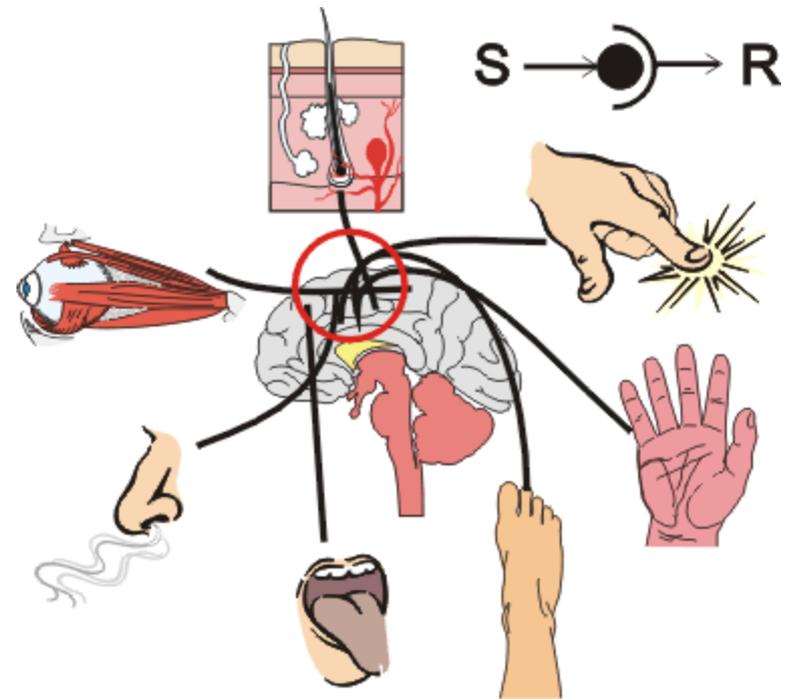


- To accomplish the primary functions of the nervous system there are neural pathways to transmit impulses from receptors to the circuitry of the brain, which manipulates the circuitry to form directives that are transmitted via neural pathways to effectors as a response.



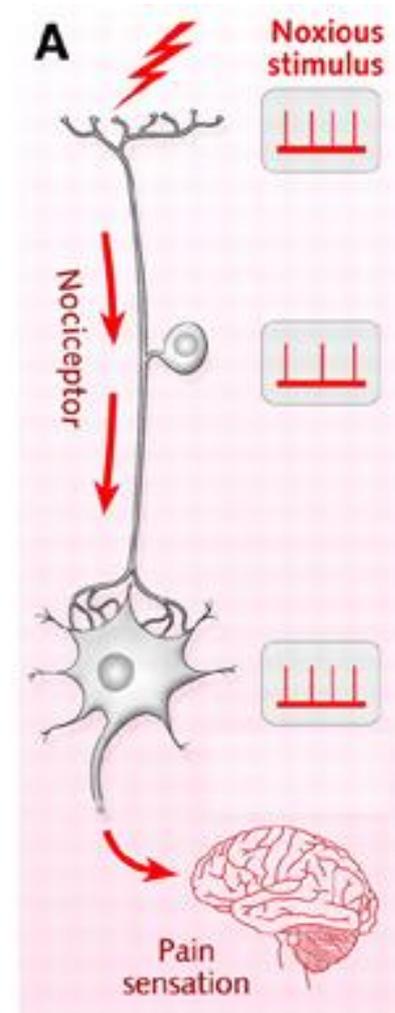
# SENSATION

- **Sensation** is a conscious or unconscious awareness of external or internal stimuli.
- **Perception** is the conscious awareness and interpretation of sensations.

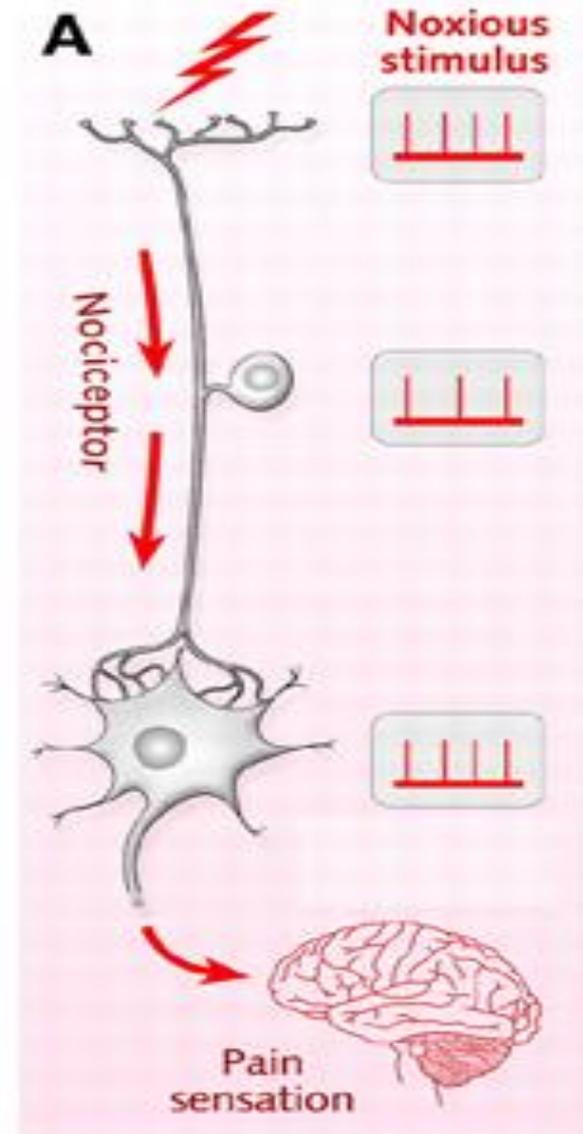


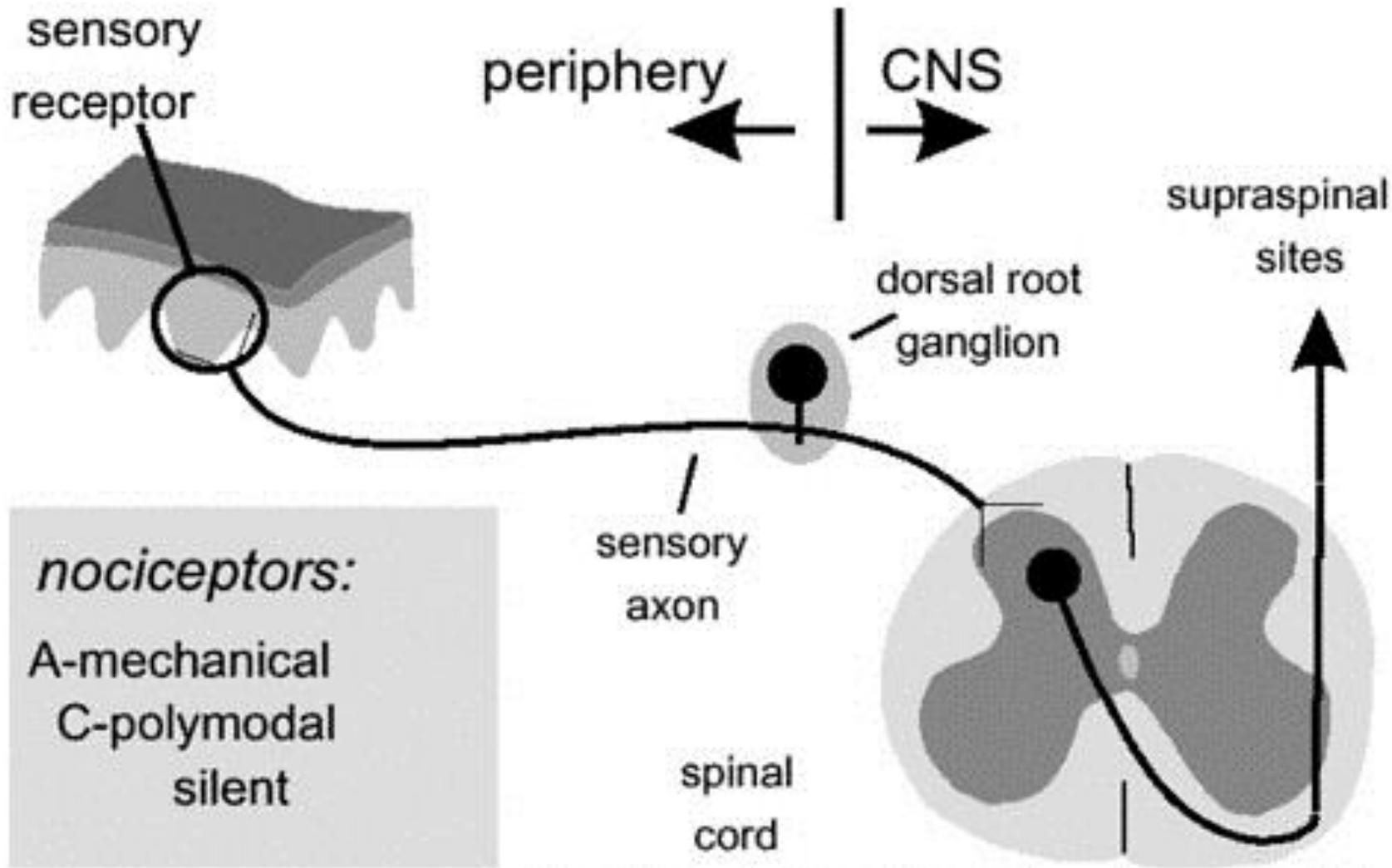
# Components of Sensation

- For a sensation to arise, four events must occur.
- These are
  - *stimulation,*
  - *transduction,*
  - *conduction,*
  - *translation.*



- A stimulus, or change in the environment, capable of initiating a nerve impulse by the nervous system must be present.
- A sensory receptor or sense organ must pick up the stimulus and transduce (convert) it to a nerve impulse by way of a generator potential.
- The impulse(s) must be conducted along a neural pathway from the receptor or sense organ to the brain.
- A region of the brain or spinal cord must translate the impulse into a sensation.



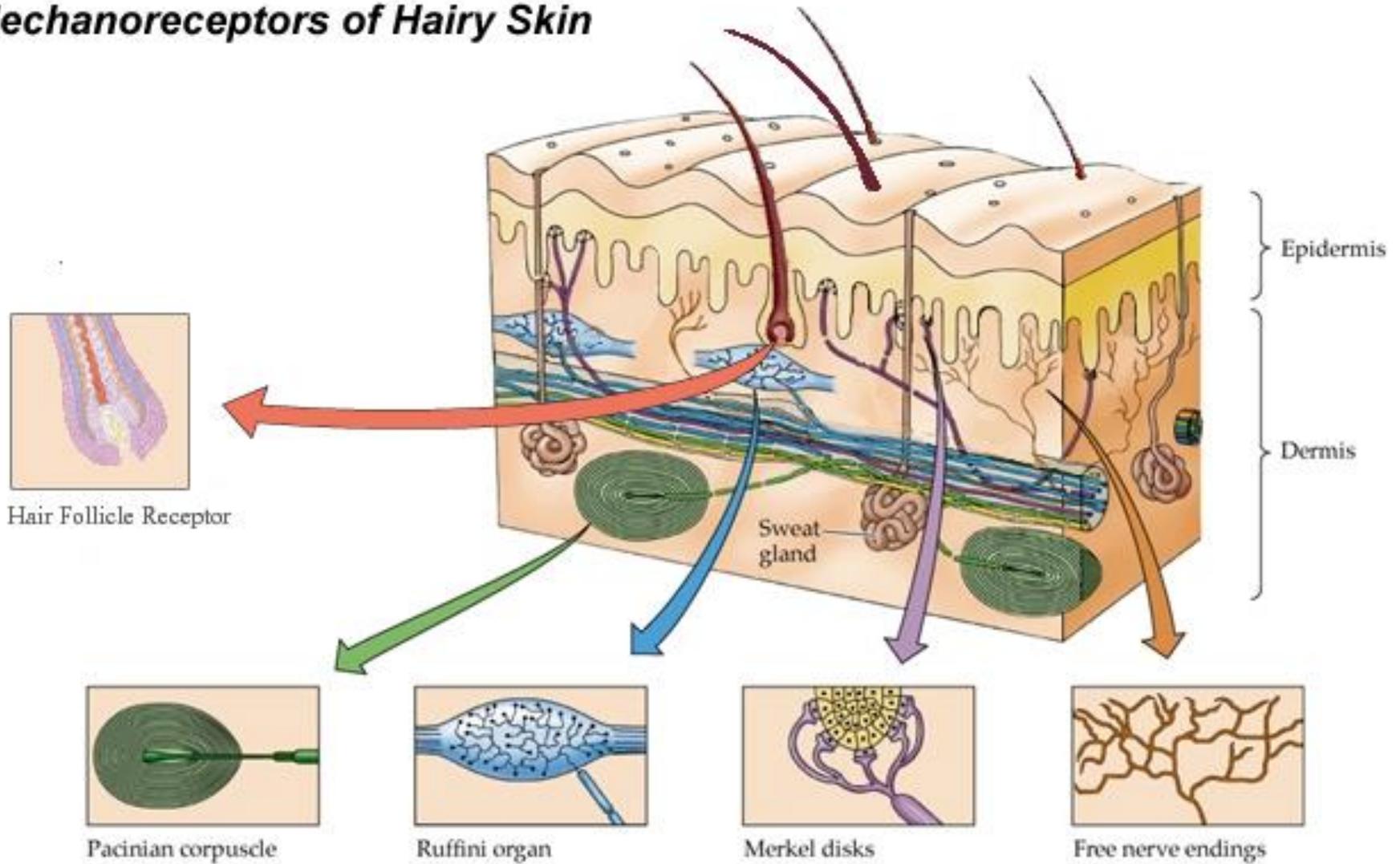


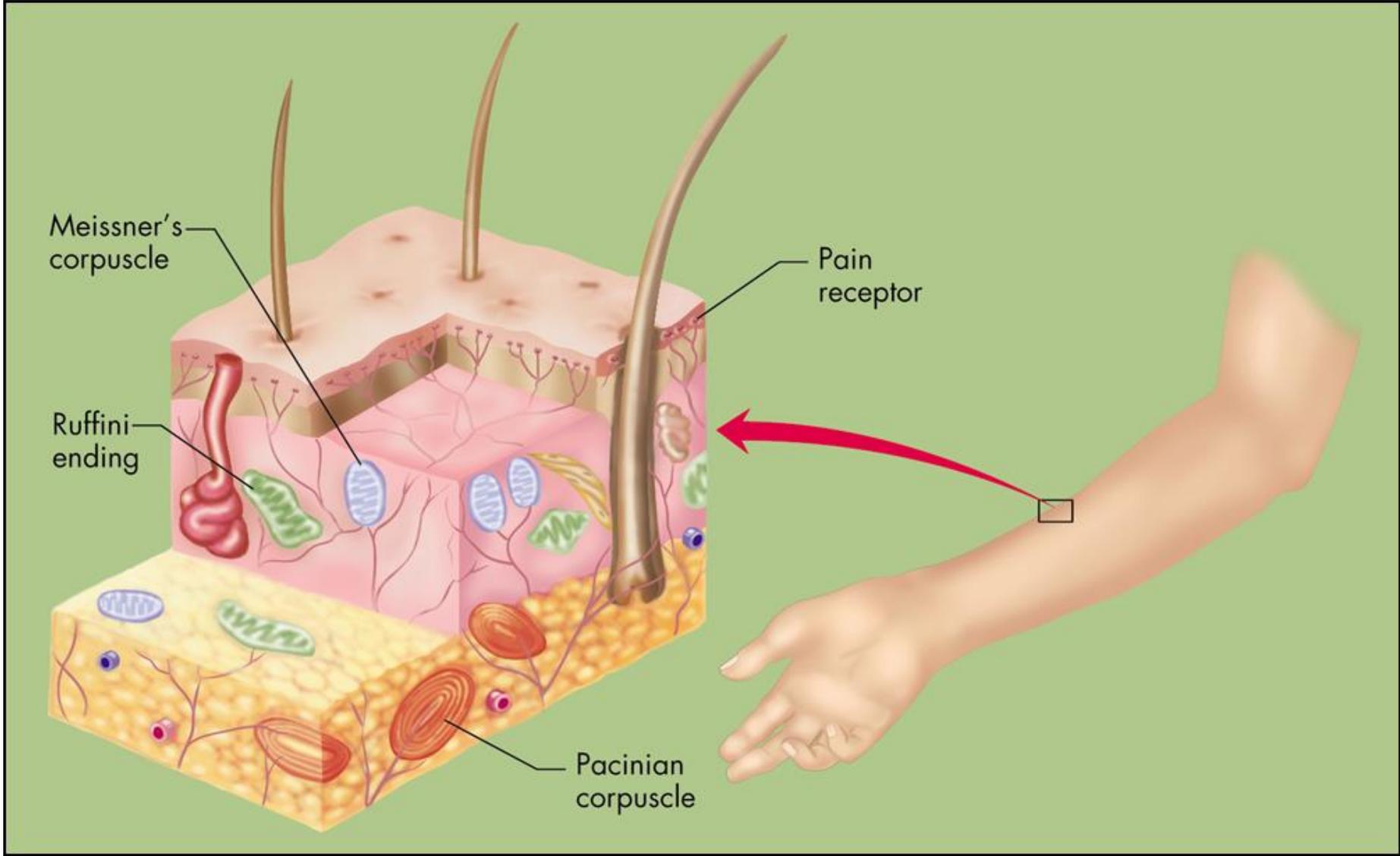
# Sensory Receptors

- According to location, receptors are classified as
  - *exteroceptors*,
  - *interoceptors* (visceroceptors),
  - *proprioceptors*.



## Mechanoreceptors of Hairy Skin





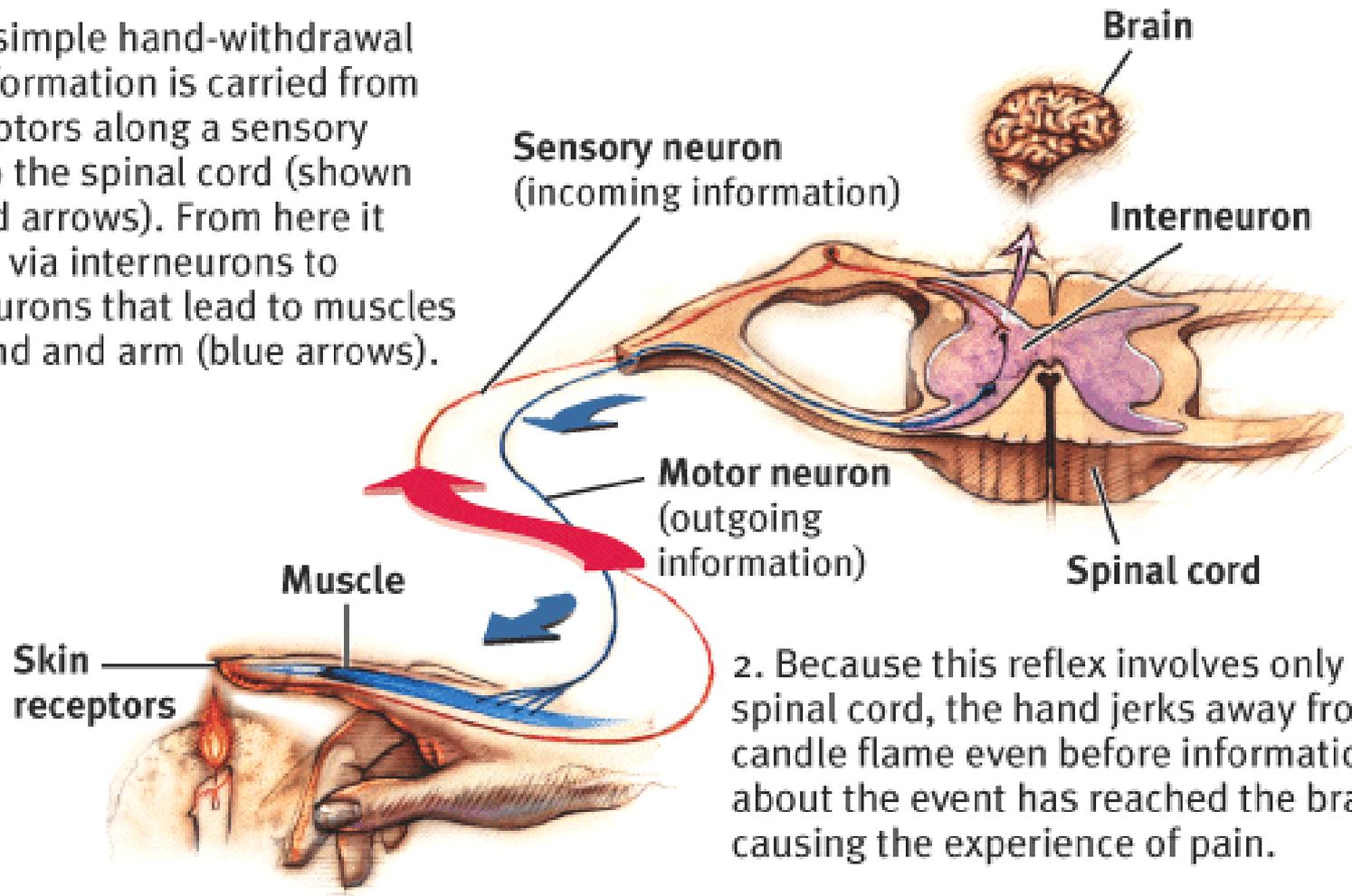
Meissner's corpuscle

Pain receptor

Ruffini ending

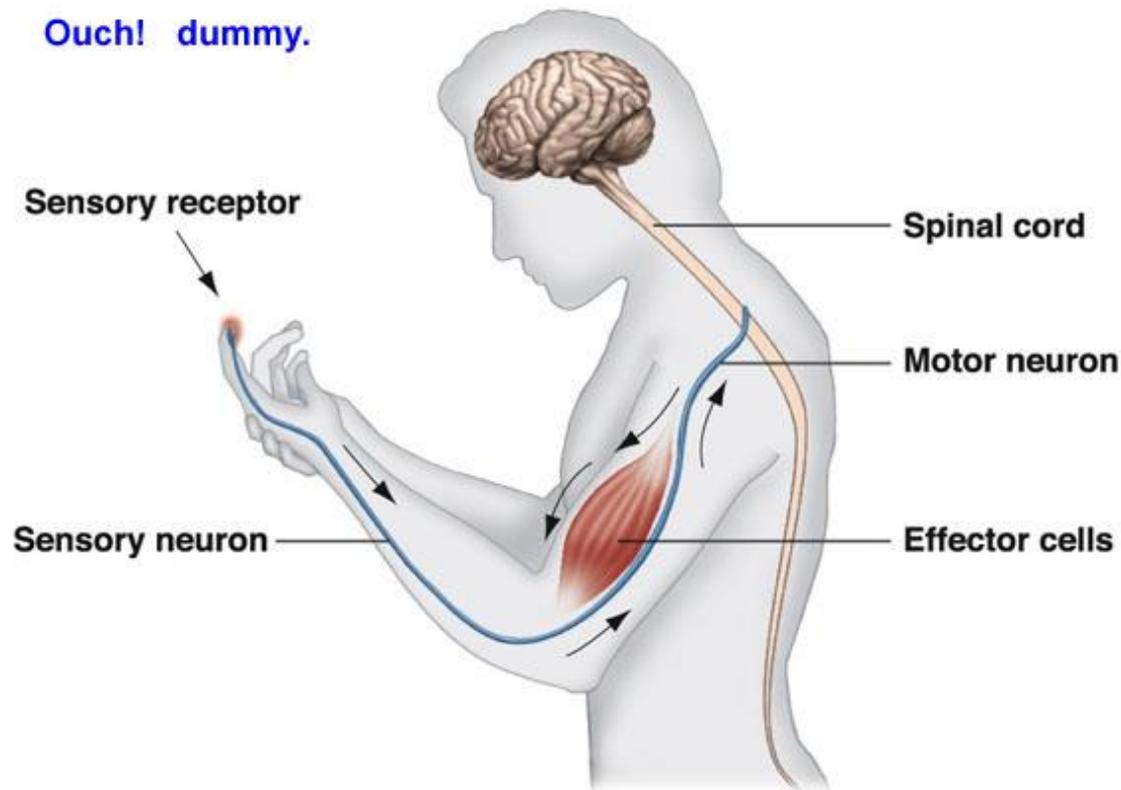
Pacinian corpuscle

1. In this simple hand-withdrawal reflex, information is carried from skin receptors along a sensory neuron to the spinal cord (shown by the red arrows). From here it is passed via interneurons to motor neurons that lead to muscles in the hand and arm (blue arrows).



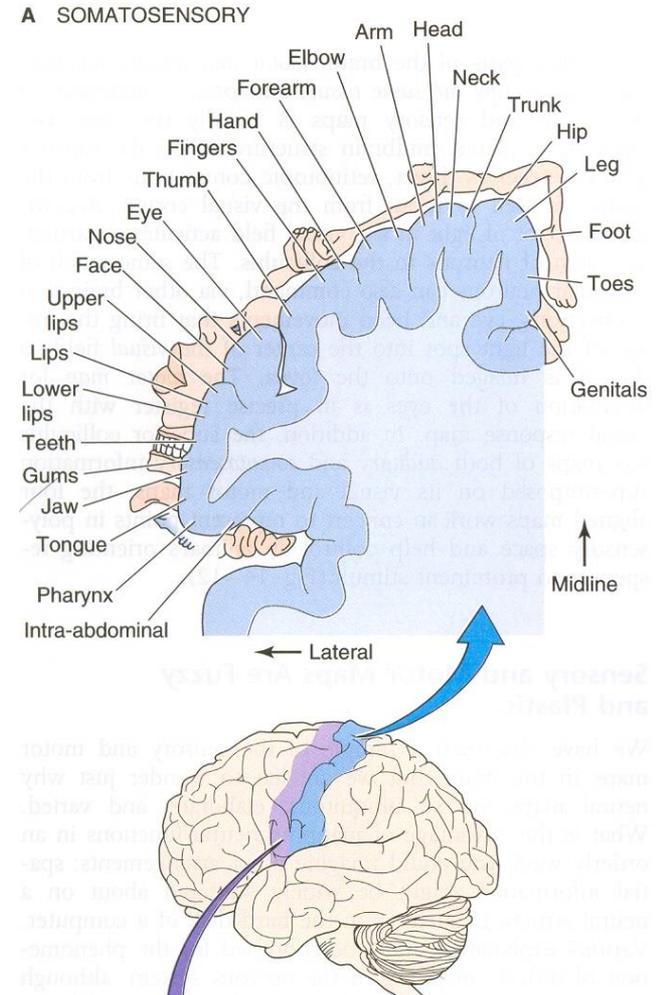
2. Because this reflex involves only the spinal cord, the hand jerks away from the candle flame even before information about the event has reached the brain, causing the experience of pain.

- The impulse(s) must be conducted along a neural pathway from the receptor or sense organ to the brain.
- A region of the brain or spinal cord must translate the impulse into a sensation.



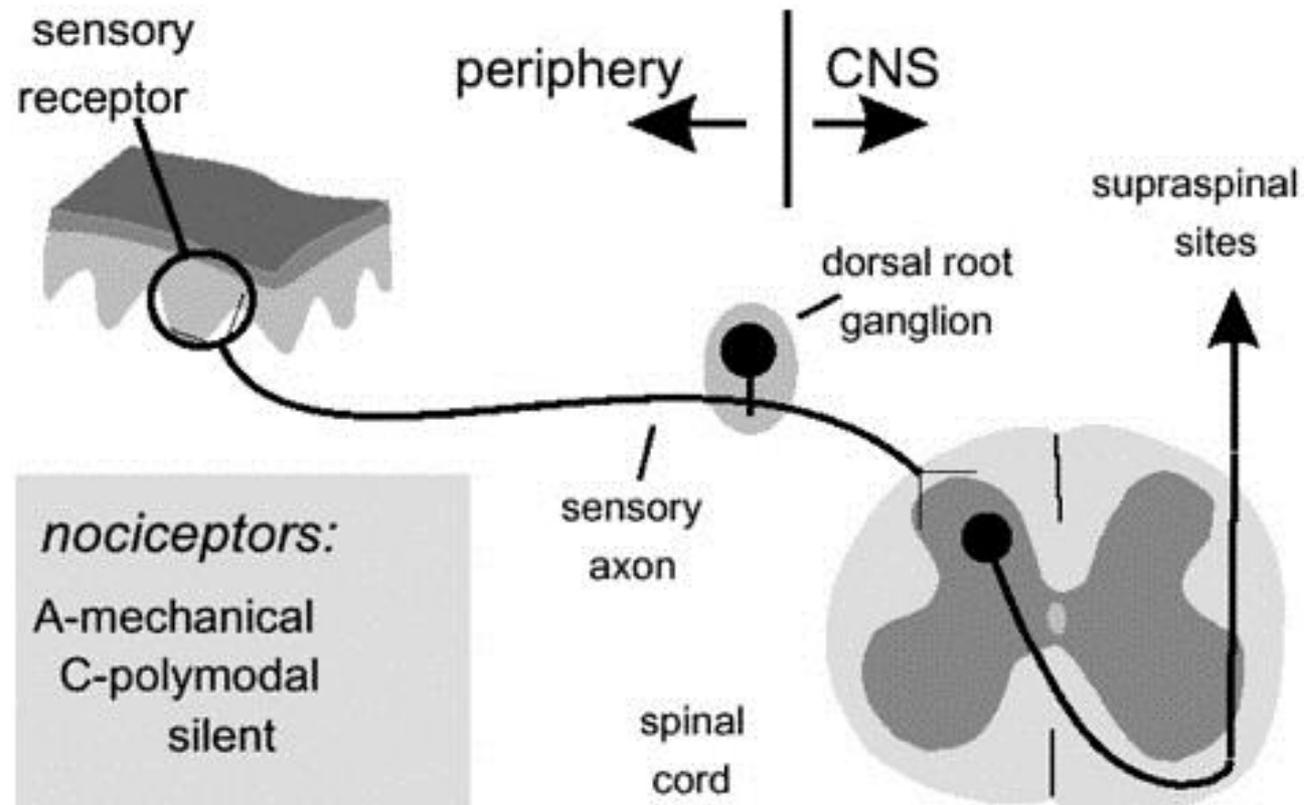
# SOMATIC SENSORY PATHWAYS

- Somatic sensory pathways relay information from somatic receptors to the primary somatosensory area in the cerebral cortex.



# SOMATIC SENSORY PATHWAYS

- **The peripheral axons arise from dorsal root ganglia** and enter spinal cord through the dorsal roots

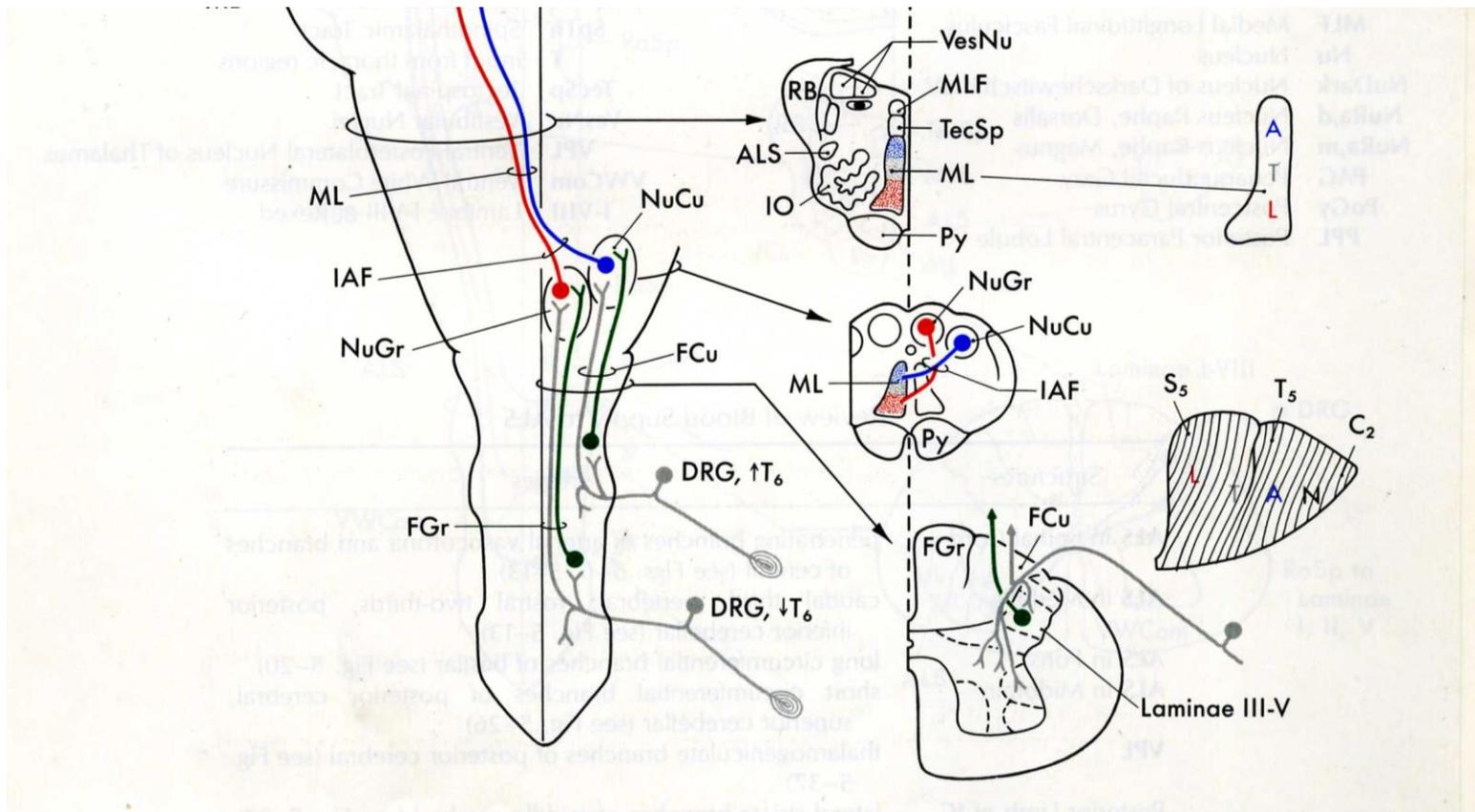


# Posterior Column-Medial Lemniscus Pathway

- Impulses conducted along this pathway are concerned with
  - *discriminative touch,*
  - *stereognosis,*
  - *proprioception,*
  - *weight discrimination,*
  - *vibratory sensations.*

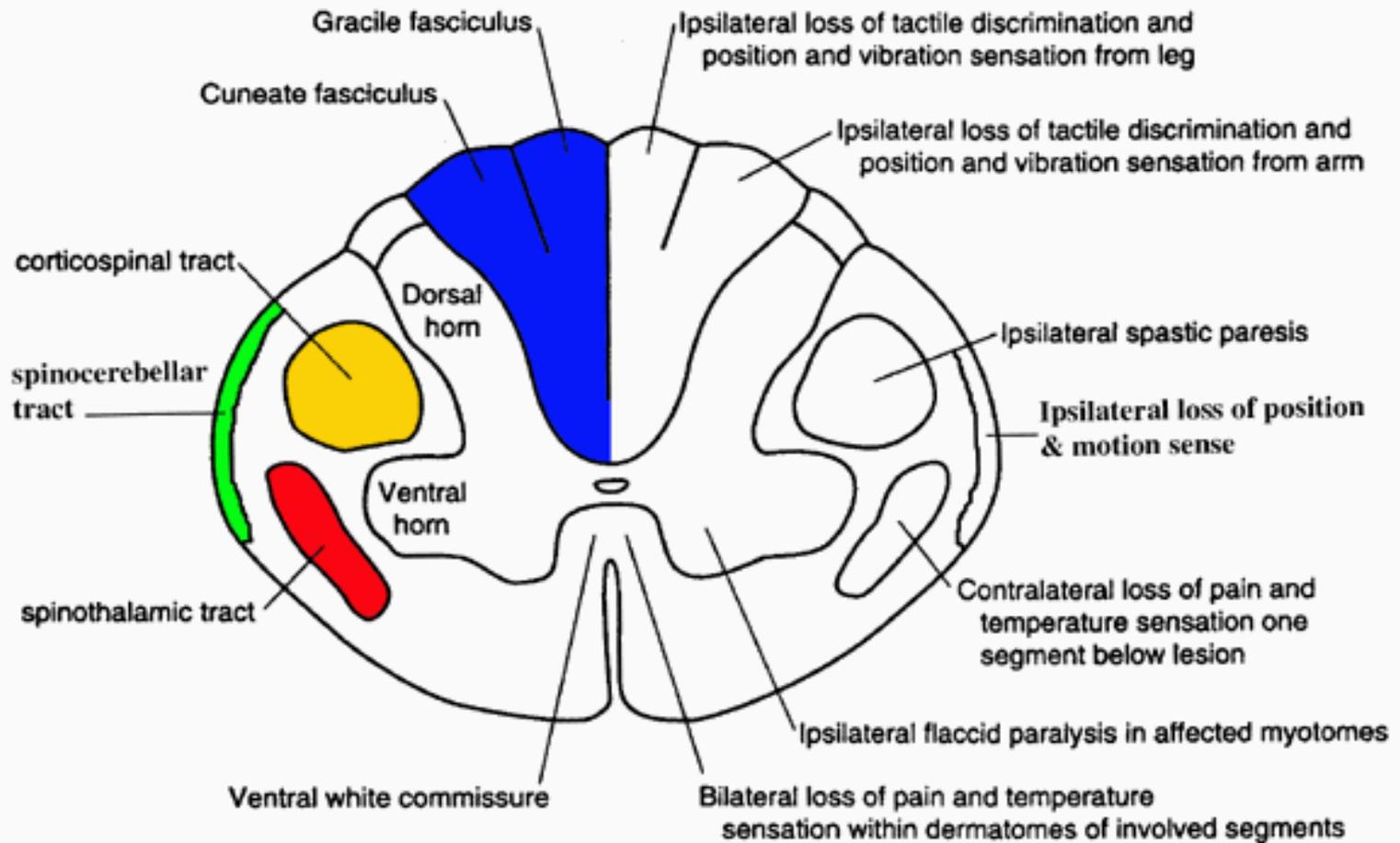


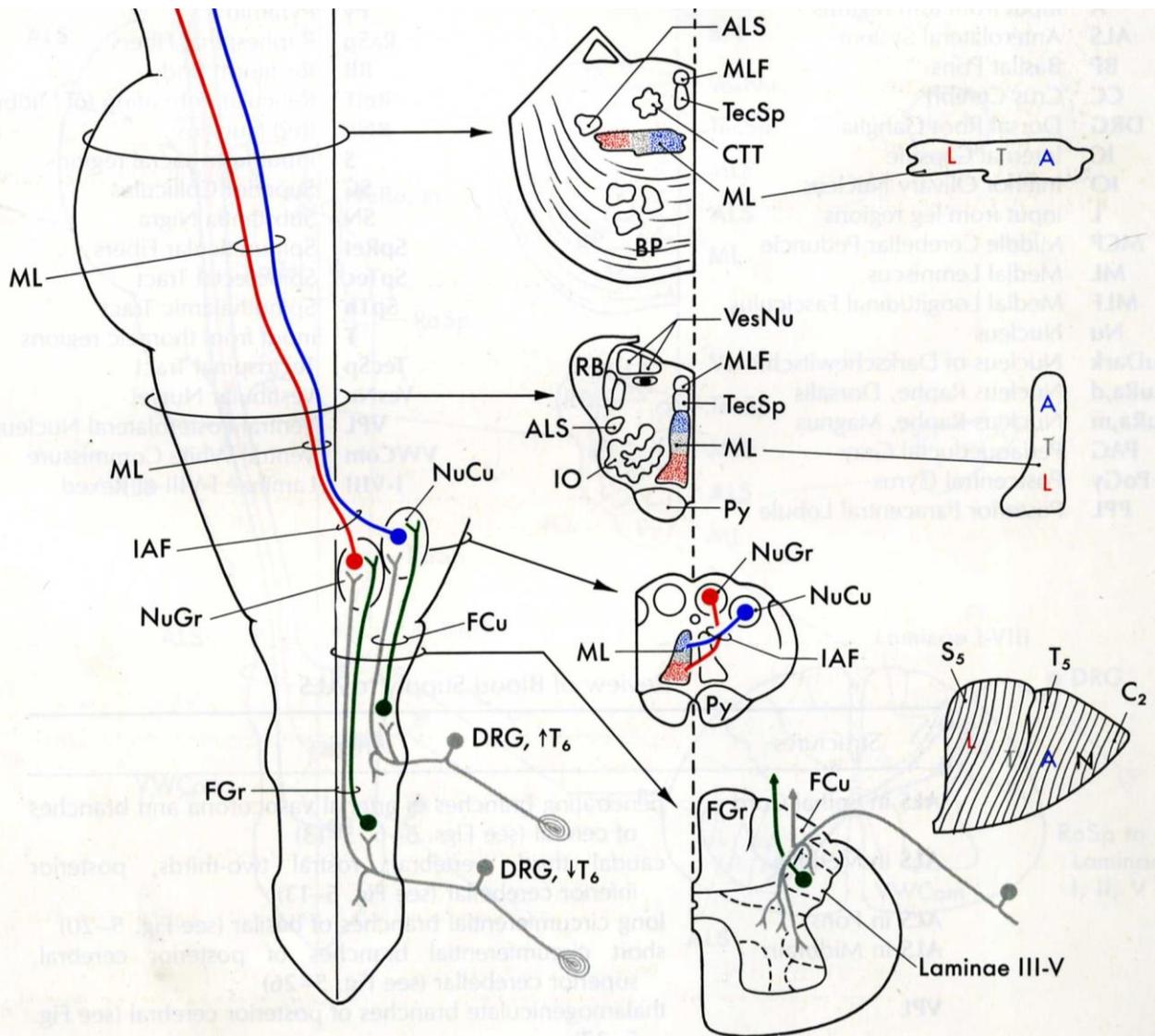
**The primary, or first-order, neuron has its perikaryon in dorsal root ganglion**



# The primary, or first-order, neuron has its perikaryon in dorsal root ganglion

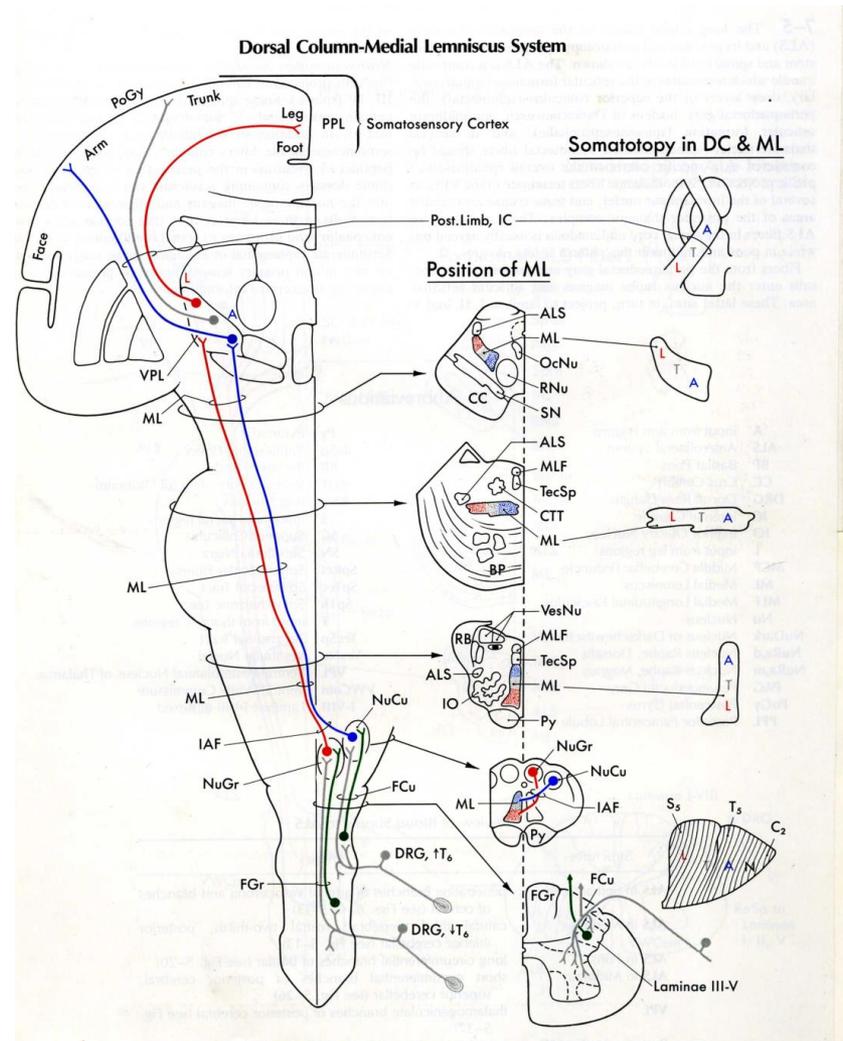
- The ***ascending axonal branch*** runs up the ***ipsilateral*** dorsal column
- The sacral fibers, the medial-most wedge, the lumbar fibers, and the thoracic fibers 6-12 form the ***fasciculus gracilis (Goll's column)***
- The arm fibers, the lateral-most wedge, and the thoracic fibers 1-6 form the ***fasciculus cuneatus (Burdach's column)***
- The ascending spinal axons terminate in the dorsal column nuclei.



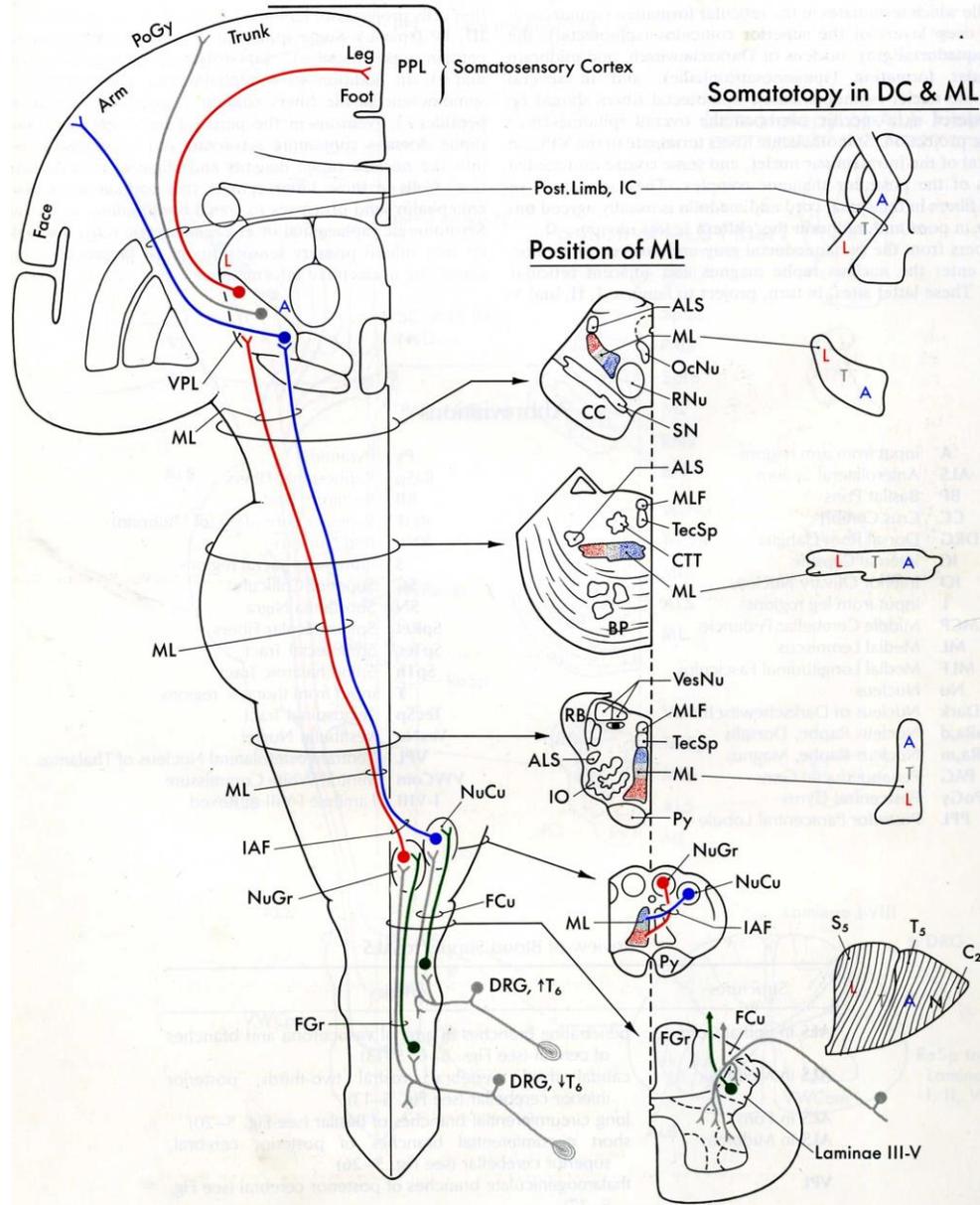


# The secondary, or second-order neuron is in the dorsal column nuclei, *the nucleus gracilis* and *nucleus cuneatus*

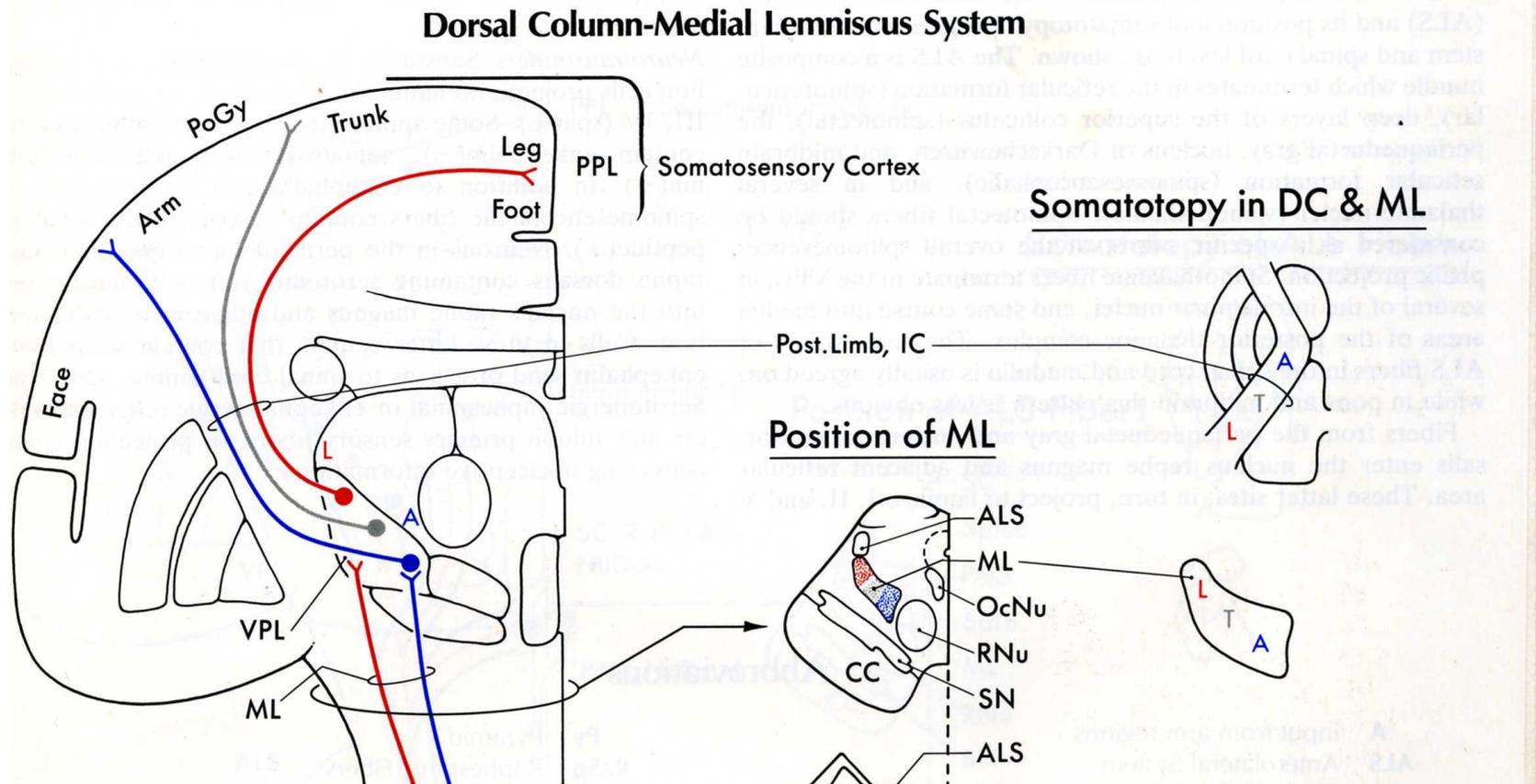
- From the dorsal column nuclei the axons decussate, form the origin of the *medial lemniscus*, and ascend to the thalamus.



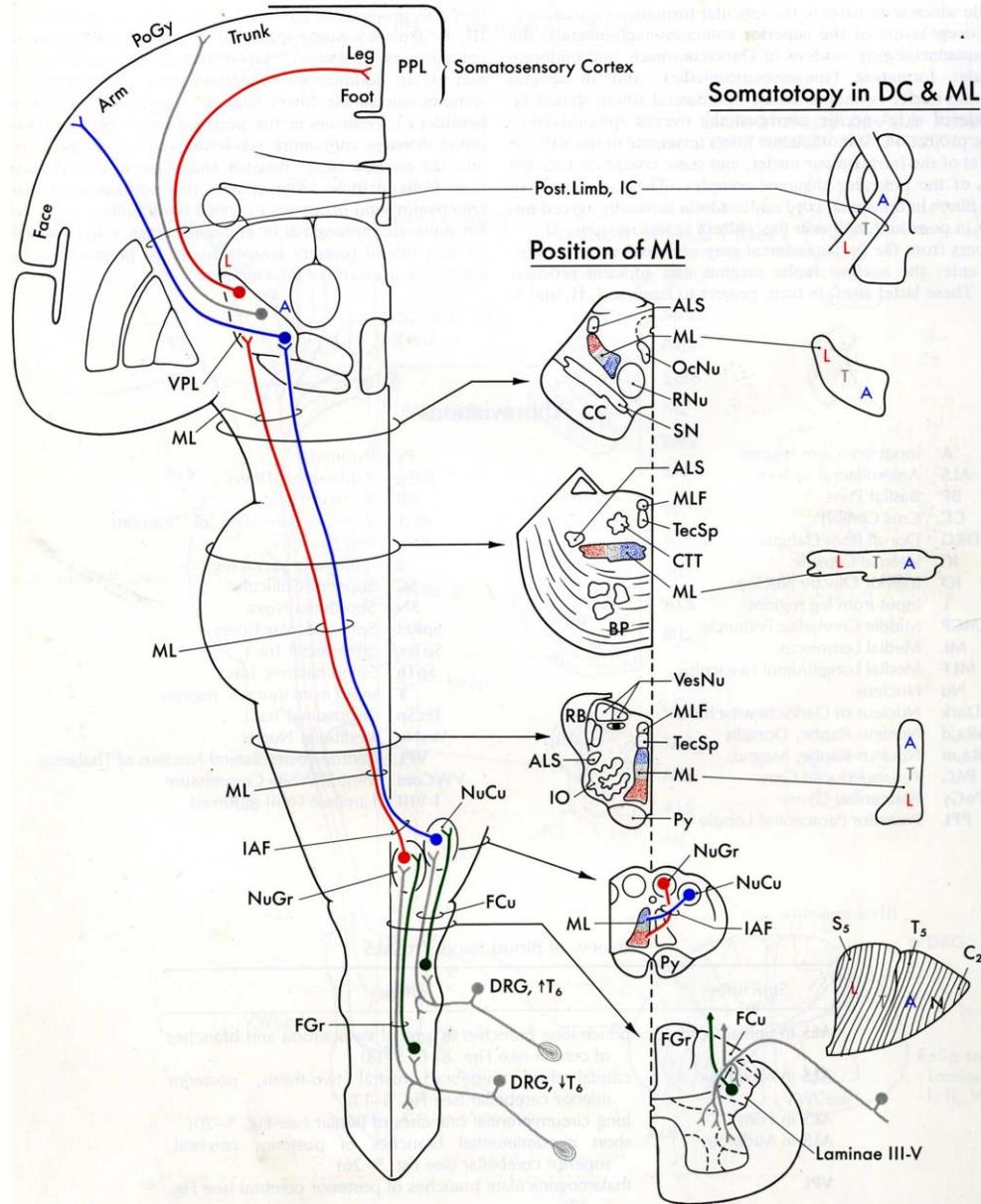
# Dorsal Column-Medial Lemniscus System



**The tertiary, or third-order, neuron runs from the thalamus to the somatosensory area of the cerebral cortex, the postcentral gyrus.**



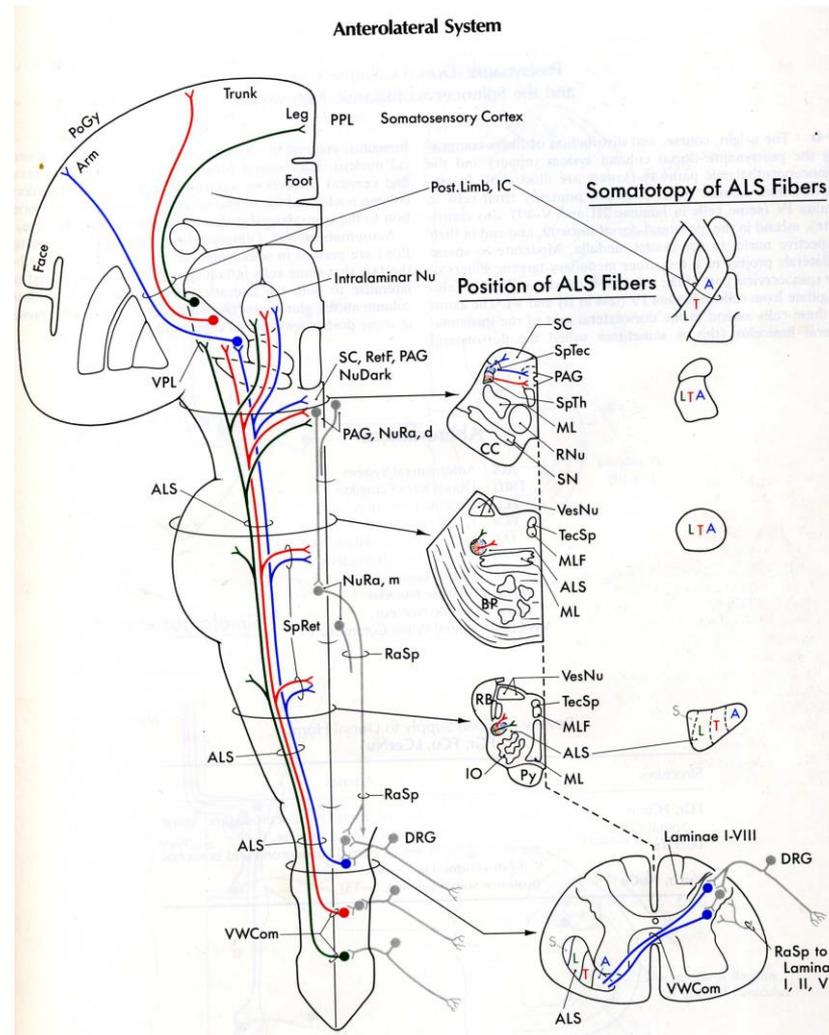
# Dorsal Column-Medial Lemniscus System



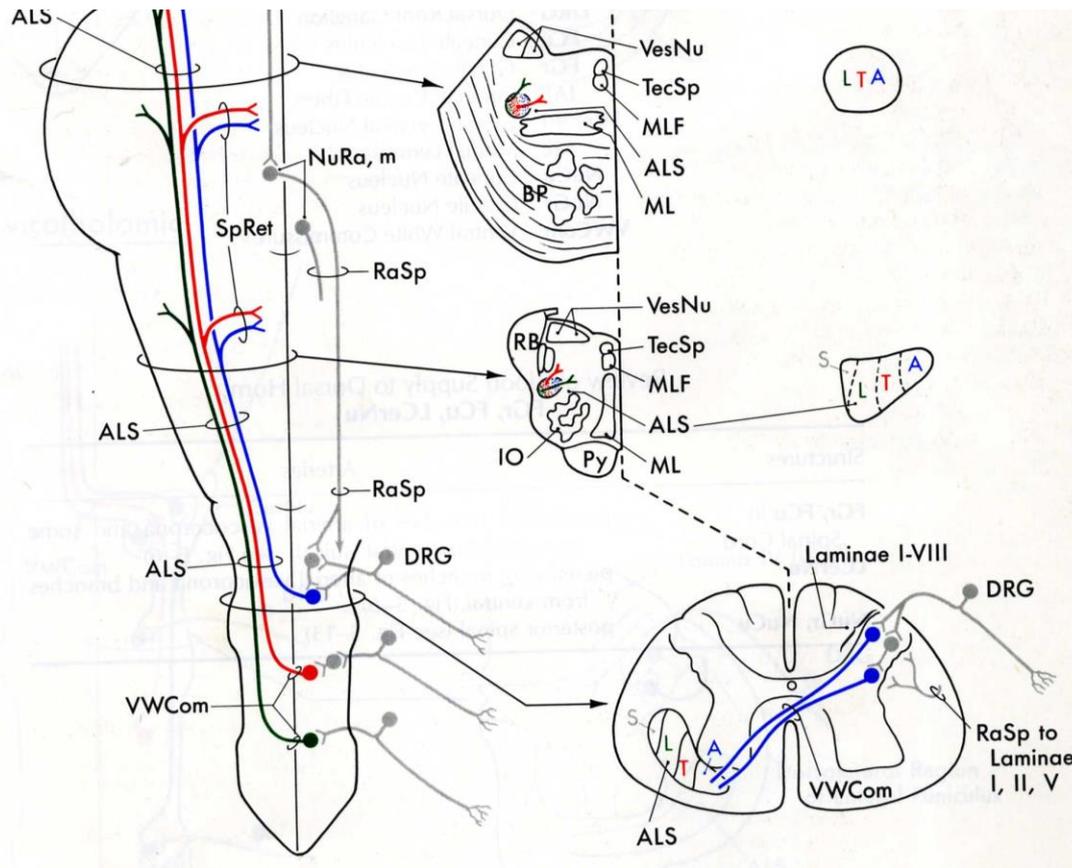
# Anterolateral Pathways to the Cortex

- The anterolateral or spinothalamic pathways carry mainly
  - *pain and*
  - *temperature impulses.*

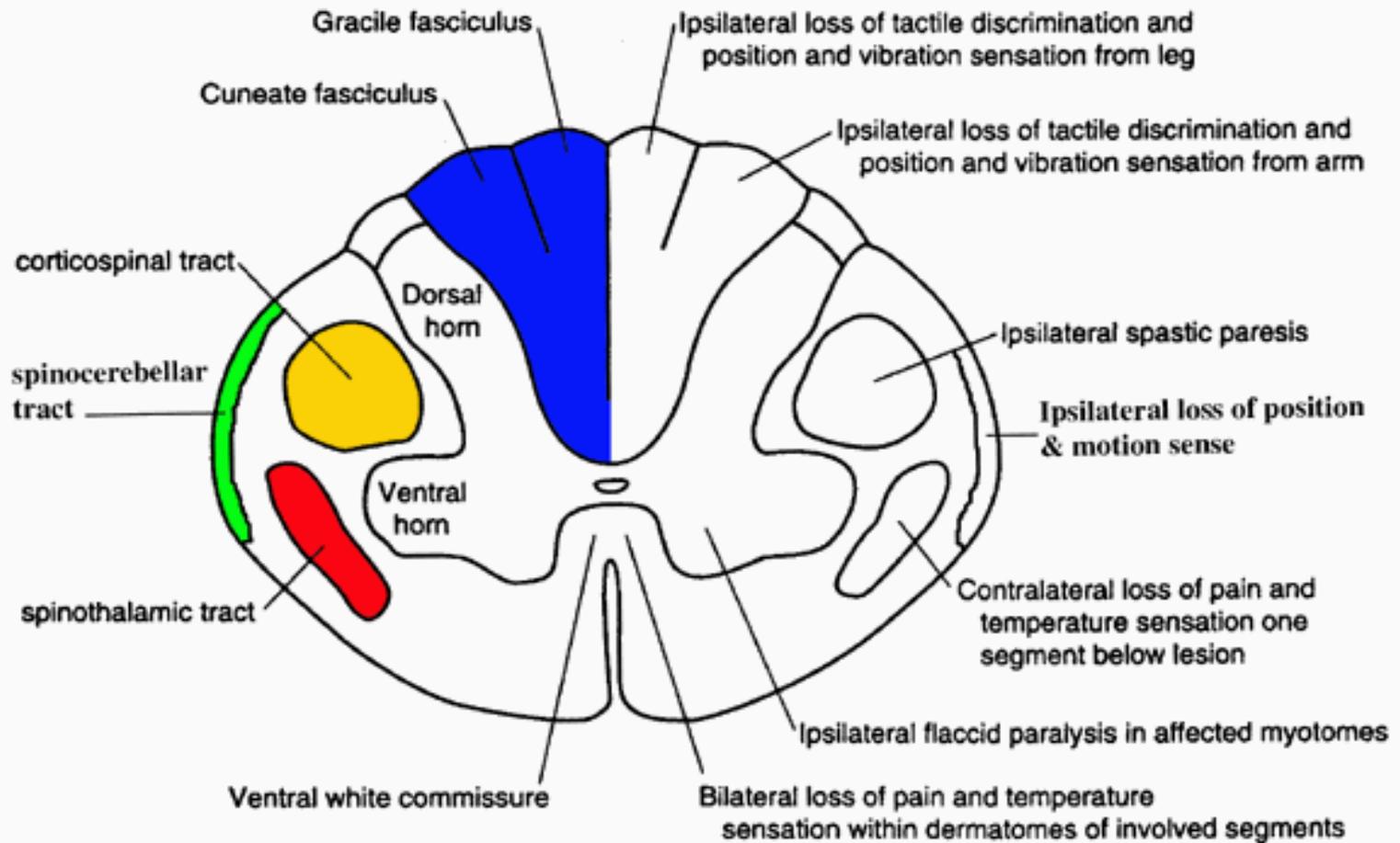
# The primary, or first-order, neuron has its perikaryon in dorsal root ganglion.



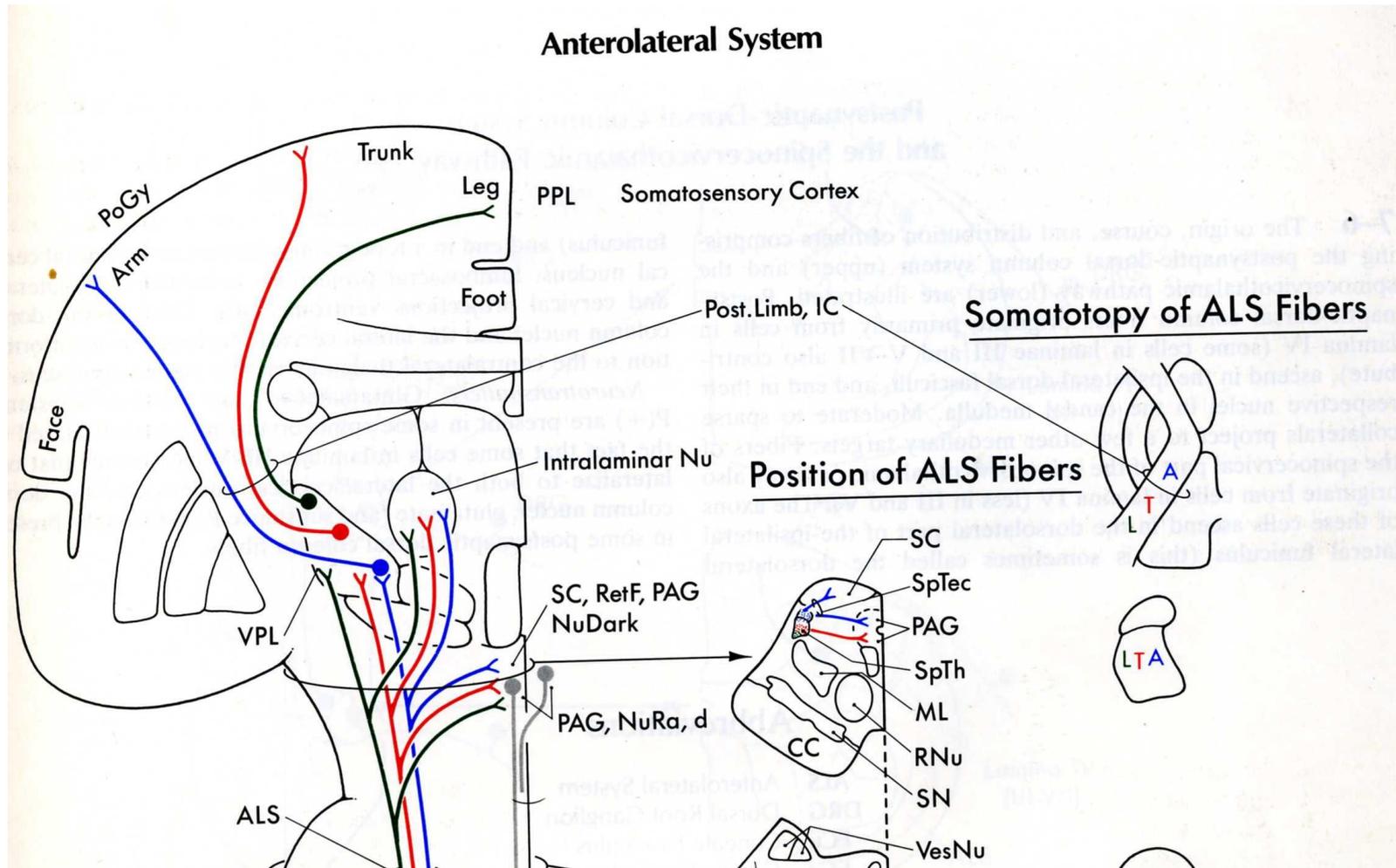
# The secondary, or second-order neuron is in the spinal cord.

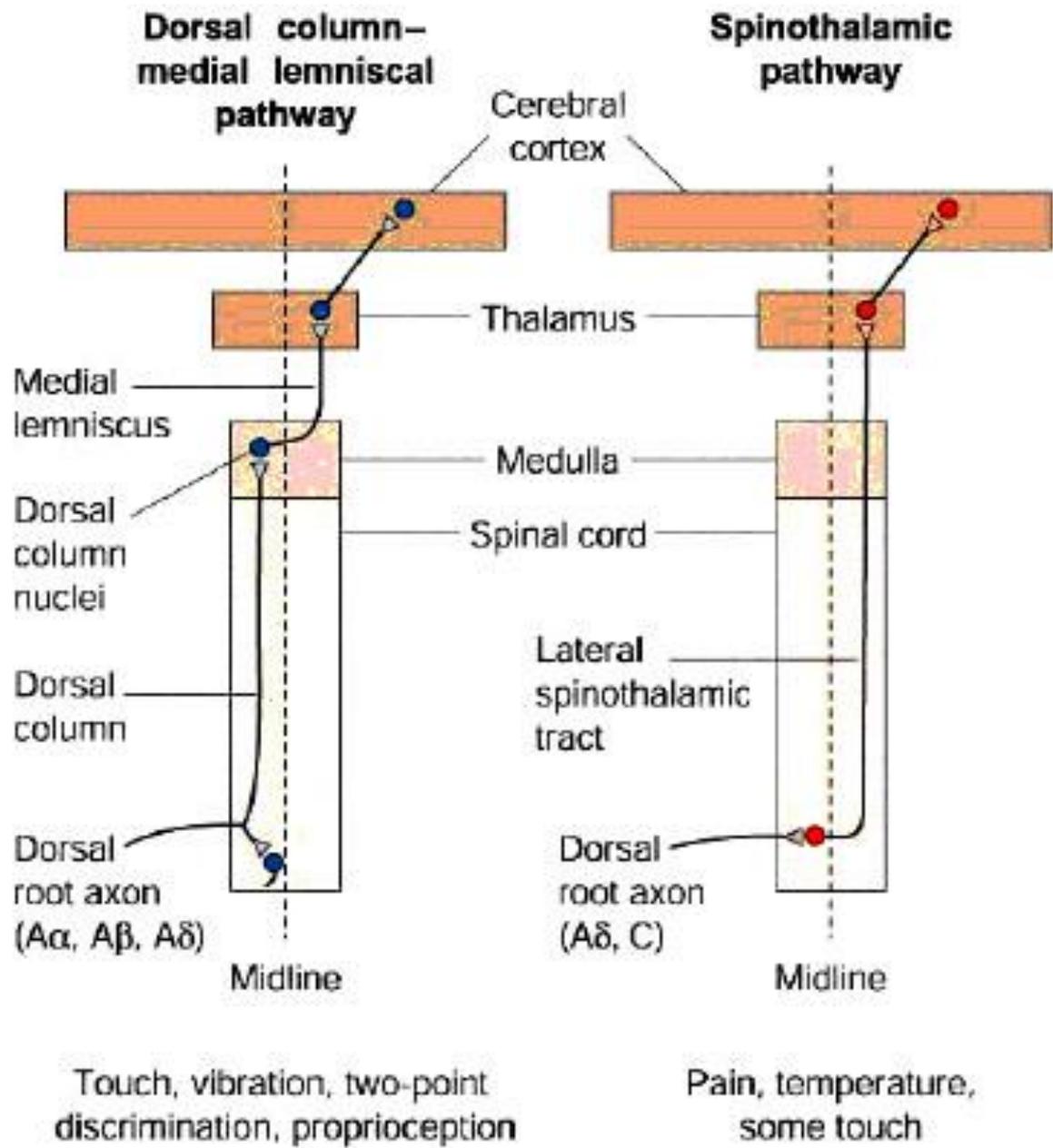


The axons decussate at the ventral white commissure and then turn rostrally in the ventrolateral quadrant as the lateral spinothalamic tract



**The tertiary, or third-order, neuron runs from the thalamus to the somatosensory area of the cerebral cortex, the postcentral gyrus.**

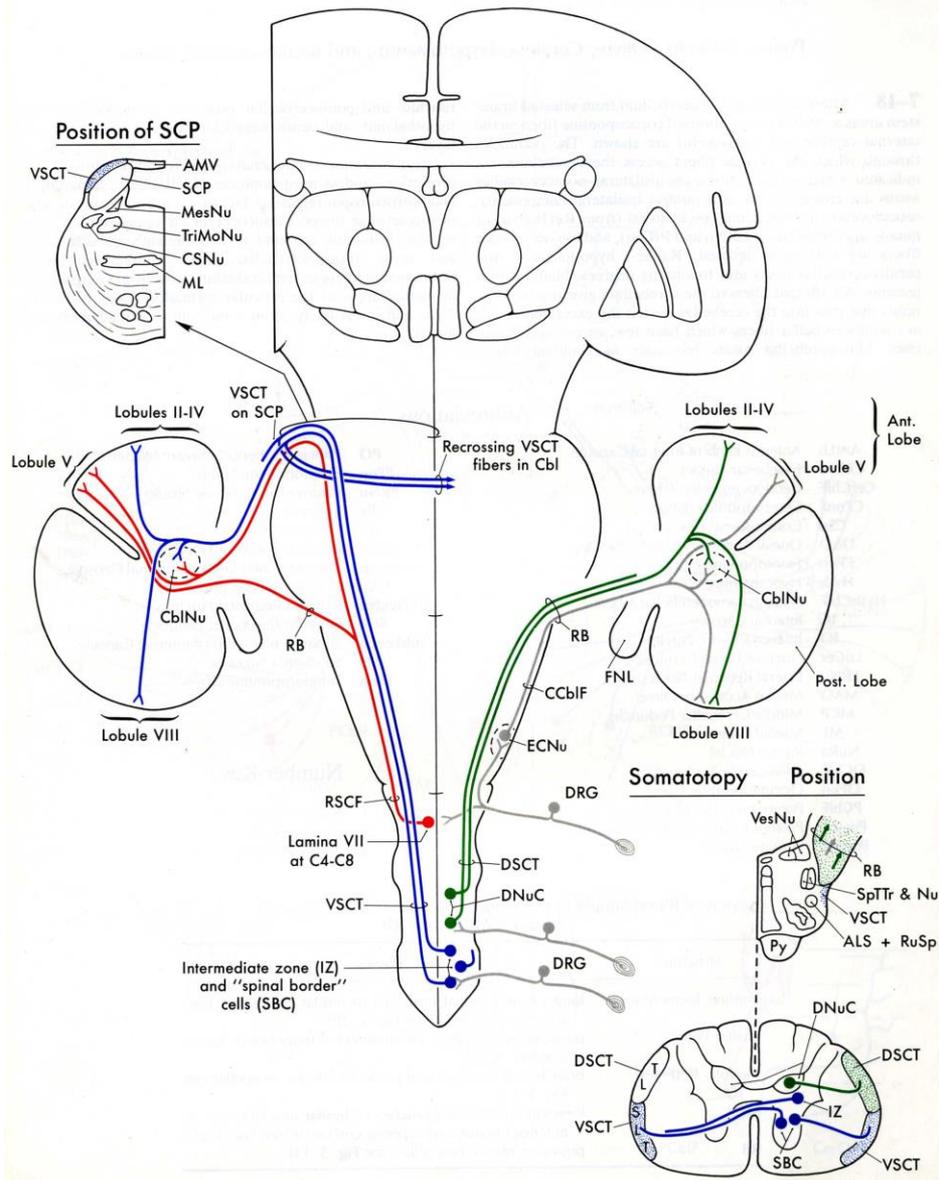




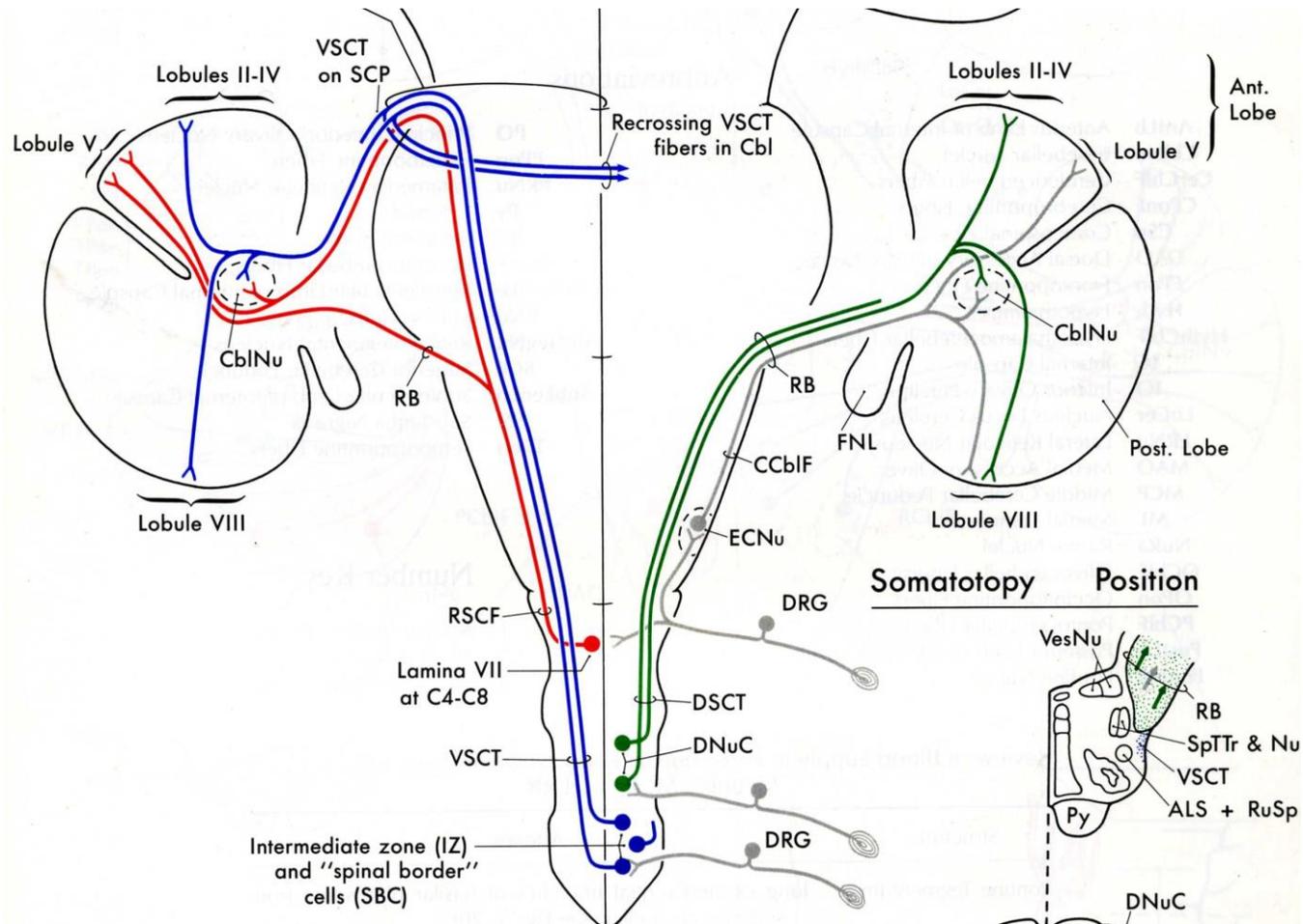
# Somatic Sensory Pathways to the Cerebellum

- The posterior spinocerebellar and the anterior spinocerebellar tracts are the major routes whereby ***proprioceptive impulses reach the cerebellum.***
- The receptors are the Golgi tendon organs and muscle spindles.

# Spinocerebellar Tracts

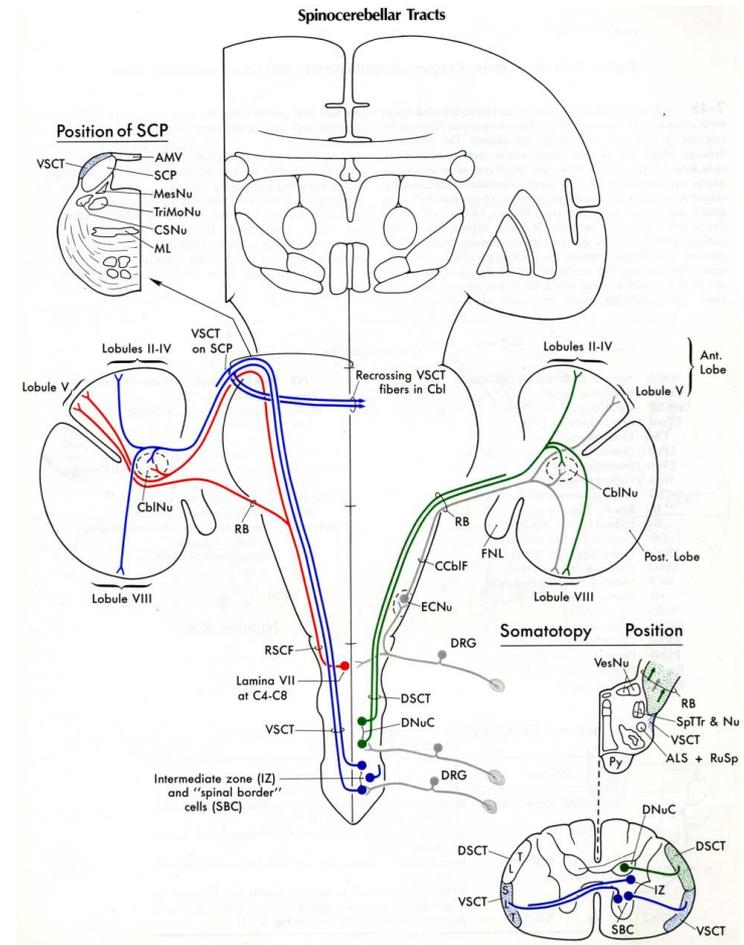


# The primary, or first-order, neuron has its perikaryon in dorsal root ganglion.



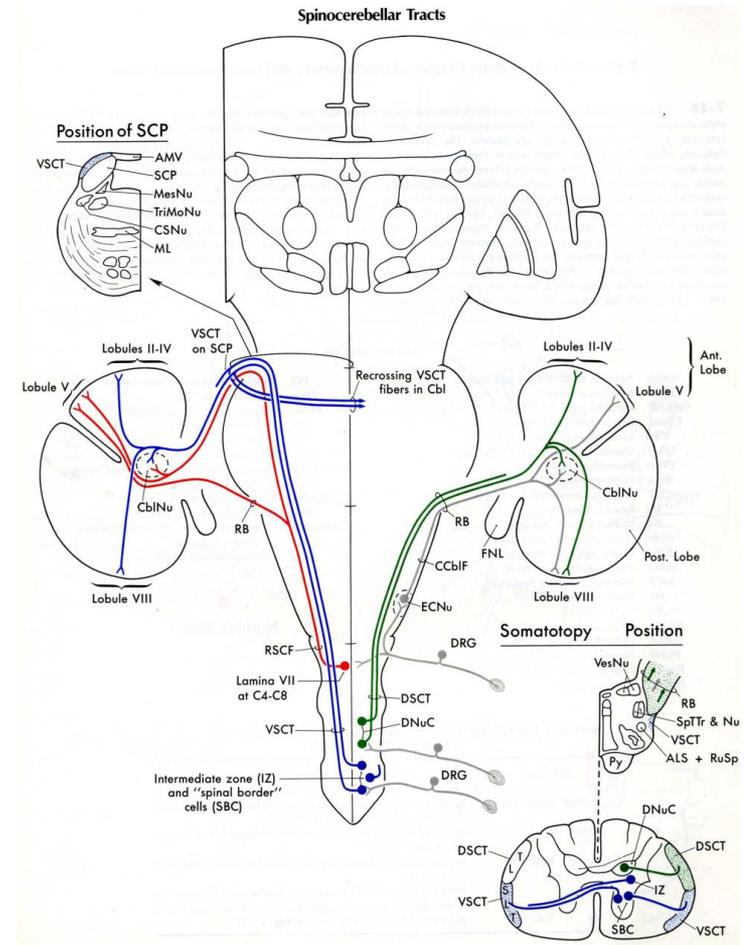
# Dorsal spinocerebellar tract (green)

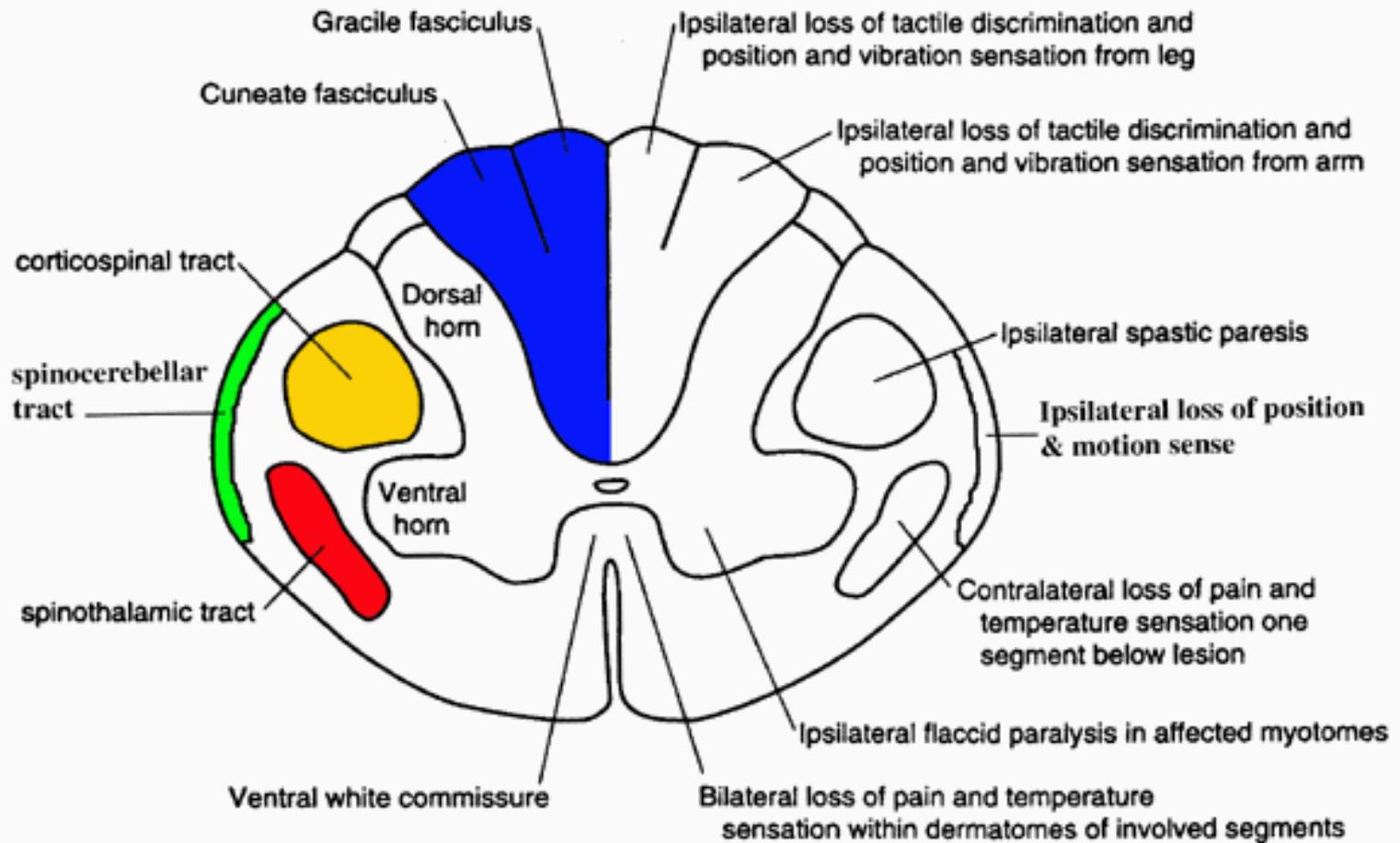
- **The secondary, or second-order neuron** is the neurons of the nucleus dorsalis of Clarke



# Dorsal spinocerebellar tract (green)

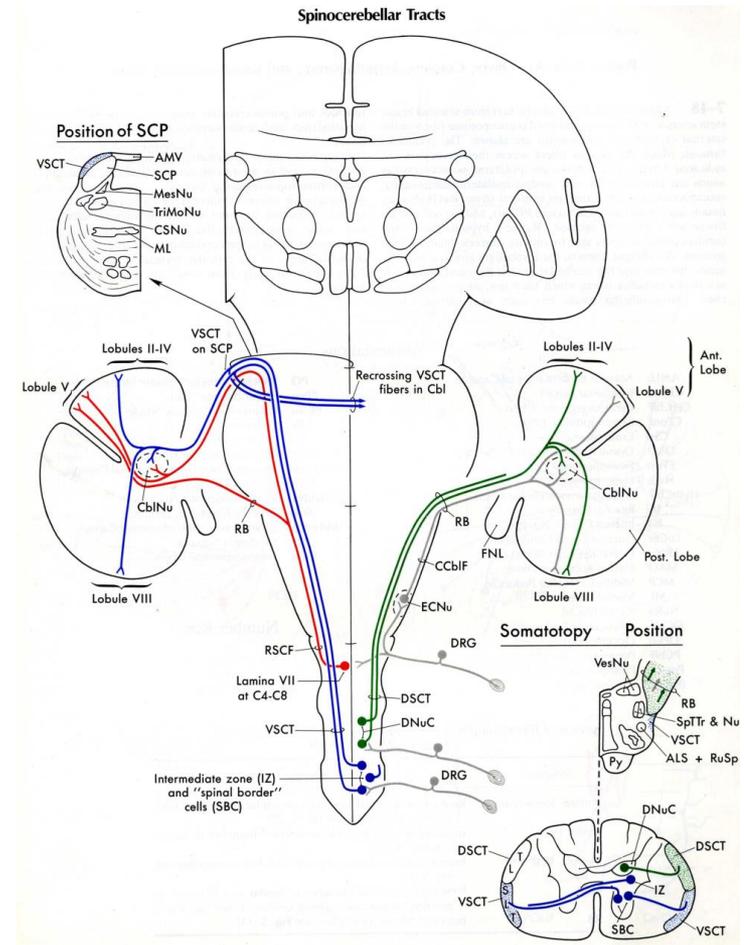
- The neurons of the nucleus dorsalis send their axons laterally to the periphery of the **ipsilateral** column, where they ascend as the **dorsal spinocerebellar tract**





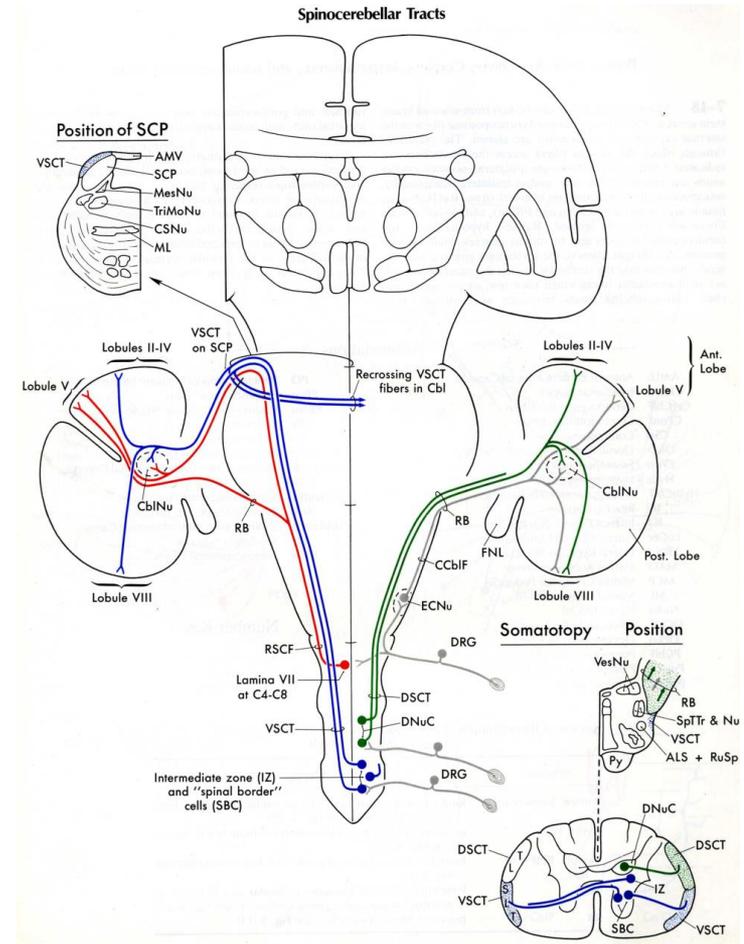
# Dorsal spinocerebellar tract (green)

- the dorsal tract enters the cerebellum through **the inferior cerebellar peduncle**



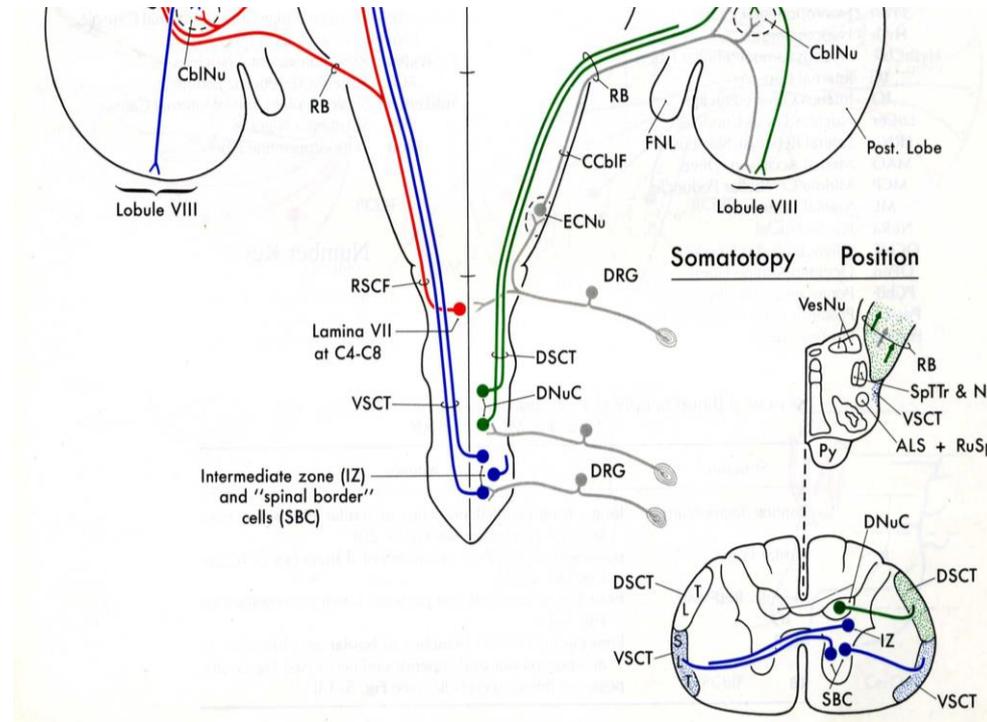
# Ventral spinocerebellar tract (blue)

- **The secondary, or second-order neuron** is the neurons of the spinal cord



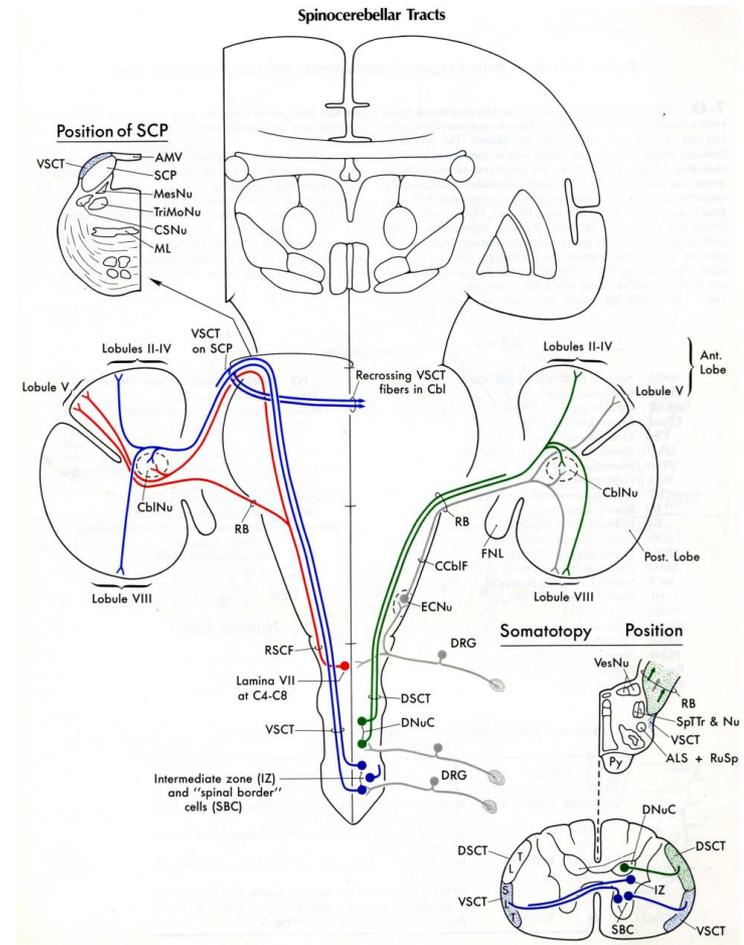
# Ventral spinocerebellar tract (blue)

- **The nucleus** in the spinal gray matter is **not clearly identified** for the ventral tract, as is the nucleus dorsalis for the dorsal tract
- The axons of the ventral spinocerebellar tract decussate in the white commissure of the spinal cord before ascending in the periphery of the **contralateral** lateral column

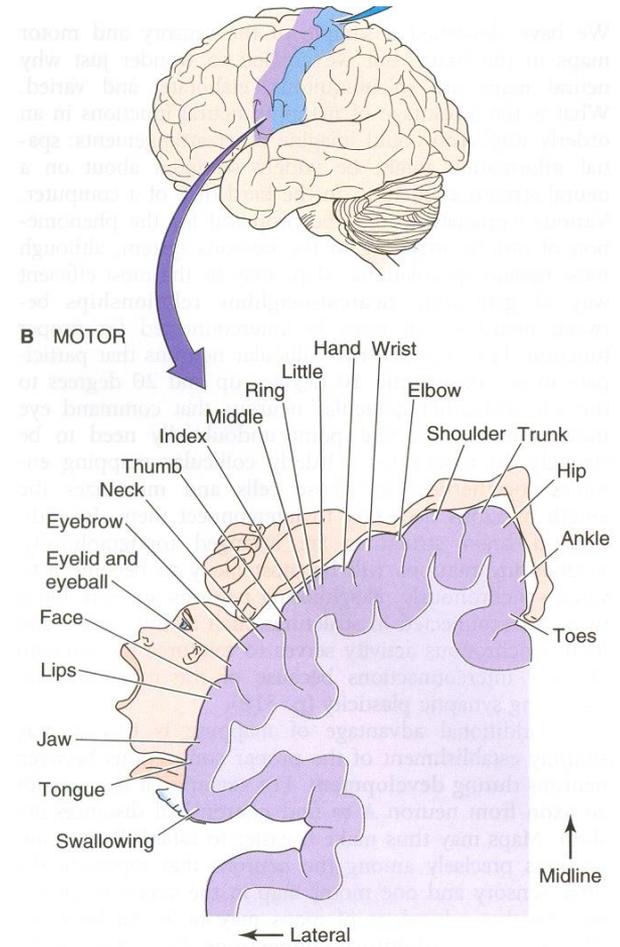
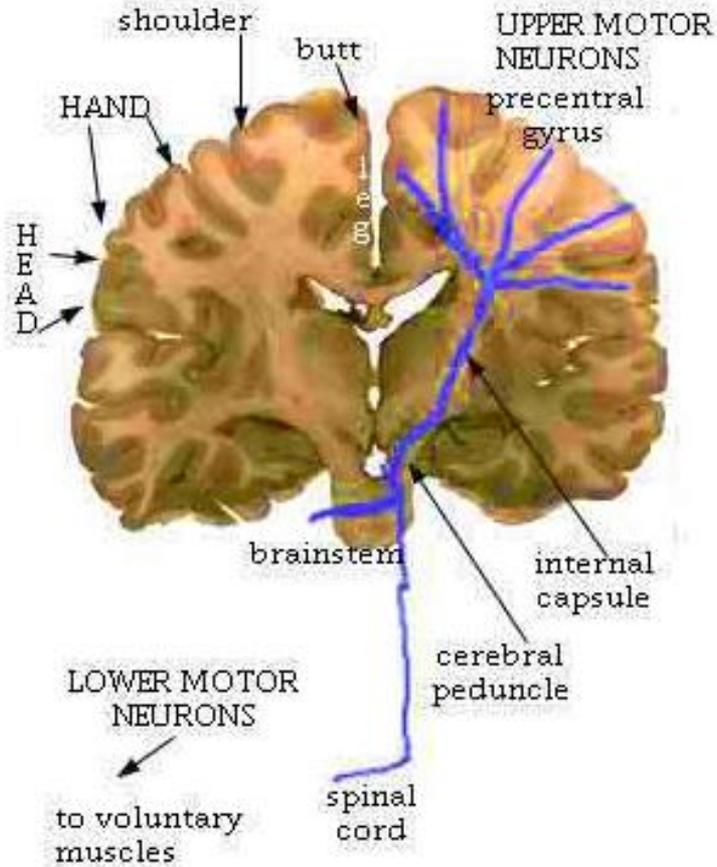


# Ventral spinocerebellar tract (blue)

- the ventral tract enters the cerebellum through **the superior cerebellar peduncle**



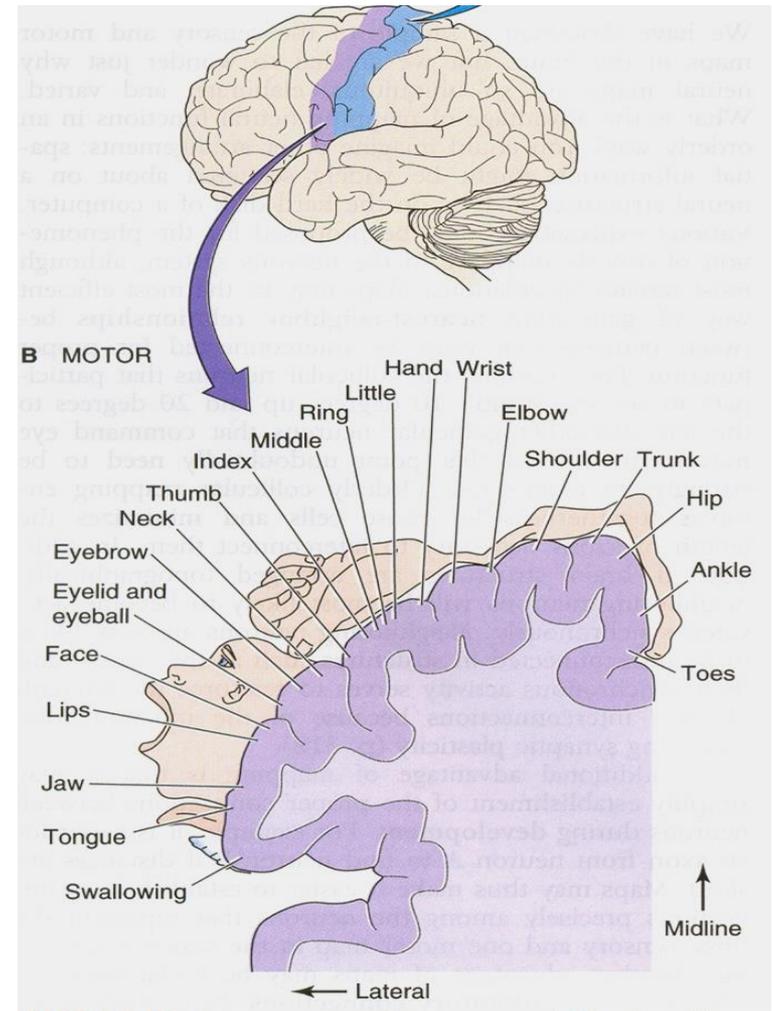
# SOMATIC MOTOR PATHWAYS



- The brain influences somatic motor activity through groups of descending pathways designated in the early clinical literature as **the pyramidal and extrapyramidal** systems.
- The pyramidal system constitutes a **direct link** and the extrapyramidal system an **indirect link** from the motor cortical areas to the lower motoneurons of the cranial and spinal nerves.

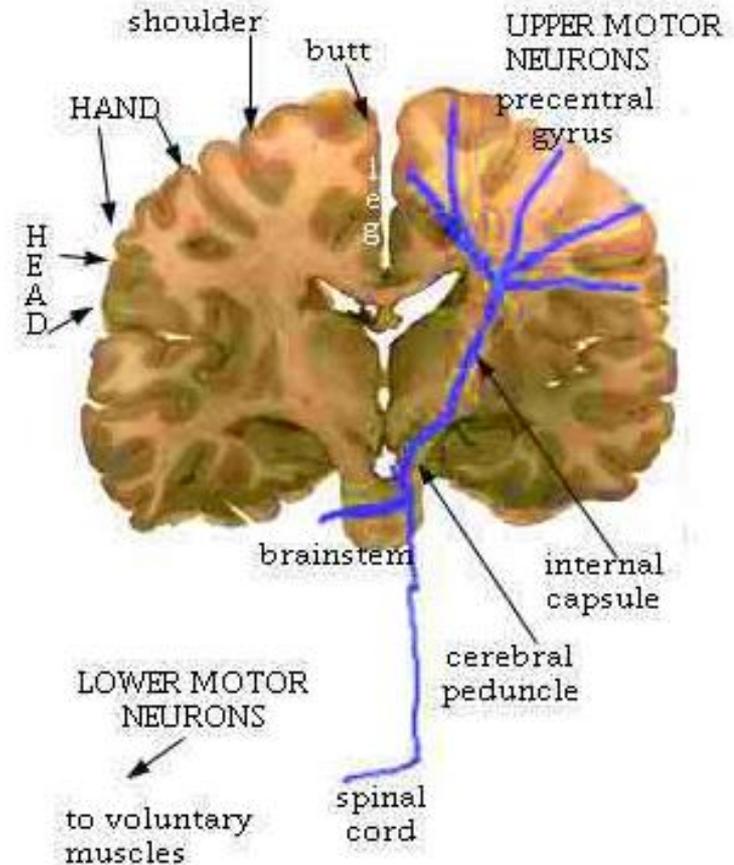
# The direct (pyramidal) pathways

- The motor cortex (primary motor area or **precentral gyrus**) is the major control region for initiation of **voluntary movements**.



# The direct (pyramidal) pathways

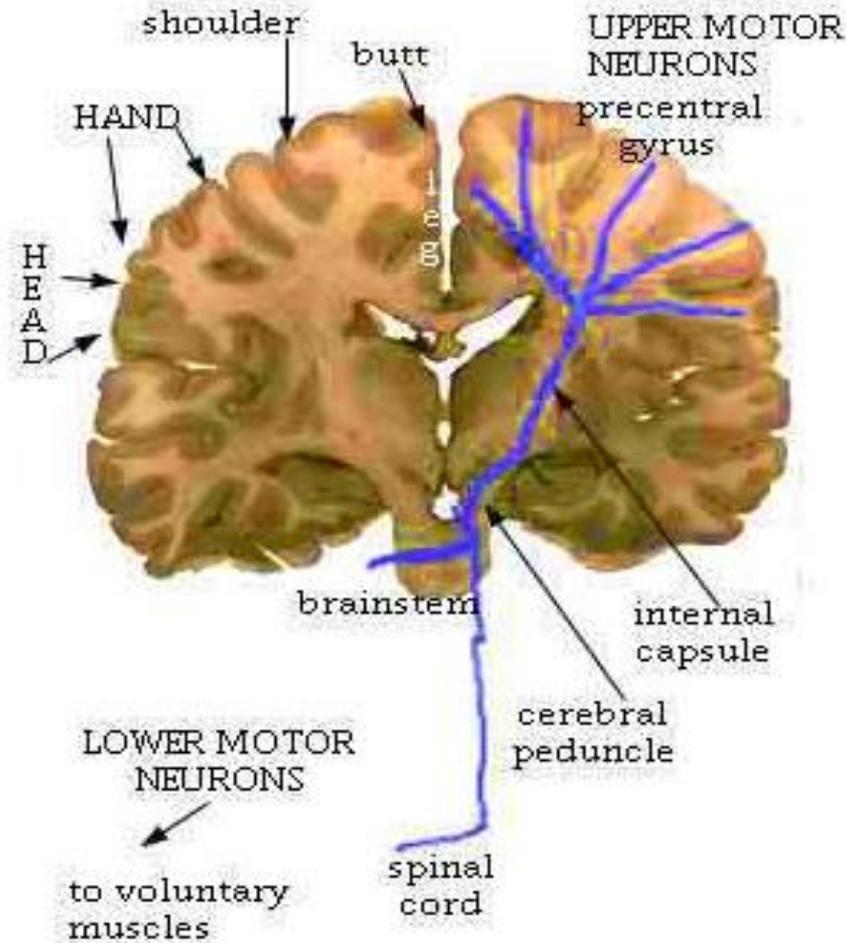
- **Voluntary motor impulses** are propagated from the motor cortex to somatic efferent neurons (voluntary motor neurons) that innervate skeletal muscles via the direct or **pyramidal pathways**.
- The simplest pathways consist of upper and lower motor neurons.



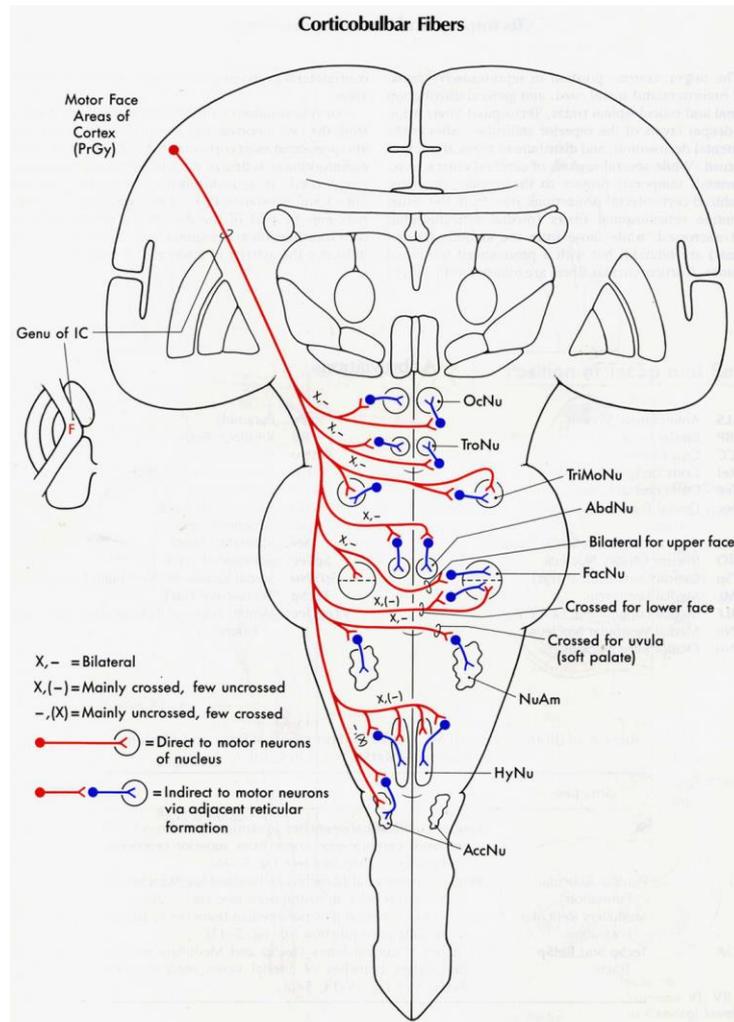
# **The direct (pyramidal) pathways include**

- **lateral corticospinal tracts**
- **anterior corticospinal tracts**
- **corticobulbar tracts.**

The lateral corticospinal, anterior corticospinal, and corticobulbar tracts contain axons of **upper motor neurons (precentral gyrus)**.

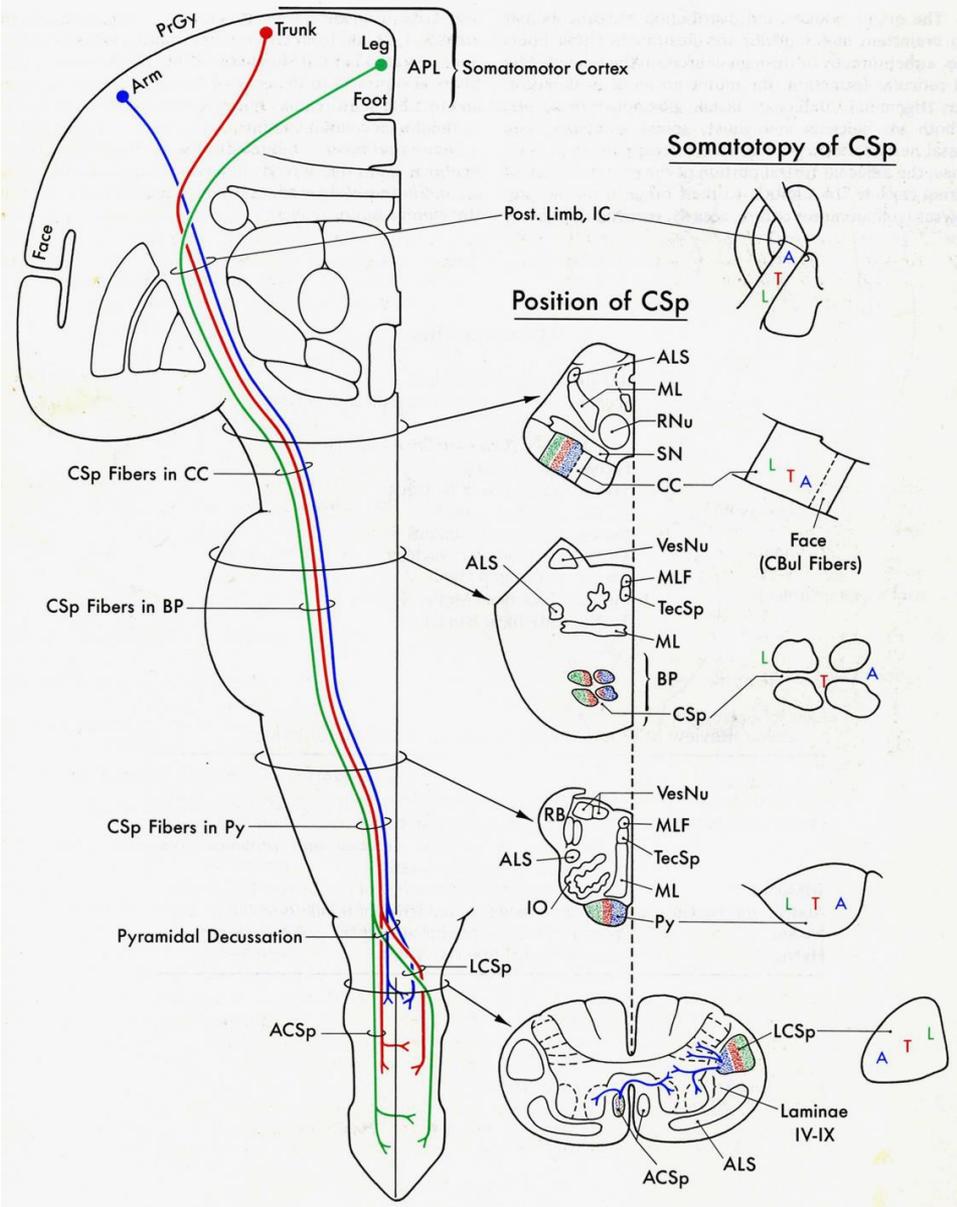


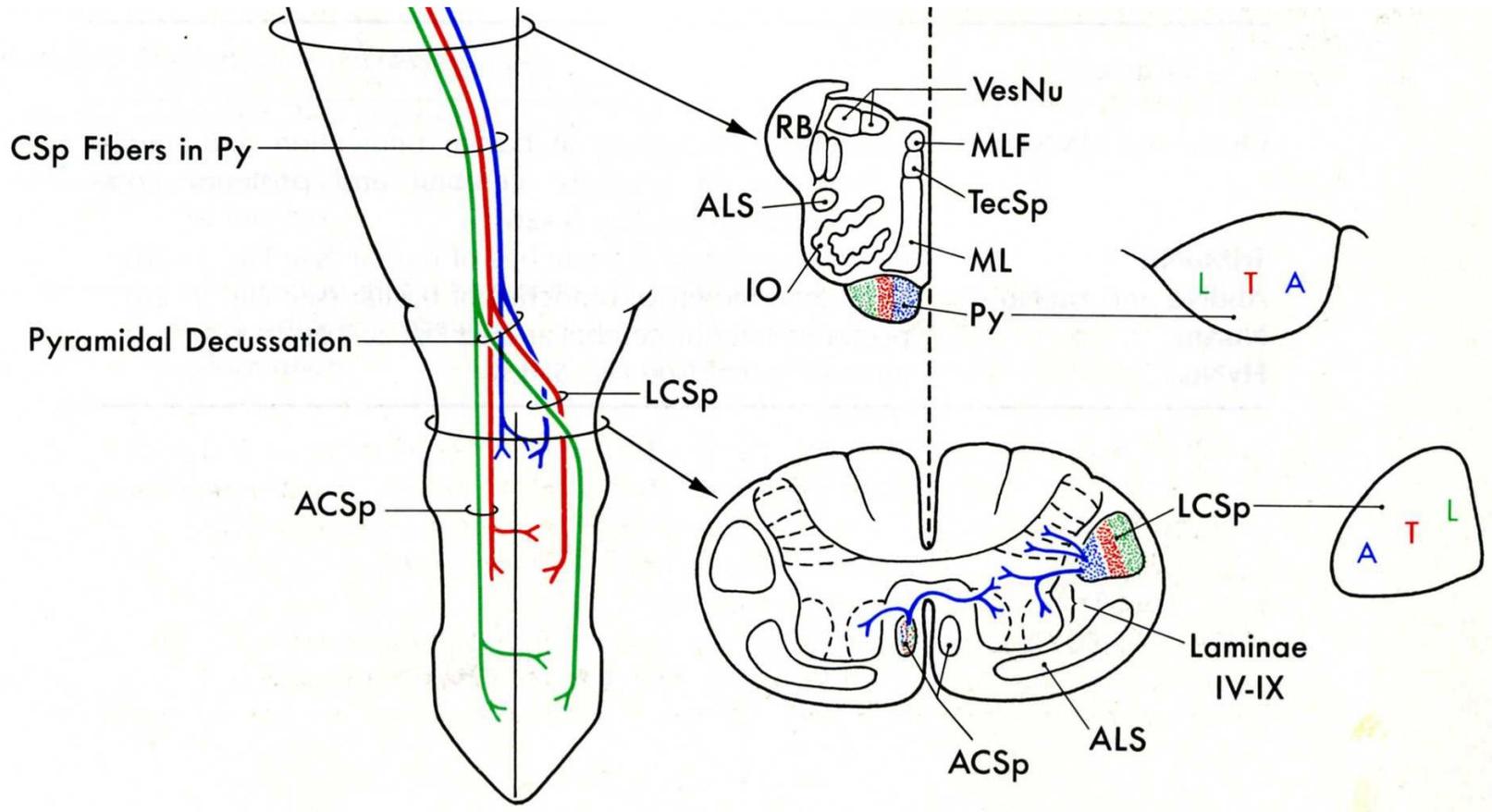
# Corticobulbar fibers depart **ipsilaterally** and **contralaterally** to end at various brainstem levels – **motoneurons of cranial nerves (lower motor neurons)**



- **Corticospinal fibers** descend ipsilaterally through *the brainstem*, passing through the *basis pontis* and *the medullary pyramids* to the cervicomedullary junction.
- **Corticospinal axons** terminate at **motoneurons of the ventral horn (lower motor neurons)**

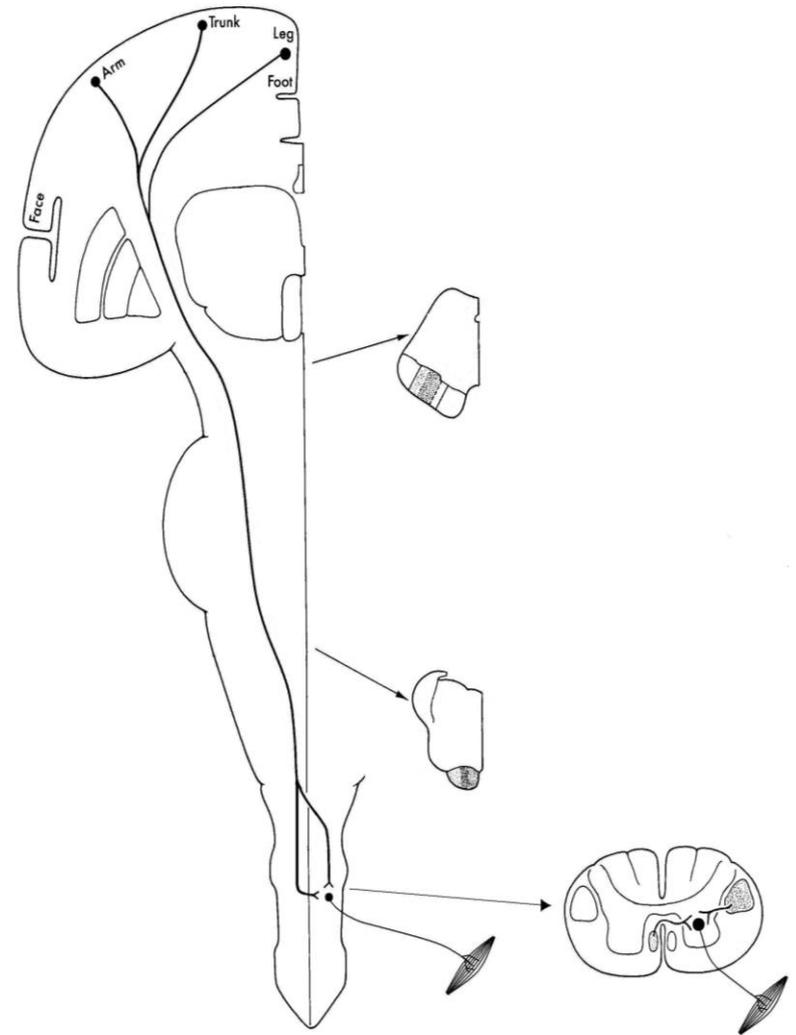
# Corticospinal Tracts



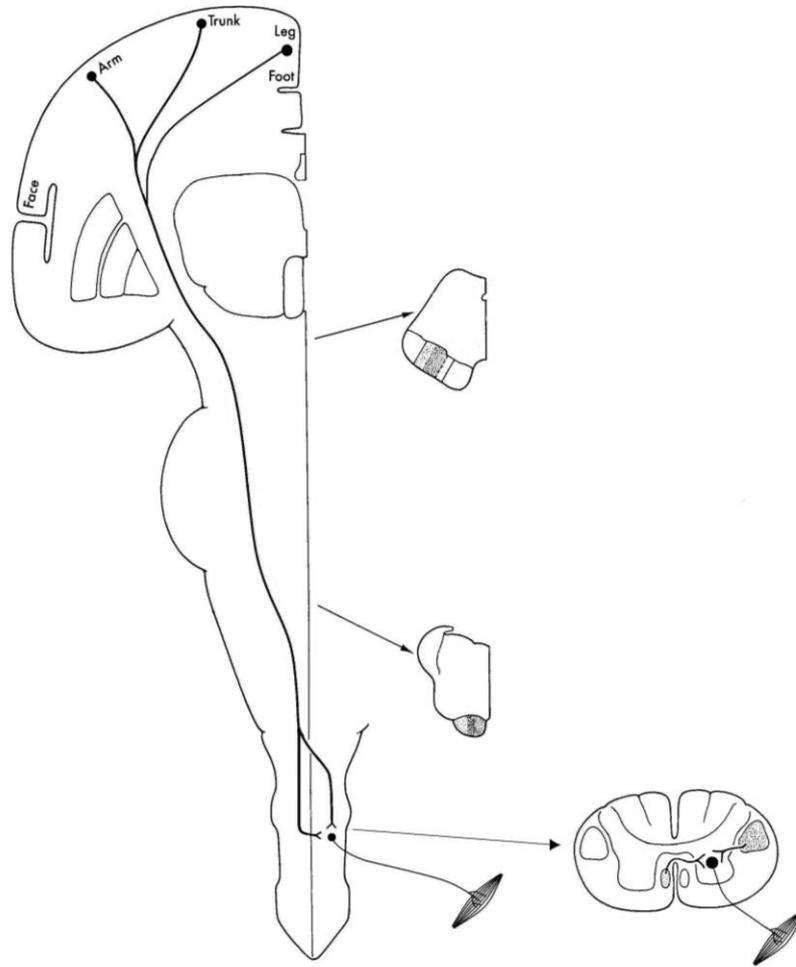


# Lateral corticospinal tract

- The majority of the corticospinal fibers **decussate at the cervicomedullary junction** to descend in the **contralateral lateral column** as the **lateral corticospinal tract**



# Anterior corticospinal tract



- A minority of fibers continue **ipsilaterally** into the ventral column as the anterior (ventral) corticospinal tract
- The anterior (ventral) corticospinal tract **crosses in the ventral white commissure**

- Damage or disease of lower motor neurons produces flaccid paralysis of muscles on the same side of the body.
- Injury or disease of upper motor neurons results in spastic paralysis of muscles on the opposite side of the body.

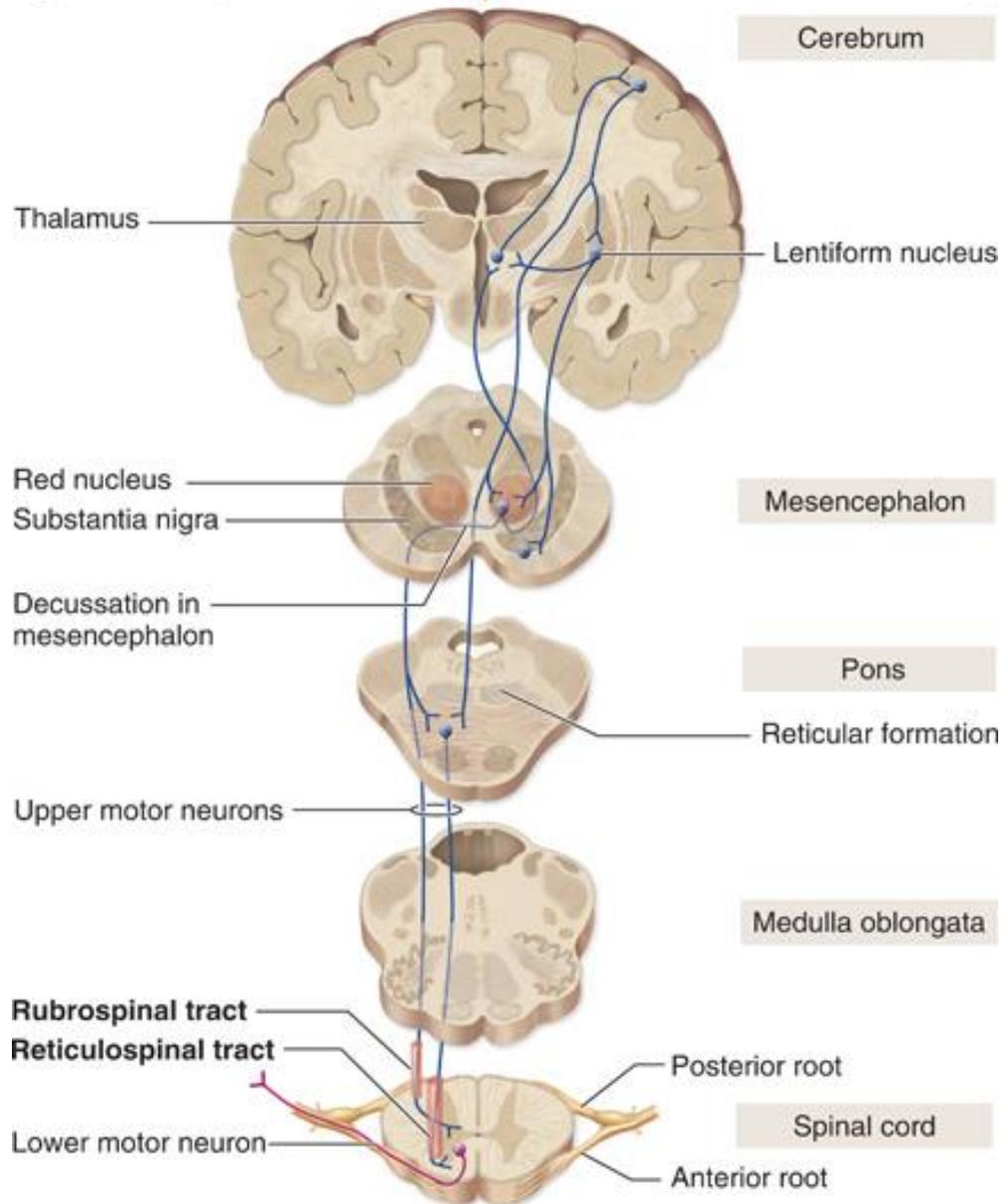
# Indirect Pathways

- **Indirect or extrapyramidal pathways** include all somatic motor tracts other than the corticospinal and corticobulbar tracts.
- Indirect pathways involve the motor cortex, basal ganglia, thalamus, cerebellum, reticular formation, and nuclei in the brain stem.
- Major indirect tracts are the **rubriospinal, tectospinal, vestibulospinal, and reticulospinal tracts.**

Pathway direction

Right side of body

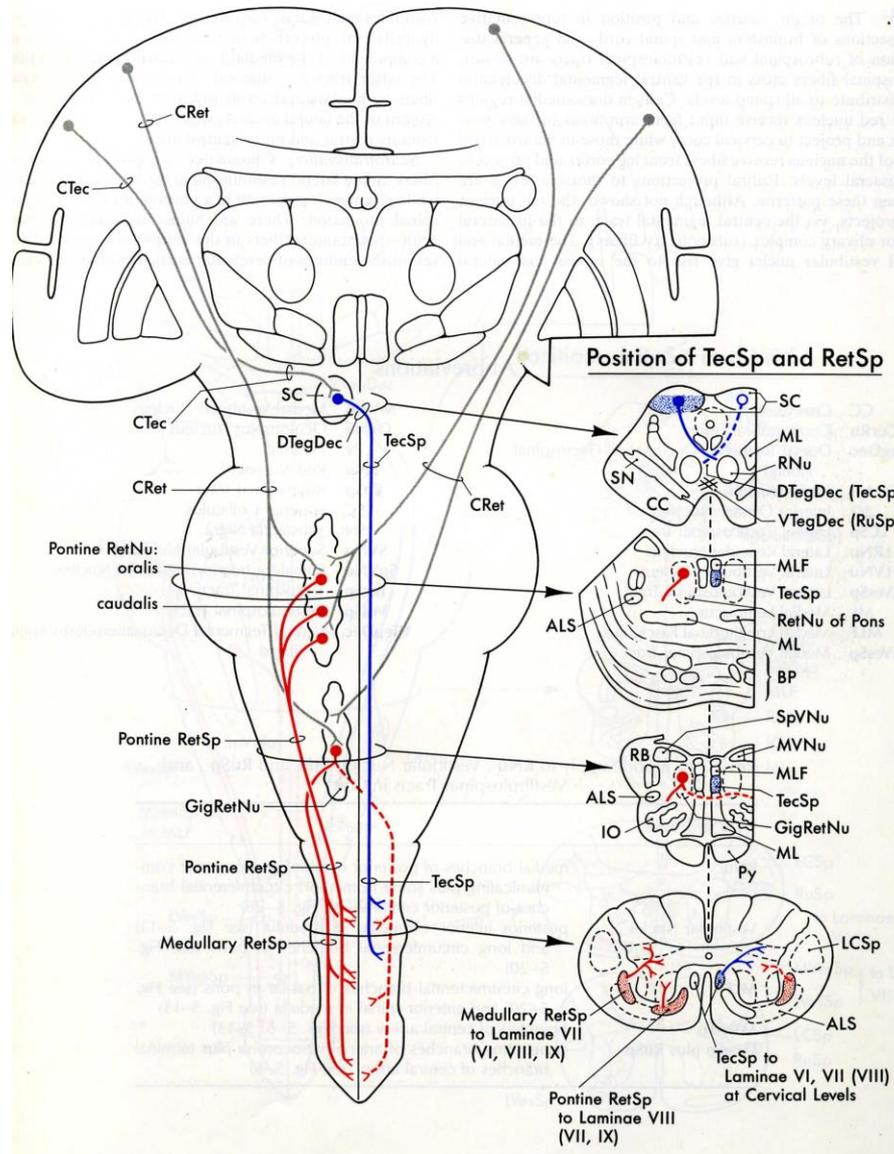
Left side of body



# RUBROSPINAL TRACT

- The corticorubral tract originates in the premotor cortex and terminates in the nucleus ruber
- **The rubrospinal tract originates in the red nucleus, crosses over in the ventral tegmentum of the midbrain, descends in the lateral funiculus of spinal cord.**
- Because these tracts decussate, they exert their influences on the opposite side from their sites of origin.
- **Functionally**, these pathways have a critical role in the **fine manipulative and independent movements of the extremities.**

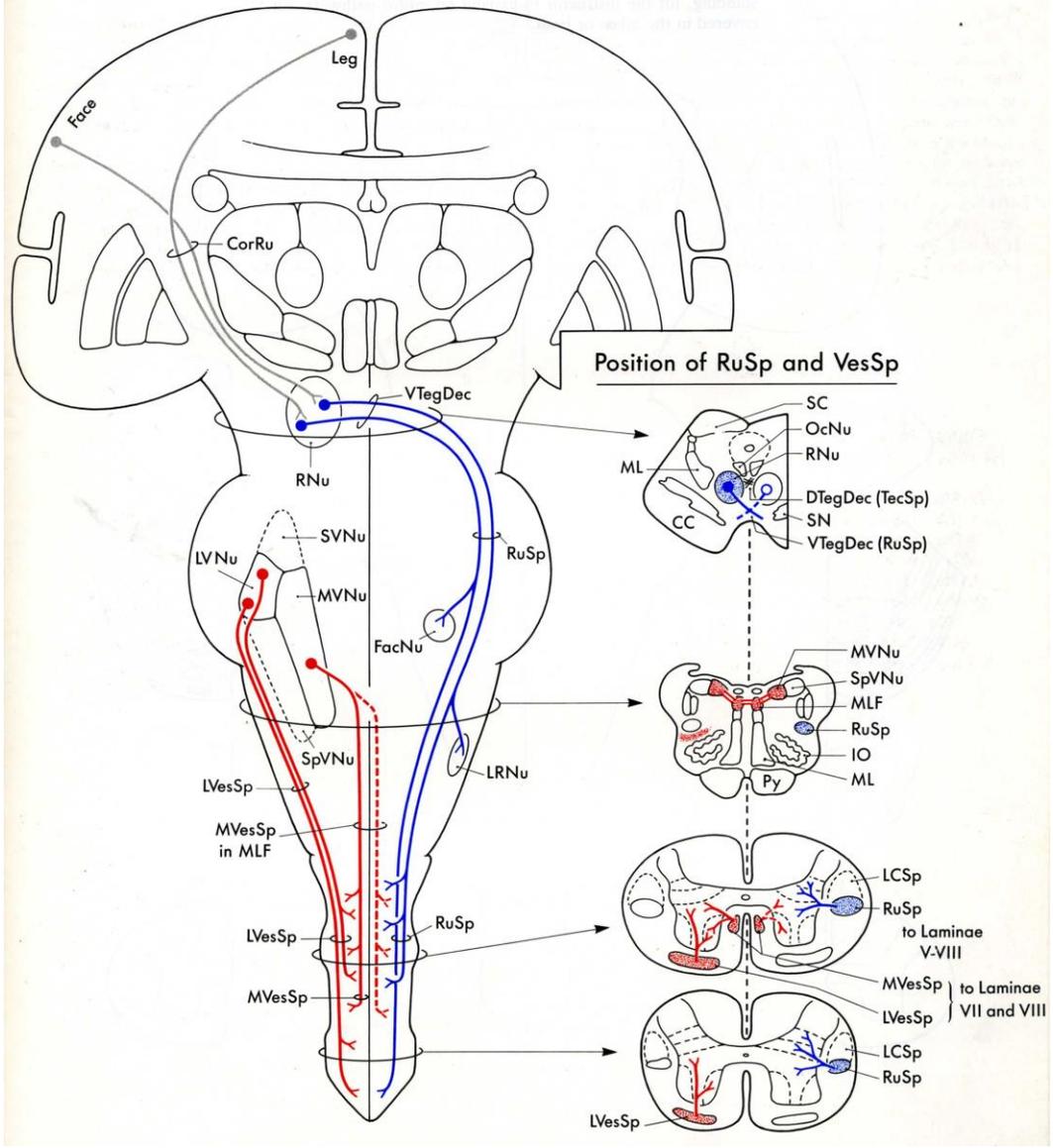
## Tectospinal and Reticulospinal Tracts



# TECTOSPINAL TRACT

- The corticotectal tract originates in visual association cortical areas 18 & 19 and terminates in the superior colliculus of the tectum
- **The tectospinal tract from the superior colliculus *decussates in the midbrain tegmentum (dorsal tegmental decussation)* and joins the medial longitudinal fasciculus.**
- This tract is presumed to be involved with **coordinating head and neck movements with eye movements**

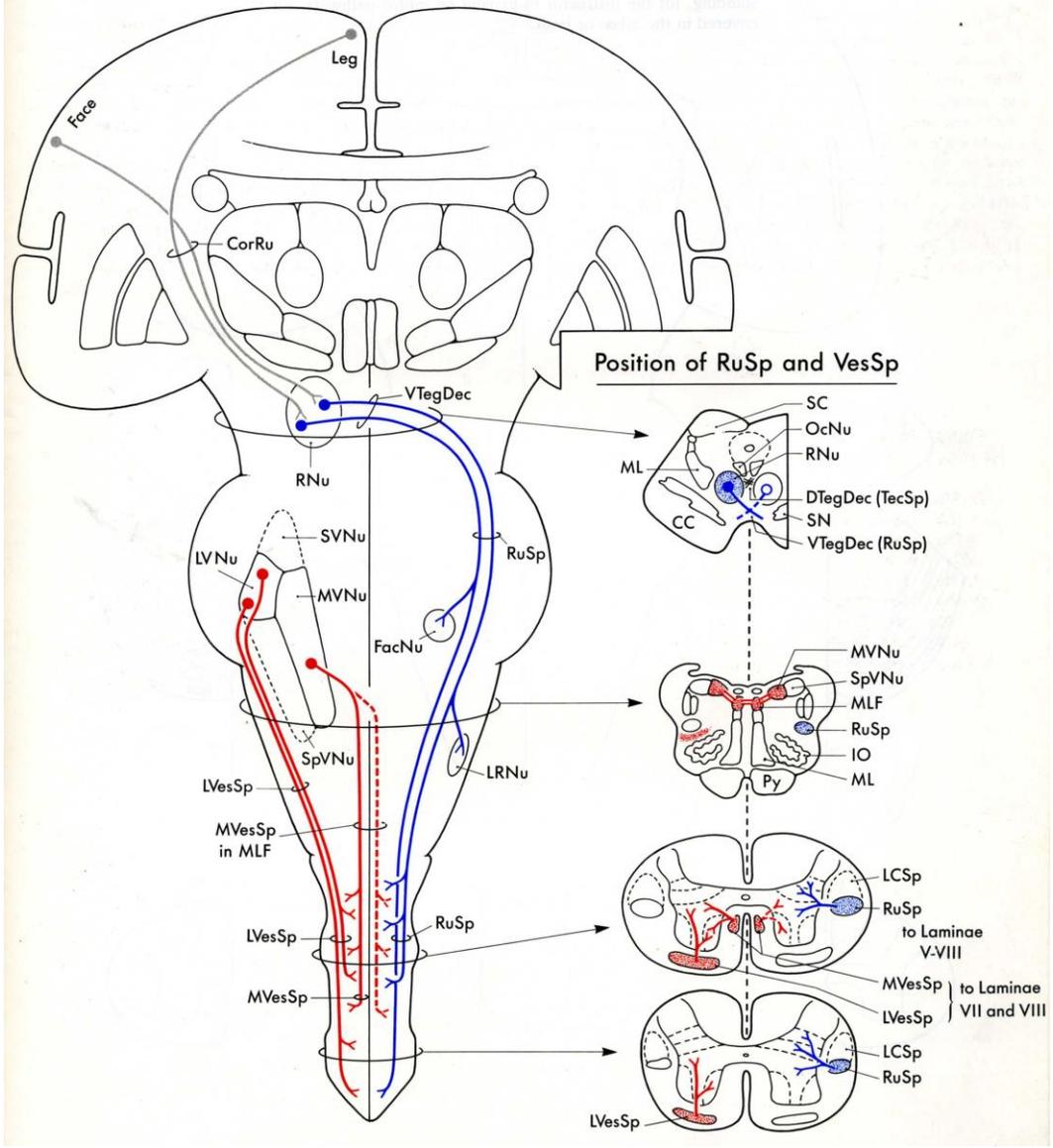
# Rubrospinal and Vestibulospinal Tracts



# VESTIBULOSPINAL TRACT

- The lateral vestibular nucleus gives rise to the lateral **vestibulospinal tract**, which descends as an **uncrossed somatotopically organized tract throughout the entire length of the spinal cord** in the anterior region of the lateral funiculus
- The descending tracts of the vestibular system are primarily **involved in maintaining muscle tone and antigravity postural poses** (e.g. standing erect).

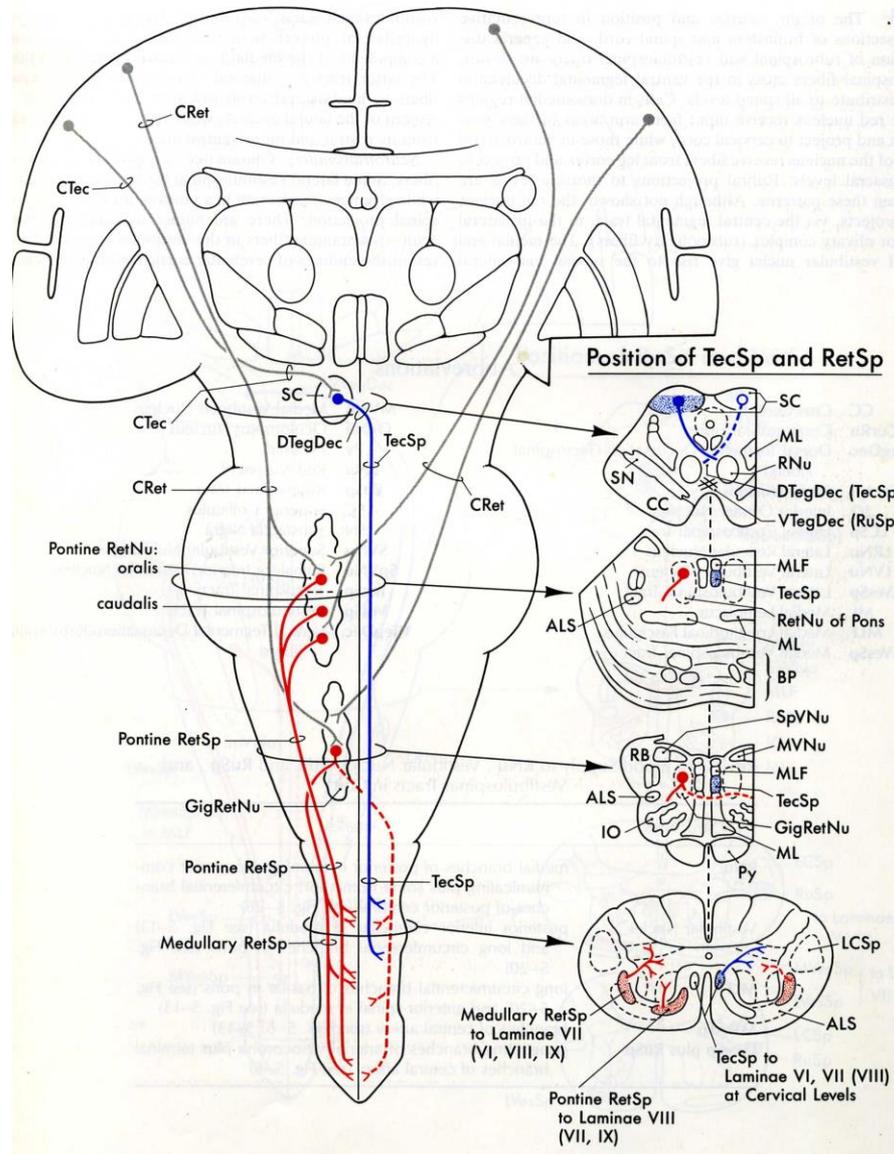
# Rubrospinal and Vestibulospinal Tracts



# RETICULOSPINAL TRACTS

- The sequence of corticoreticular and reticulospinal tracts comprises the corticoreticulospinal pathways
- From their origin in the premotor cortex corticoreticular fibers descend and terminate in the pontine and medullary reticular nuclei of the brainstem reticular formation on both sides. The latter also receives input from the cerebellum
- **The reticulospinal tracts include the lateral (medullary) reticulospinal tract and medial(pontine) reticulospinal tract**
- These tracts are primarily **uncrossed** and are not somatotopically organized
- **The medial(pontine) reticulospinal tract** originates **from** the nuclei reticularis **pontis** and descends as uncrossed fibers in the **anterior funiculus**
- **The lateral (medullary) reticulospinal tract** originates **from the nucleus reticularis gigantocellularis** and descends as uncrossed fibers in the **anterior region of the lateral funiculus.**
- The reticulospinal tracts are thought to be involved in the more **automatic, involuntary movements** of the axial and limb musculature involved with posture and locomotion

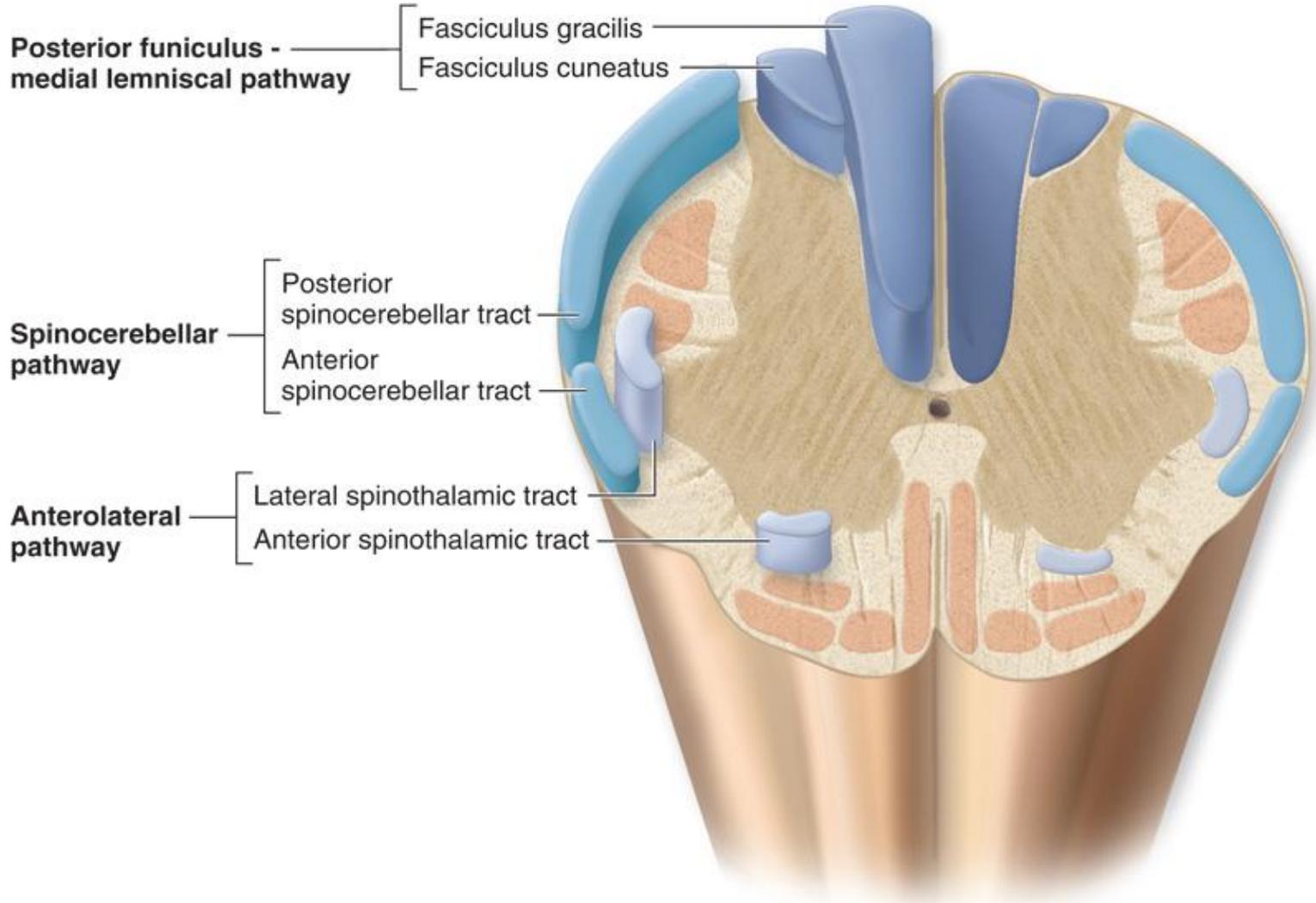
## Tectospinal and Reticulospinal Tracts



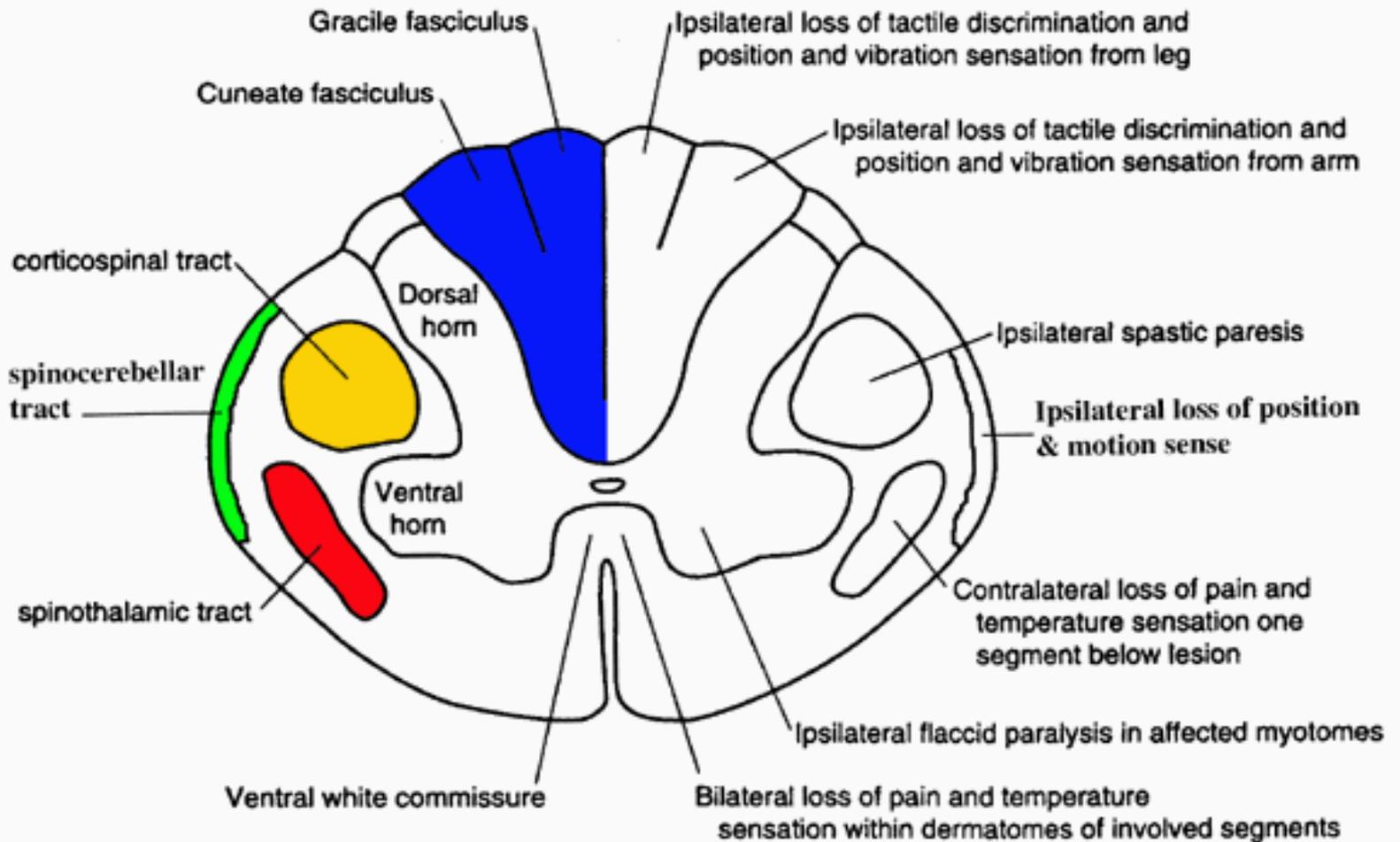
# DISORDERS:

- **Spinal cord injury** can be due to damage in a number of ways, such as compression or transection, and the location and extent of damage determines the type and degree of loss in neural abilities.
- 1. Cord damage caused by anything from tumors to trauma can compress neurons and either permanently or temporarily diminish capacity, depending on the type of nerves compromised.
- a. Sensory nerve damage leads to the loss of the particular sensation that normally travels along the injured route, below the level of incident.
- b. Motor pathway injury leads to paralysis that is described by the extent of motor loss, below the level of incident.
- 2. Damage to the cord, particularly transection, results in spinal cord shock, described as the loss of spinal reflexes, such as with incontinence.

*Posterior*



*Anterior*



# Cerebral Palsy

- This condition entails loss of muscle control due to problems during development that impact the motor control areas of the brain.
- The conditions are non-progressive, but permanent.

- **Parkinson's disease** is a progressive degeneration of CNS neurons of the basal nuclei region due to unknown causes that decreases dopamine neurotransmitter production.
- 1. This condition produces motor coordination problems of involuntary tremor and/or rigidity.
- 2. Motor performance can be described as bradykinesia (slow) and hypokinesia (limited).
- 3. Limited treatment is provided with L-dopa, a precursor to dopamine, or through acetylcholine inhibitors.

