

# Spinal Cord: Pathways

Grace Kimbaris, MD

Assistant Professor of Neurology  
University of Pennsylvania

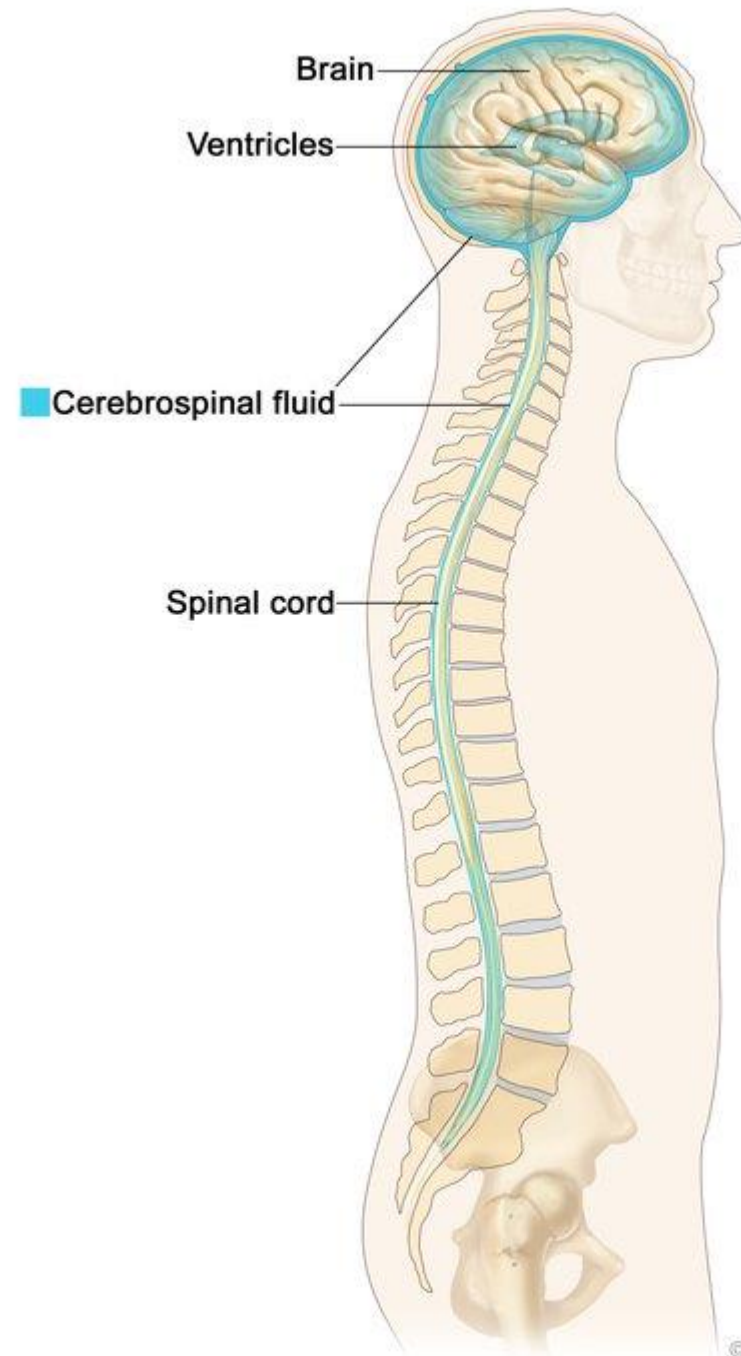
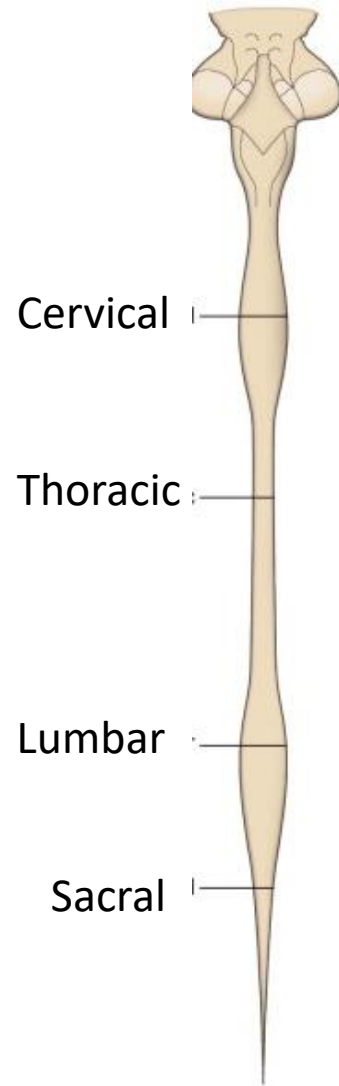
# Outline

- Spinal cord anatomy
- Motor pathways
  - Lateral corticospinal tract
  - Rubrospinal tract
- Sensory pathways
  - Dorsal columns/medial lemniscal system
  - Spinothalamic/anterolateral system
- Spinocerebellar pathways
  - Dorsal spinocerebellar tract
  - Cuneocerebellar tract

# Learning objectives

1. Compare and contrast functions of dorsal and ventral roots, and where their axons arise from or project to in the spinal cord
2. Describe and locate the cell bodies and axons of motor neurons that generate voluntary contraction of skeletal muscle
3. Describe and locate the cell bodies and axons of sensory neurons that form the dorsal column/medial lemniscal system, the anterolateral system, and the spinocerebellar systems.

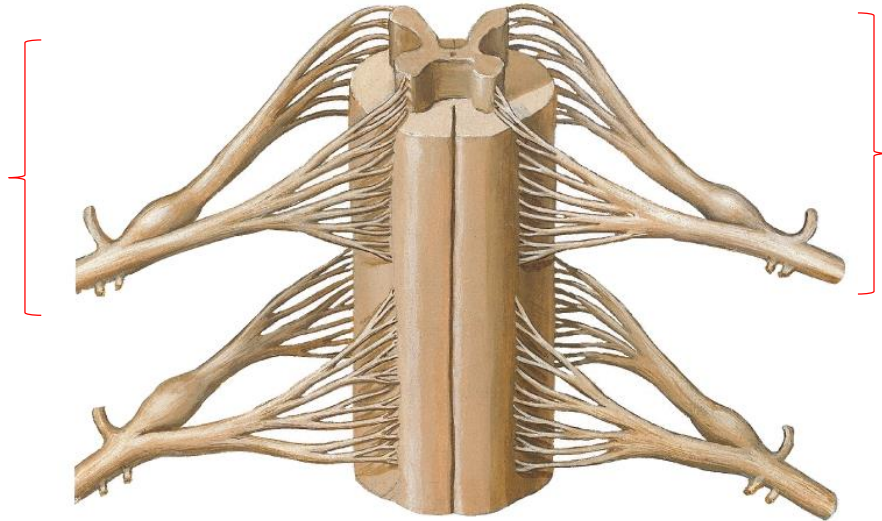
# Spinal cord anatomy



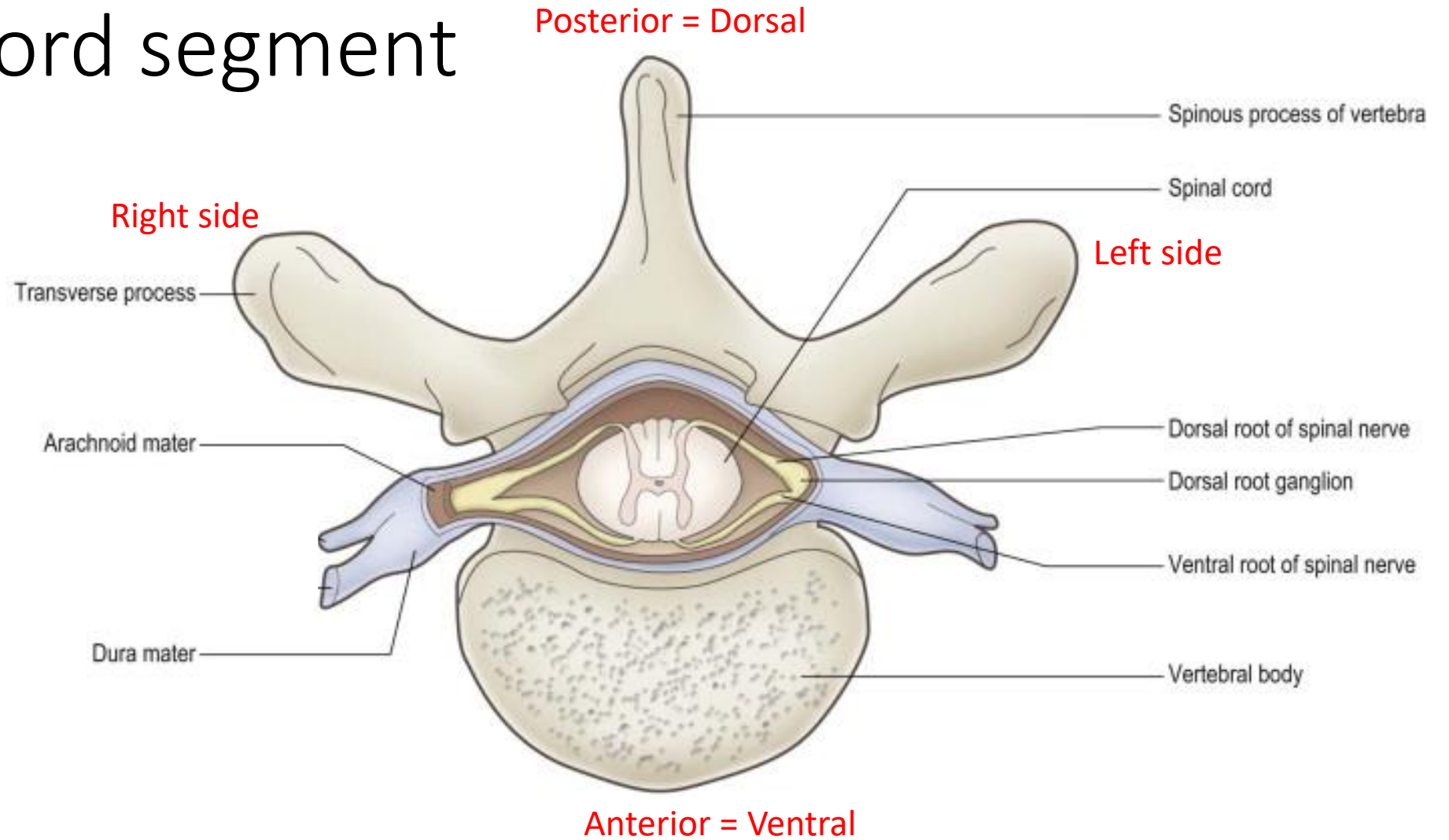
# Spinal cord: segments

31 segments:

- 8 cervical
- 12 thoracic
- 5 lumbar
- 5 sacral
- 1 coccygeal



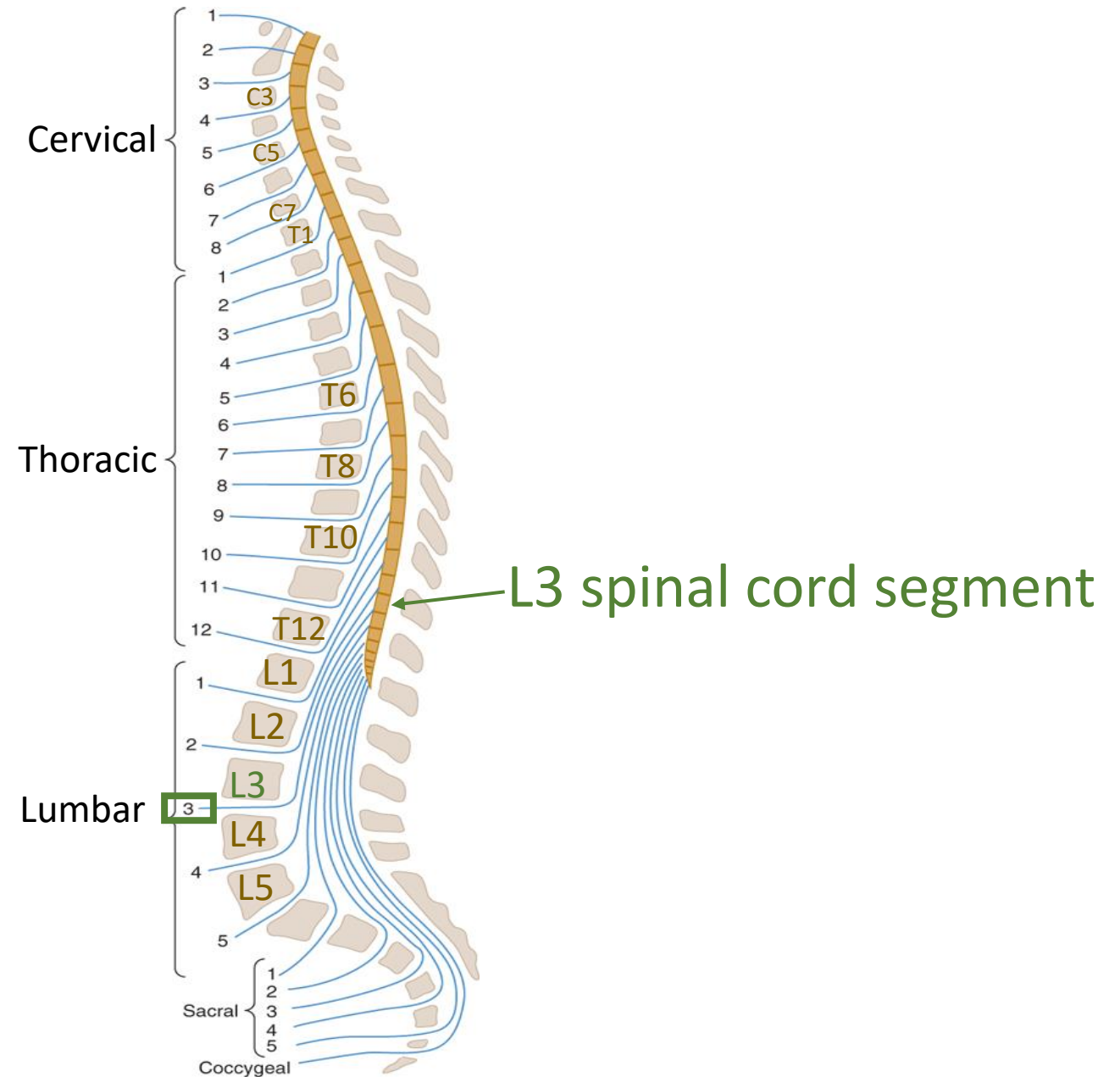
# Spinal cord segment



# Spinal cord

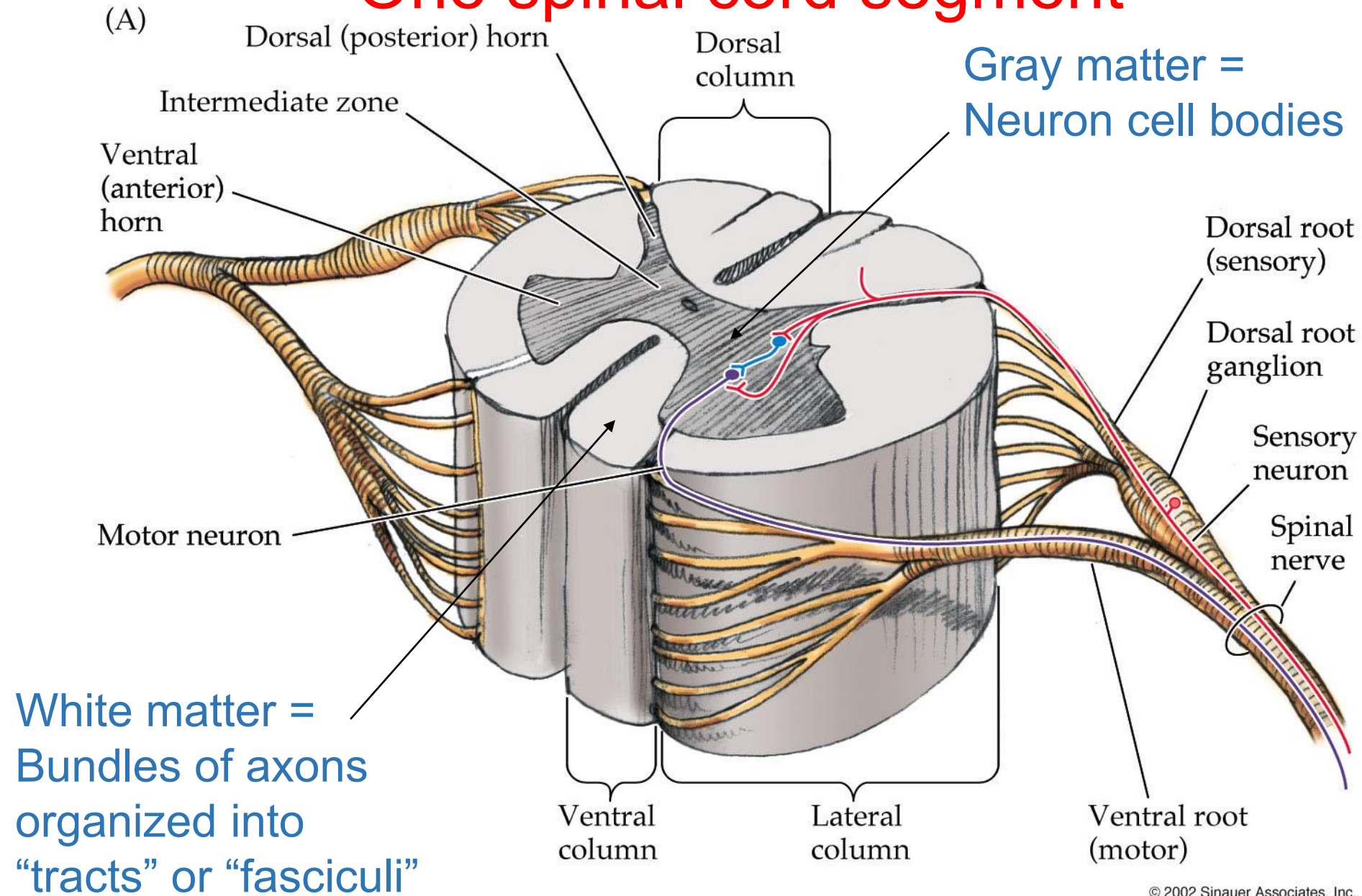
Adult:

Spinal cord ends around  
L1-2 vertebral body



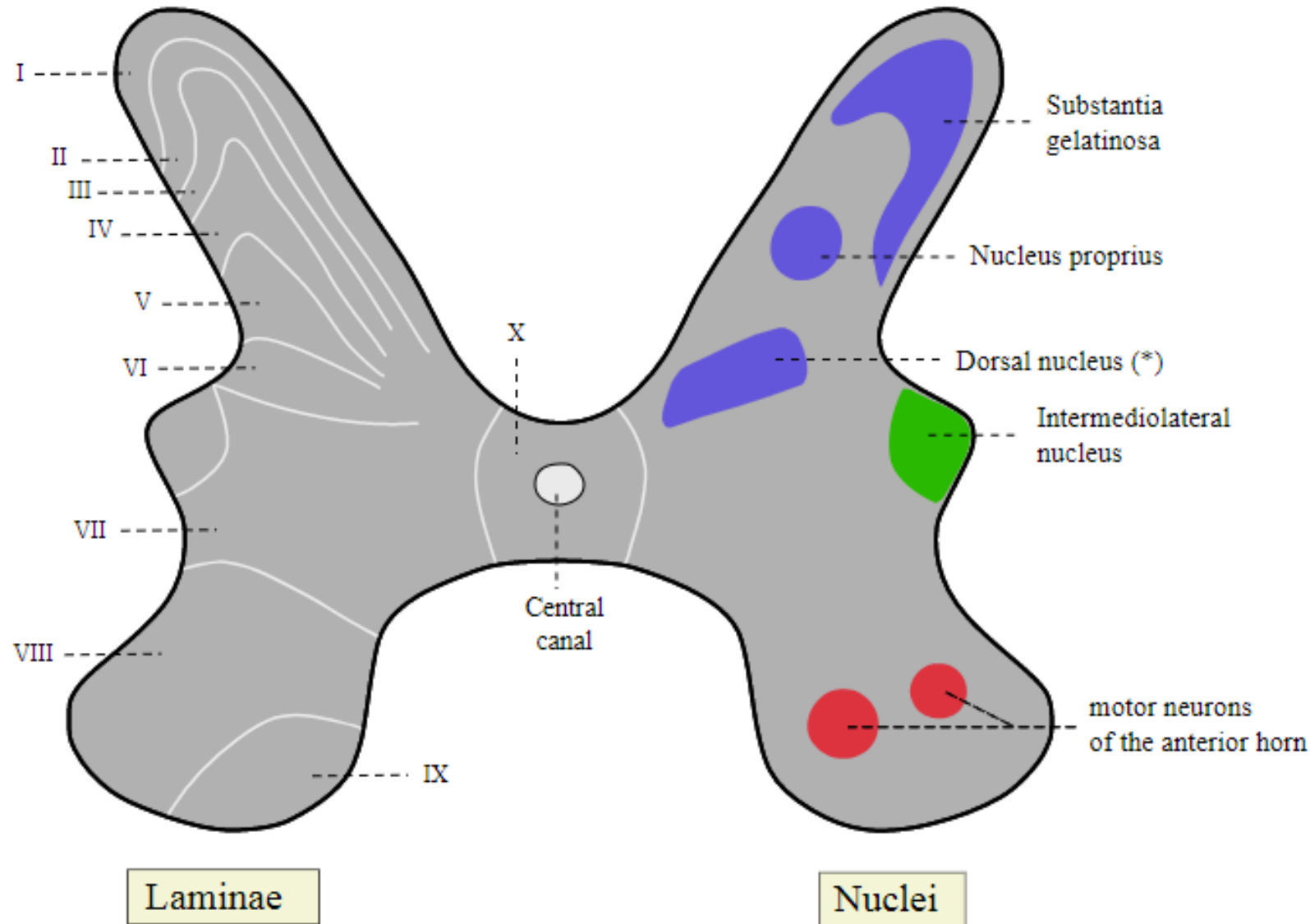
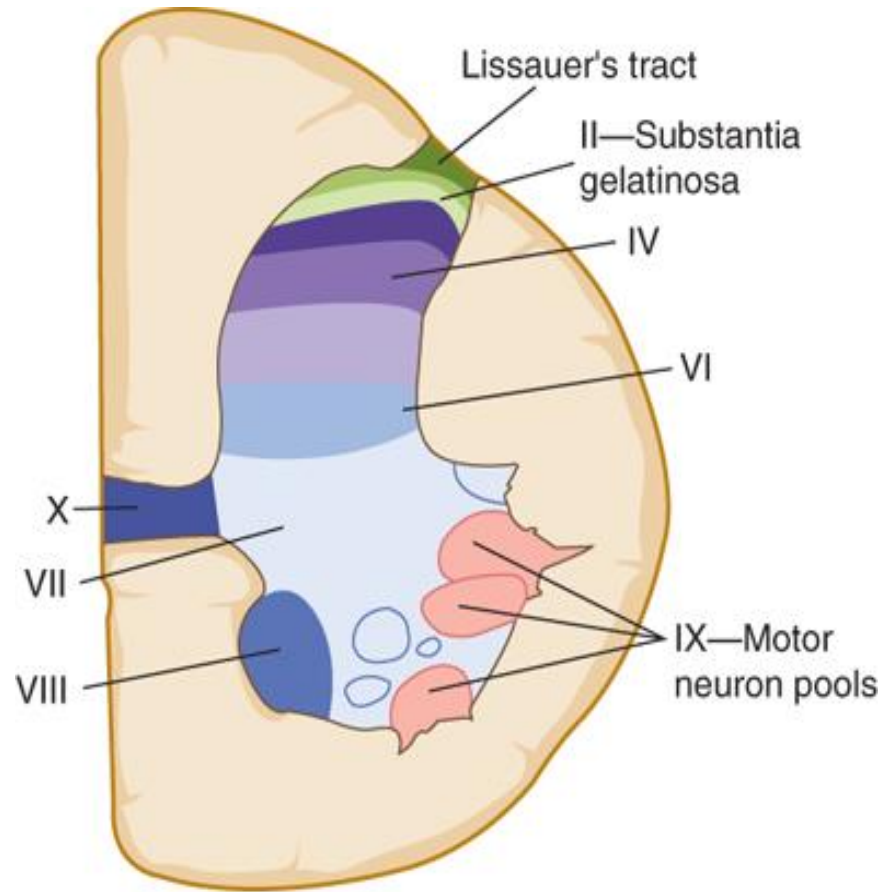


# One spinal cord segment



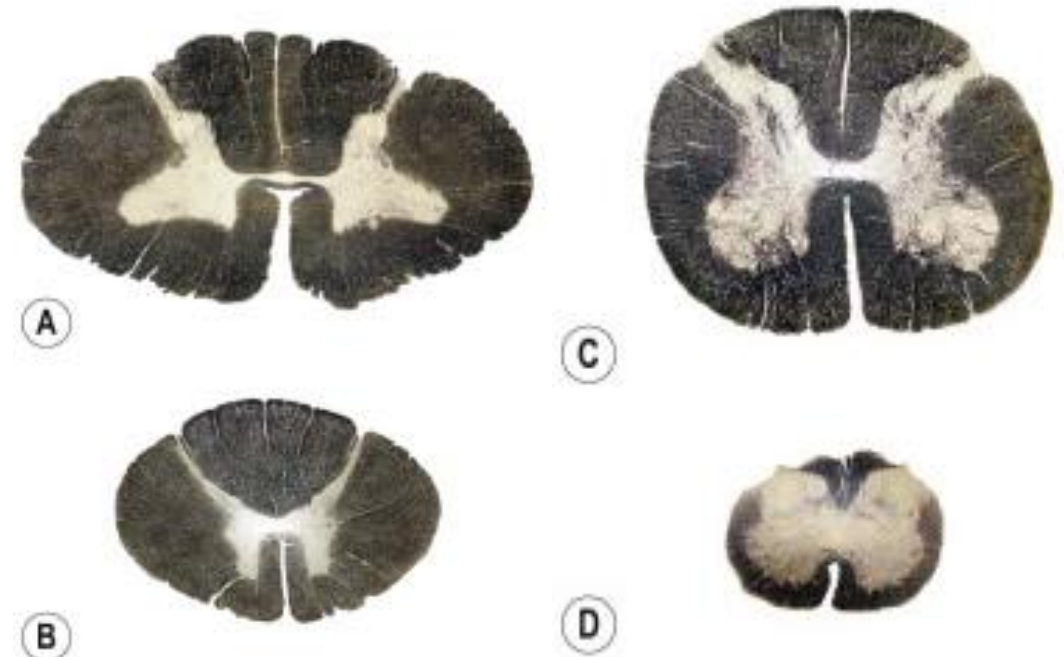
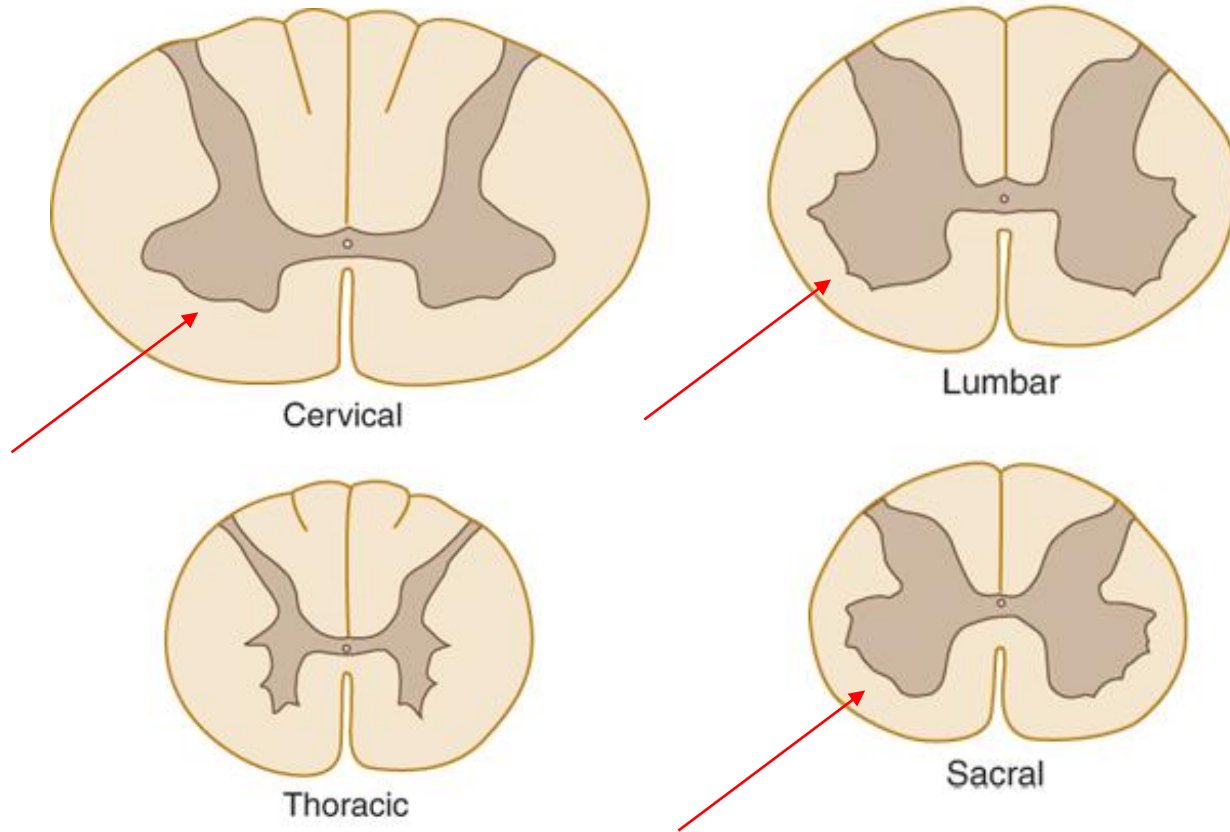


# Rexed laminae



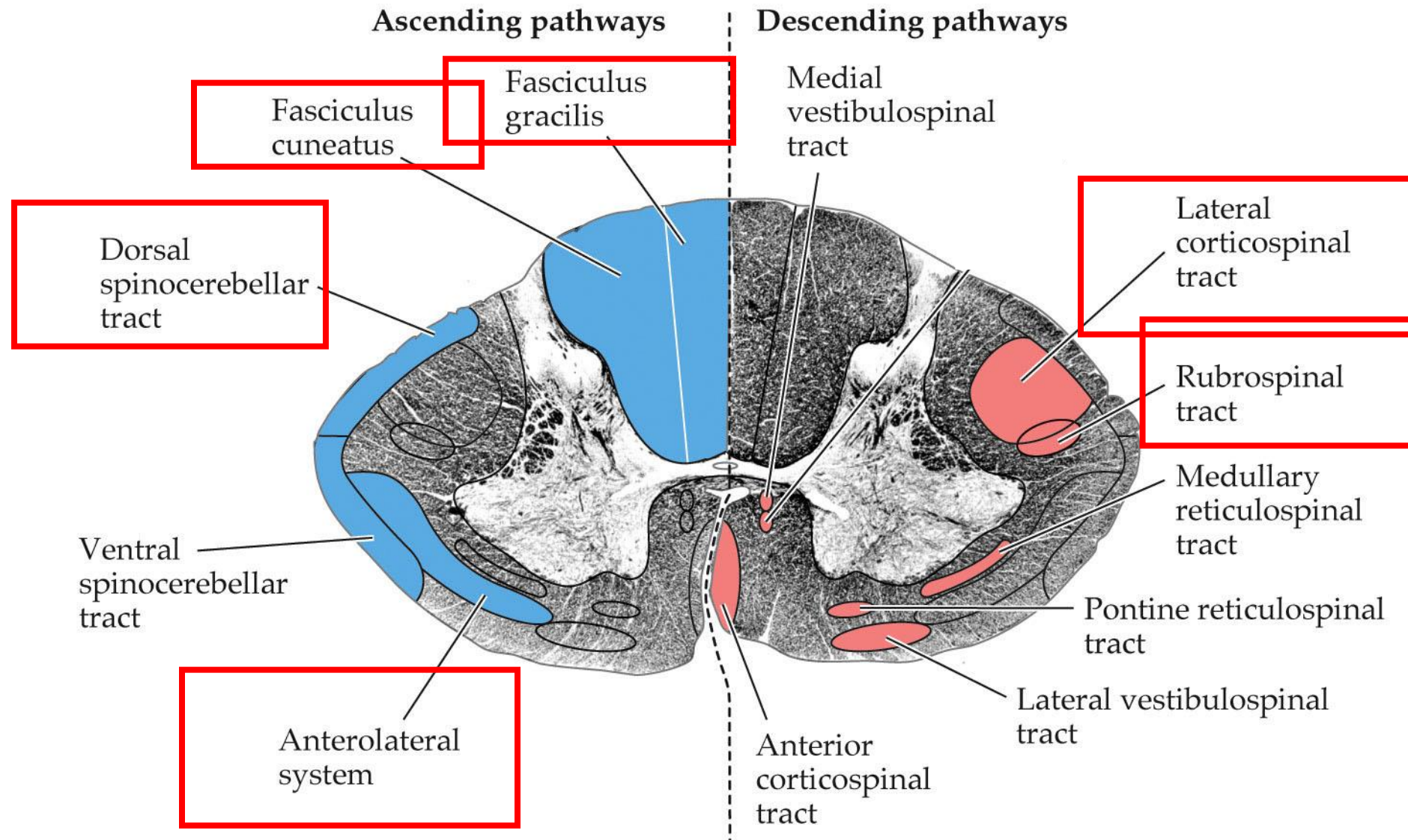
\* Posterior thoracic nucleus or Column of Clarke

# Cervical and lumbosacral enlargements



## Important cord tracts are in red boxes

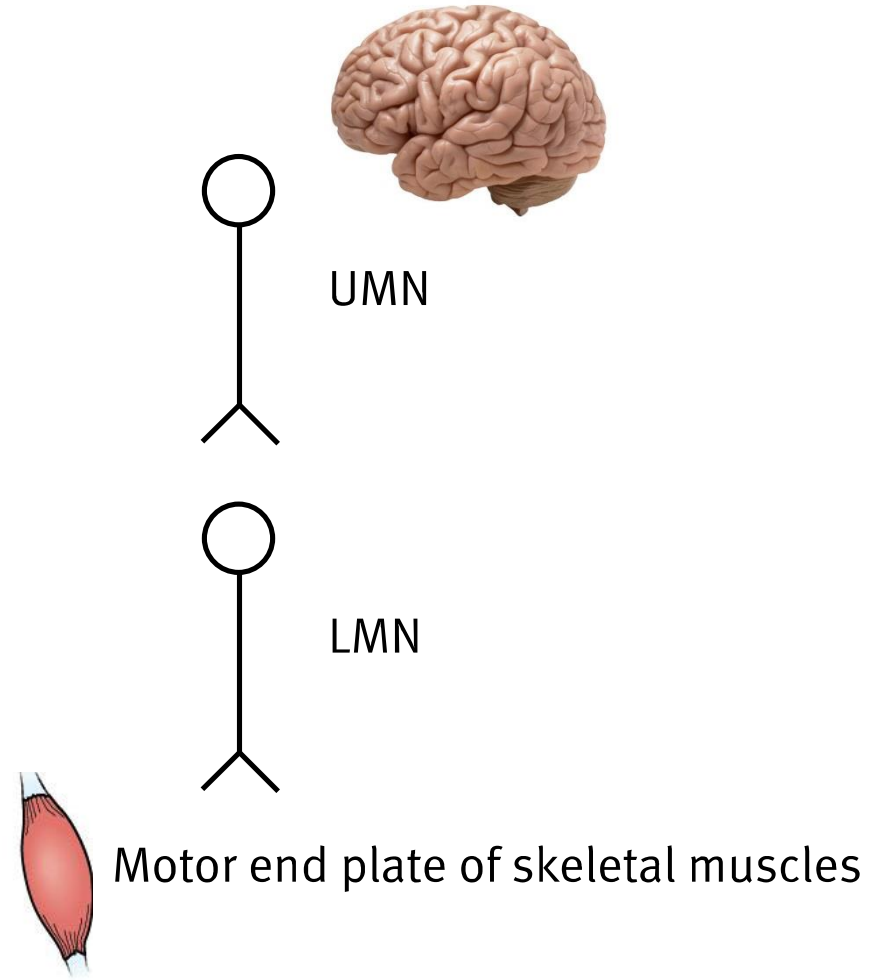
Where are their cell bodies and where do their axons project?



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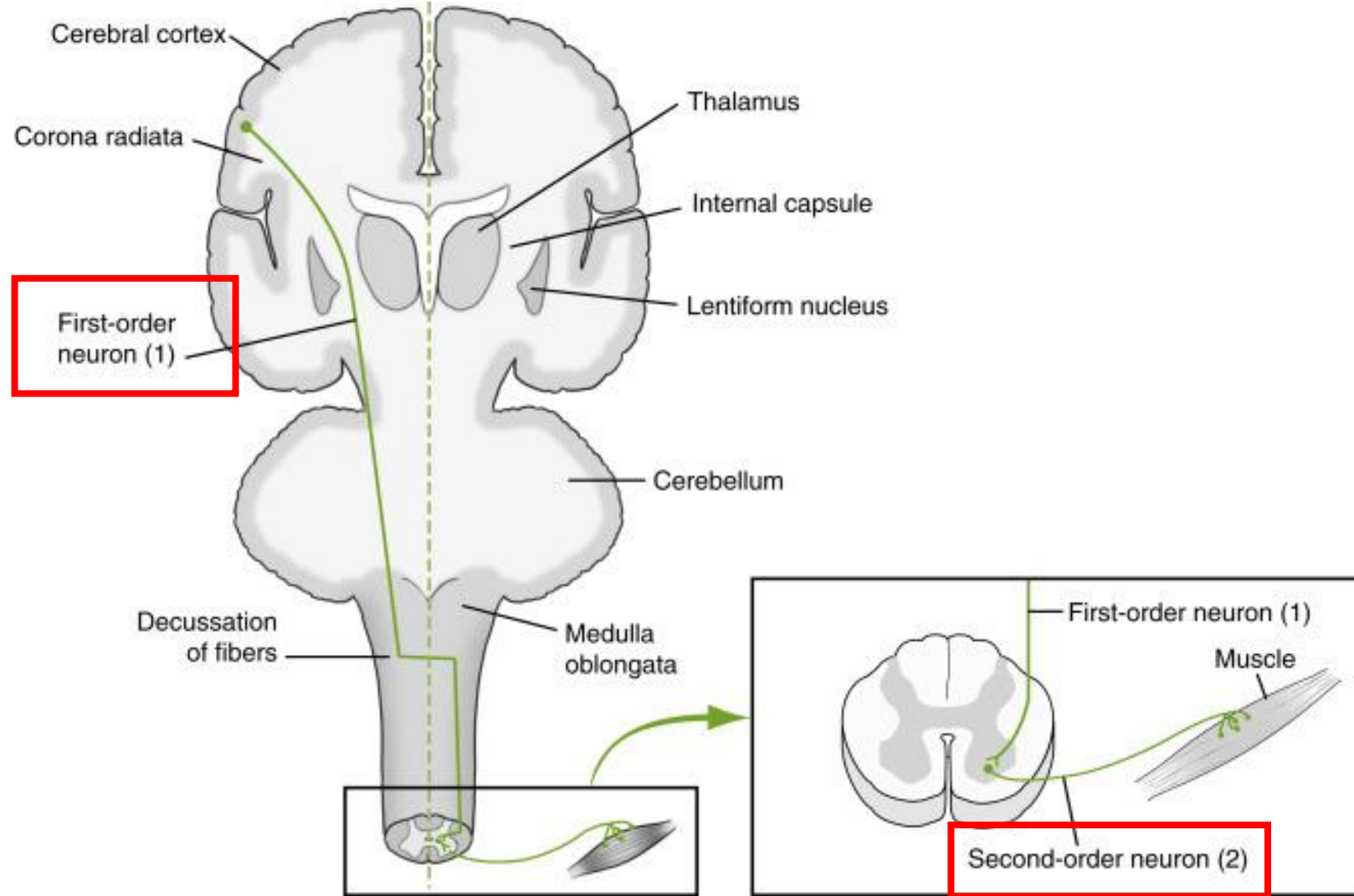
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  - **Lateral corticospinal tract**
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# Motor system

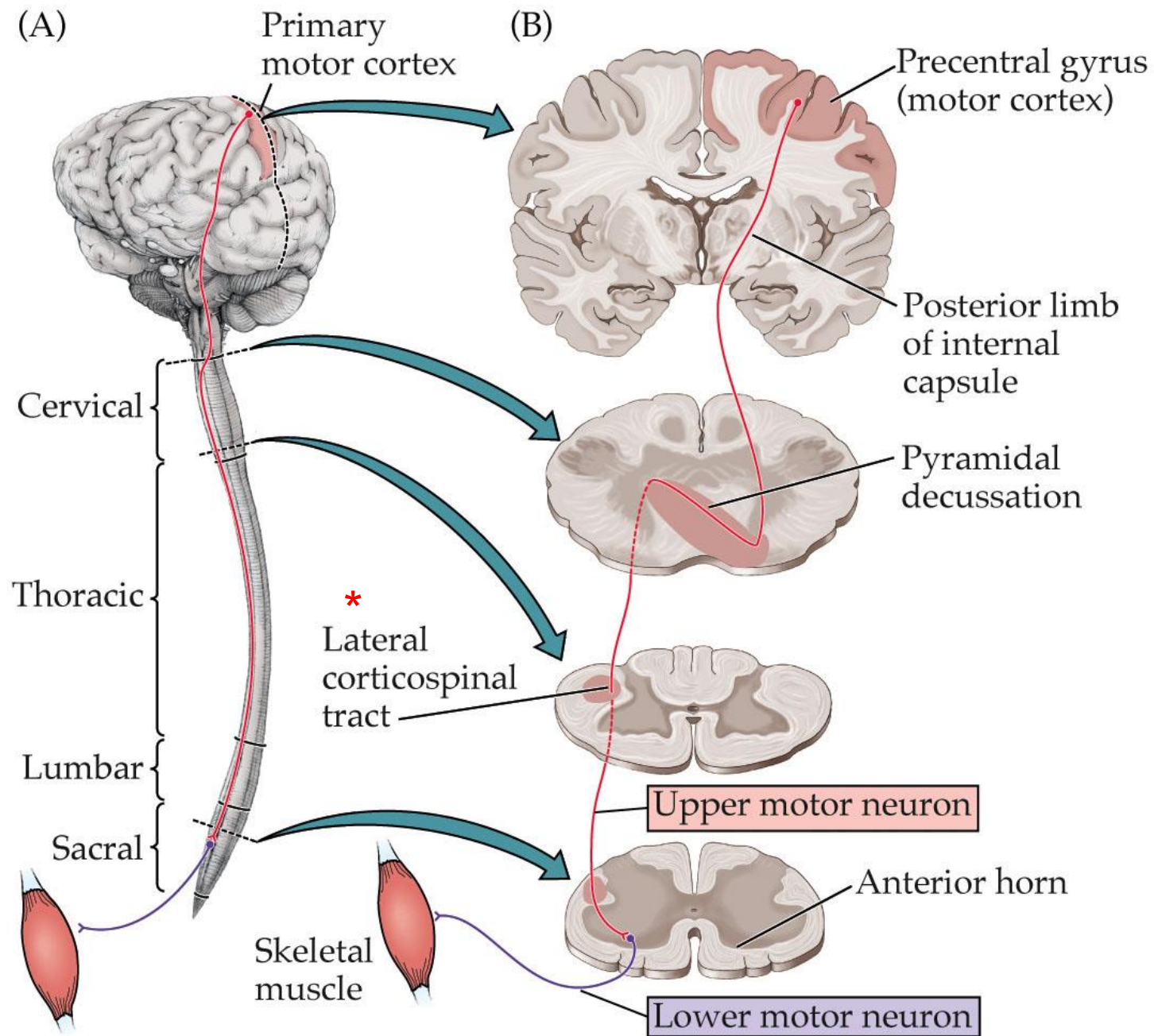


(UMN = upper motor neuron, LMN = lower motor neuron)

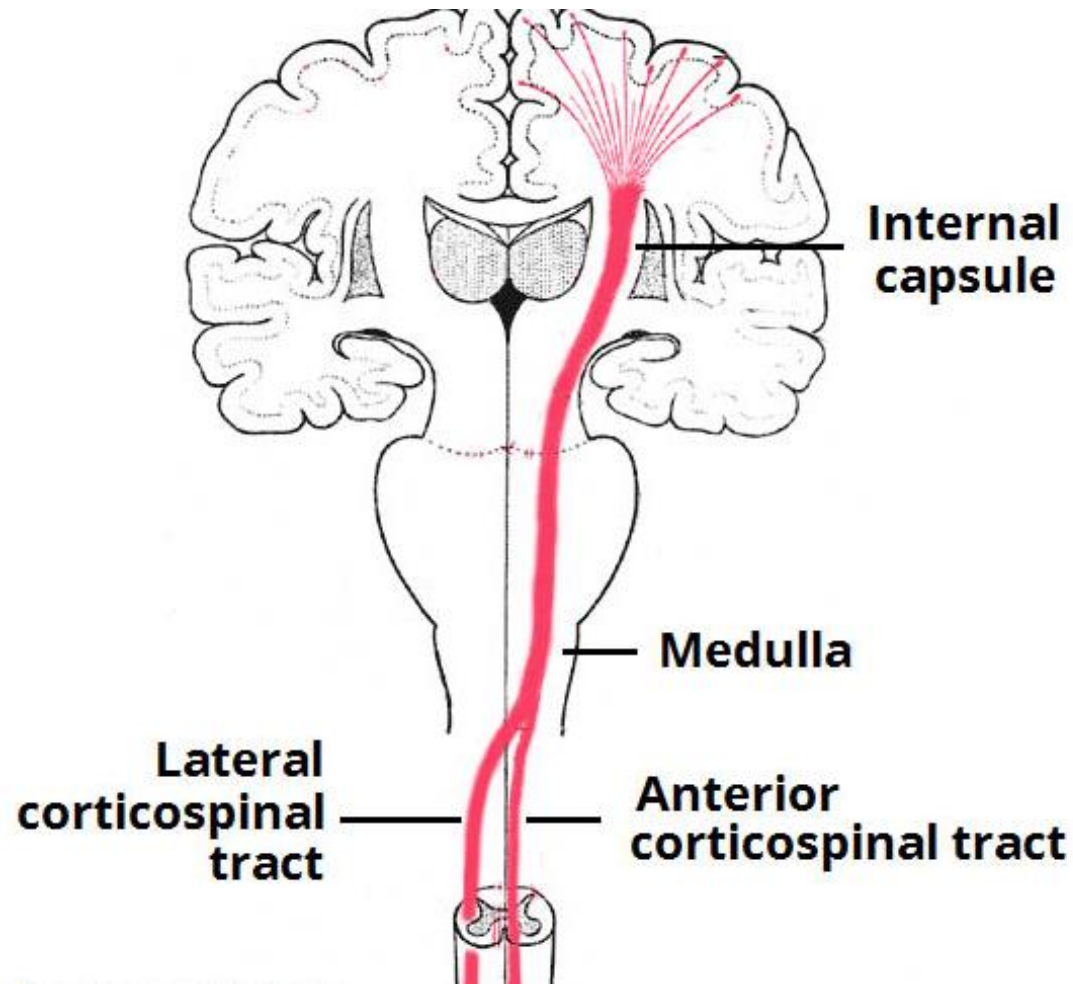




Pyramidal tract =  
Lateral  
corticospinal tract

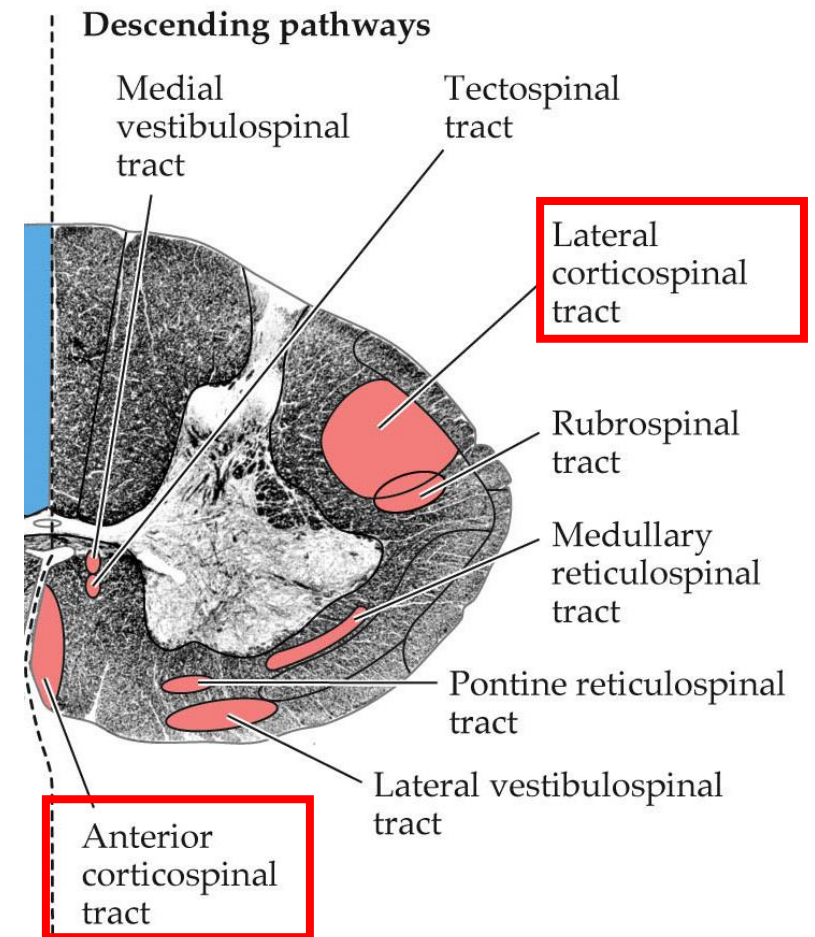






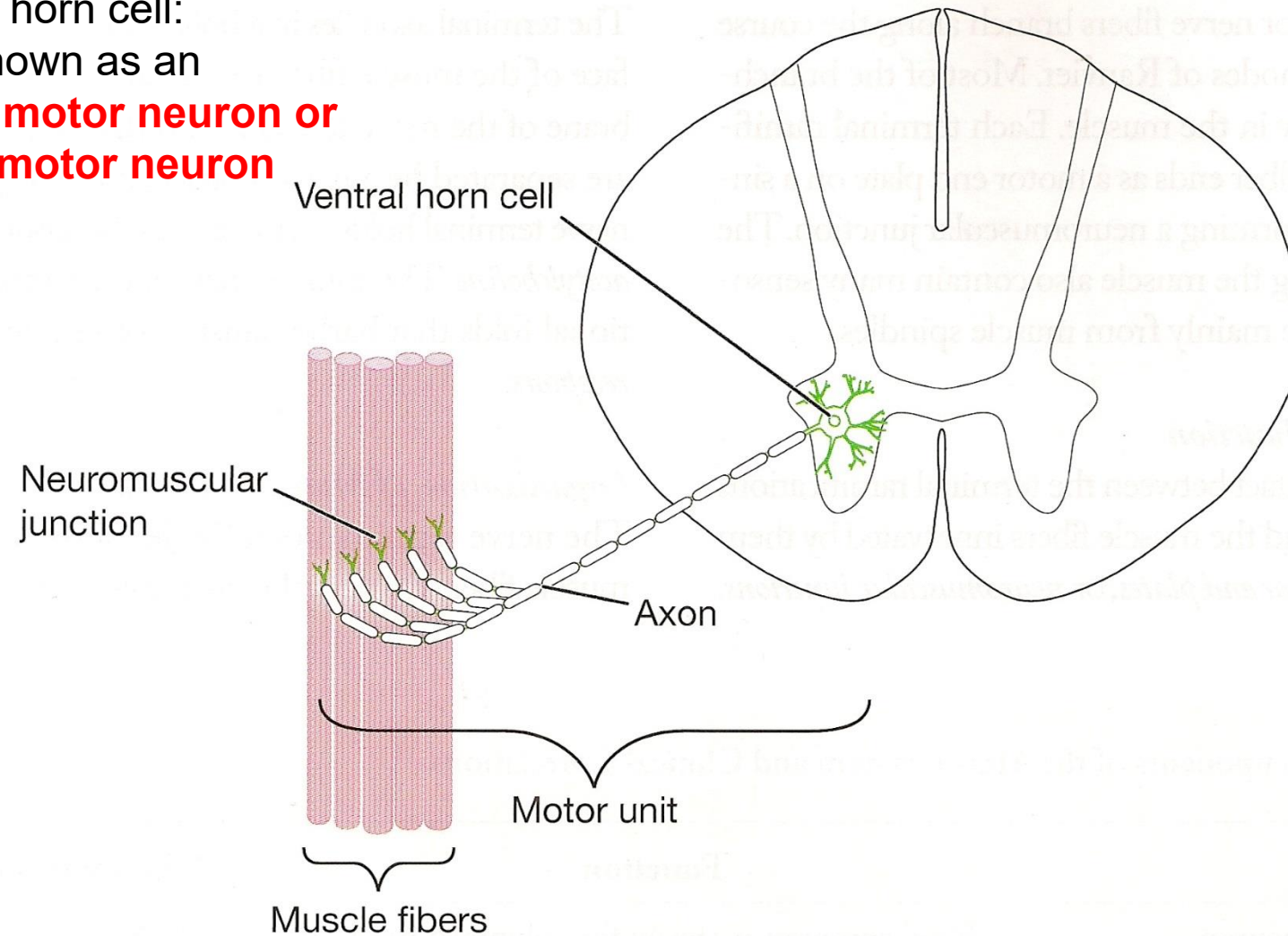
Lateral corticospinal tract:  
 Crossed fibers (90%)  
 Fibers cross to contralateral side  
**Major pathway for voluntary movement**

Anterior corticospinal tract:  
 Uncrossed fibers (10%)  
 Fibers stay on ipsilateral side  
**Not important for voluntary movement**



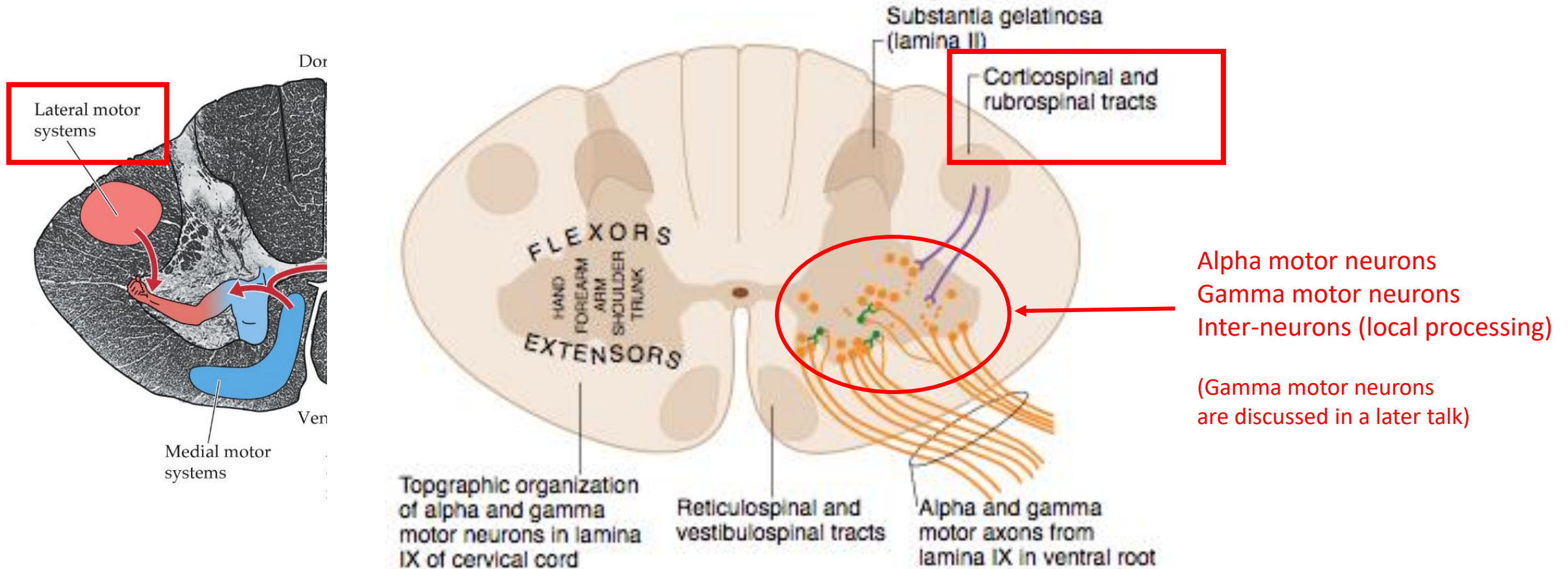
*"Ipsilateral" = same side*  
*"Contralateral" = opposite side*

Ventral horn cell:  
Also known as an  
**Lower motor neuron or  
Alpha motor neuron**



**Fig. 8.2.** A single motor unit and its components: the lower motor neuron and muscle fibers innervated by it.

# Organization of the ventral horn



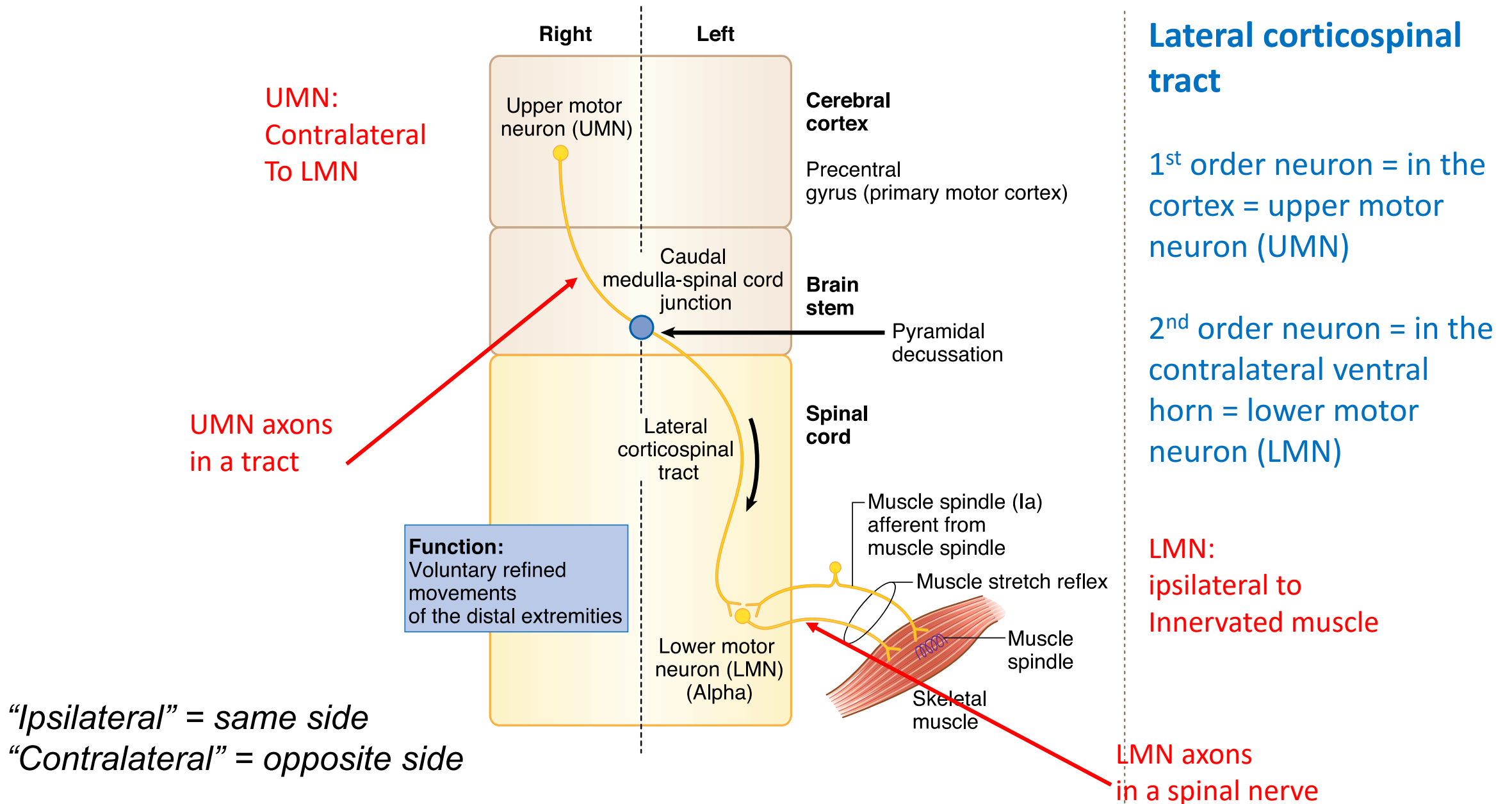


Figure IV-4-5. Voluntary Contraction of Skeletal Muscle: UMN and LMNs

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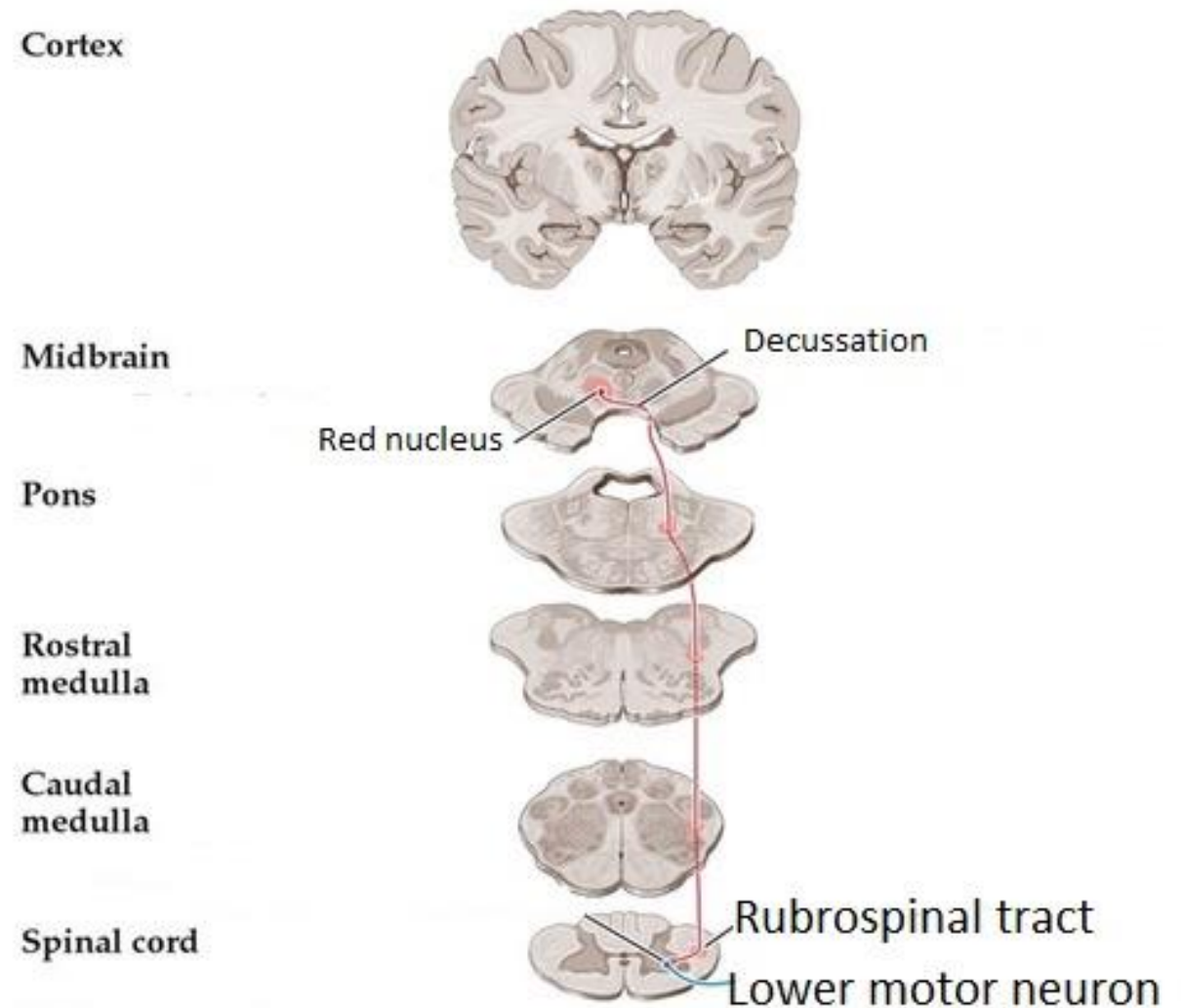
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  - Lateral corticospinal tract
  - **Rubrospinal tract**
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  - Dorsal spinocerebellar tract
  - Cuneocerebellar tract





# Rubrospinal tract

- Facilitates contralateral upper limb flexor muscles
- Origin: red nucleus of midbrain
- Crosses in midbrain
- Descends through cervical segments
- Synapses on lower motor neurons





## Important descending (motor) pathways

Tract	Purpose	First-order	Second-order	Site of crossover
Lateral corticospinal tract	Upper and lower extremity voluntary movement	Motor cortex	Alpha motor neuron (and gamma motor neurons and inter-neurons)	Medulla (pyramidal decussation)
Rubrospinal tract	Upper extremity flexors	Red nucleus	Alpha motor neuron (and gamma motor neurons and inter-neurons)	Midbrain

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# Sensory pathways

- Each is a 3-neuron system
- Dorsal columns/medial lemniscal system:  
Fine touch, pressure, vibration, proprioception/position sense
- Spinothalamic/anterolateral system  
Touch, pain, temperature

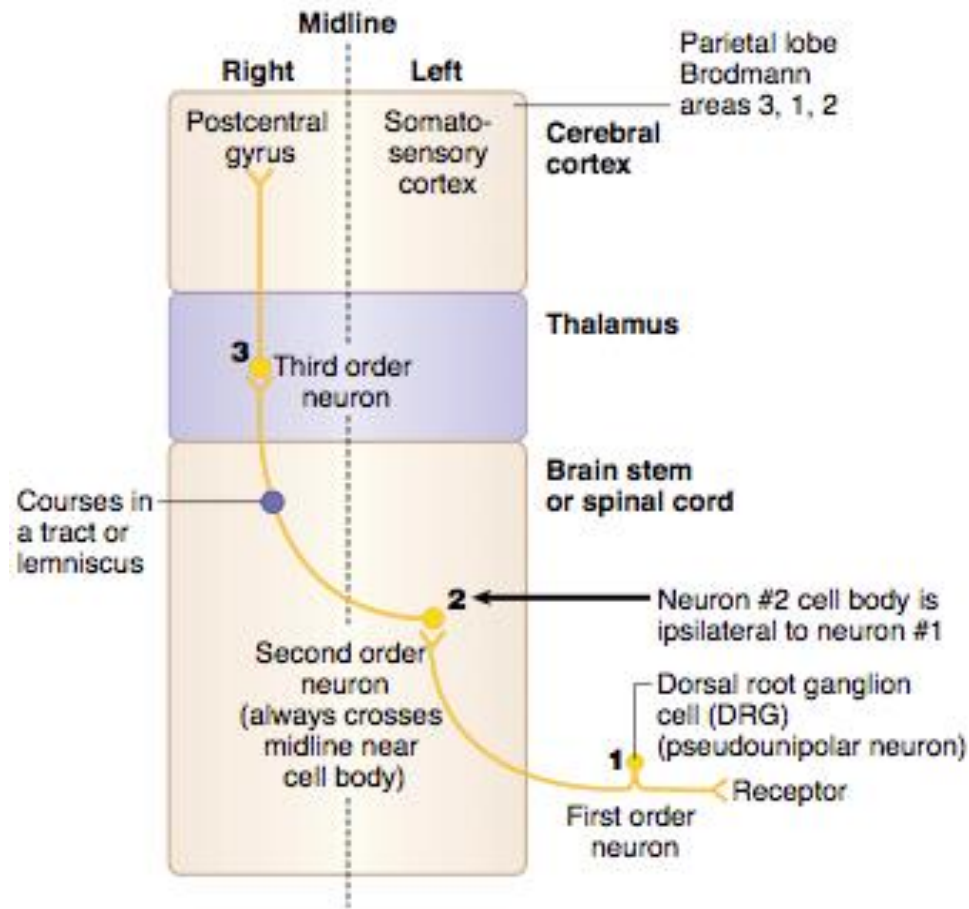
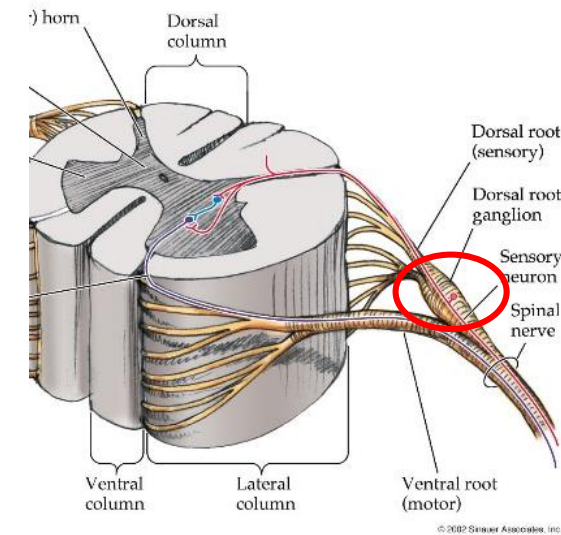


Figure IV-4-9. General Sensory Pathways

## Both sensory pathways

1. First-order neuron in sensory ganglion
2. Ipsilateral second-order neuron in the central nervous system
3. Third-order neuron: in contralateral thalamus

(Crossing occurs between 2. and 3.)



*"Ipsilateral" = same side*

*"Contralateral" = opposite side*

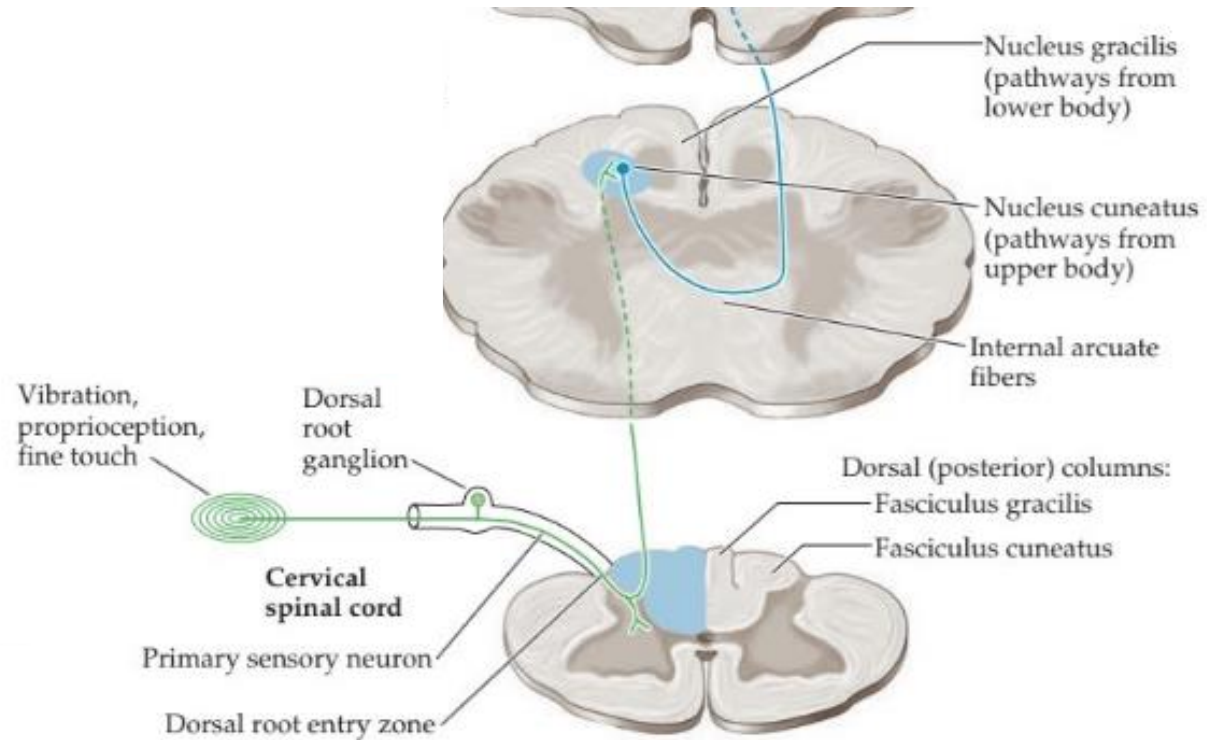
# Dorsal Columns/ Medial Lemniscal System

*3-neuron sensory pathway*

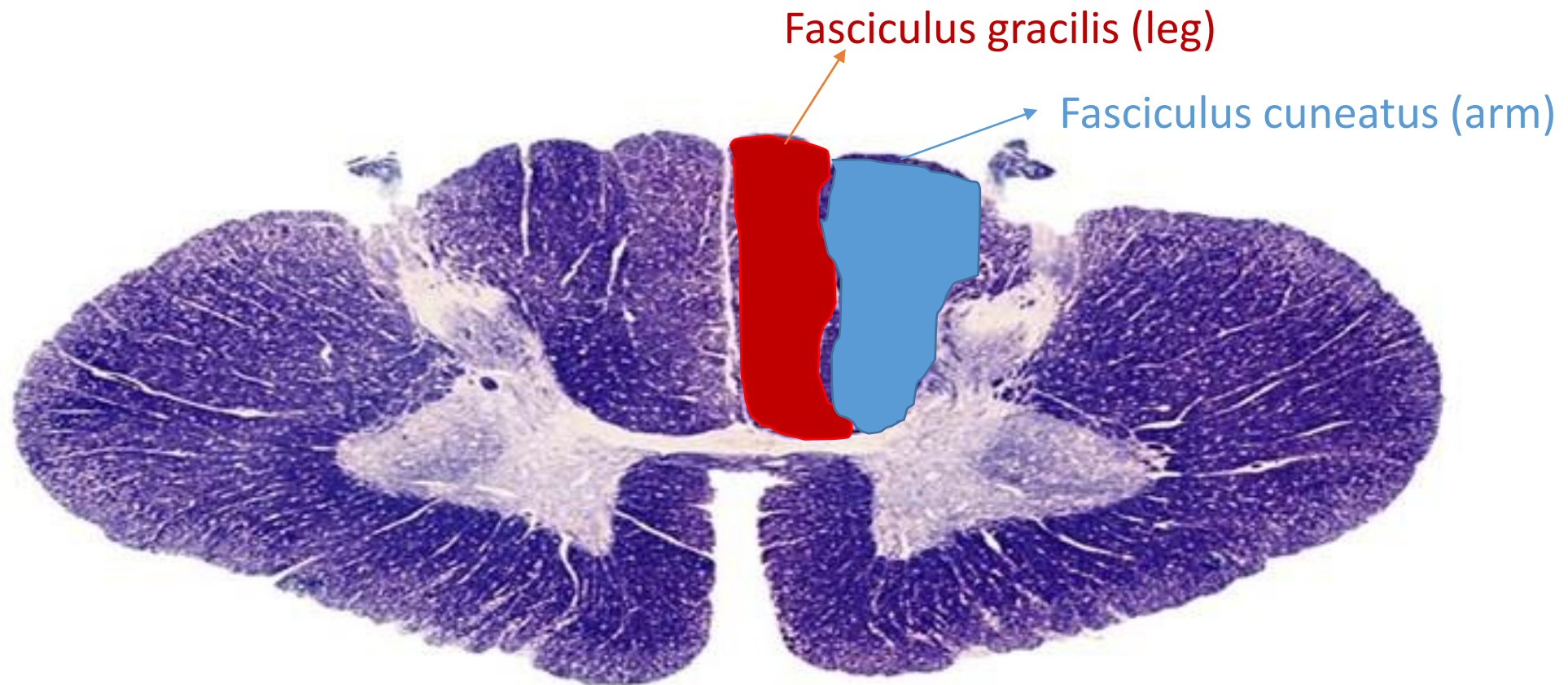
1 = Dorsal root ganglion cell

2 = Medulla

3 = Ventral postero-lateral  
nucleus (VPL) in the thalamus

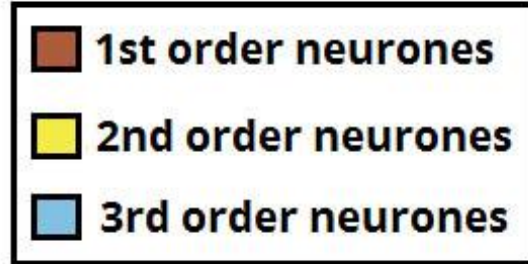
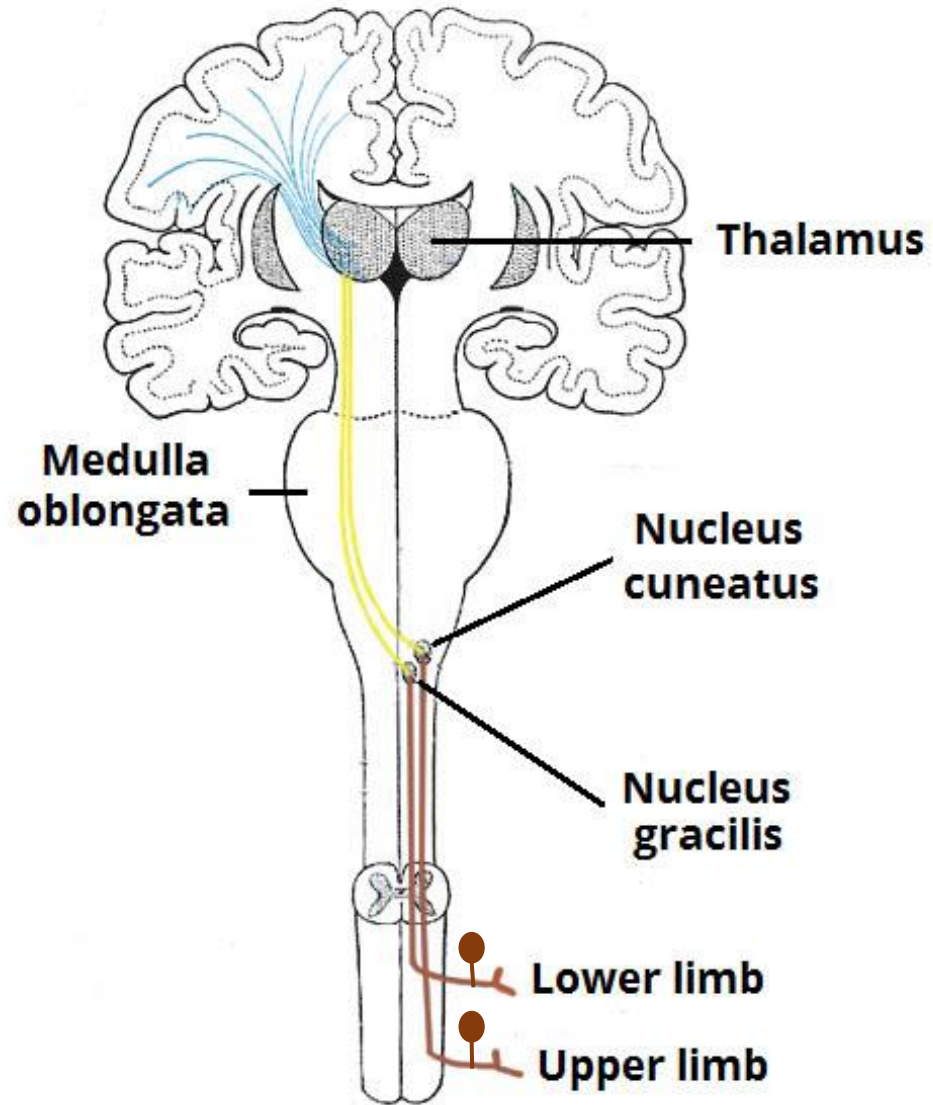


# Dorsal columns/medial lemniscal pathway



Transverse view of a cervical segment







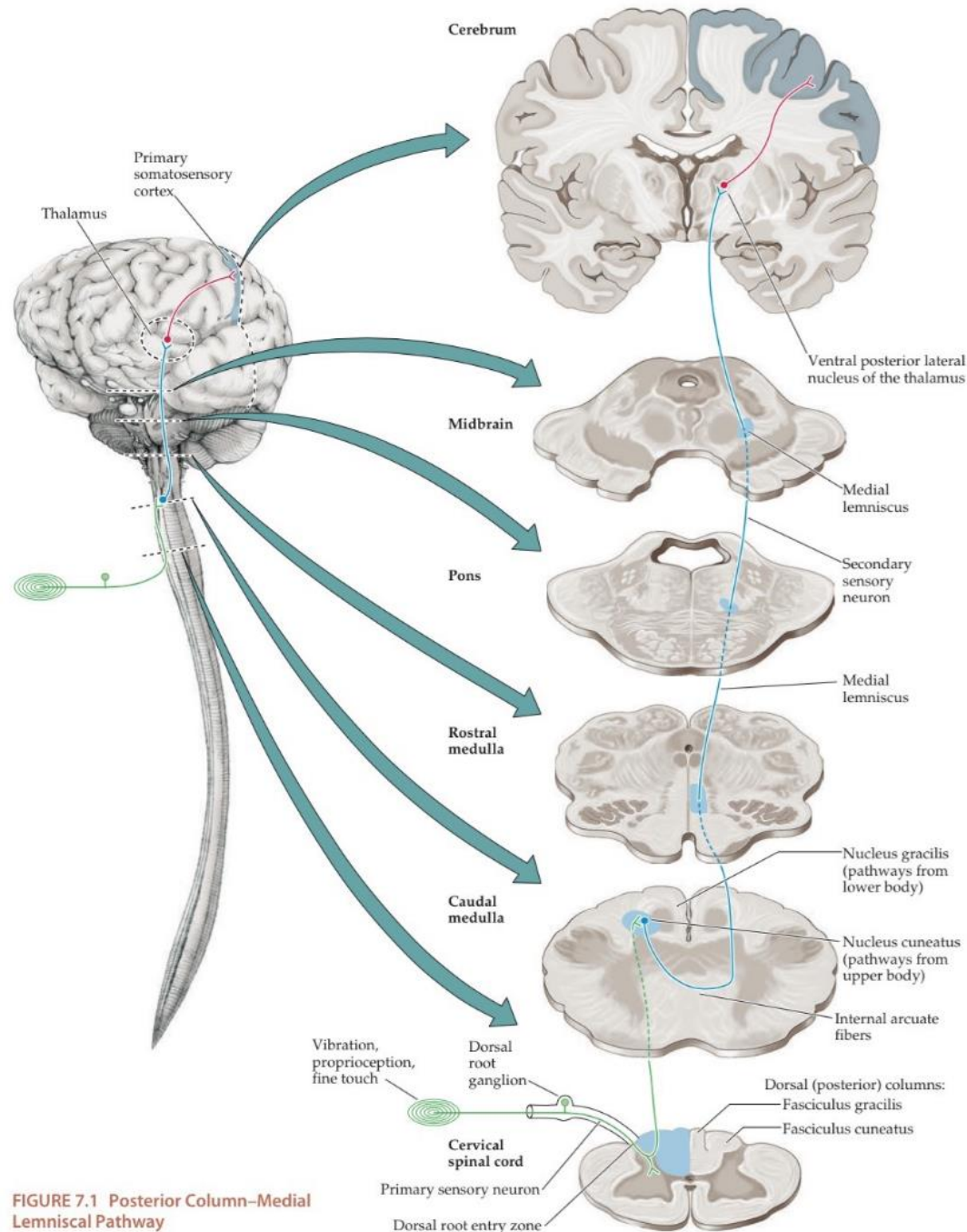


FIGURE 7.1 Posterior Column–Medial Lemniscal Pathway

## Dorsal Columns/ Medial Lemniscal System

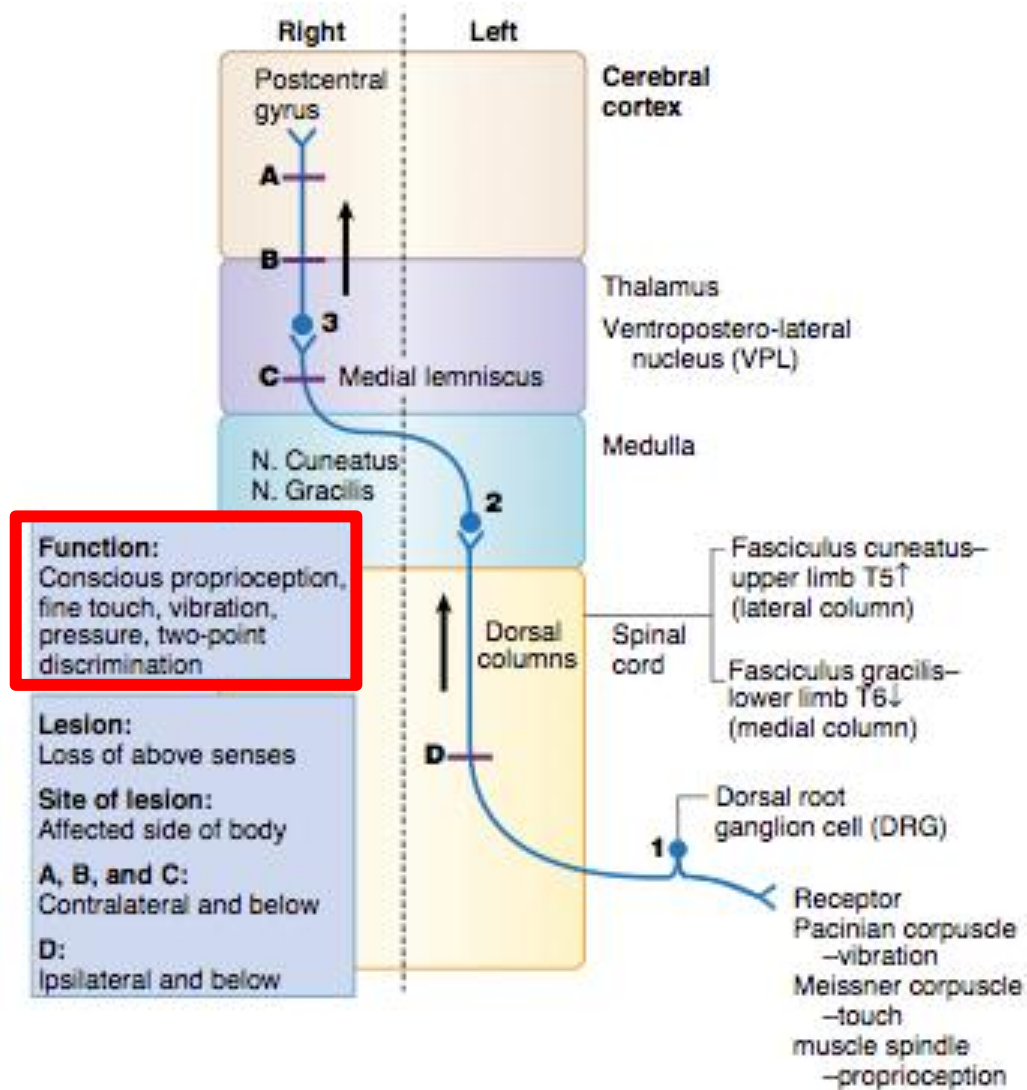
1= Dorsal root ganglion cell

Ascends as fasciculus gracilis and cuneatus

2 = nucleus cuneatus (for arm) and  
nucleus gracilis (for leg) in the medulla

Crosses as the internal arcuate fibers, then  
ascends as medial lemniscus to 3.

3 = ventral posterolateral nucleus  
(VPL) in the thalamus



## Dorsal Columns/ Medial Lemniscal System

The level of lesion dictates what sensory deficits a patient will have

# Spinothalamic/Anterolateral system

- 3-neuron sensory pathway
- Major differences compared to dorsal columns:
  - Type of information carried: pain/temperature
  - Location of 2<sup>nd</sup> neuron and site of decussation

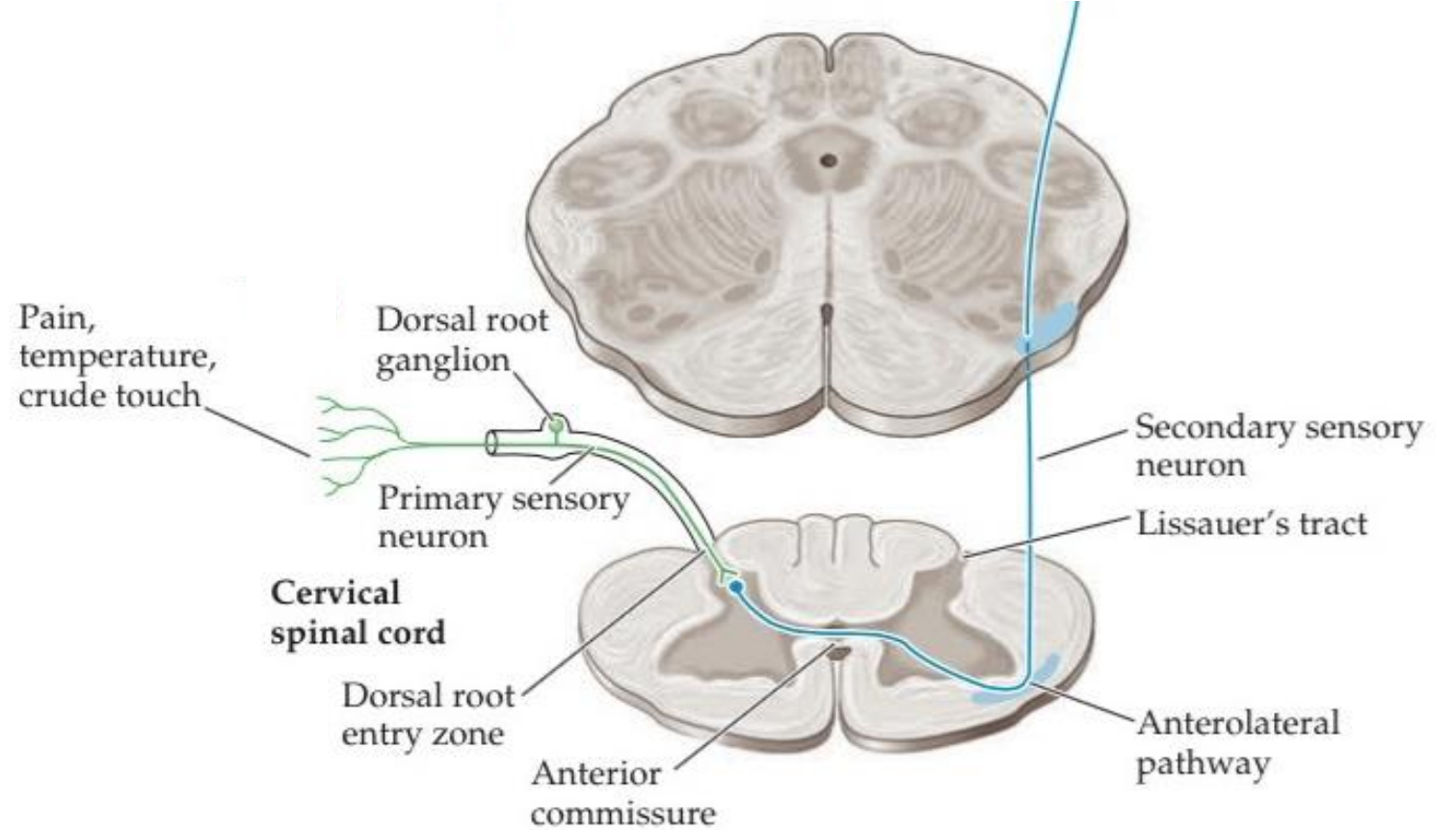
Spinothalamic/  
Anterolateral system:  
Pain and temperature

*3-neuron sensory pathway*

1 = Dorsal root ganglion cell

2 = Dorsal horn of spinal cord

3 = ventral postero-lateral nucleus  
(VPL) in the thalamus



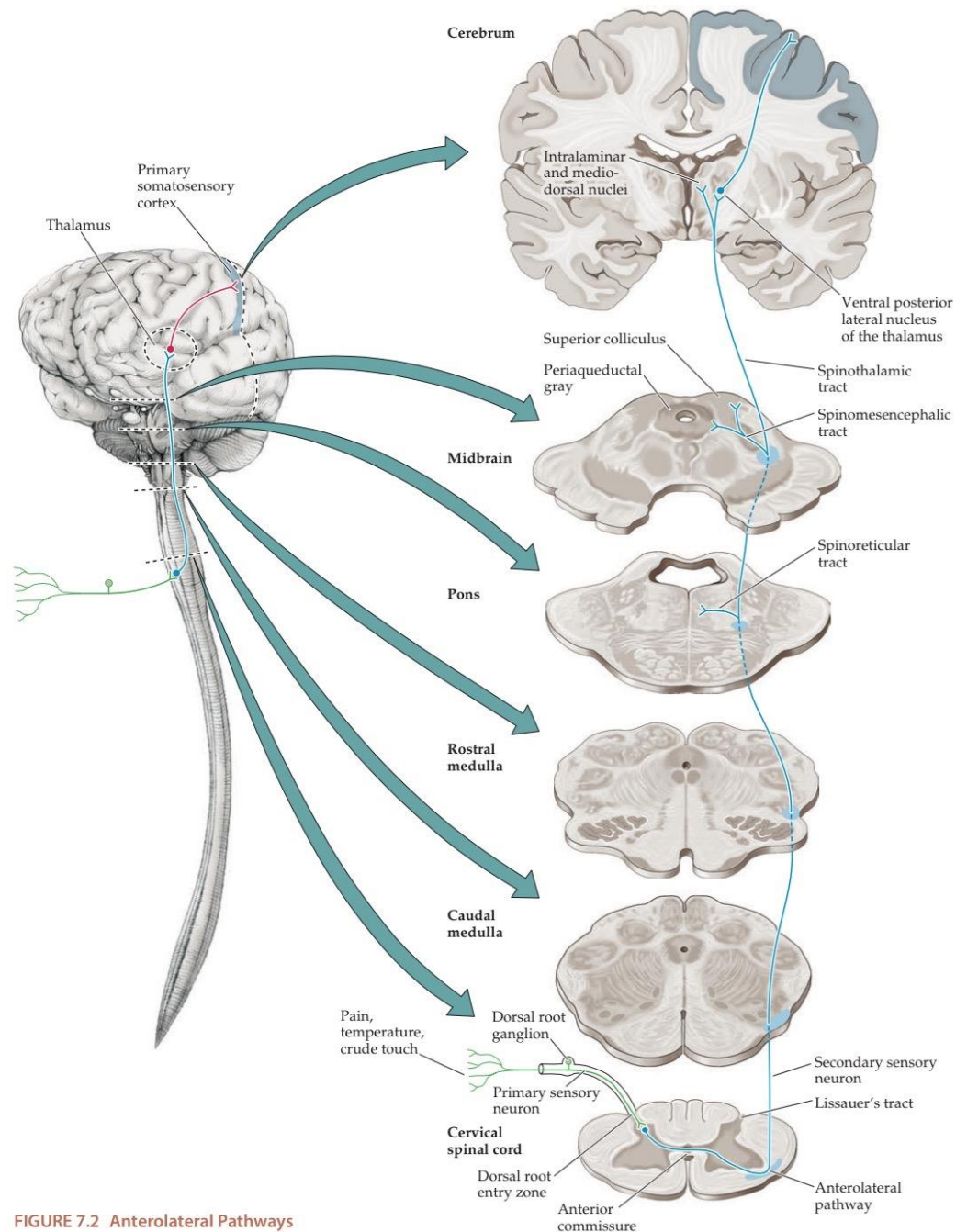


FIGURE 7.2 Anterolateral Pathways

## Spinothalamic/ Anterolateral system

1= Dorsal root ganglion cell

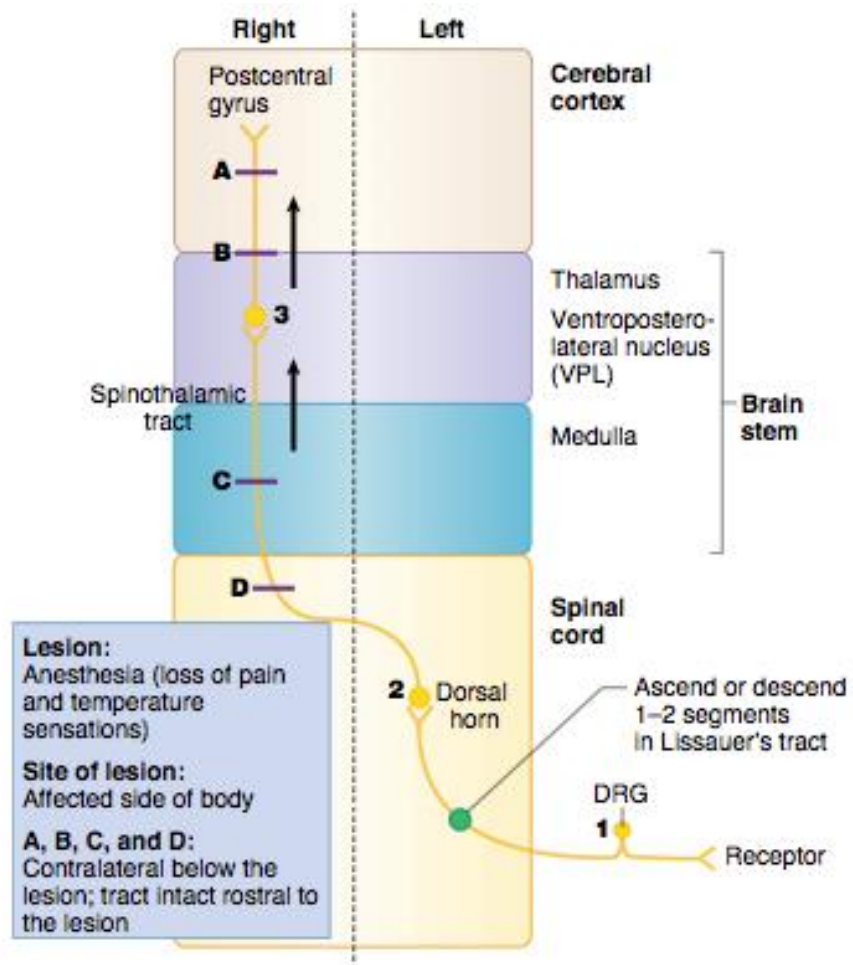
Ascend/descend in Lissauer's tract by 1-2 segments

2 = Dorsal horn of the spinal cord

Cross in anterior commissure  
Ascend in anterolateral white matter of cord

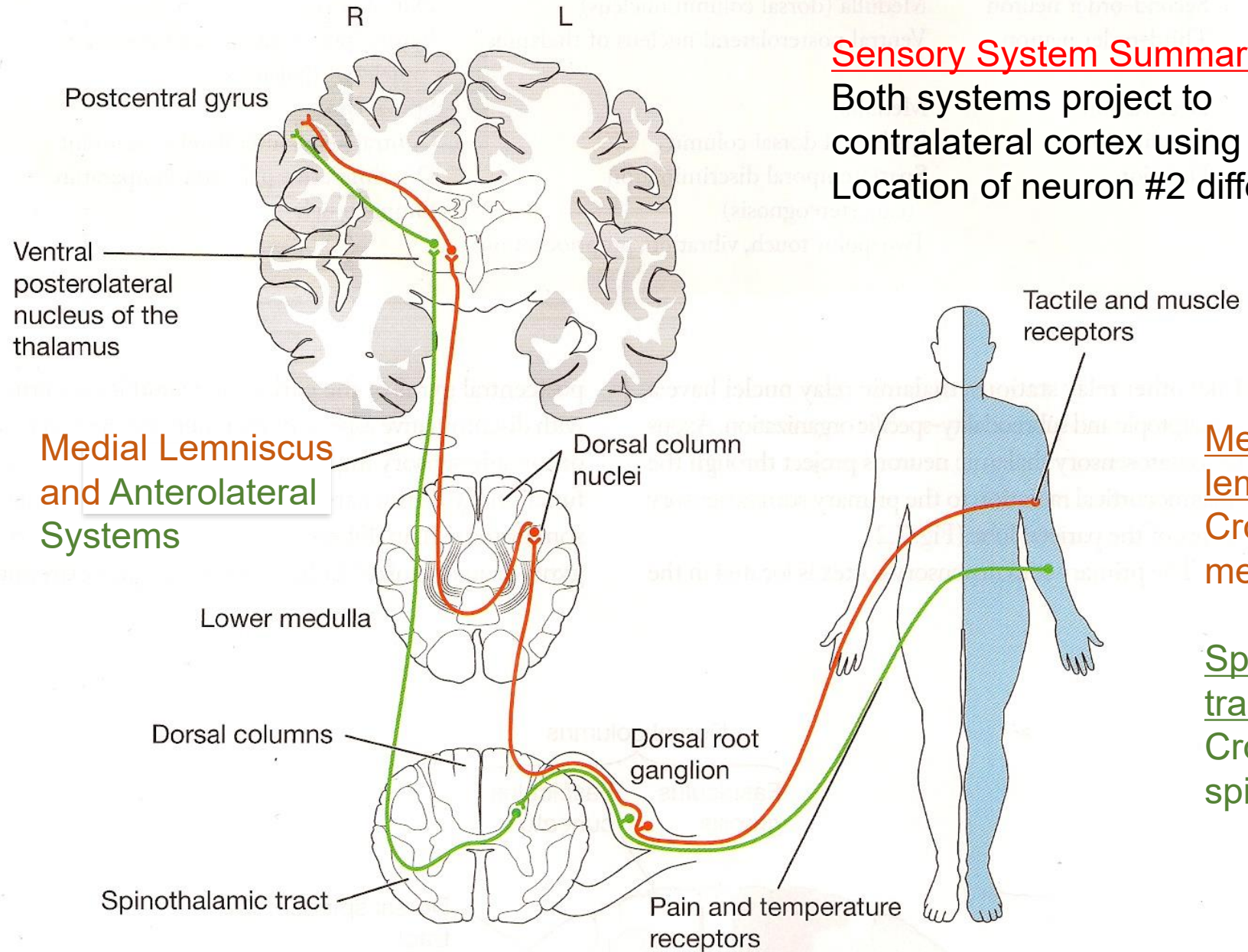
3 = ventral posterolateral nucleus  
(VPL) in the thalamus





## Anterolateral system: Pain and temperature

The level of lesion dictates what sensory deficits a patient will have



## Sensory System Summary:

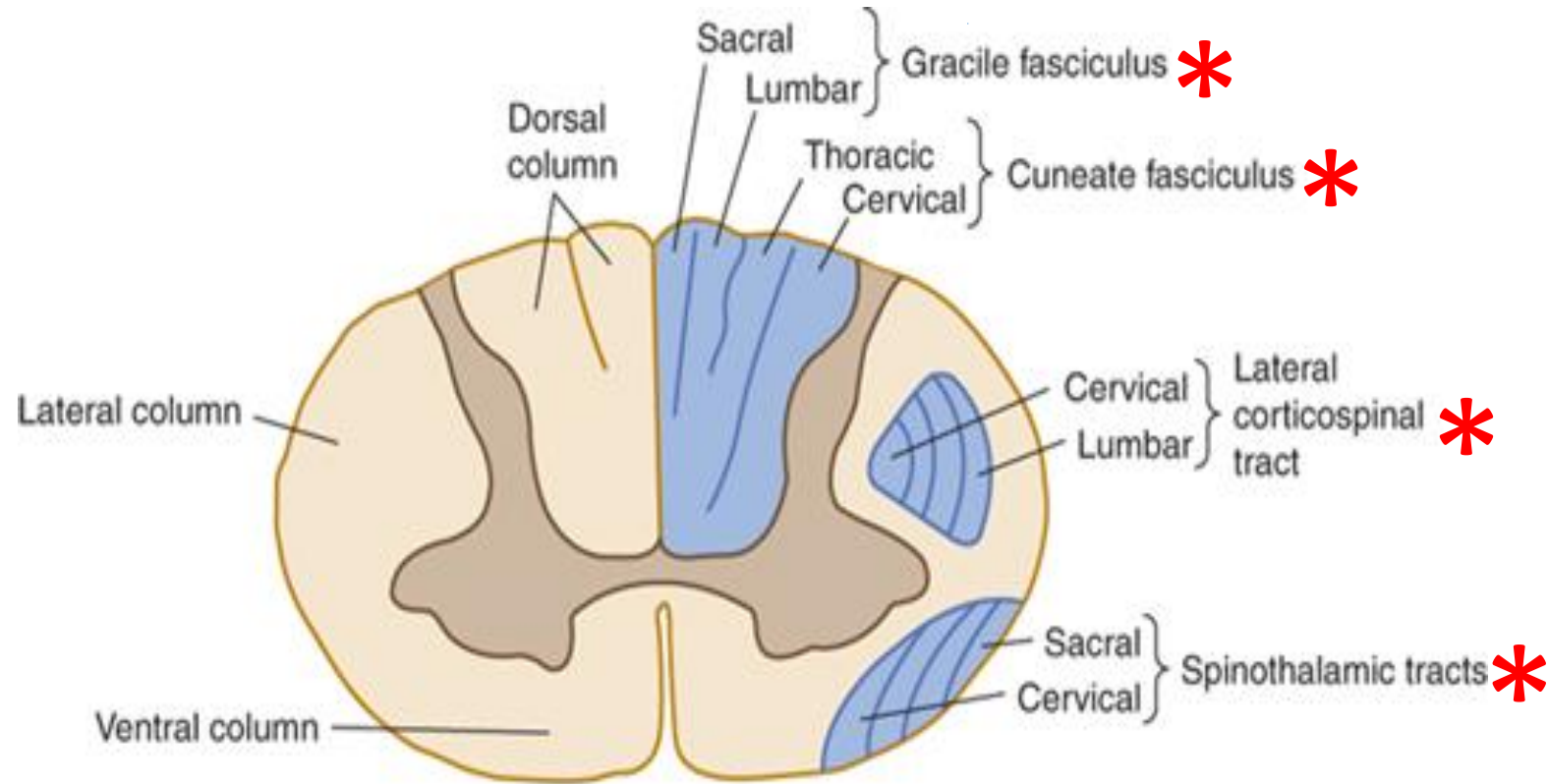
Both systems project to contralateral cortex using 3 neurons. Location of neuron #2 differs.

Medial lemniscus:  
Crosses in medulla

Spinothalamic tract:  
Crosses in spinal cord



# Spinal cord: Somatotopic organization



# Important ascending (sensory) pathways

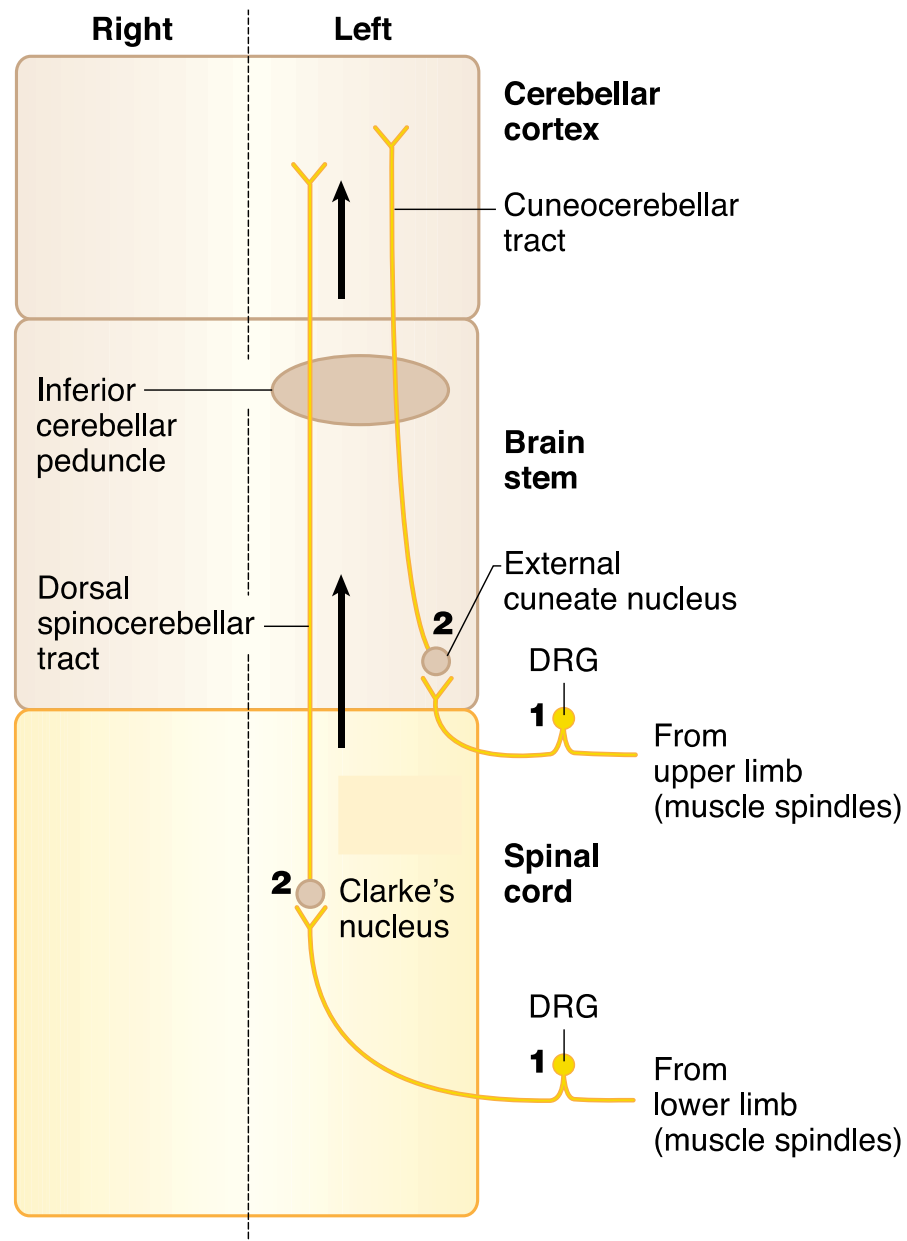
Tract	Sensation	First-order	Second-order	Third-order	Final Destination	Site of crossover
Fasciculus gracilis	Proprioception, fine touch, pressure, and vibration from levels inferior to T6	Dorsal root ganglia	Nucleus gracilis (medulla)	Ventral posterolateral nucleus (VPL) of thalamus	Primary sensory cortex contralateral to sensory stimulus	Medulla
Fasciculus cuneatus	Proprioception, fine touch, pressure, and vibration from levels at or superior to T6	Dorsal root ganglia	Nucleus cuneatus (medulla)	VPL of thalamus	Primary sensory cortex contralateral to sensory stimulus	Medulla
Spinothalamic tracts	Pain, temperature	Dorsal root ganglia	In dorsal horn	VPL of thalamus	Primary sensory cortex contralateral to sensory stimulus	Within 1-2 segments of level of dorsal root entry
Dorsal spinocerebellar tract						
Cuneocerebellar tract						

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# Spinocerebellar pathways

- 2-neuron system
- Carries limb position sensation to same-side (ipsilateral) cerebellum
- “Unconscious”
- Dorsal spinocerebellar tract = for leg
- Cuneocerebellar tract = for arm



### Cuneocerebellar tract (arm)

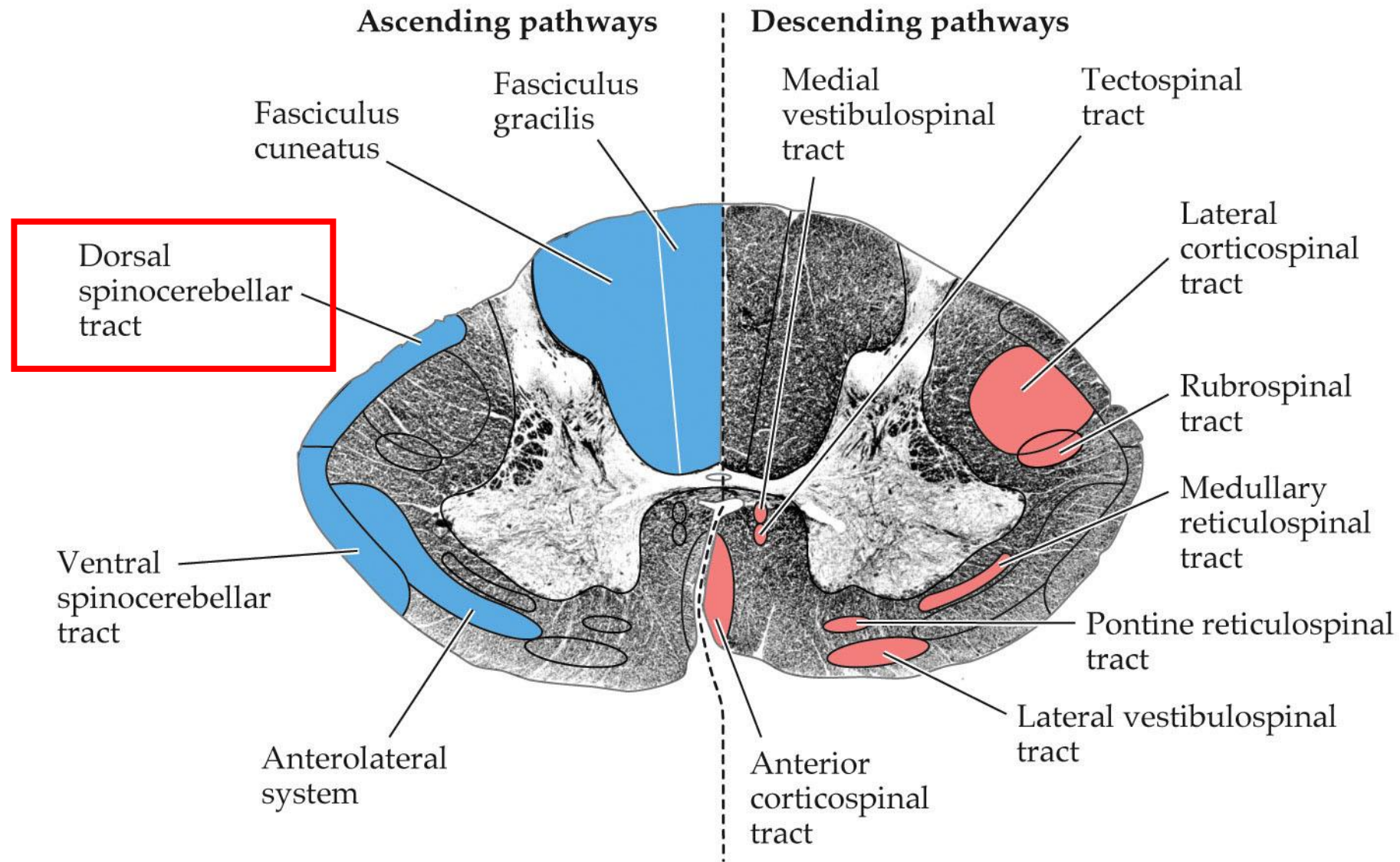
1 = Dorsal root ganglion (DRG) cell  
 2 = Medulla (accessory cuneate nucleus, aka external or lateral cuneate nucleus)

### Dorsal spinocerebellar tract (leg)

1 = Dorsal root ganglion cell  
 2 = Intermediate zone of spinal cord ("Clarke's nucleus" aka nucleus dorsalis, T1 to L2 spinal cord segments)

- Both tracts stay ipsilateral
- Both travel to cerebellum via ICP (inferior cerebellar peduncle)



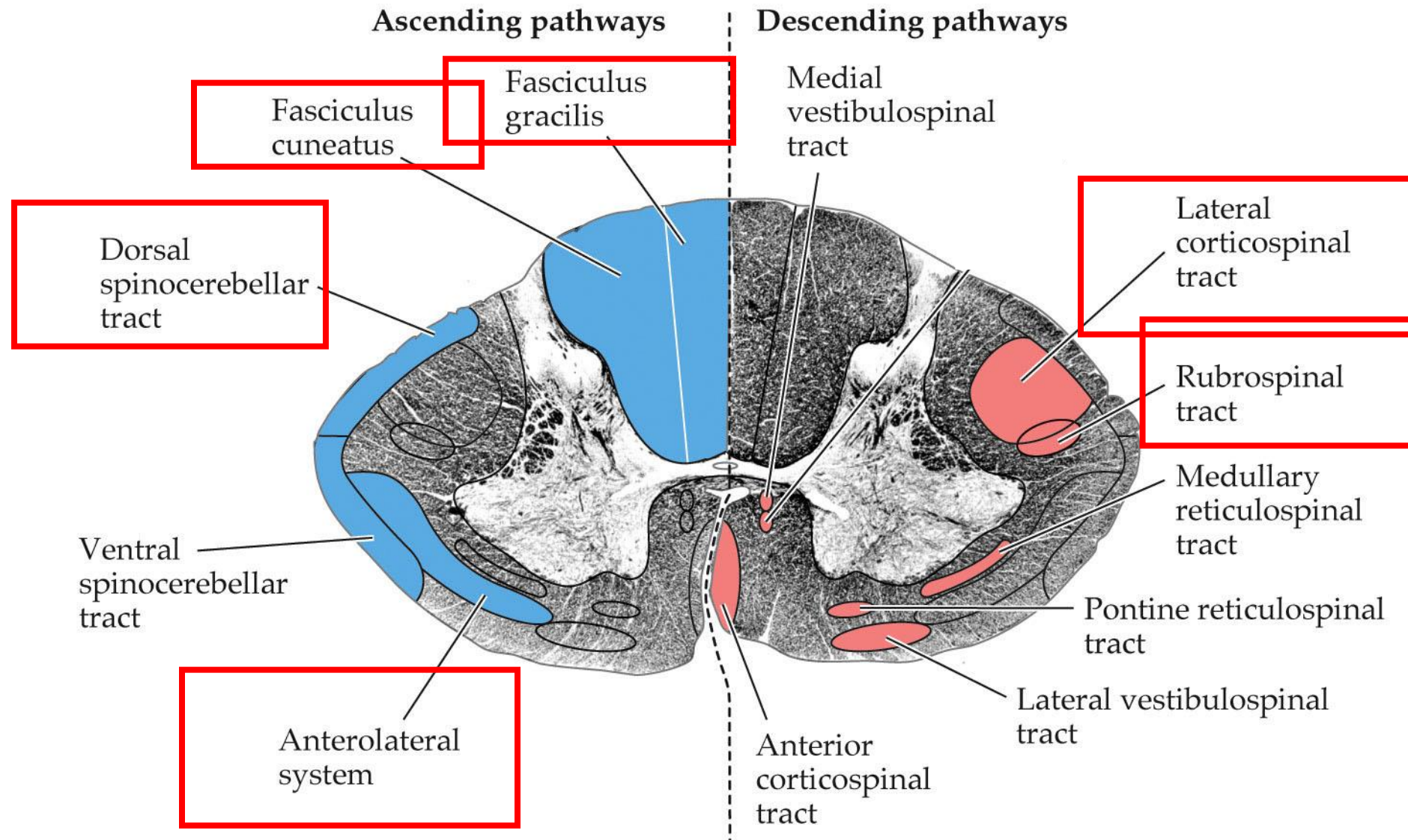


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Where are their cell bodies and where do their axons project?



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Spinothalamic tracts	Pain, temperature	Dorsal root ganglia	In dorsal horn	VPL of thalamus	Primary sensory cortex contralateral to sensory stimulus	Within 1-2 segments of level of dorsal root entry
Dorsal spinocerebellar tract	Proprioception	Dorsal root ganglia	Clarke's nucleus/Clarke's column (from T1-L2)	None	Ipsilateral cerebellar cortex	None
Cuneocerebellar tract	Proprioception	Dorsal root ganglia	Lateral cuneate nucleus (medulla) - Aka accessory cuneate nucleus or external cuneate nucleus	None	Ipsilateral cerebellar cortex	None