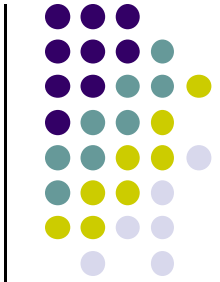
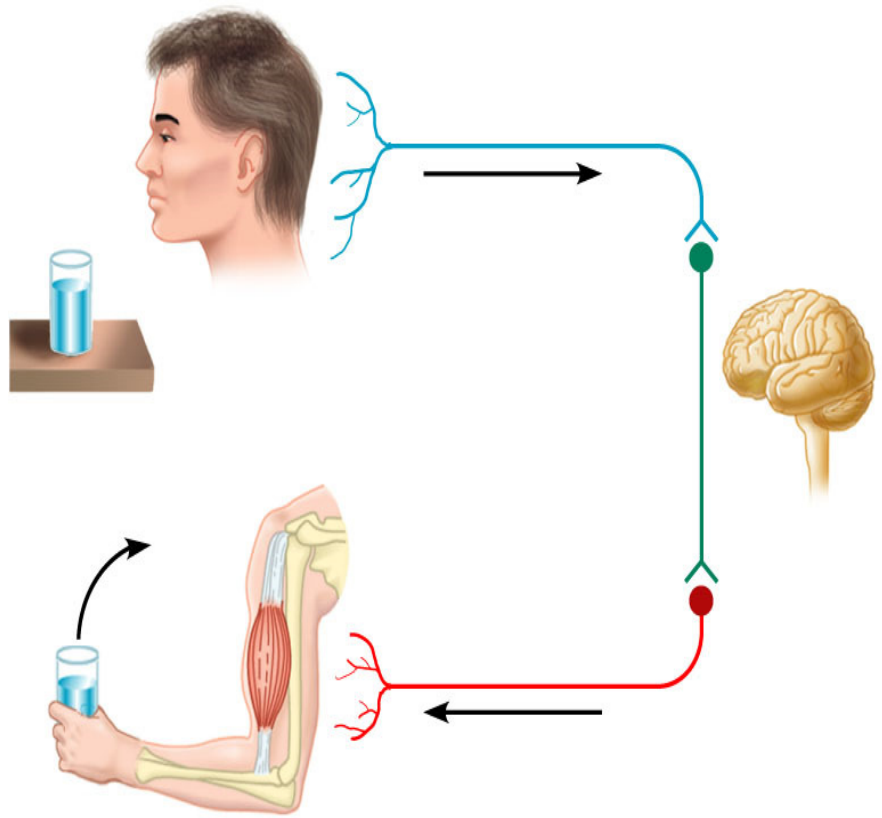
# The Nervous System



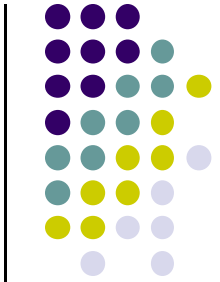
- A network of billions of nerve cells linked together in a highly organized fashion to form the rapid control center of the body.

# Basic Functions of the Nervous System

1. Sensation
   - Monitors changes/events occurring in and outside the body. Such changes are known as *stimuli* and the cells that monitor them are *receptors*.
2. Integration
   - The parallel processing and interpretation of sensory information to determine the appropriate response
3. Reaction
   - Motor output.
     - The activation of muscles or glands (typically via the release of neurotransmitters (NTs))

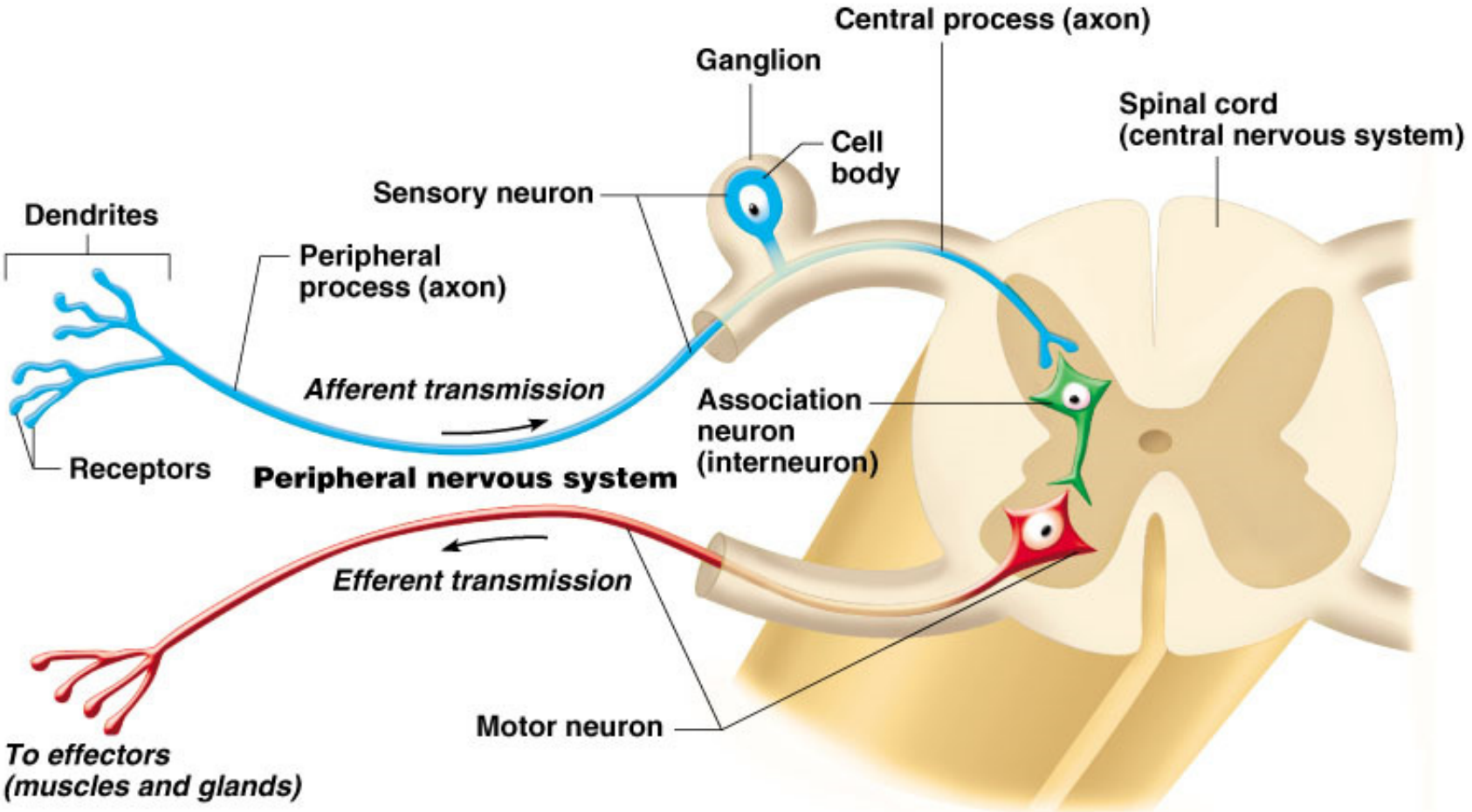


# Nervous Tissue



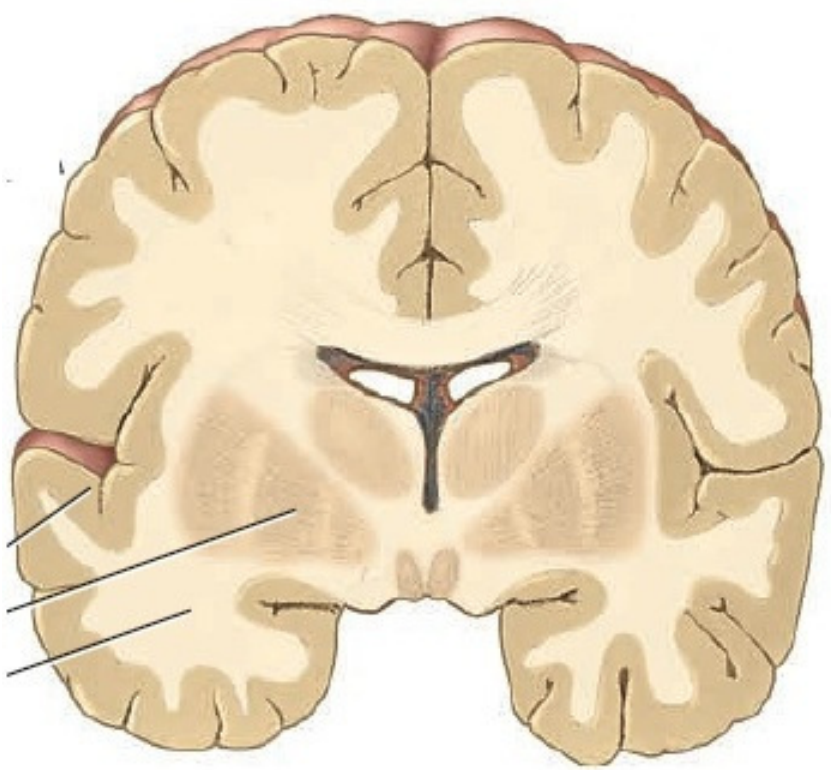
- Highly cellular
- 2 cell types
  1. Neurons
     - Functional, signal conducting cells
     - Do not divide
     - Long lived
     - High metabolic activity
     - Electrically excitable
  2. Neuroglia
     - Support, nourish, and protect neurons
     - Divide
     - Smaller cells but they greatly outnumber neurons by about 5 to 50
     - 6 types of supporting cells: (4 are found in the CNS, and 2 are found in the PNS.

# Functional Classification of Neurons

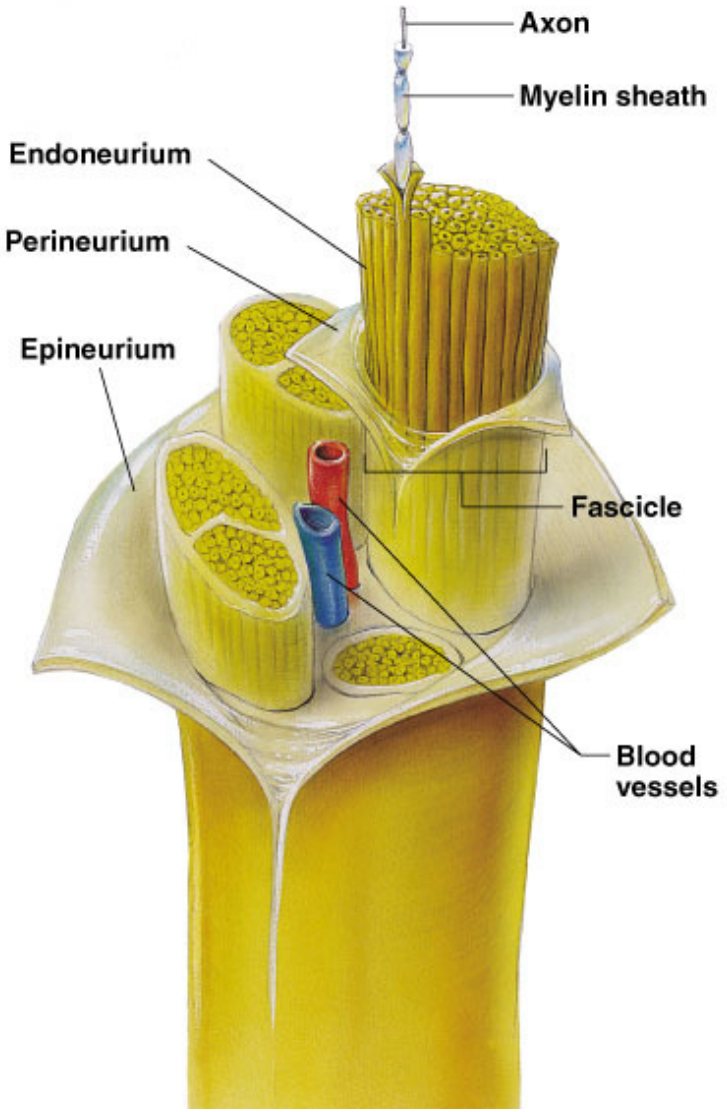


- **White matter:** aggregations of myelinated and unmyelinated axons of many neurons
- **Gray matter:** contains neuronal cell bodies, dendrites, unmyelinated axons, axon terminals, and neuroglia

▪**Nerves**: Bundles of processes in the PNS
▪**Tracts**: Bundles of processes in the CNS (No Connective tissue)
▪**Ganglion**: cluster of nerve cell bodies in PNS
▪**Nucleus**: cluster of nerve cell bodies in CNS (surrounded by white matter)
➢ If not surrounded (Cortex)

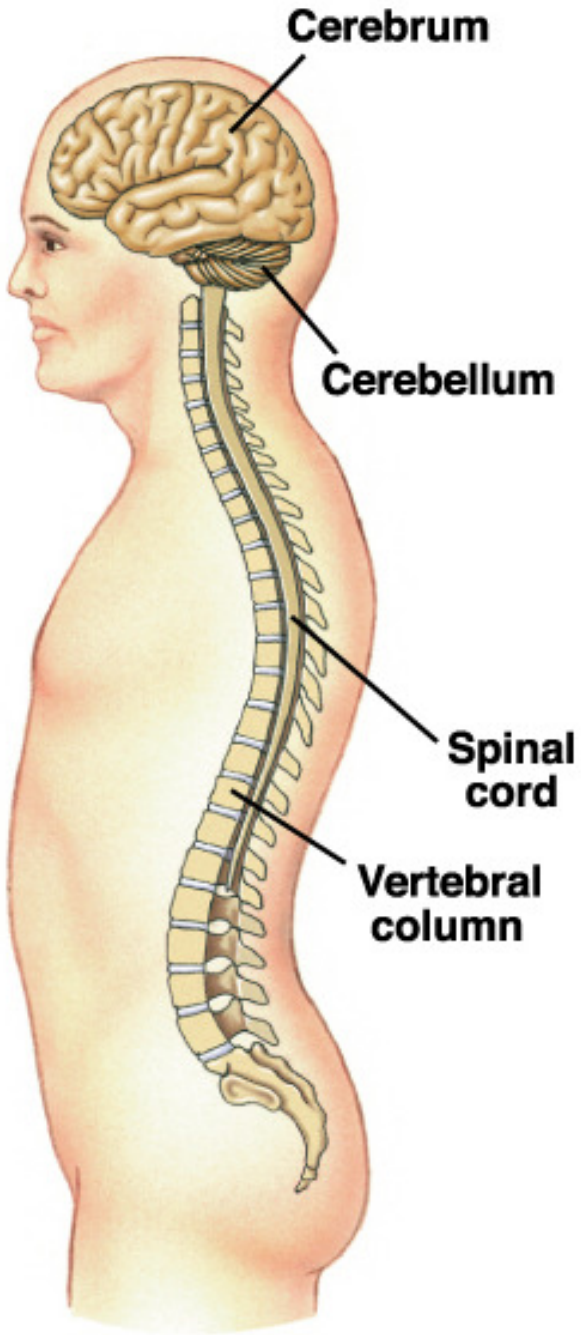


- A bundle of processes in the PNS is a **nerve**.
- Within a nerve, each axon is surrounded by an **endoneurium**
- Groups of fibers are bound together into bundles (fascicles) by a **perineurium**
- All the fascicles of a nerve are enclosed by a **epineurium**



# Organization of the Nervous System

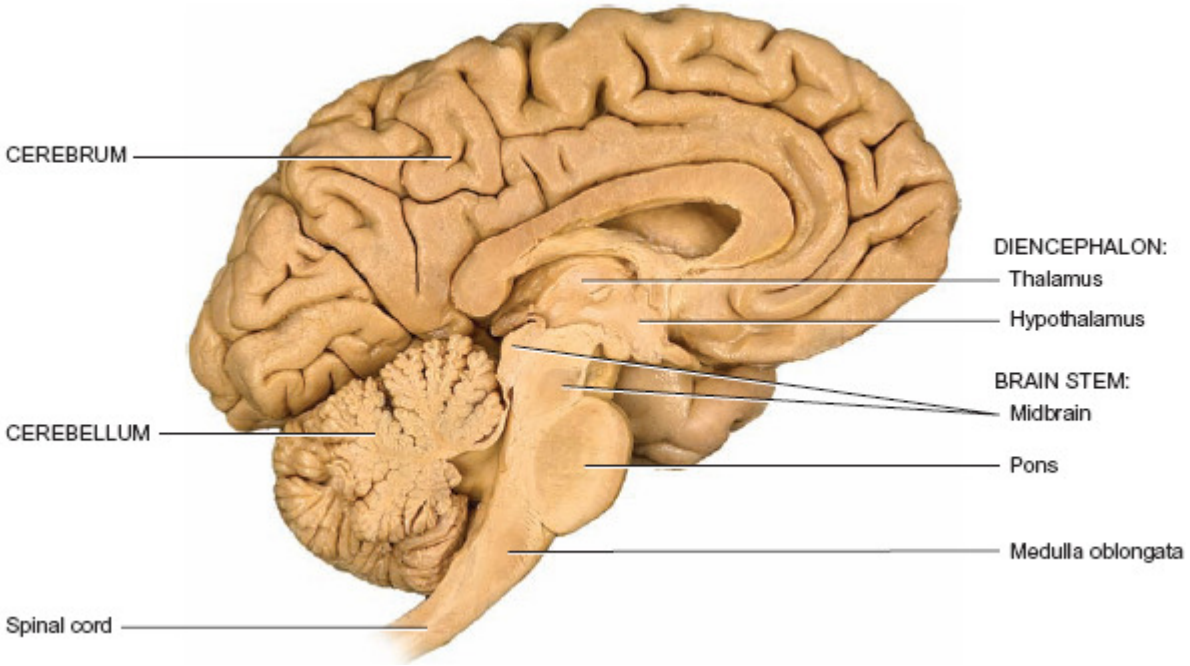
- Anatomical divisions:
  1. Central Nervous System
     - The brain + the spinal cord
       - The center of integration and control
  2. Peripheral Nervous System
     - The nervous system outside of the brain and spinal cord
     - Consists of:
       - 31 Spinal nerves
         - Carry info to and from the spinal cord
       - 12 Cranial nerves
         - Carry info to and from the brain



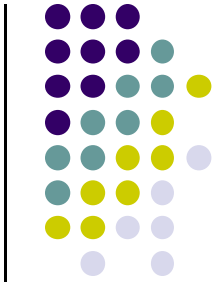
# Brain

- **Forebrain**: (Prosencephalon)
  - Cerebrum: (Telencephalon)
  - Diencephalon
    - Thalamus
    - Hypothalamus
    - Epithalamus
    - Subthalamus
- **Midbrain:**

  (Mesencephalon)
- **Hindbrain**: (Rhombencephalon)
  - Pons
  - Medulla oblingata
  - Cerebellum

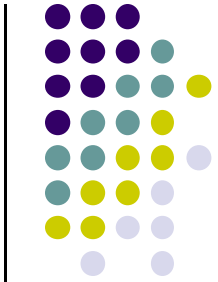


# Peripheral Nervous System



- Responsible for communication between the CNS and the rest of the body.
- Can be divided into:
  - Sensory Division
    - Afferent division
      - Conducts impulses from receptors to the CNS
      - Informs the CNS of the state of the body interior and exterior
      - Sensory nerve fibers can be **somatic** (from skin, skeletal muscles or joints) or **visceral** (from organs within the body cavity)
  - Motor Division
    - Efferent division
      - Conducts impulses from CNS to effectors (muscles/glands)
      - Motor nerve fibers

# Peripheral Nervous System

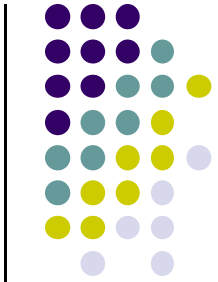


- Somatic nervous system

1) Sensory neurons: (*somatic sensory neurons)*
   - convey information to the CNS from sensory receptors in the skin, skeletal muscles, and joints, and from the receptors for the special senses.

2) Motor neurons: (*somatic motor neurons)*
   - VOLUNTARY
   - conduct impulses from the CNS to skeletal muscles

# Peripheral Nervous System



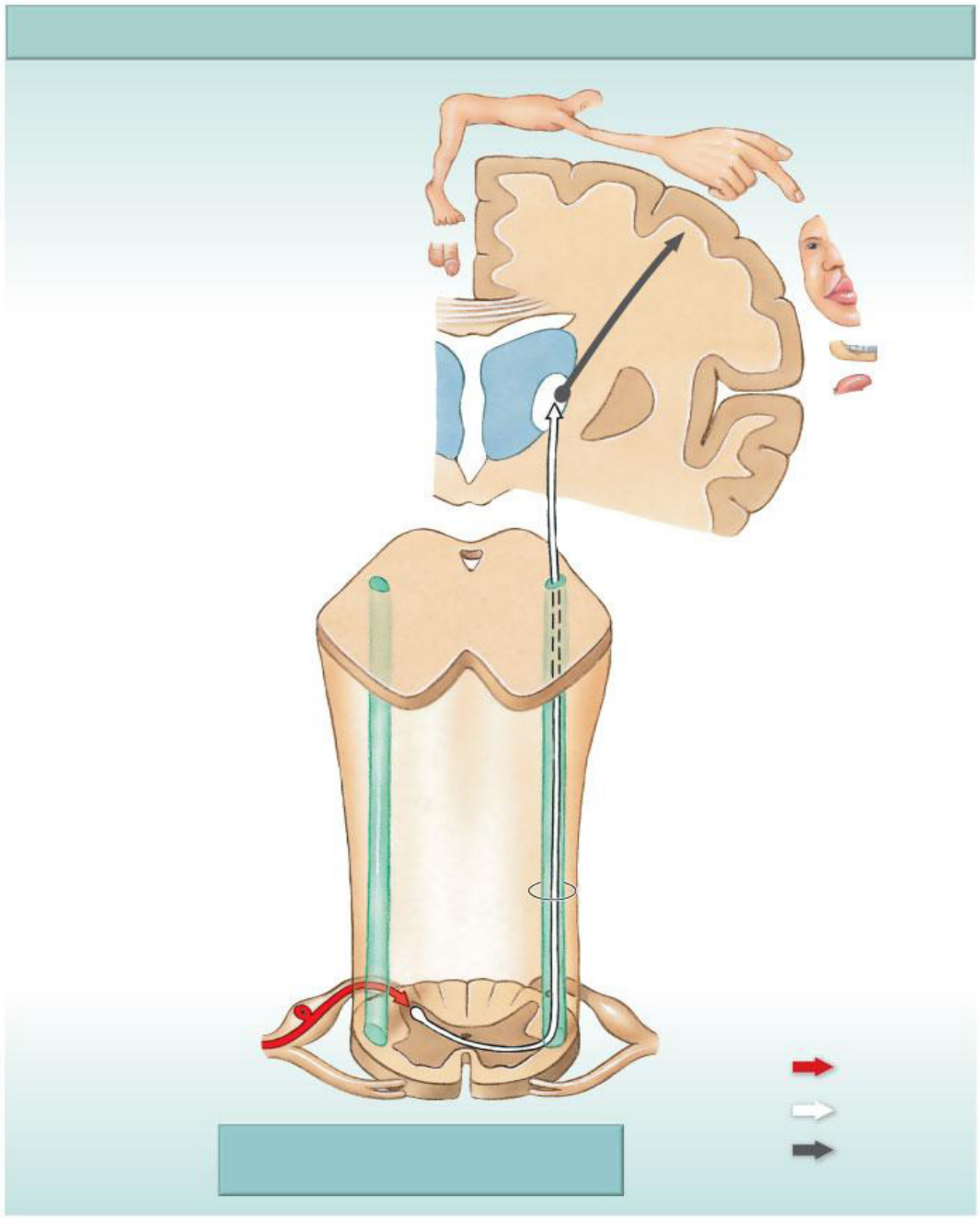
- Autonomic nervous system

1) Sensory neurons: Autonomic (visceral) sensory neurons

convey information to the CNS from autonomic sensory receptors, located primarily in the visceral organs (smooth muscle organs in the thorax, abdomen,and pelvis)

2) Motor neurons: Autonomic motor neurons

- INVOLUNTARY (generally)
- Conducts impulses from the CNS to smooth muscle, cardiac muscle, and glands.



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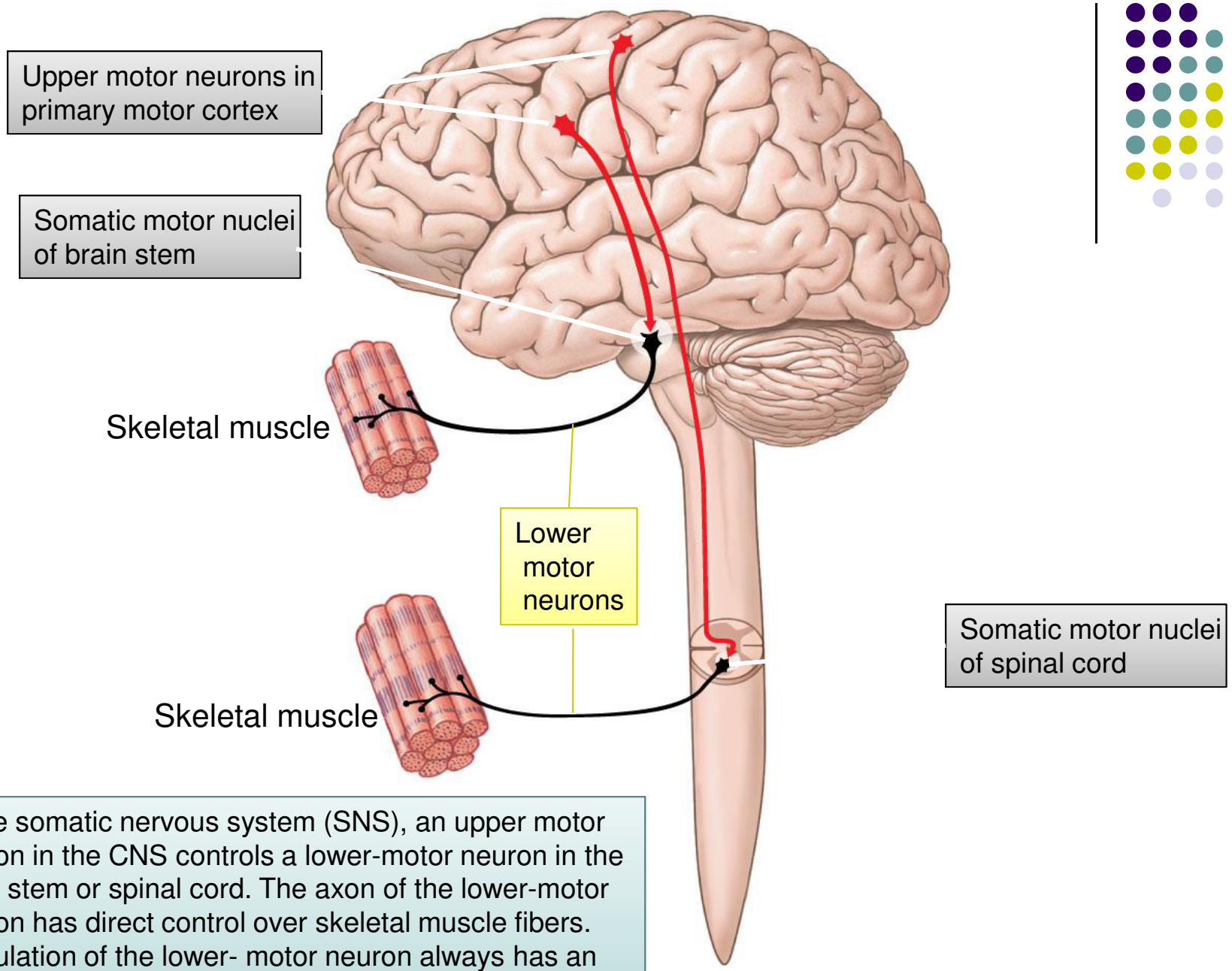
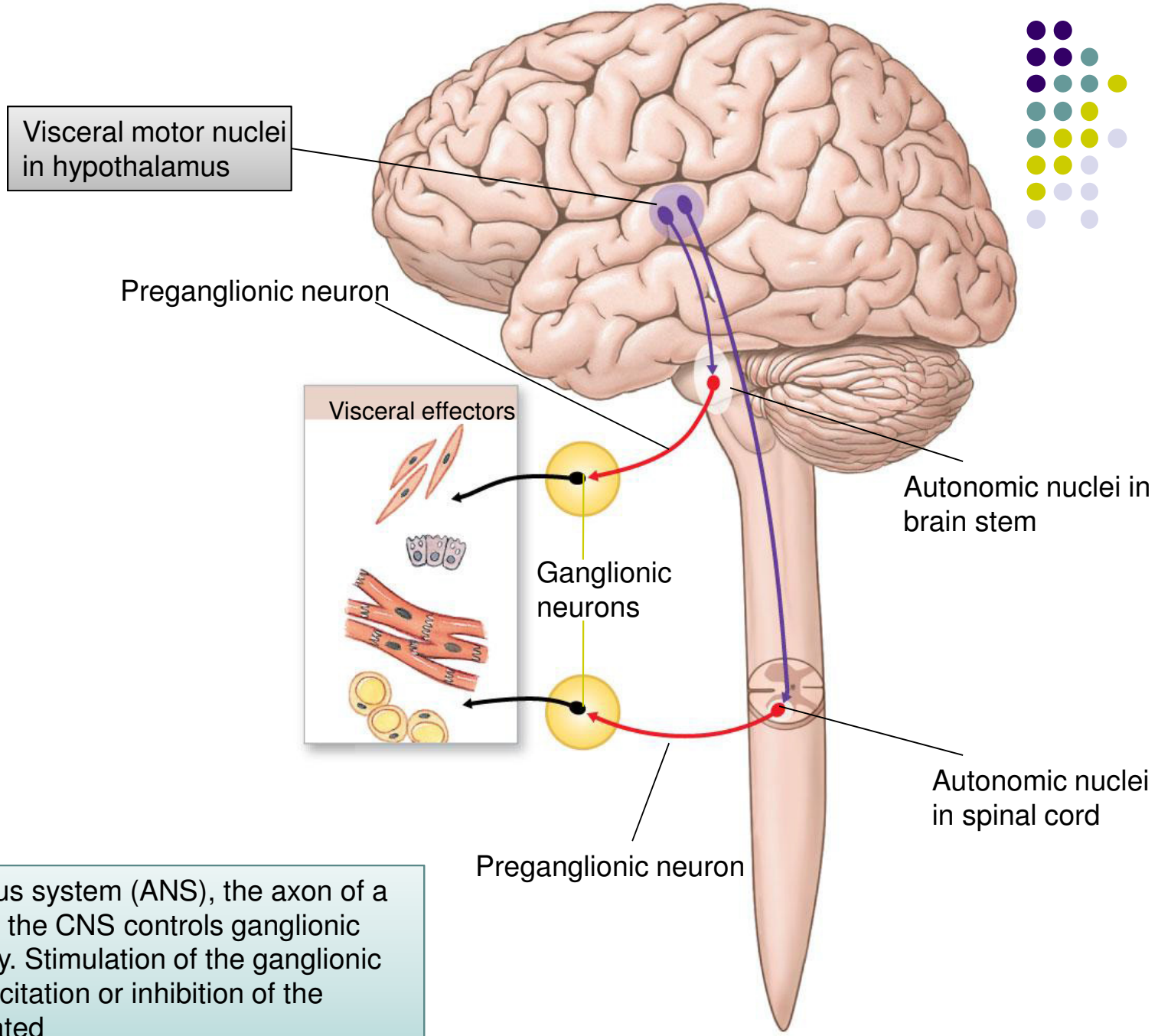


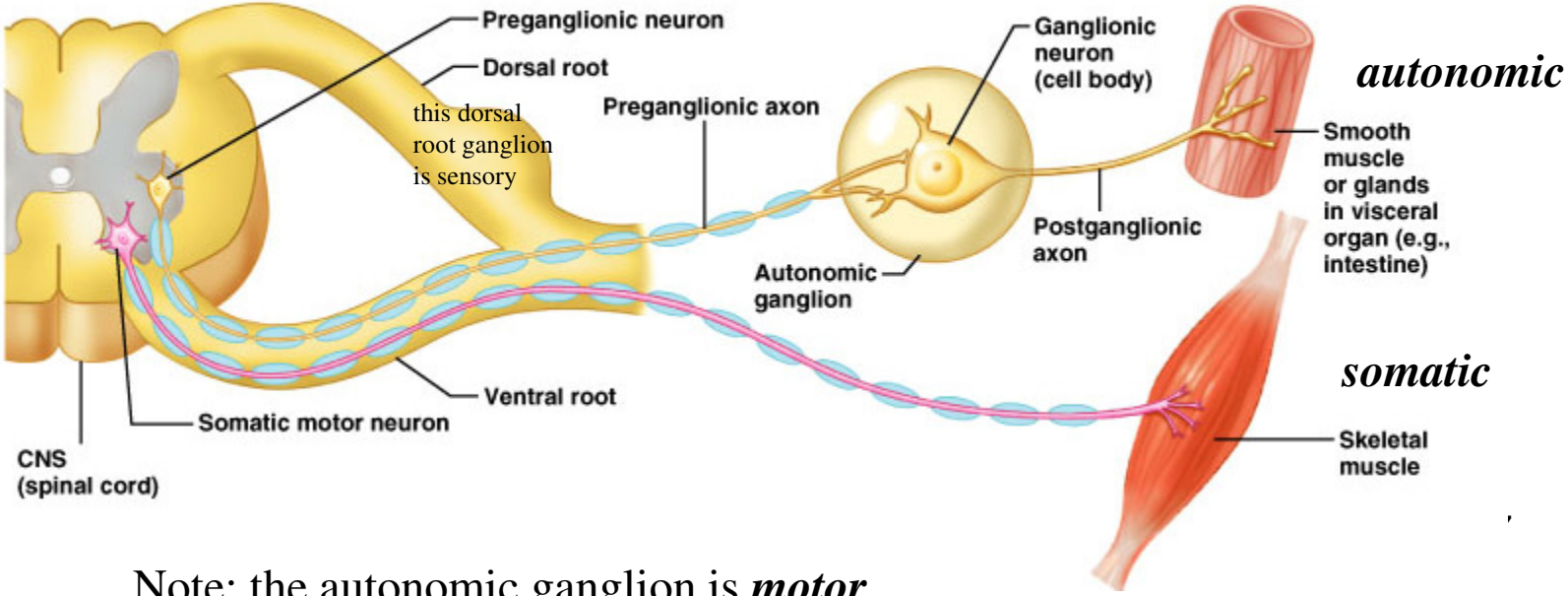

In the somatic nervous system (SNS), an upper motor neuron in the CNS controls a lower-motor neuron in the brain stem or spinal cord. The axon of the lower-motor neuron has direct control over skeletal muscle fibers. Stimulation of the lower- motor neuron always has an excitatory effect on the skeletal muscle fibers.




In the autonomic nervous system (ANS), the axon of a preganglionic neuron in the CNS controls ganglionic neurons in the periphery. Stimulation of the ganglionic neurons may lead to excitation or inhibition of the visceral effector innervated

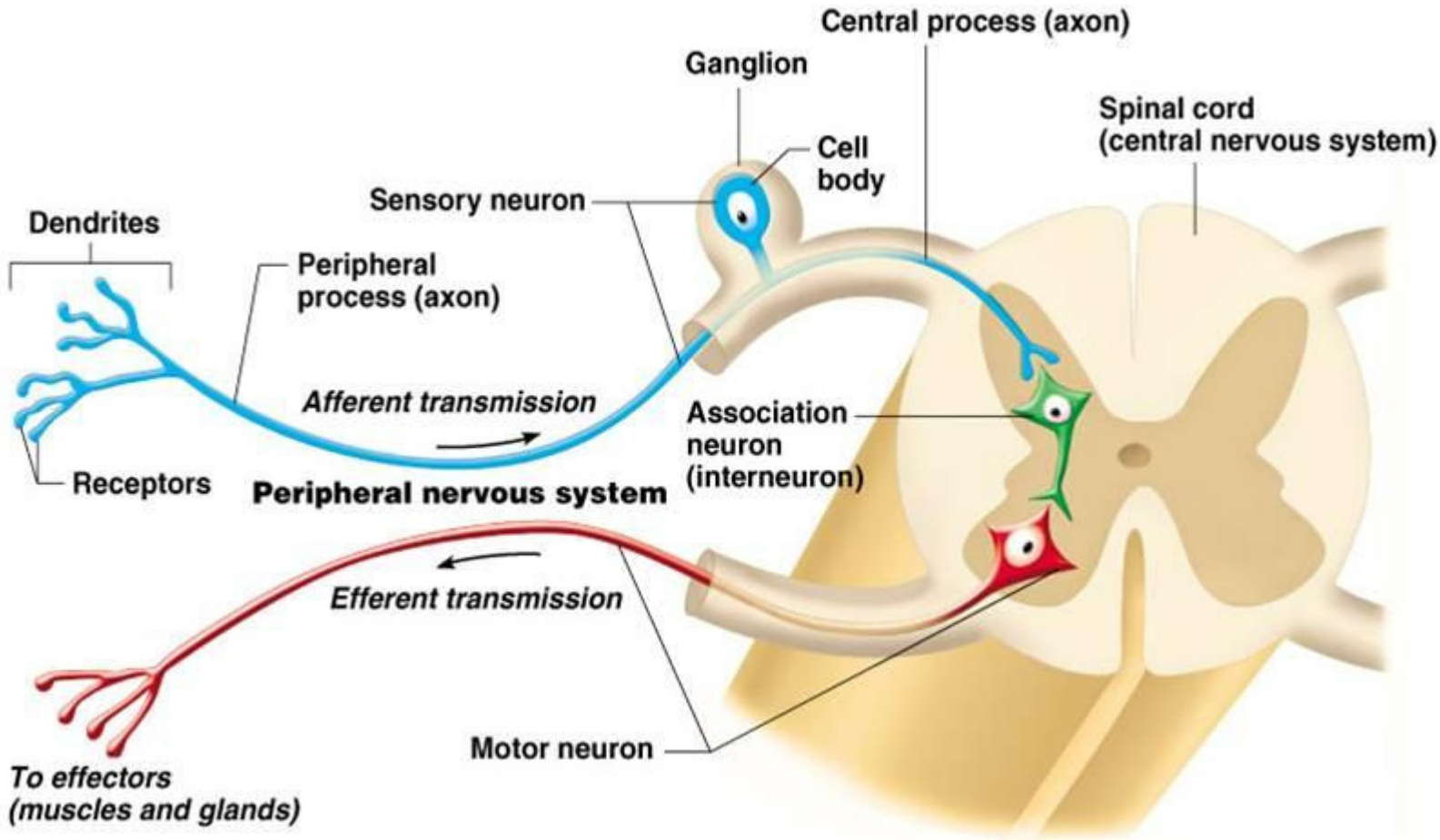
- Axon of 1st (*preganglionic*) neuron leaves CNS to synapse with the 2nd (*ganglionic*) neuron
- Axon of 2nd (*postganglionic*) neuron extends to the organ it serves

Diagram contrasts somatic (lower) and autonomic:




Note: the autonomic ganglion is ***motor***

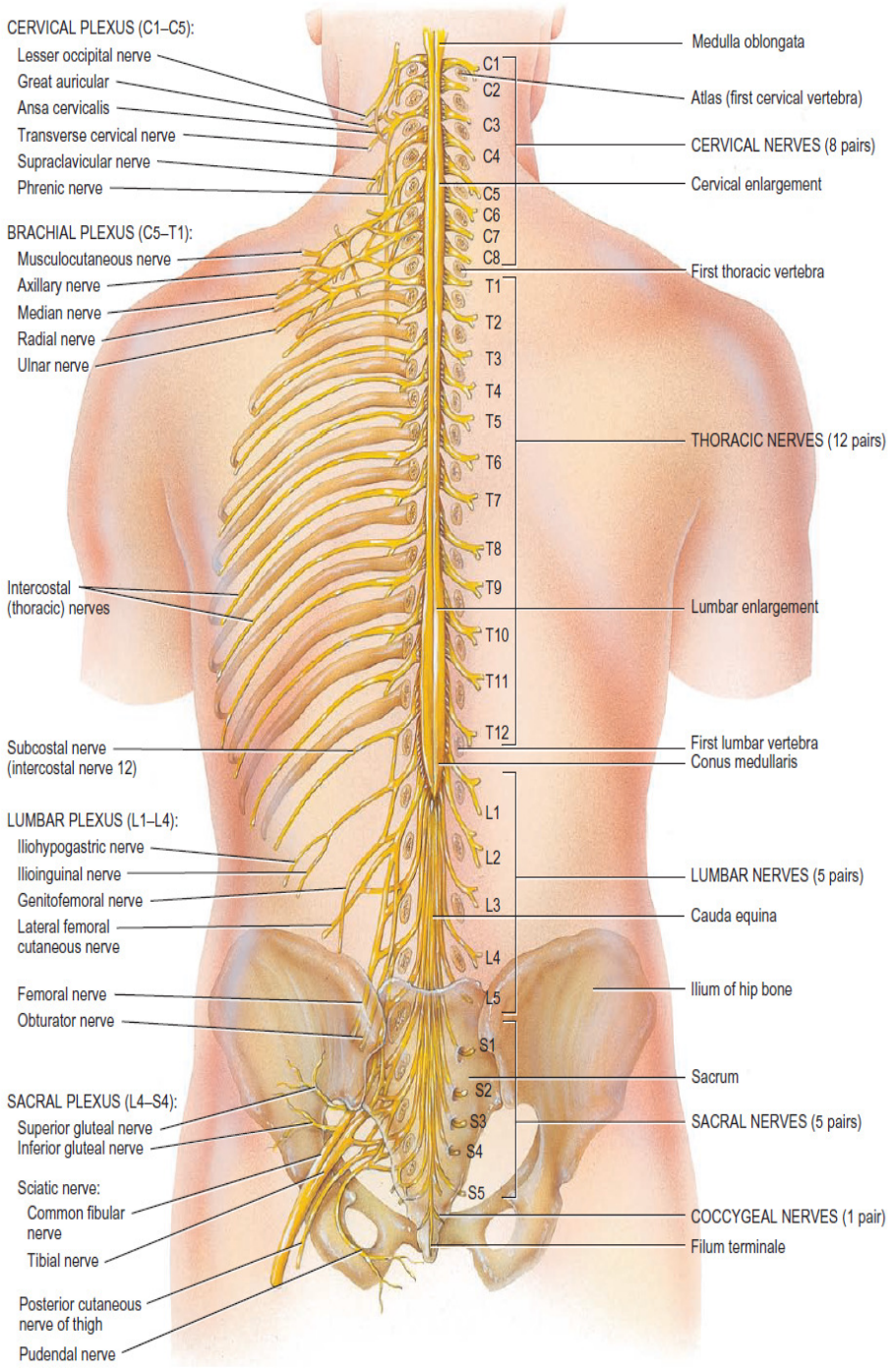
# Sensory ganglion




Ganglion cells in dorsal root ganglia do not receive synapses

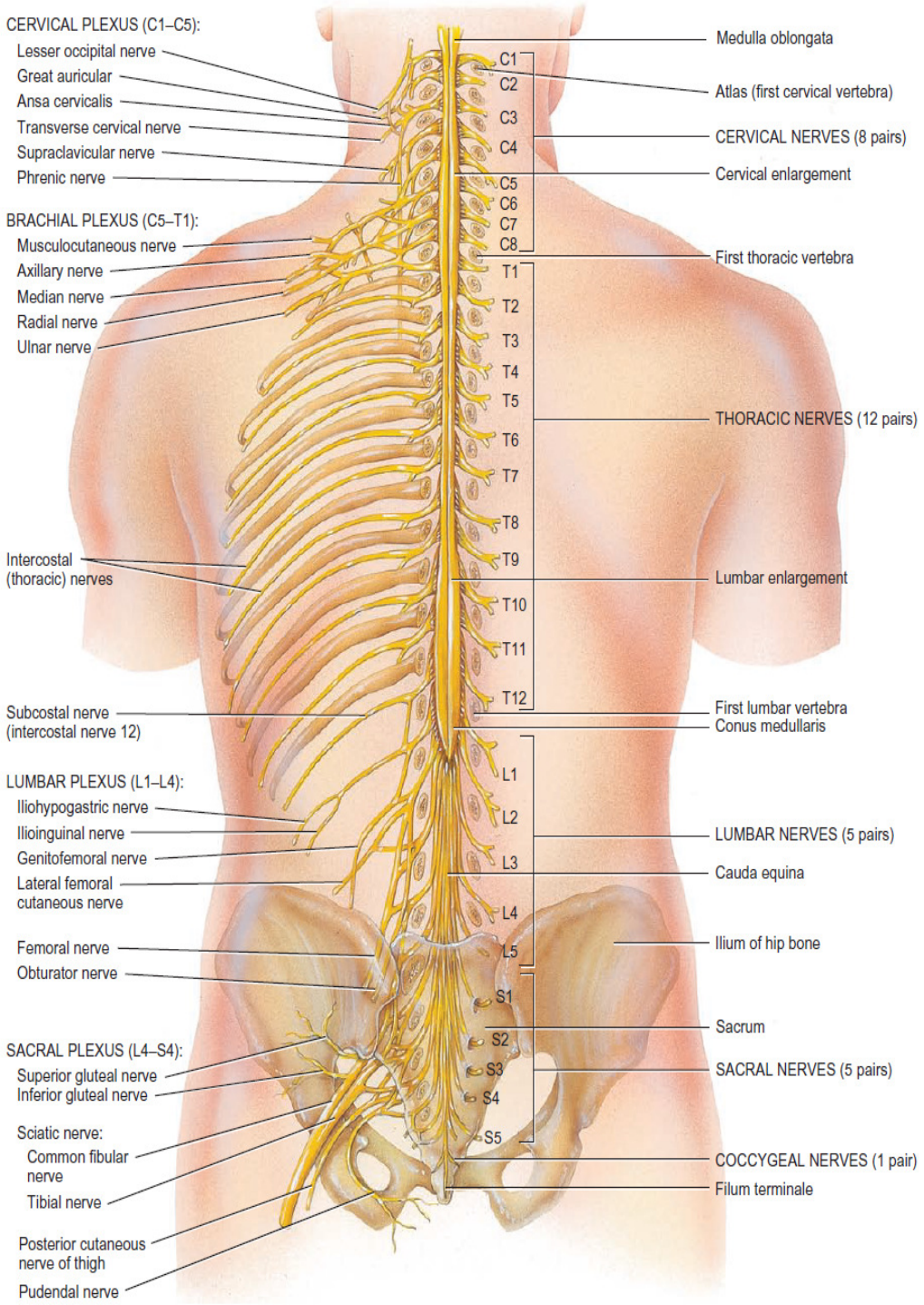
# External anatomy of Spinal Cord

- Runs through the vertebral canal
- Extends from foramen magnum to second lumbar vertebra
- Regions
  - Cervical (8)
  - Thoracic (12)
  - Lumbar (5)
  - Sacral (5)
  - Coccygeal (1)
- Gives rise to (31) pairs of spinal nerves
  - All are *mixed* nerves
- Not uniform in diameter
  - Cervical enlargement: supplies upper limbs
  - Lumbar enlargement: supplies lower limbs



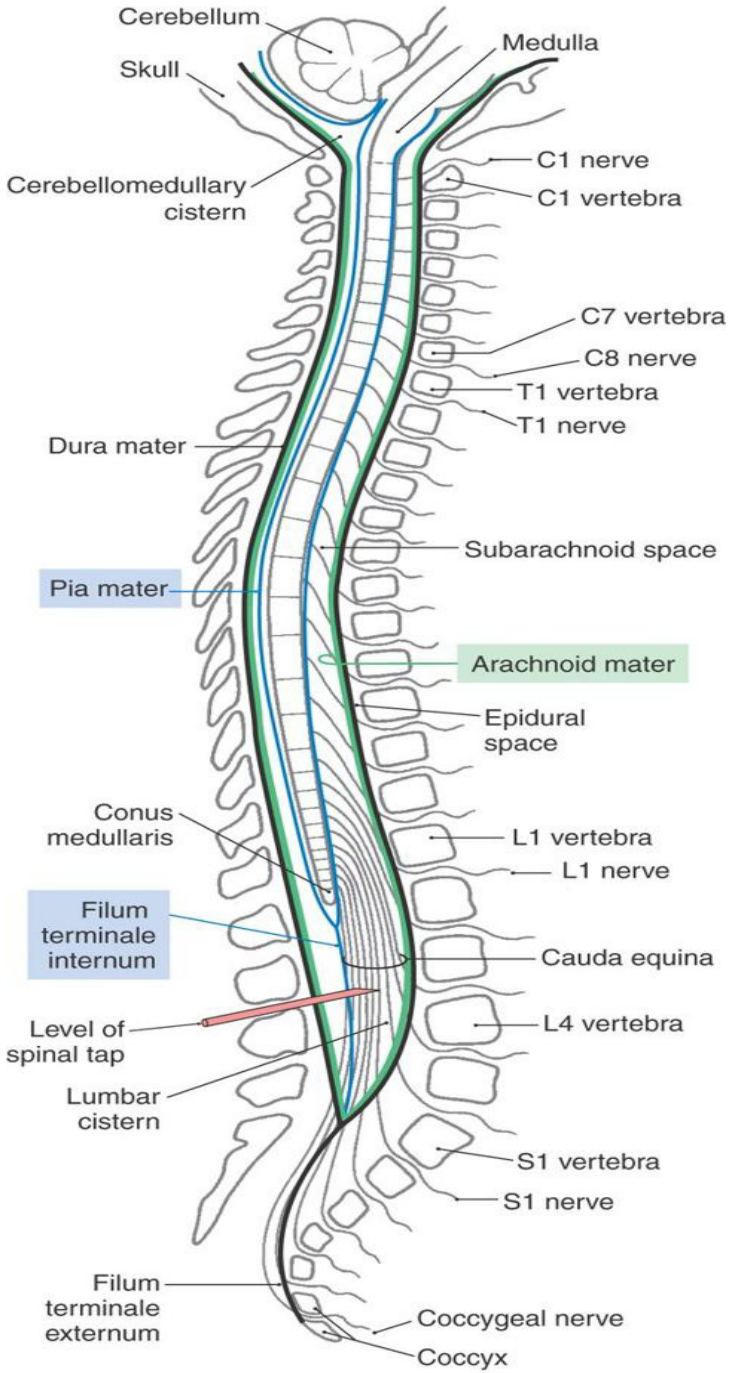
# External anatomy of Spinal Cord

- Flattened slightly anteriorly and posteriorly
- length of the adult spinal cord ranges from 42 to 45 cm
- Conus medullaris- tapered inferior end (conical structure)
  - Ends between L1 and L2
- Cauda equina - origin of spinal nerves extending inferiorly from conus medullaris.



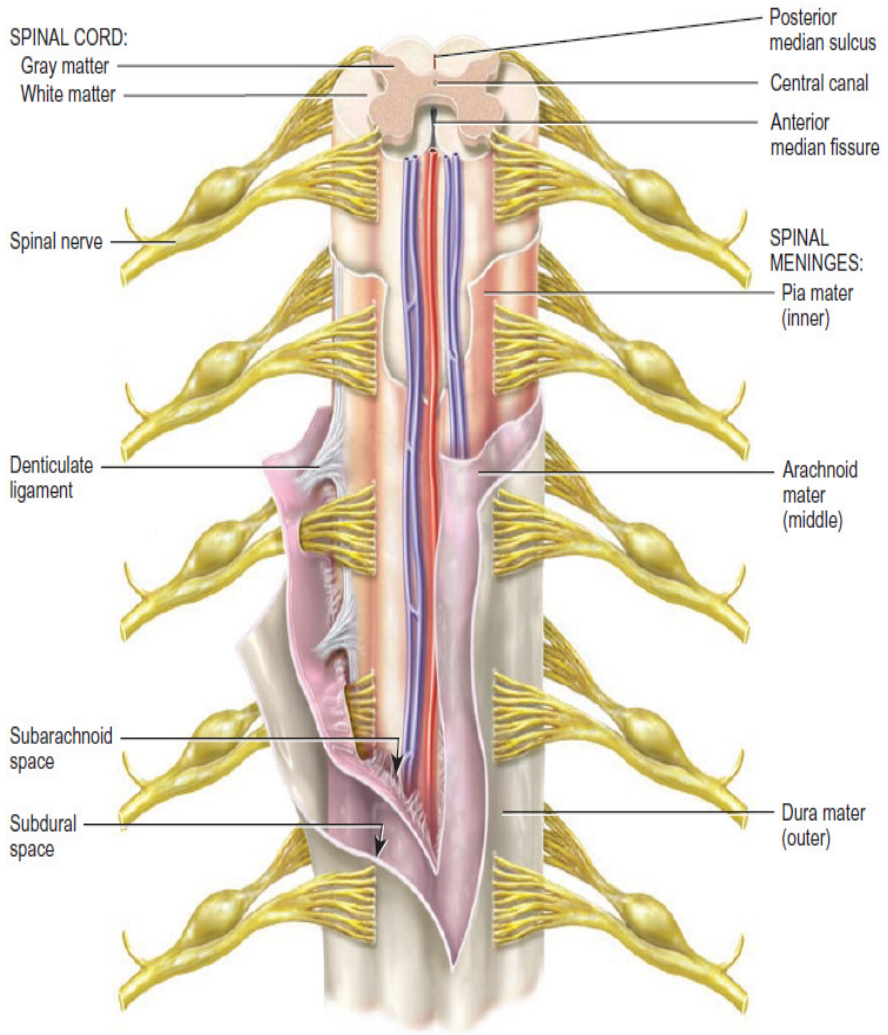
# Meninges

- Connective tissue membranes
  - **Dura mater:**
  - Outermost layer; continuous with epineurium of the spinal nerves
  - Dense irregular connective tissue
  - from the level of the foramen magnum to S2
  - Closed caudal end is anchored to the coccyx by the **filum terminale externum**
  - **Arachnoid mater**:
  - Thin web arrangement of delicate collagen and some elastic fibers.
  - Adheres to the inner surface of the dura mater



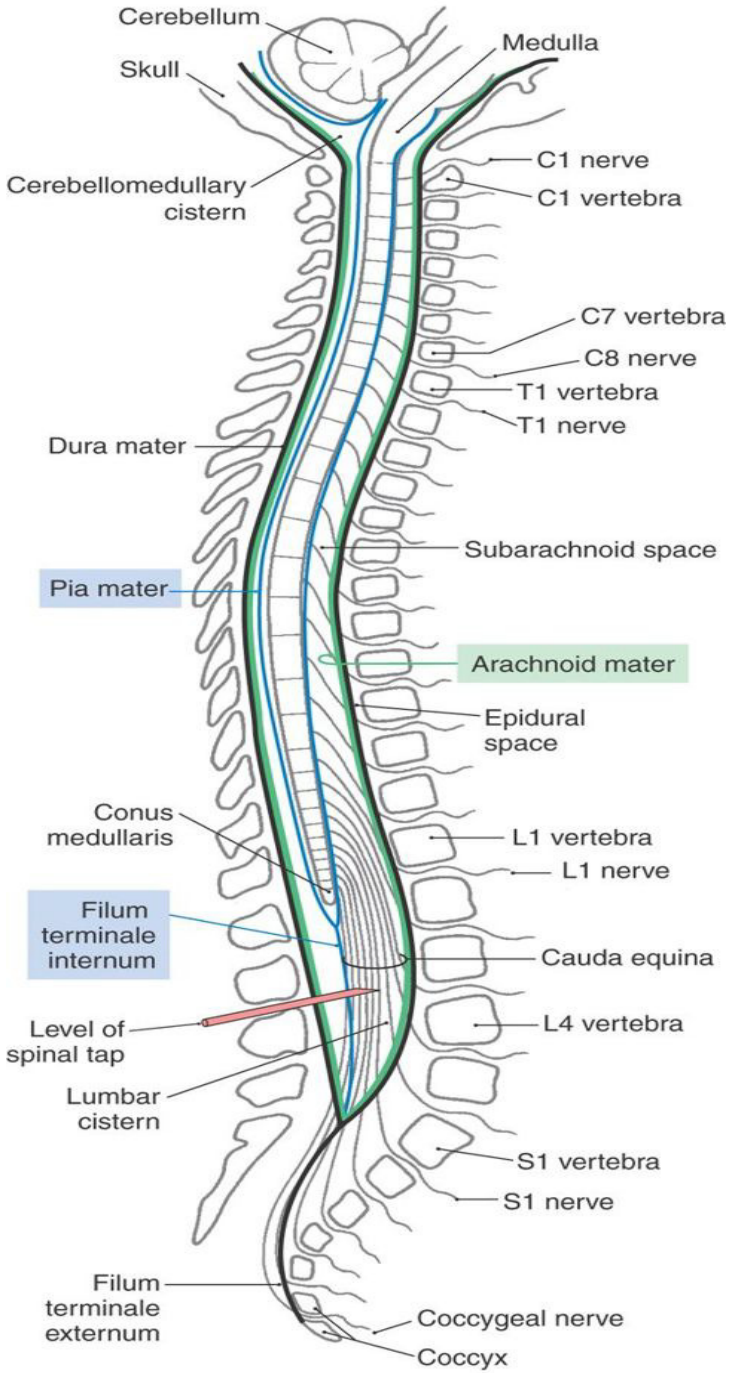
# Meninges

- Connective tissue membranes
- Pia mater:
  - Bound tightly to surface
  - Thin transparent connective tissue layer that adheres to the surface o the spinal cord and brain
  - Forms the filum terminale
    - anchors spinal cord to coccyx
  - Forms the denticulate ligaments that attach the spinal cord to the arachnoid mater and inner surface of the dura mater



# Spaces

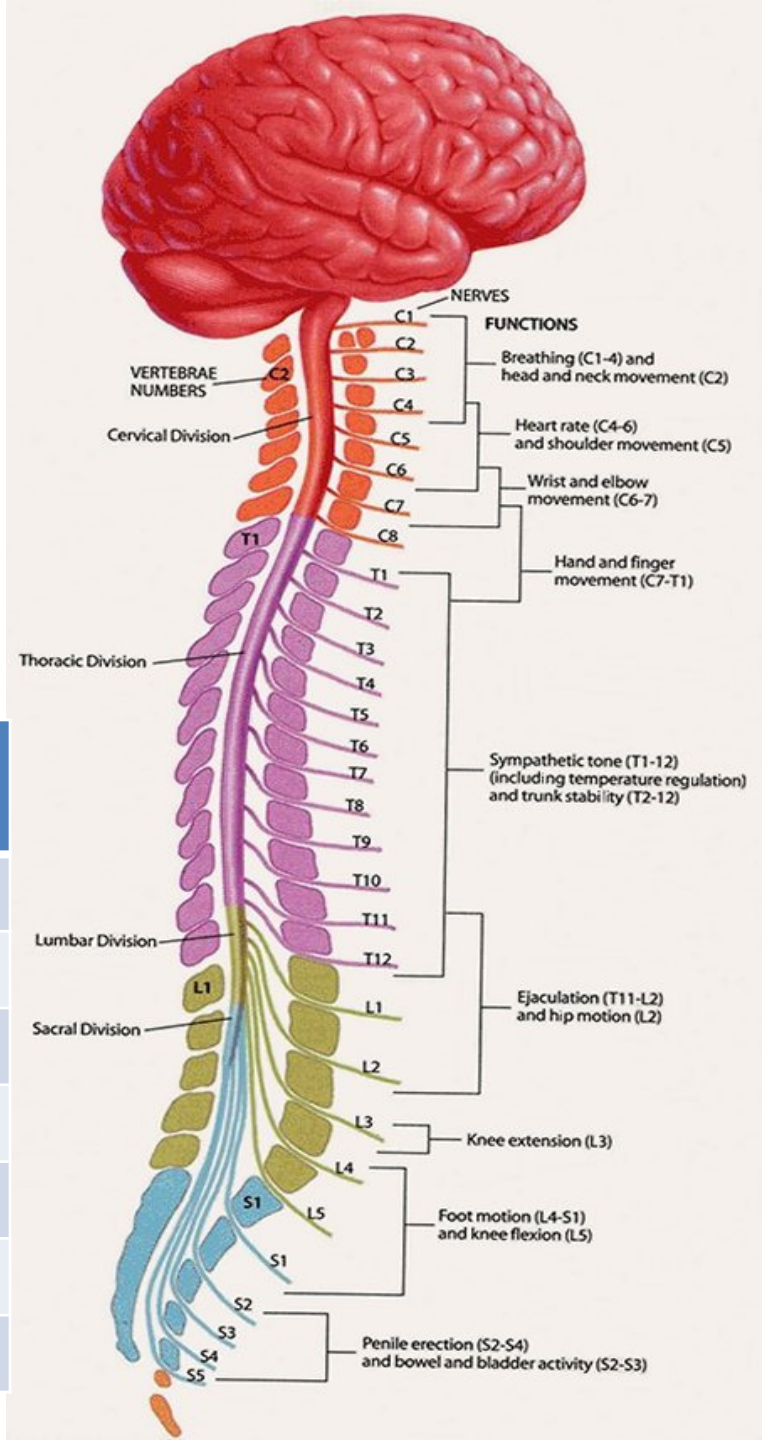
- **Epidural**: space between the dura mater and the wall of the vertebral canal.
  - Anesthestics injected here
  - Fat-fill
- **Subdural space**: serous fluid
- **Subarachnoid**: between pia and arachnoid
  - Filled with CSF
  - Lumbar puncture
  - supracristal line
  - L3-L4



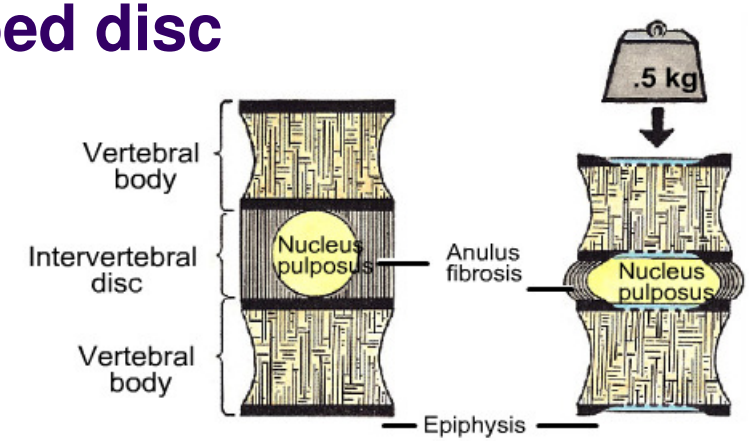
# Spinal cord segment

- The segments of the spinal cord are not in line with the corresponded vertebrae and the difference increases as we go downward.
- The roots increase in length as you go downward.
- Every spinal nerve emerges from the spinal column through the intervertebral foramen under its corresponding vertebra
- first 7 cervical nerves pass above their corresponding vertebrae

| Spinous process | spinal cord segment |
|---|---|
| C7 | C8 |
| T3 | T5 |
| T9 | T12 |
| T10 | L1-2 |
| T11 | L3-4 |
| T12 | L5 |
| L1 | S1-end |



# Herniated Disc/ ruptured disc/ slipped disc

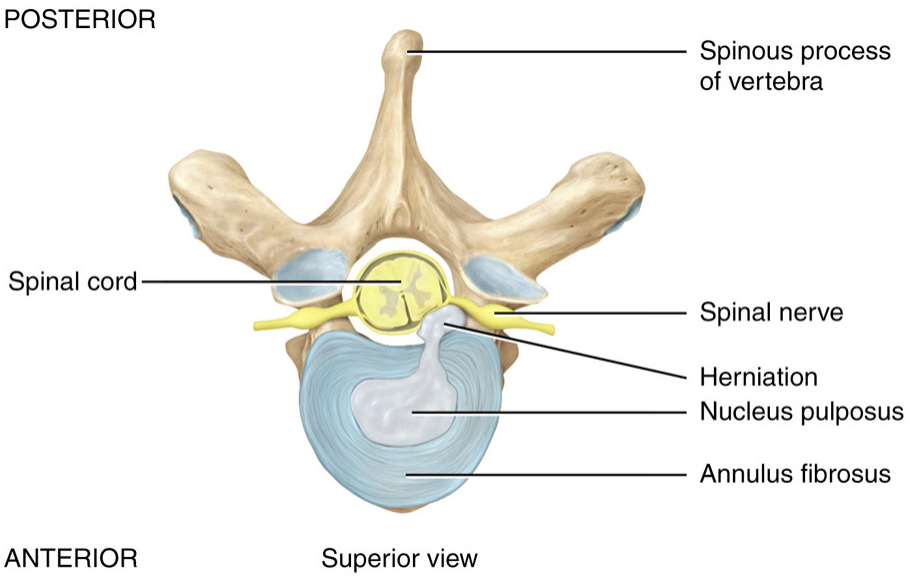


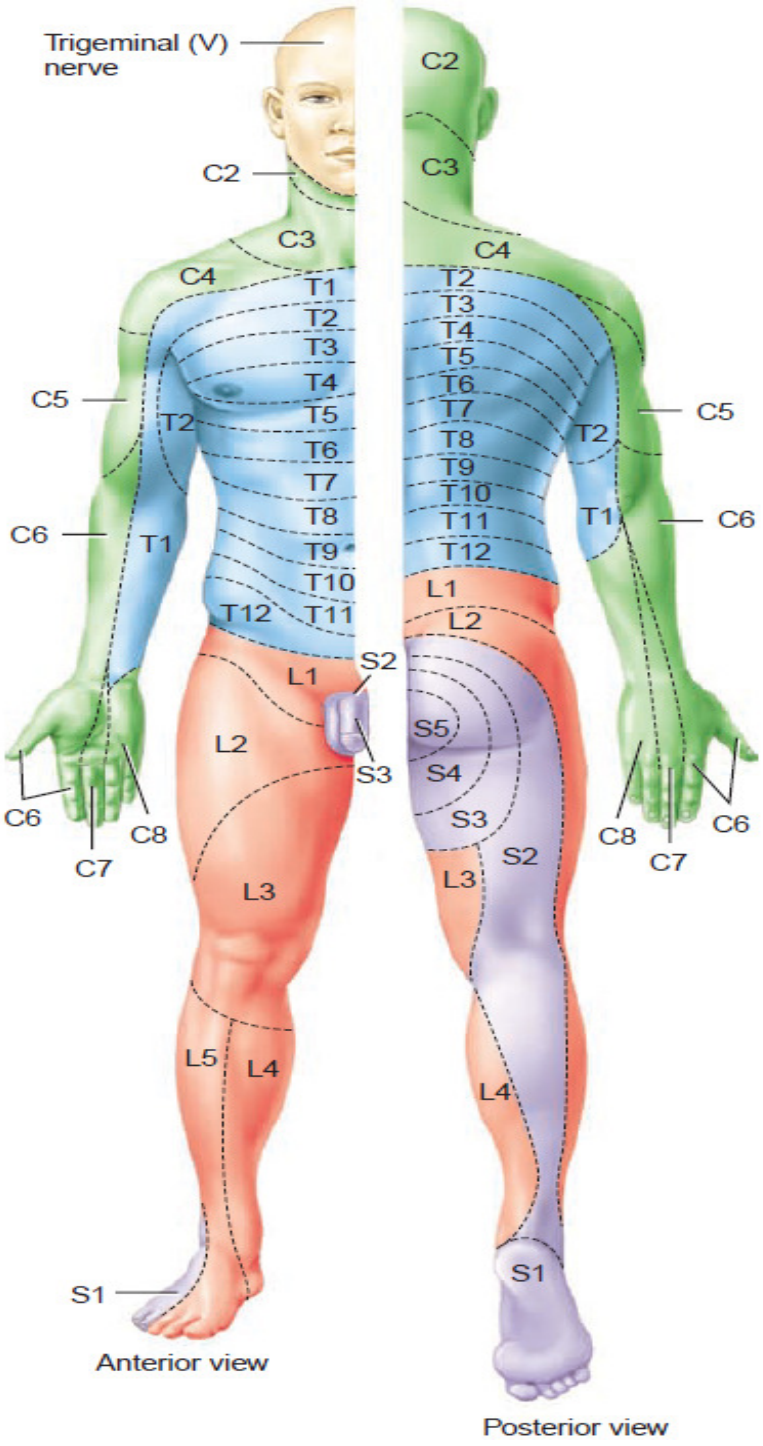

**protrusion (leakage) of the gelatinous nucleus pulposus through the anulus fibrosus of IV disc**

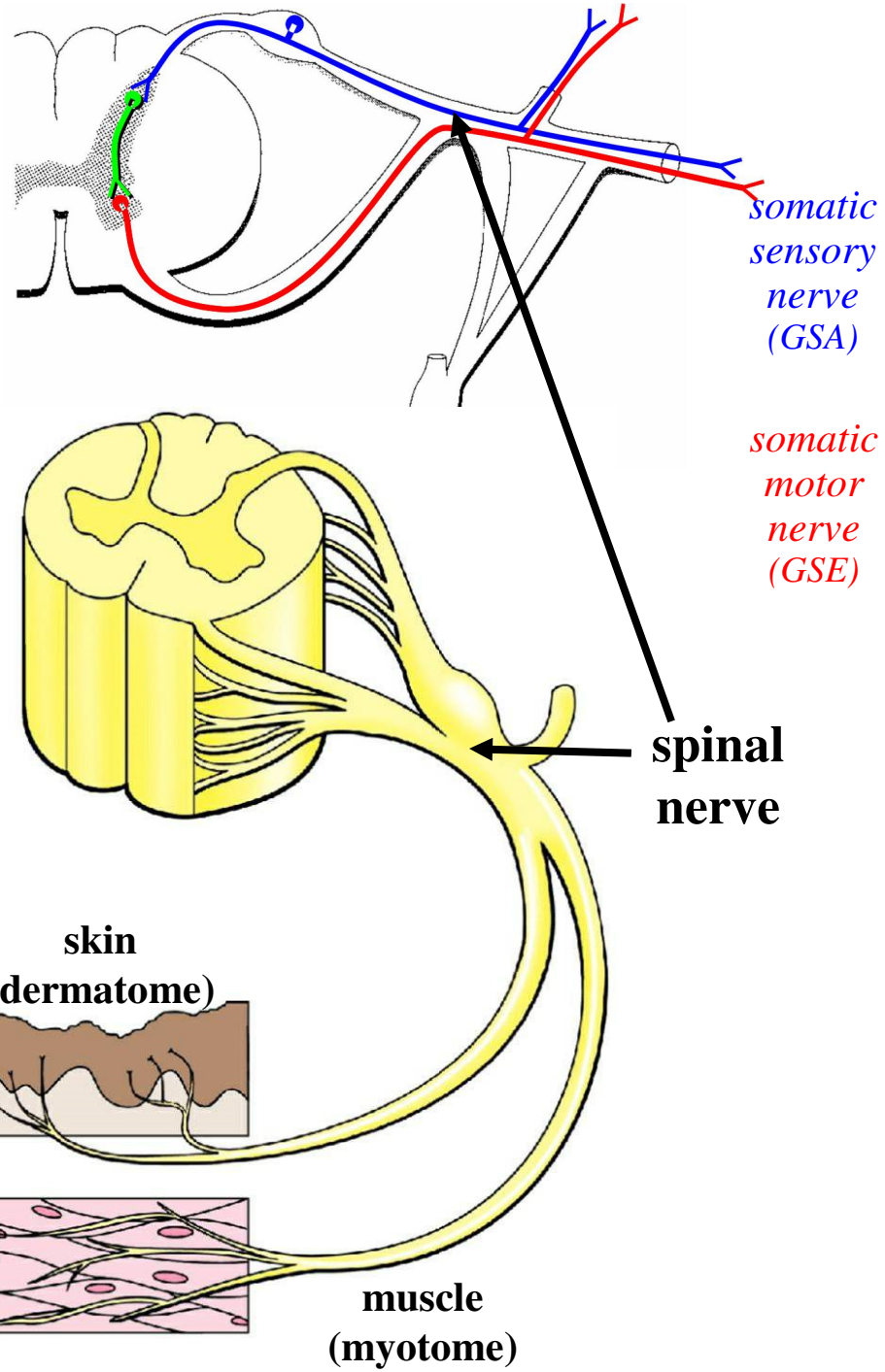
## Posterolateral direction:

**Thinner annulus fibrosus**

**95% in L4/L5 or L5/S1**




Trigeminal (V) nerve
C2
C3
C4
C5
C6
C7
C8
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
L1
L2
L3
L4
L5
S1
S2
S3
S4
S5
Anterior view
Posterior view

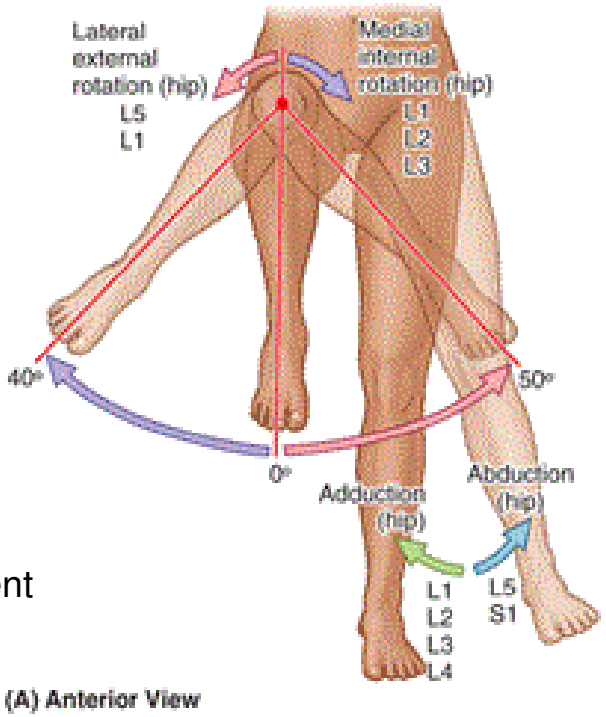

somatic sensory nerve (GSA)
somatic motor nerve (GSE)
spinal nerve
skin (dermatome)
muscle (myotome)

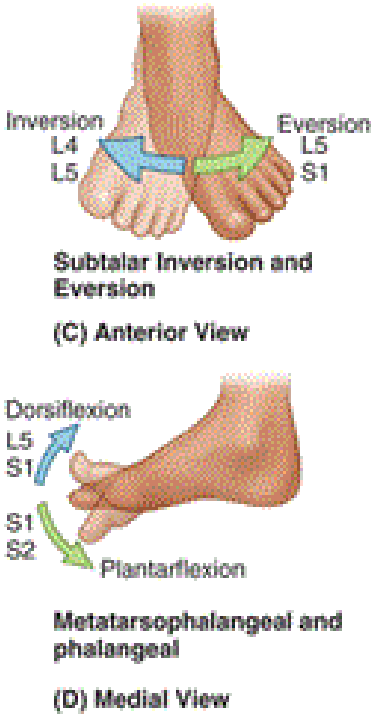
# Common lumbar disc problems

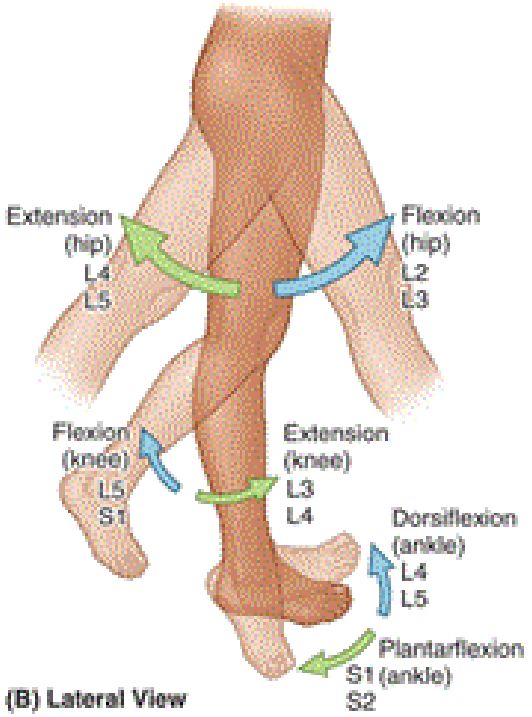
| Disc | Root | Percentage | Motor weakness | Sensory changes | Reflex affected |
|---|---|---|---|---|---|
| L3-L4 | L4 | 3-10% | Knee extension (Quadriceps femoris | Anteriomedial leg (saphenous) | Knee jerk |
| L4-L5 | L5 | 40-45% | Big toe dorsifelxion (EHL) and TA | Big toe , anteriolateral leg (Common P) | Hamstring jerk |
| L5-S1 | S1 | 45-50% | Foot planter flextion (Gastrocnemius) | Lateral border of foot (sural) | Ankle jerk |

**Important myotomes of lower limb**

- **Test L5**: by asking the patient to stand on his heels
- **Test S1**: by asking the patient to stand on his tiptoes

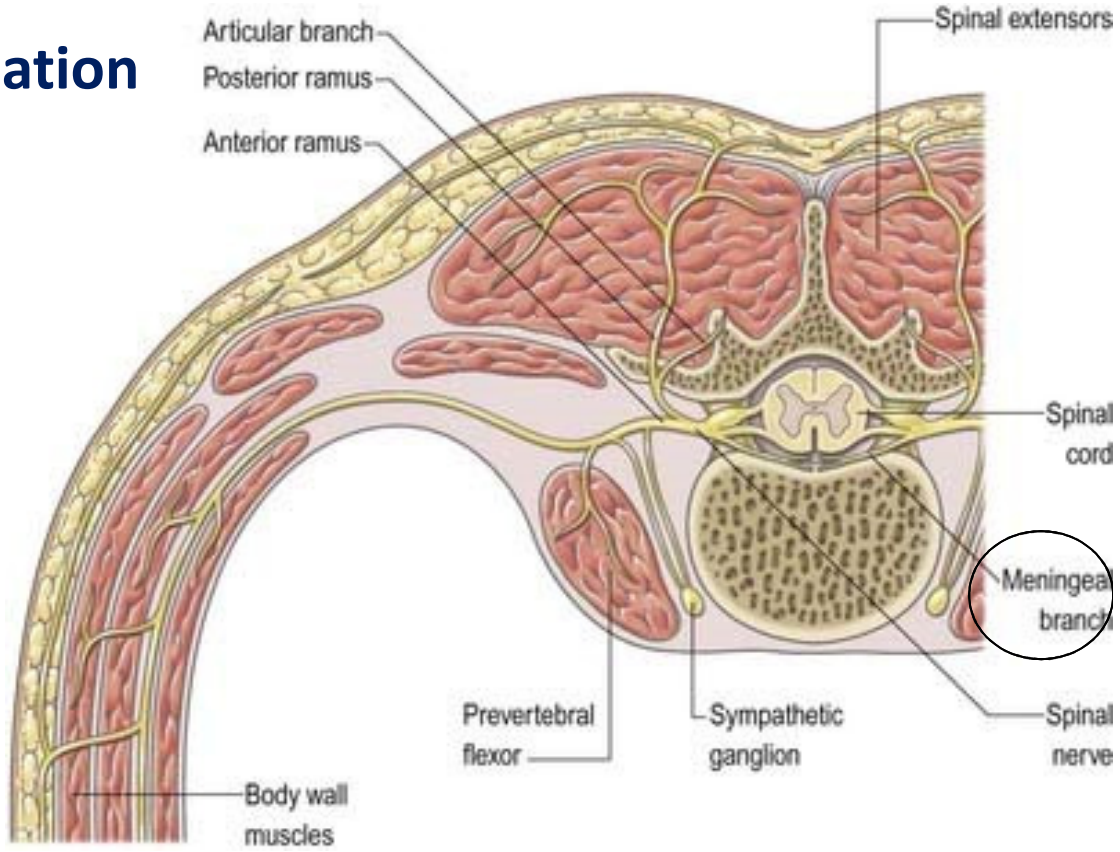


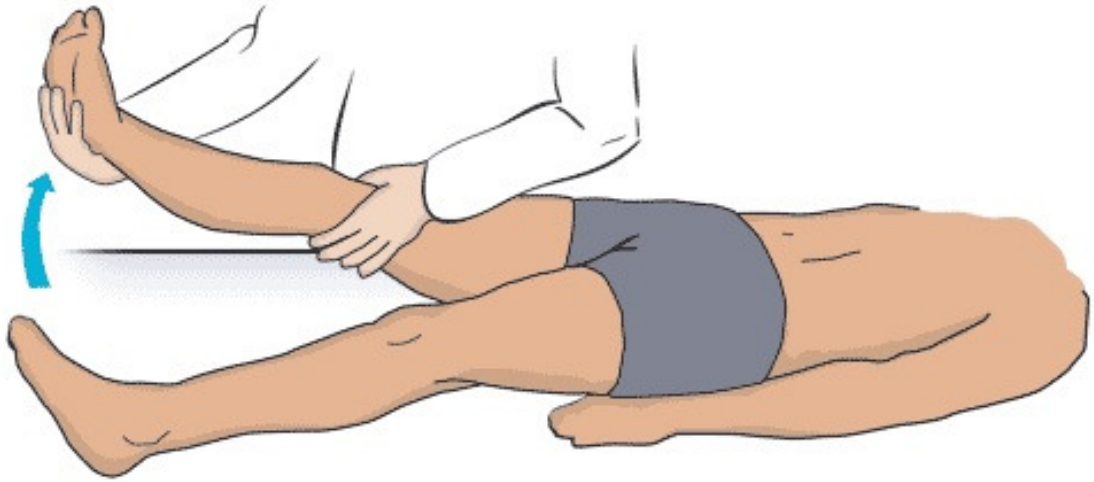



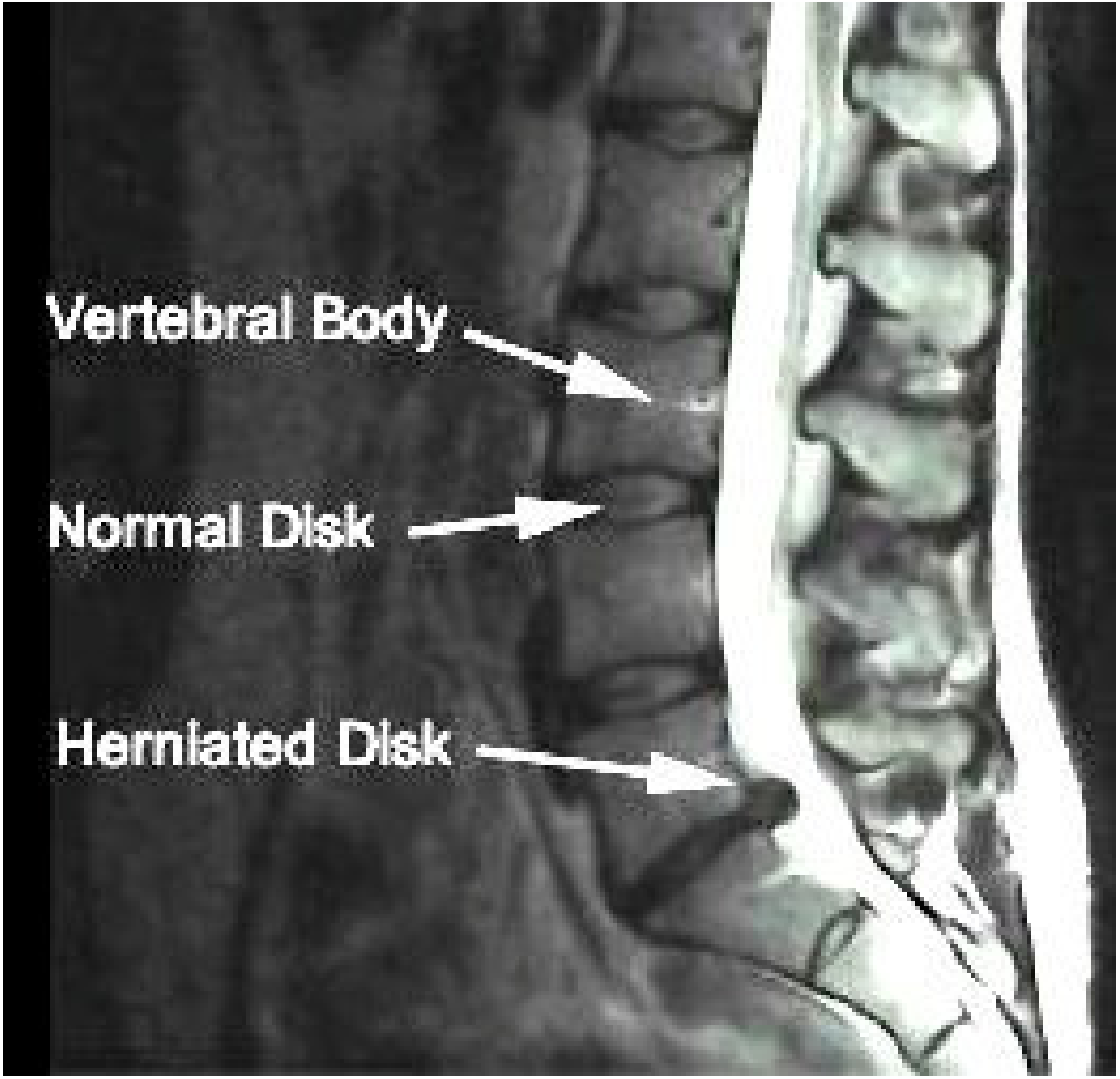
# Major symptoms of disc herniation

- **Low back pain**: radiating to the gluteal region, the back of the thigh and back of the leg
- spinal nerve gives a meningeal branch bring sensation from the dura matter
- Dura matter is sensitive to stretch
- Pain is diffused due to overlapping dermatomes
- **Straight Leg Raise Test (SLR)**



- MRI is commonly used to aid in making the diagnosis of a herniated disc



# Cross Section of Spinal Cord

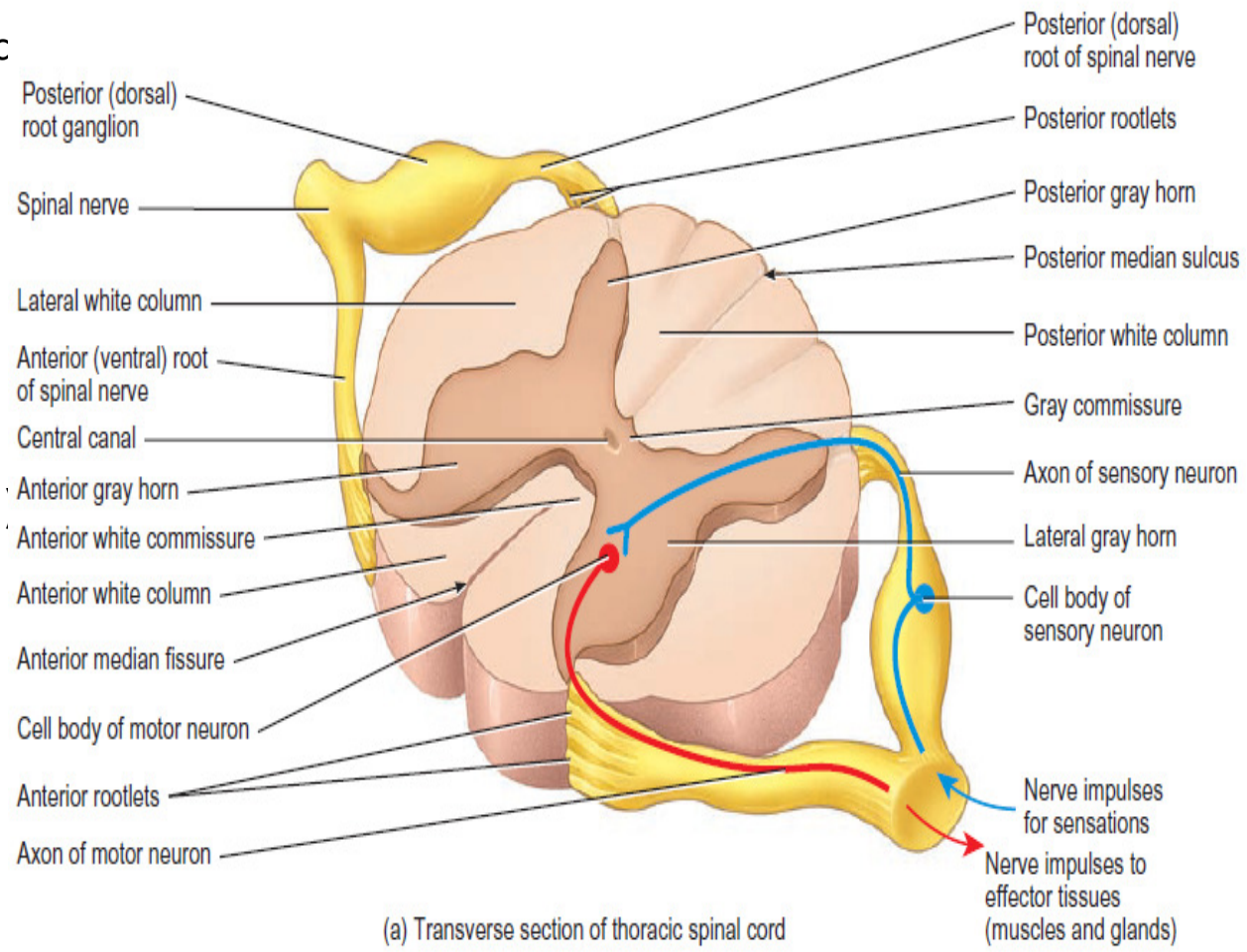
- Anterior median fissure:

wide groove on the Anterior aspec

- posterior median sulcus:

Narrow groove on the posterior aspect

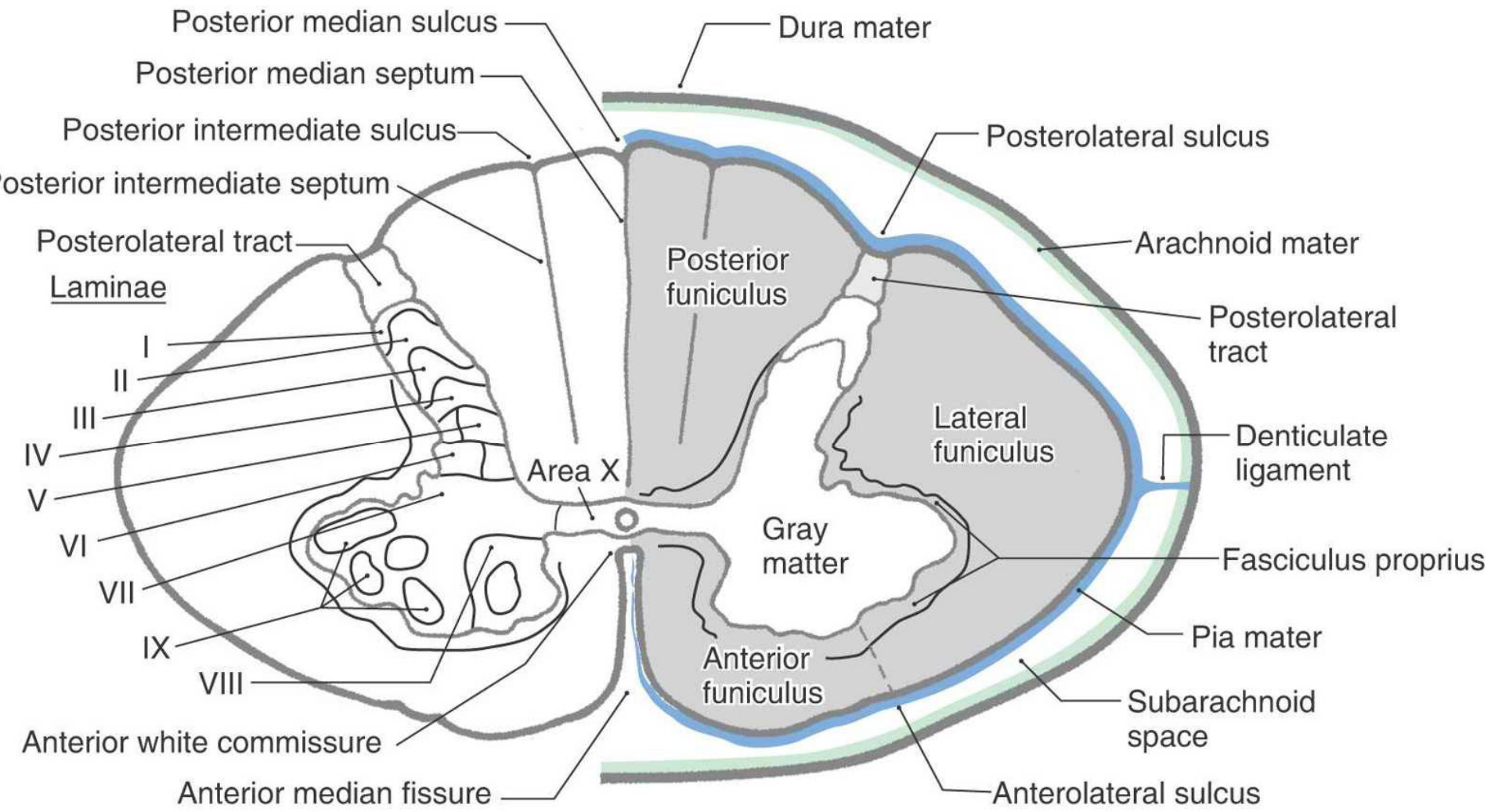
- Gray matter: neuron cell bodies, dendrites, axons
  - Divided into *horns*
  - **Posterior** (dorsal) horn (cell body of sensory N
  - **Anterior** (ventral) horn (cell body of motor N to skeletal M)
  - **Lateral** horn (cell body of motor N to cardiac M, smooth M, glands)

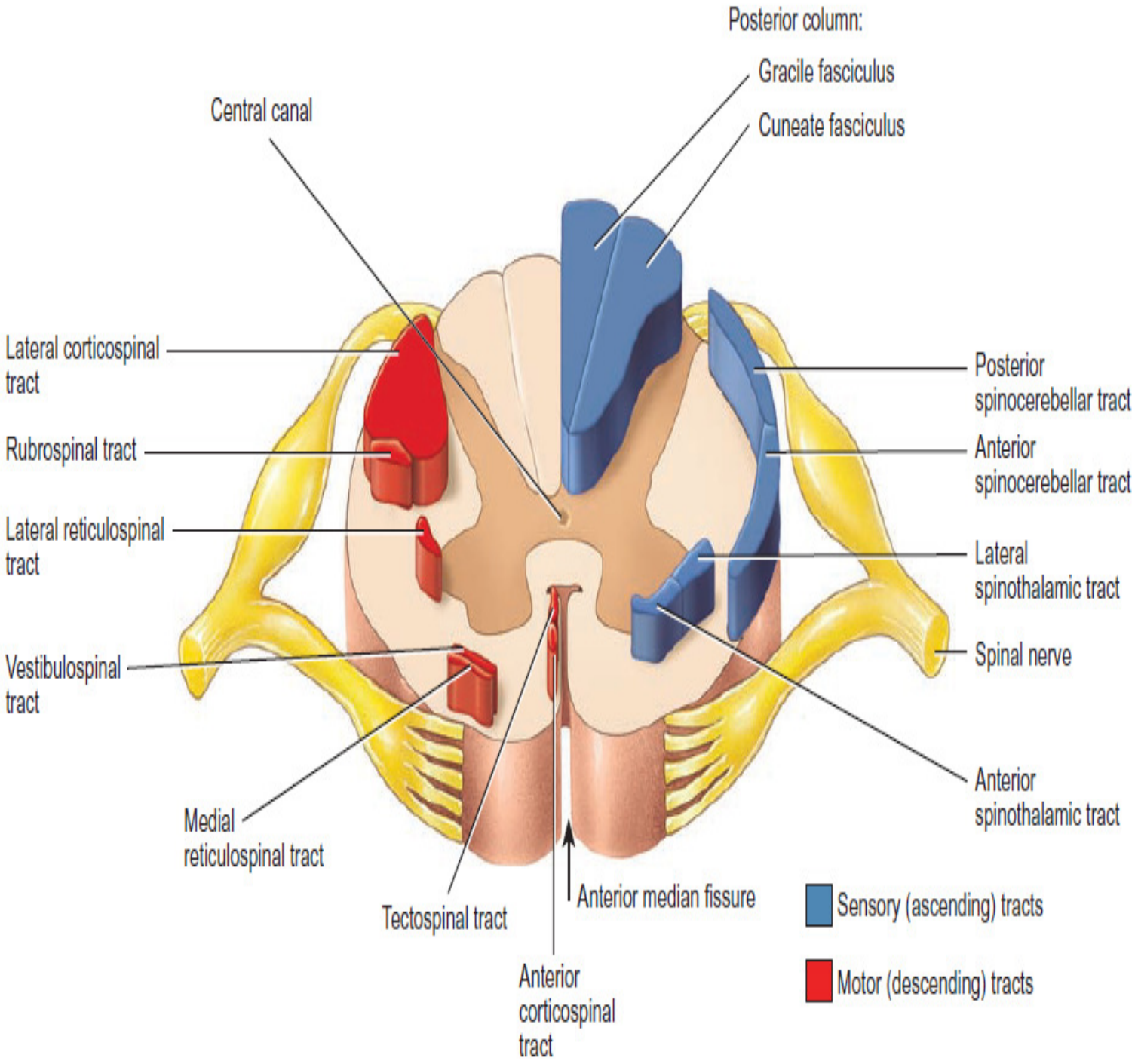



(a) Transverse section of thoracic spinal cord

# Cross Section of Spinal Cord

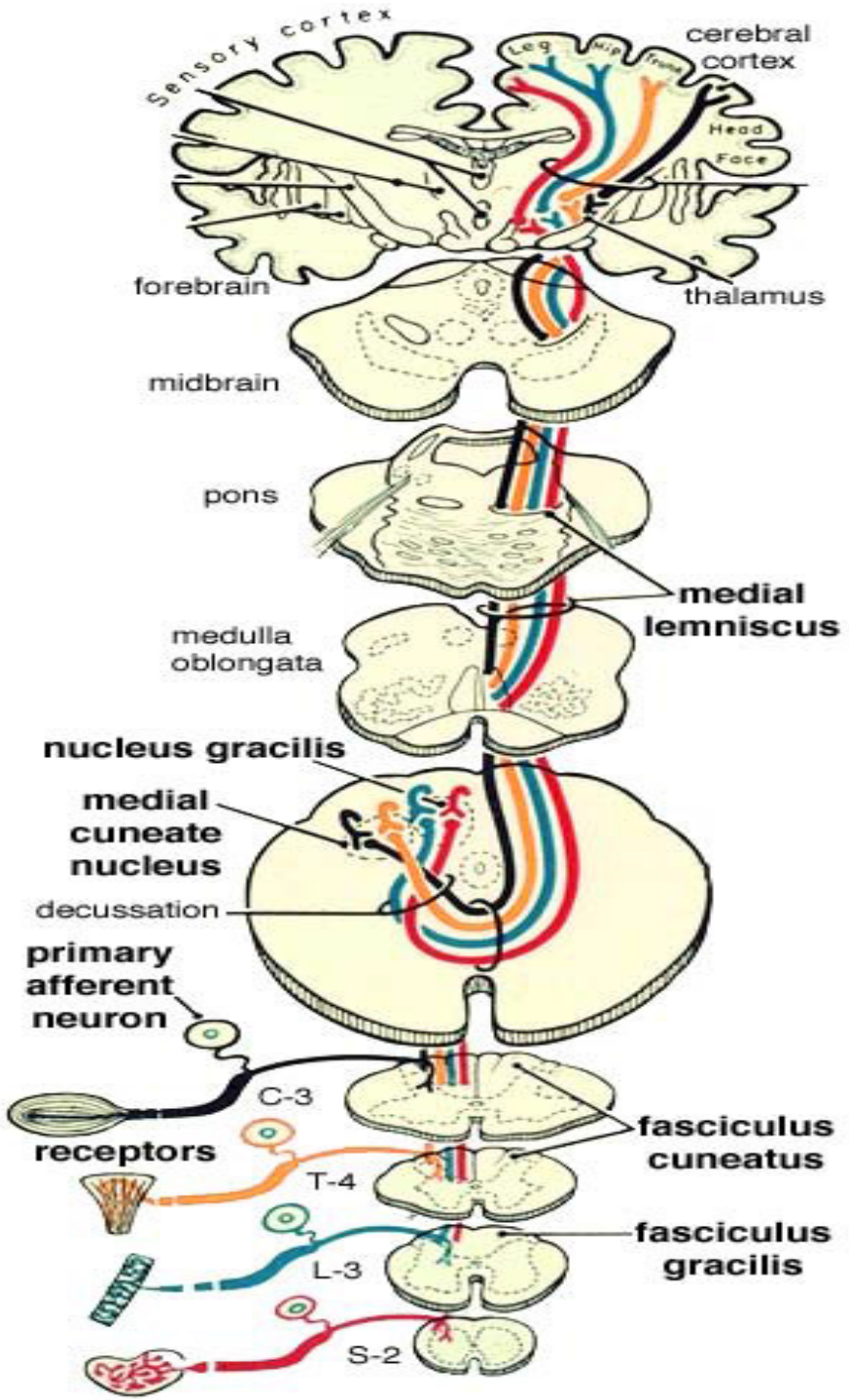
- I



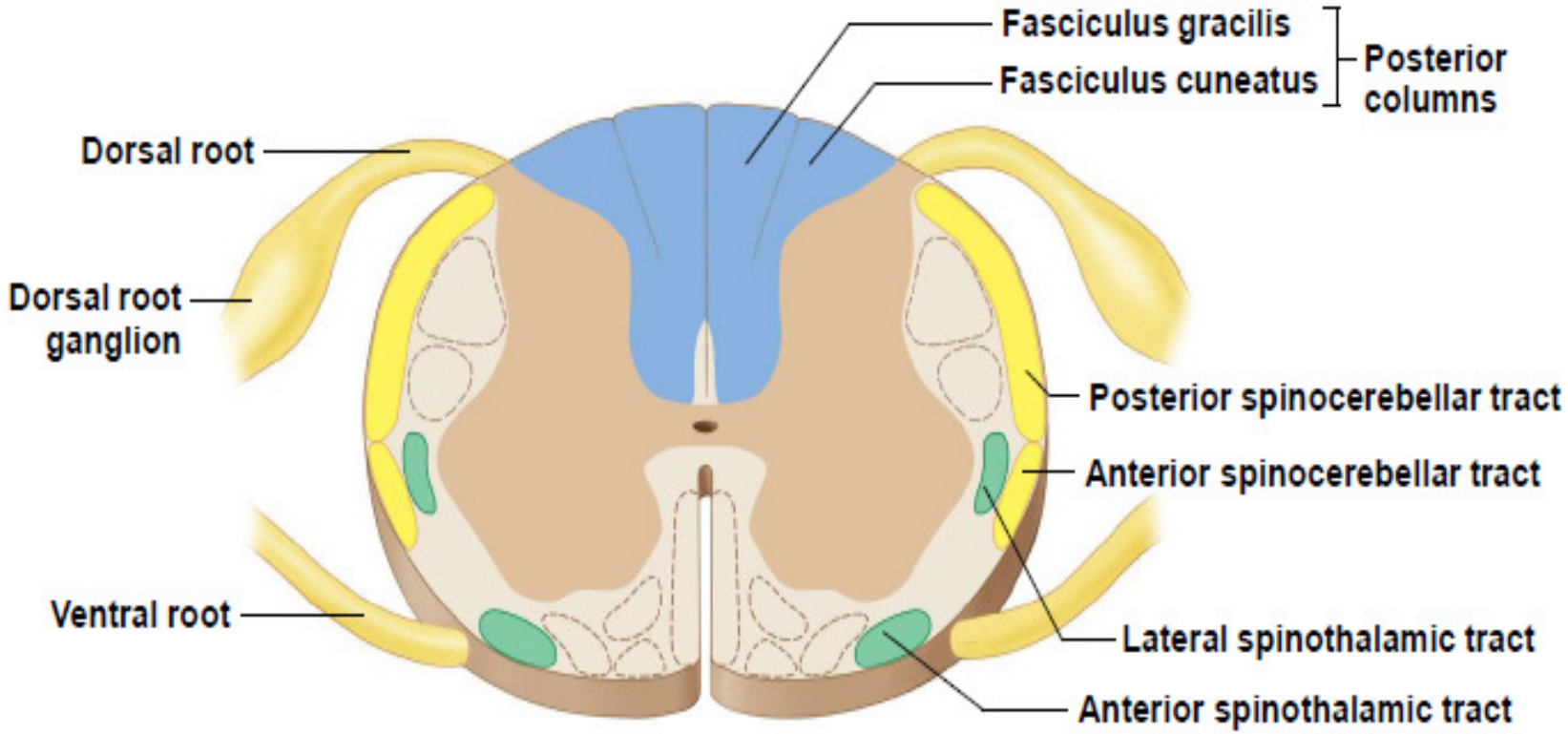

Posterior column:
Gracile fasciculus
Cuneate fasciculus
Central canal
Lateral corticospinal tract
Rubrospinal tract
Lateral reticulospinal tract
Vestibulospinal tract
Medial reticulospinal tract
Tectospinal tract
Anterior median fissure
Anterior corticospinal tract
Posterior spinocerebellar tract
Anterior spinocerebellar tract
Lateral spinothalamic tract
Spinal nerve
Anterior spinothalamic tract
Sensory (ascending) tracts
Motor (descending) tracts

# Posterior White Column-Medial Lemniscal Pathway

- Modality: Discriminative Touch Sensation (include Vibration) and Conscious Proprioception
- Receptor: Most receptors except free nerve endings
- Ist Neuron: Dorsal Root Ganglion
- 2nd Neuron: Dorsal Column Nuclei (Nucleus Gracilis and Cuneatus)
  ---Internal Arcuate Fiber - Lemniscal Decussation
  ---Medial Lemniscus
- 3rd Neuron: Thalamus (VPL) Internal Capsule ----- Corona Radiata
- Termination: Primary Somesthetic Area (S I)



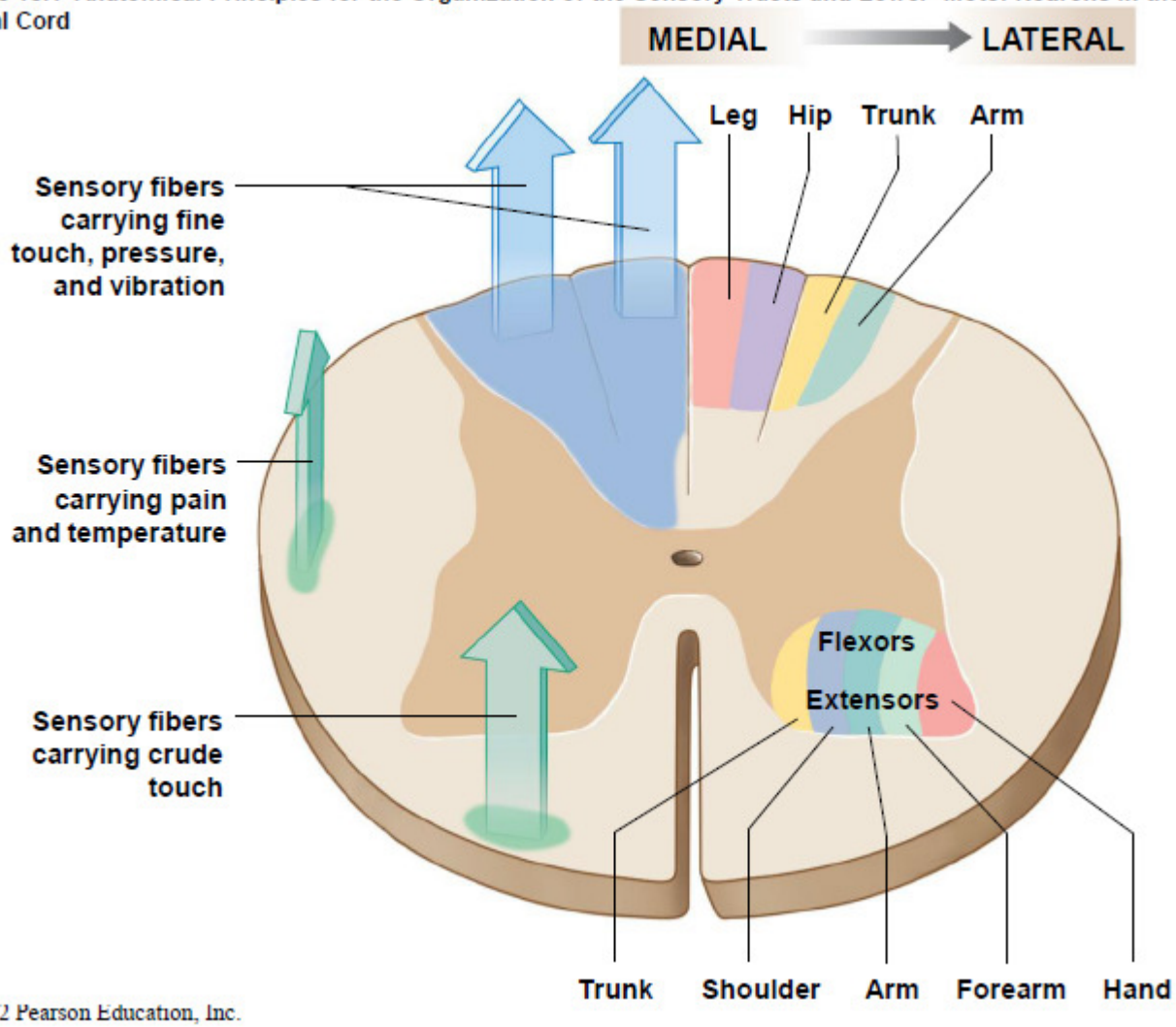
# Posterior White Column-Medial Lemniscal Pathway



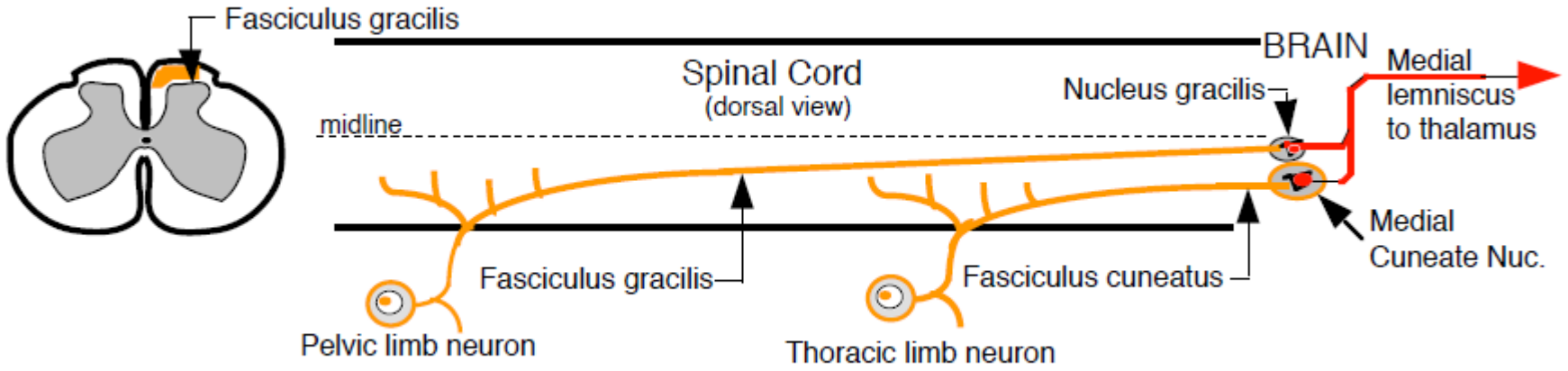

Discriminative touch, vibratory sense, and conscious muscle-joint sense

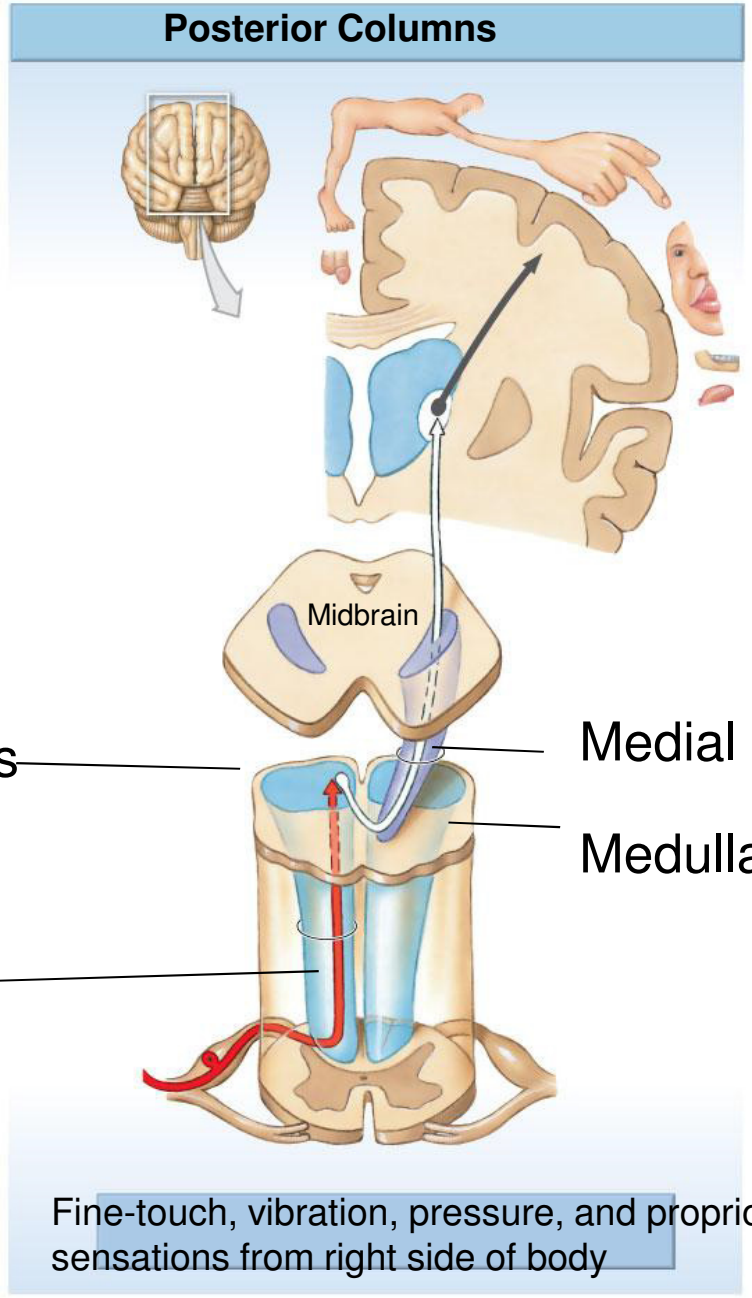
- **Posterior Column tract consists of:**
- **Fasciculus gracilis**
- Transmits information coming from areas inferior to T6
- **Fasciculus cuneatus**
- Transmits information coming from areas superior to T6

Figure 15.1 Anatomical Principles for the Organization of the Sensory Tracts and Lower–Motor Neurons in the Spinal Cord

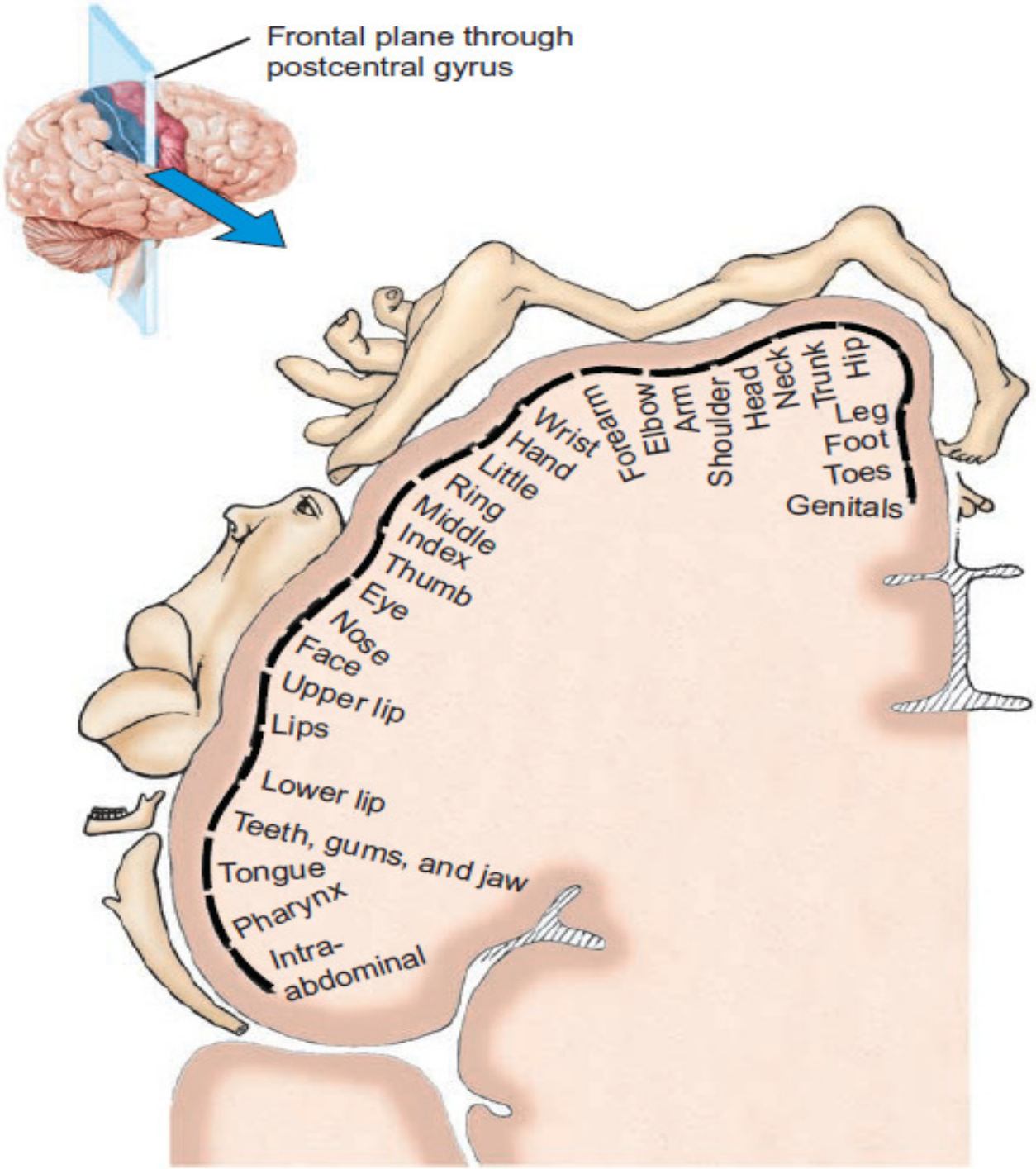


# Discriminative Touch Spinal Pathway



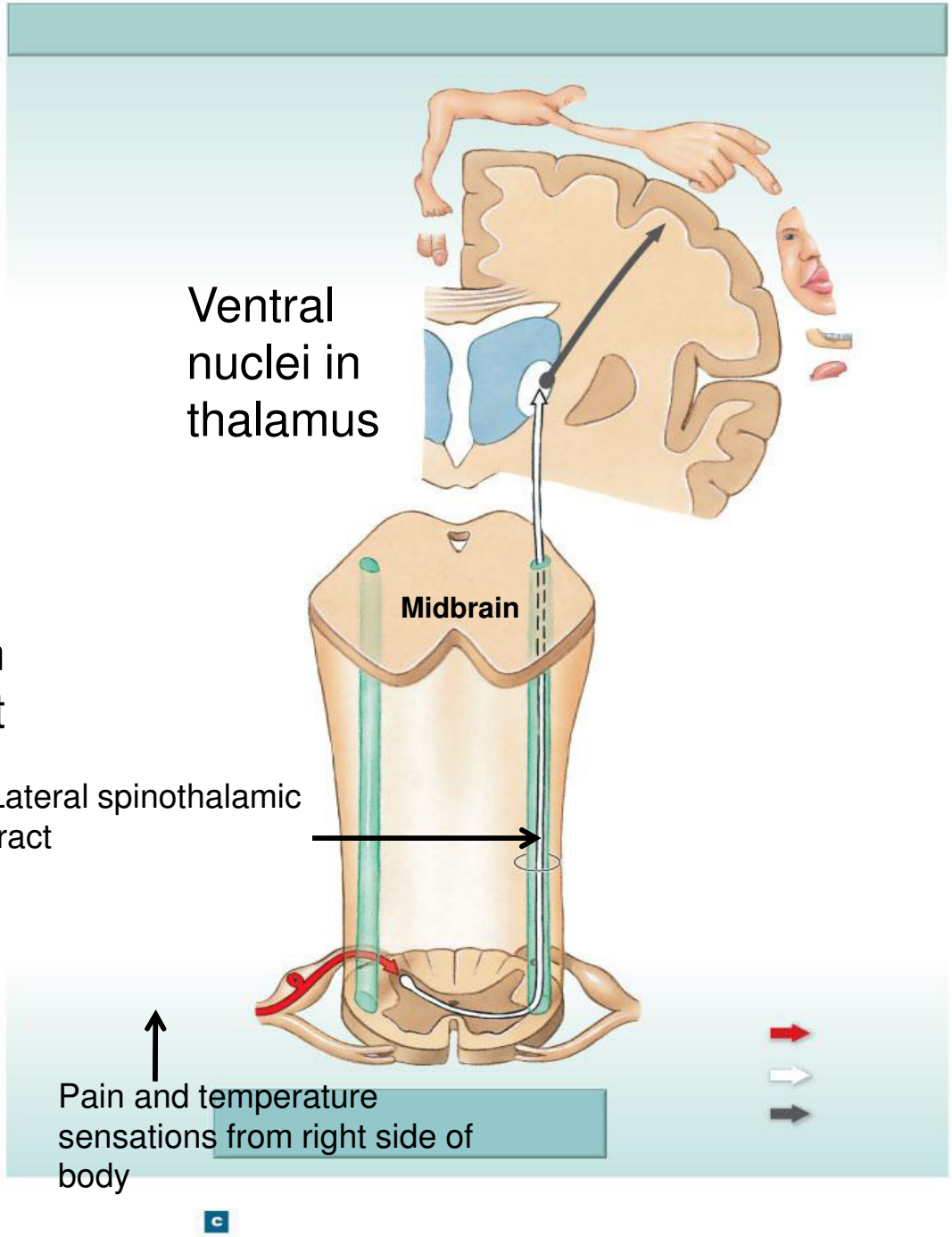

Posterior Columns
Midbrain
Nucleus gracilis
nucleus cuneatus
Medial lemniscus
Medulla oblongata
Fasciculus cuneatus
fasciculus gracilis
Fine-touch, vibration, pressure, and proprioception sensations from right side of body
a

| ELECTROPHYSIOLOGIC CLASSIFICATION OF PERIPHERAL NERVES | CLASSIFICATION OF AFFERENT FIBERS ONLY (CLASS/GROUP) | FIBER DIAMETER (μm) | CONDUCTION VELOCITY (m/s) | RECEPTOR SUPPLIED |
|---|---|---|---|---|
| Sensory Fiber Type | | | | |
| Aα | Ia and Ib | 13-20 | 80-120 | Primary muscle spindles, Golgi tendon organ |
| Aβ | II | 6-12 | 35-75 | Secondary muscle spindles, skin mechanoreceptors |
| Aδ | III | 1-5 | 5-30 | Skin mechanoreceptors, thermal receptors, and nociceptors |
| C | IV | 0.2-1.5 | 0.5-2 | Skin mechanoreceptors, thermal receptors, and nociceptors |
| Motor Fiber Type | | | | |
| Aα | N/A | 12-20 | 72-120 | Extrafusal skeletal muscle fibers |
| Aγ | N/A | 2-8 | 12-48 | Intrafusal muscle fibers |
| B | N/A | 1-3 | 6-18 | Preganglionic autonomic fibers |
| C | N/A | 0.2-2 | 0.5-2 | Postganglionic autonomic fibers |


Frontal plane through postcentral gyrus
Wrist
Hand
Little
Ring
Middle
Index
Thumb
Eye
Nose
Face
Upper lip
Lips
Lower lip
Teeth, gums, and jaw
Tongue
Pharynx
Intra-abdominal
Forearm
Elbow
Arm
Shoulder
Head
Neck
Trunk
Hip
Leg
Foot
Toes
Genitals

# lateral spinothalamic tract

- Modality: pain and temperature
- Receptors: free nerve endings
- 1st Neuron: Dorsal root ganglia
- 2nd Neuron: the posterior gray column (substantia gelatinosa) The axons of 2nd order neurons cross obliquely to the opposite side in the anterior gray and white commissures , ascending in the contralateral white column as the lateral spinothalamic tract
- 3rd Neuron: Thalamus (VPL) Internal Capsule ----- Corona Radiata
- Termination: Primary Somesthetic Area (S I) and Widespread Cortical Region



# Rexed laminae

- **Lamina 1** relay information related to pain and temperature
- **Lamina 2:** relay information related to pain and temperature **(pain modulation)**
- **Lamina 3 and 4:** nucleus proprius; these laminae have many interneurons

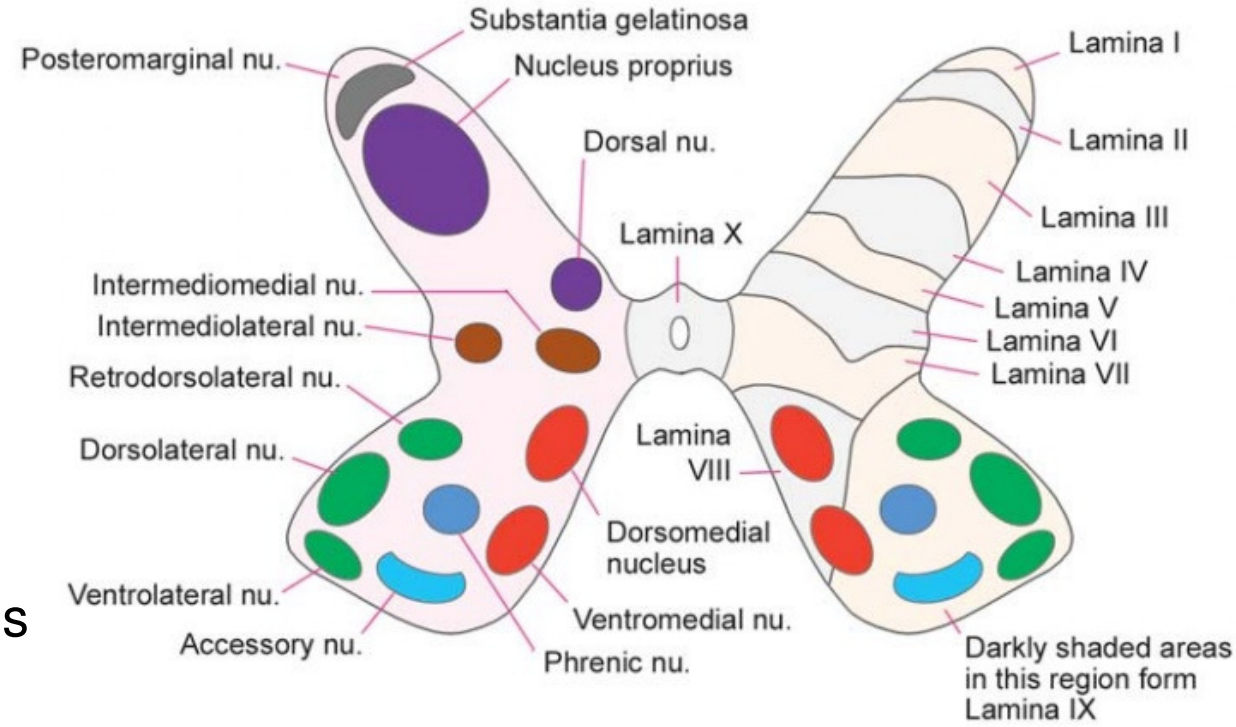
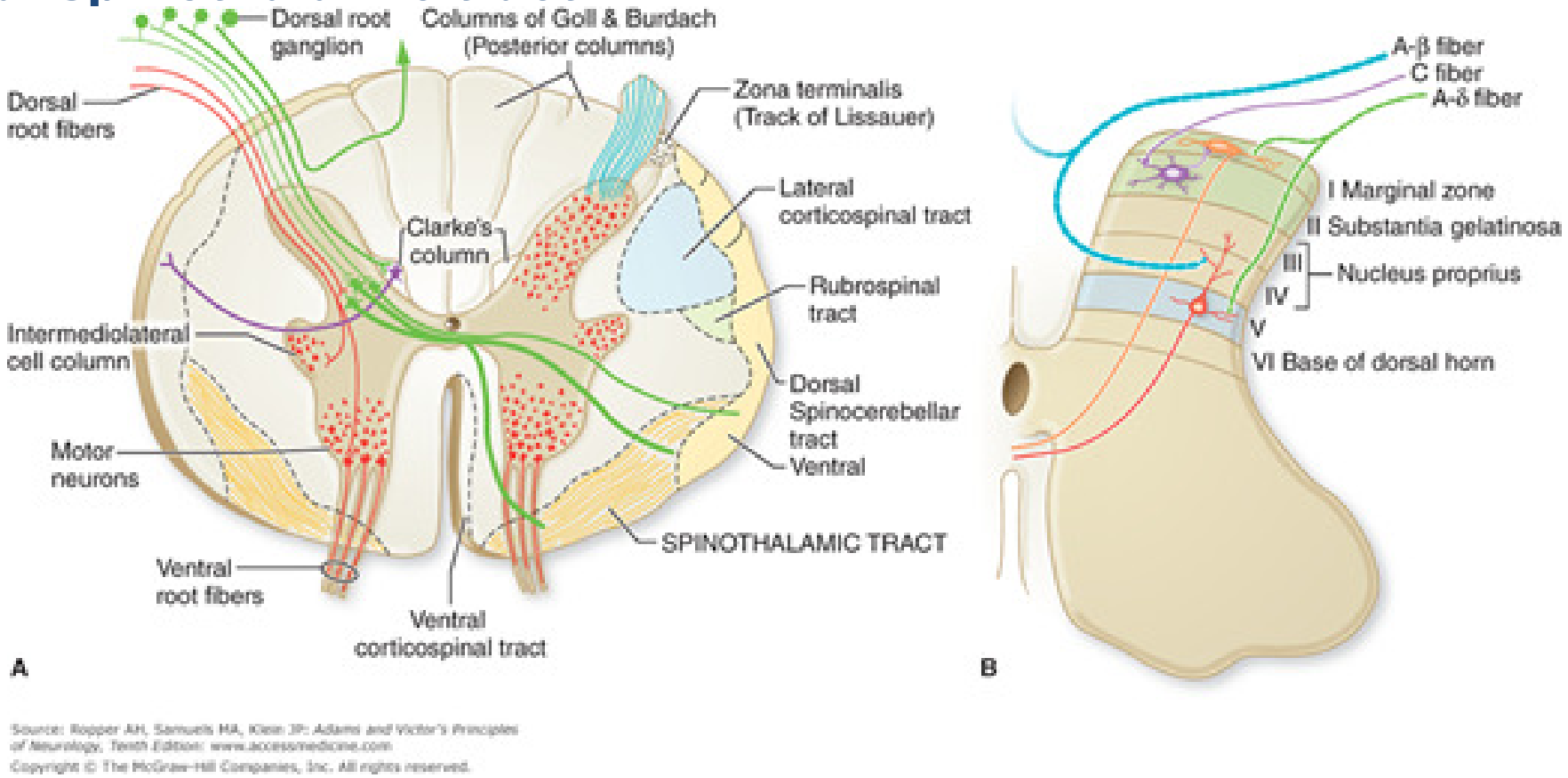



Fig. 5.2. Subdivisions of the grey matter of the spinal cord. The left half of the figure shows the cell groups usually described. The right half shows the newer concept of laminae.

- **Lamina 5:** relay information related to pain and temperature
- **Lamina 6:** presents only at the cervical and lumbar enlargements and receives proprioception
- **Lamina 7: Intermedio-lateral** nucleus, contains preganglionic fibers of sympathetic (T1 -L2). **Intermedio-medial nucleus** ,all over the spinal cord, receive visceral pain. **Dorsal nucleus of Clark's** presents at (C8 – L2 or T1-L4) , relay center for **unconscious proprioception**

# lateral spinothalamic tract

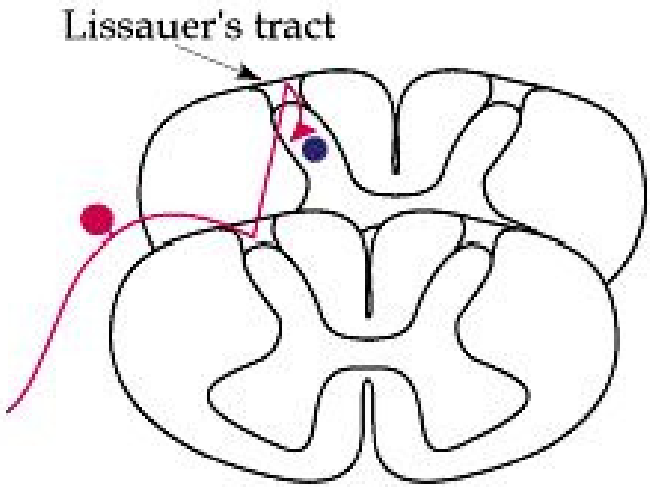


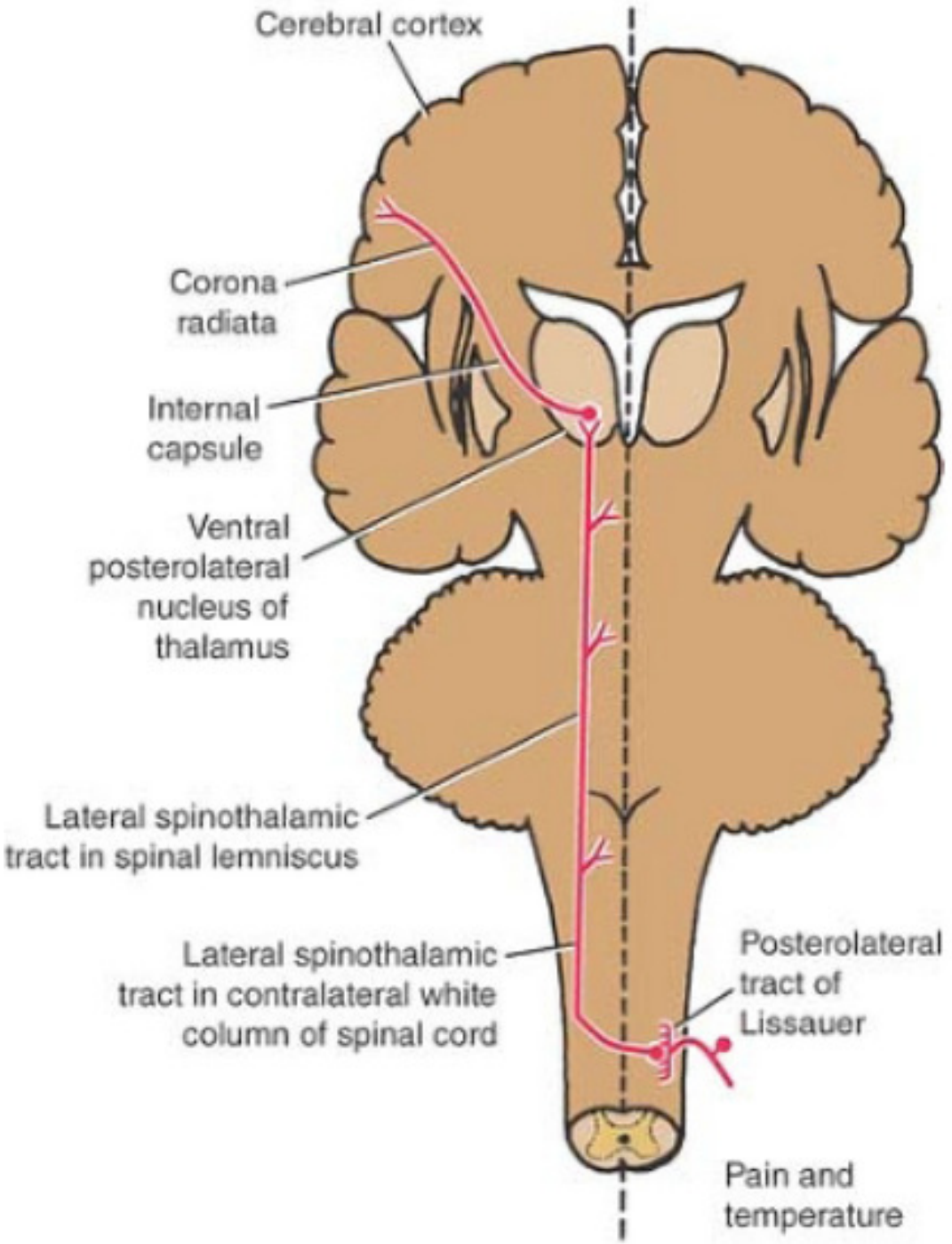



- Lamina 1+ 5: the spinothalamic tract ascend which transmit pain, temperature and touch. (A delta fibers)
- Lamina 1+ 2: the spinothalamic tract ascend (C fibers).

## Posterolateral tract of Lissauer

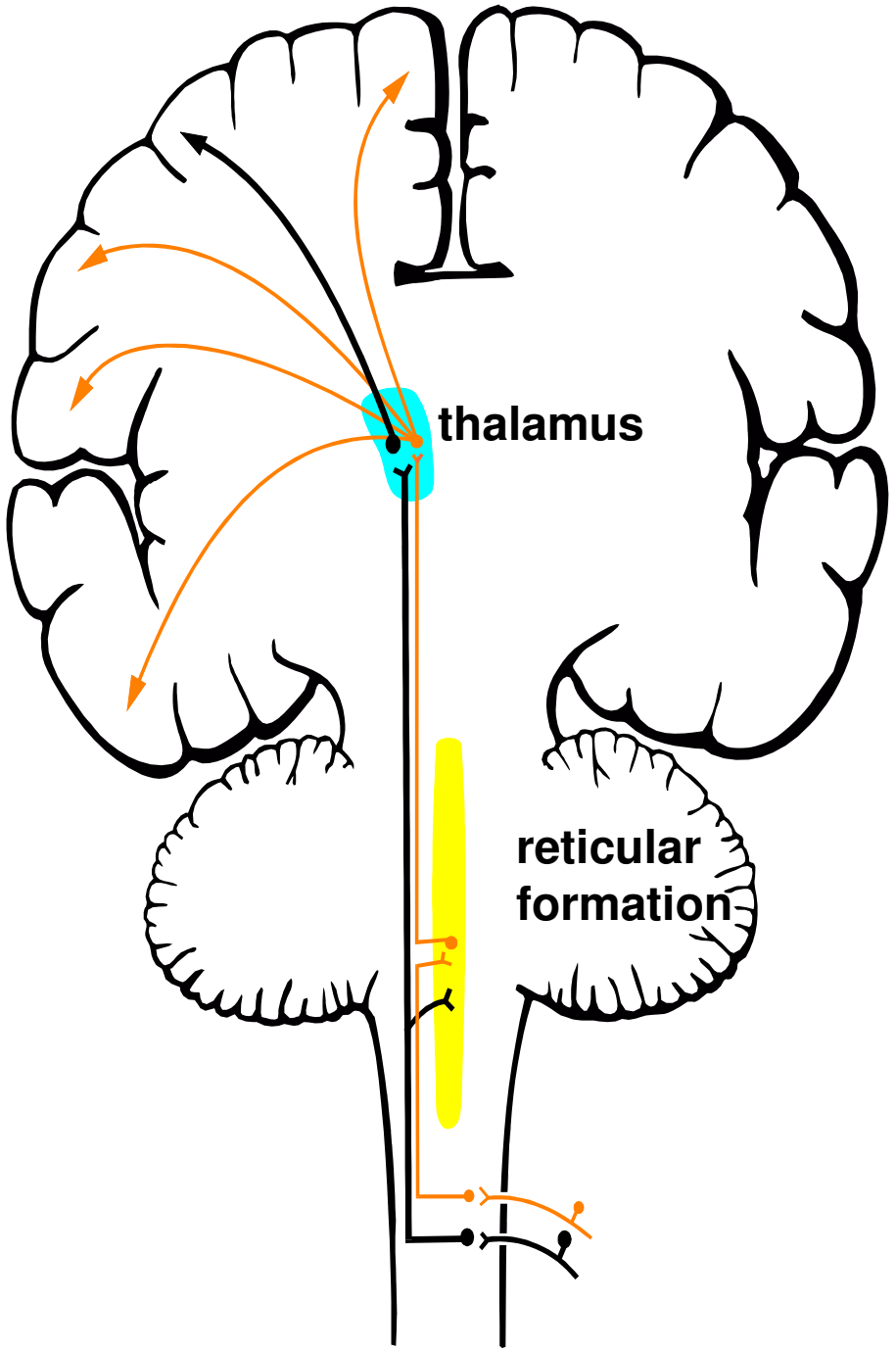
- located between the posterior white column and the lateral white column



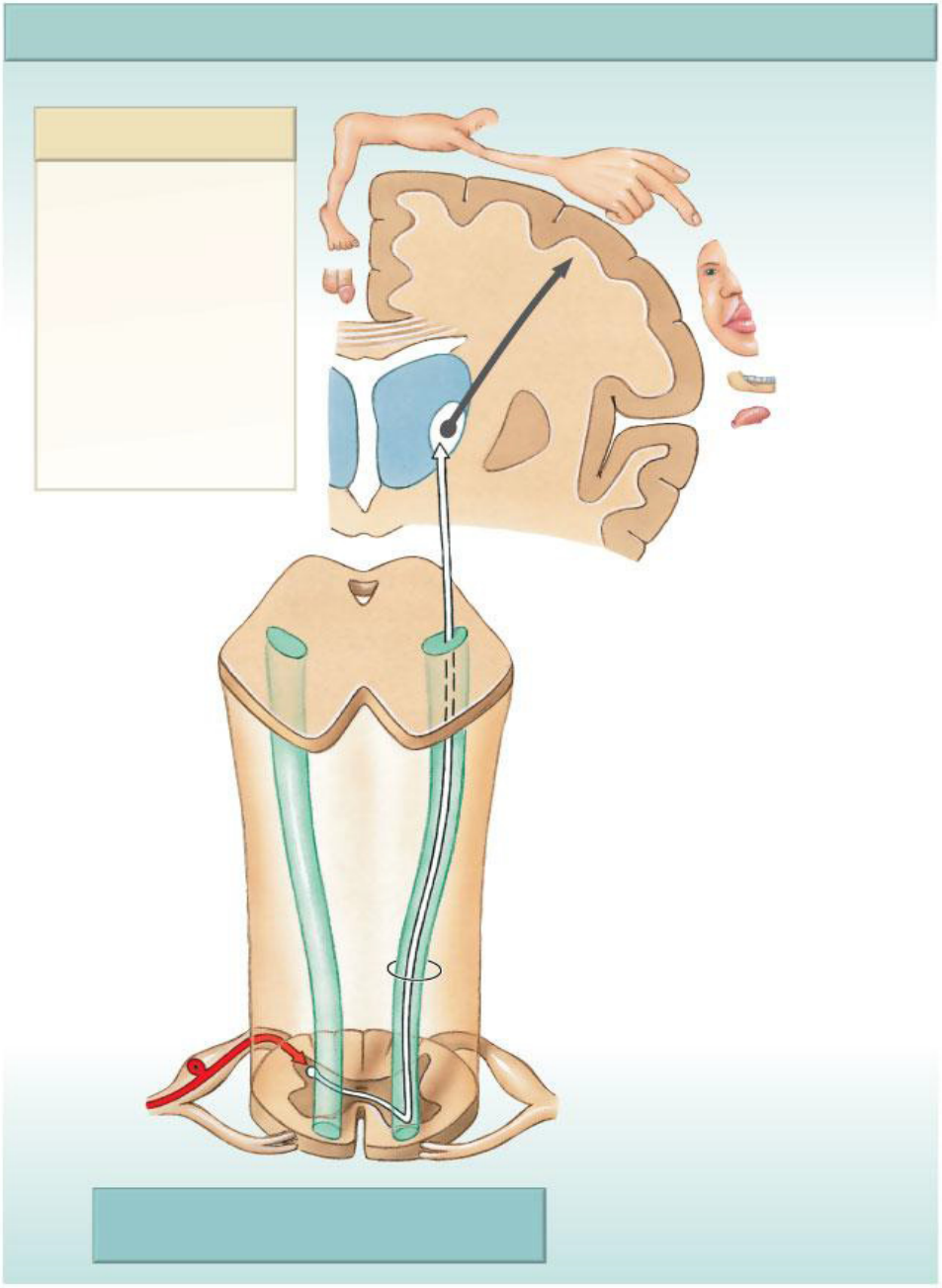
## Other Terminations of the Lateral Spinothalamic Tract

- **Reticular formation**: (majority of the slow pain fibers) individual becomes aware of the pain
- **Cingulate gyrus:** interpretation of the emotional aspect of pain
- **Insular gyrus:** concerned with the interpretation of pain stimuli from the internal organs of the body and brings about an autonomic response



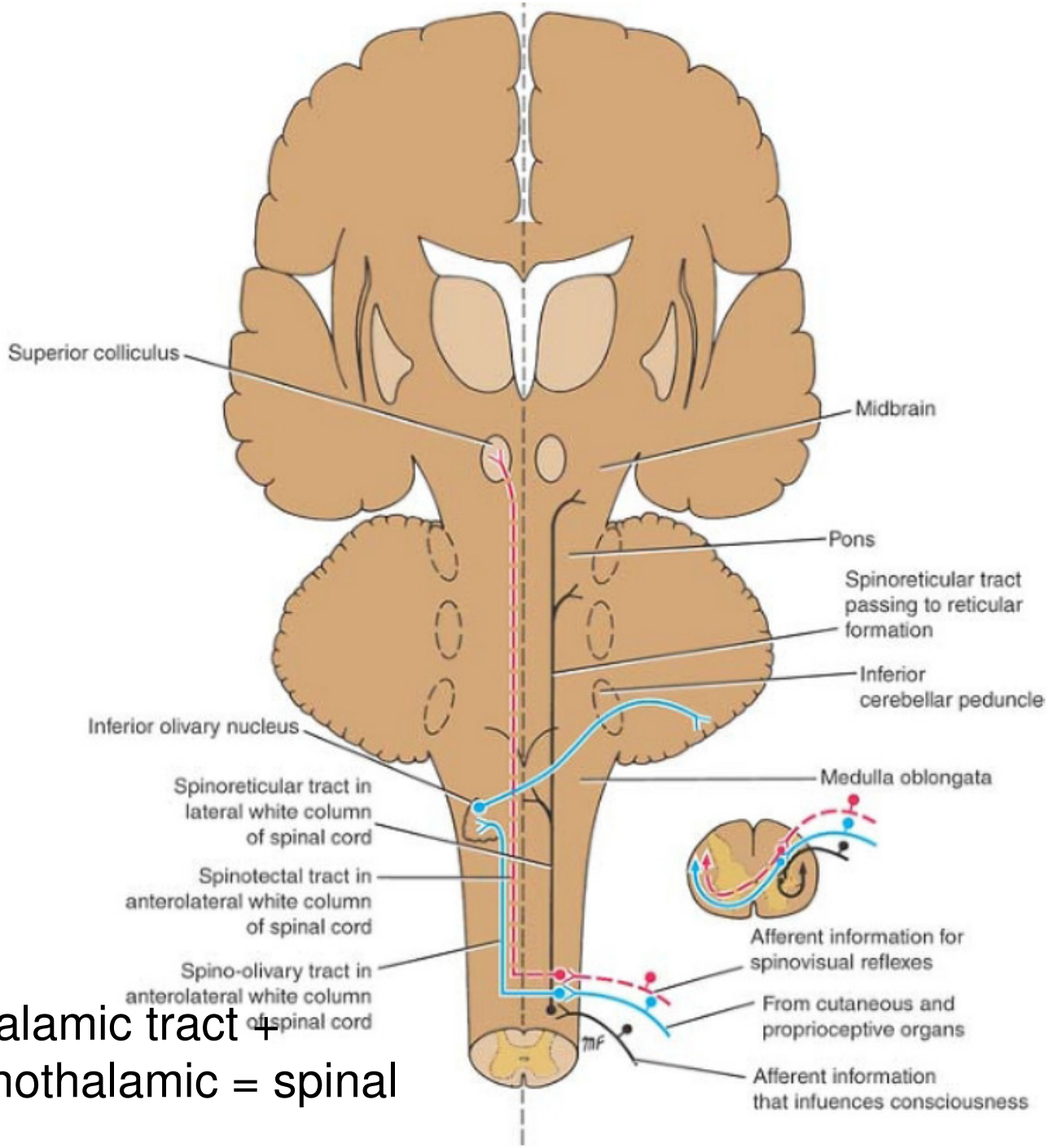
## Anterior spinothalamic tract

- Modality: crude touch and pressure
- Receptors: free nerve endings
- 1st Neuron: Dorsal root ganglia
- 2nd Neuron: the posterior gray column **(nucleus proprius)**
  The axons of 2nd order neurons cross obliquely to the opposite side in the anterior gray and white commissures , ascending in the contralateral white column as the Anterior spinothalamic tract
- 3rd Neuron: Thalamus (VPL) Internal Capsule ----- Corona Radiata
- Termination: Primary Somesthetic Area (S I)



# Spinotectal Tract

- ascend in the anterolateral white column lying close to the lateral spinothalamic tract
- Terminate: superior colliculus
- Provides afferent information for spinovisual reflexes

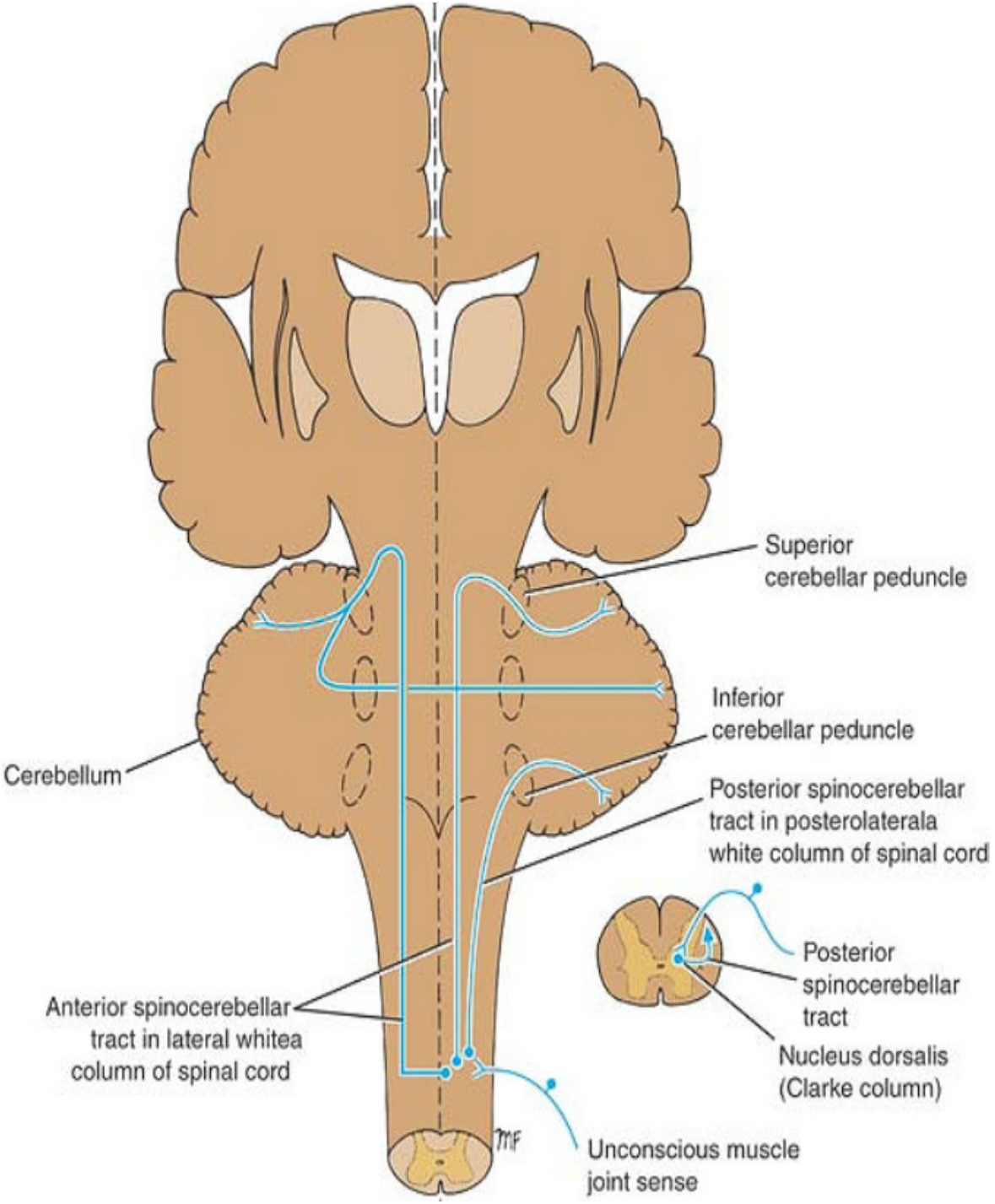



**In Medulla**: ant spinothalamic tract + spinotectal + lateral spinothalamic = spinal leminiscus

## Posterior spinocerebellar

- muscle and joint sensation
- 1st order neuron axons terminate at the base of post gray column (nucleus dorsalis or **Clarks nucleus**)
- the axons of 2nd order neurons enter posterolateral part of the lateral white matter on the **same side**
- ascend as the posterior spinocerebellar tract to medulla oblongata
- Terminates in cerebellar cortex (through inferior cerebellar peduncle)

➢ *note: axons of lower lumbar and sacral spinal nerves ascend in the posterior white column until they reach L3 or L4 segments where they synapse with nucleus dorsalis*



# Rexed laminae

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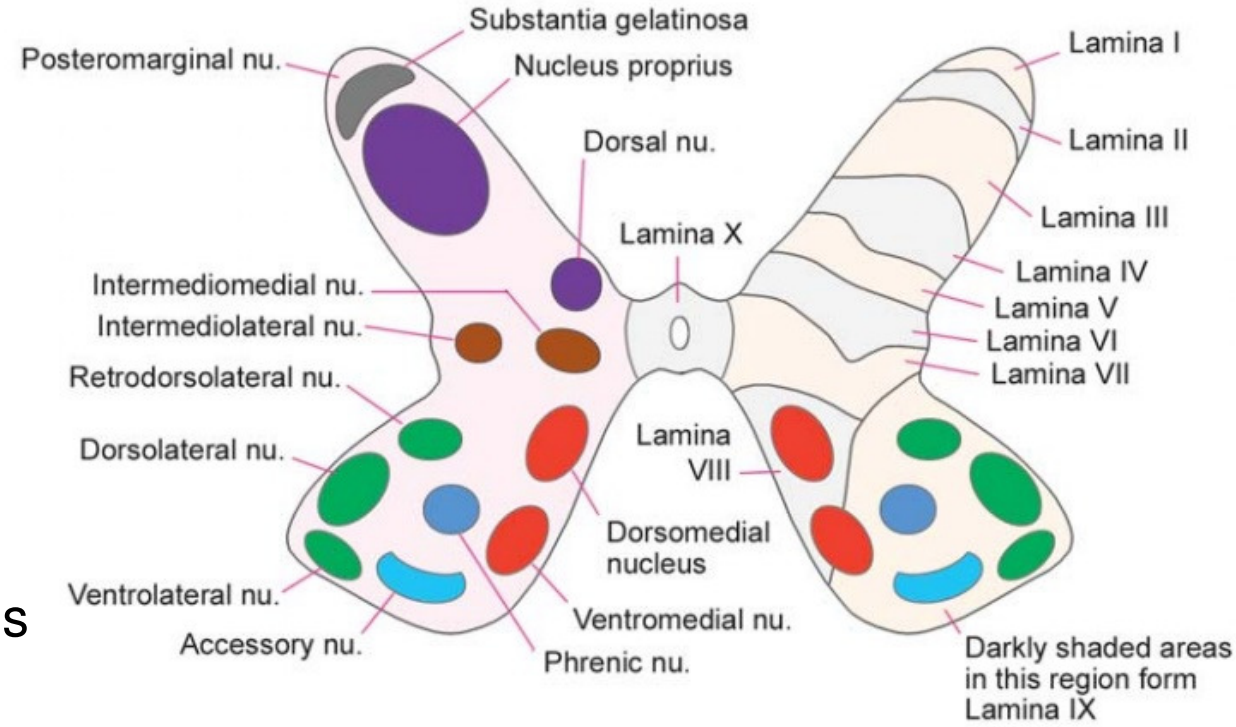


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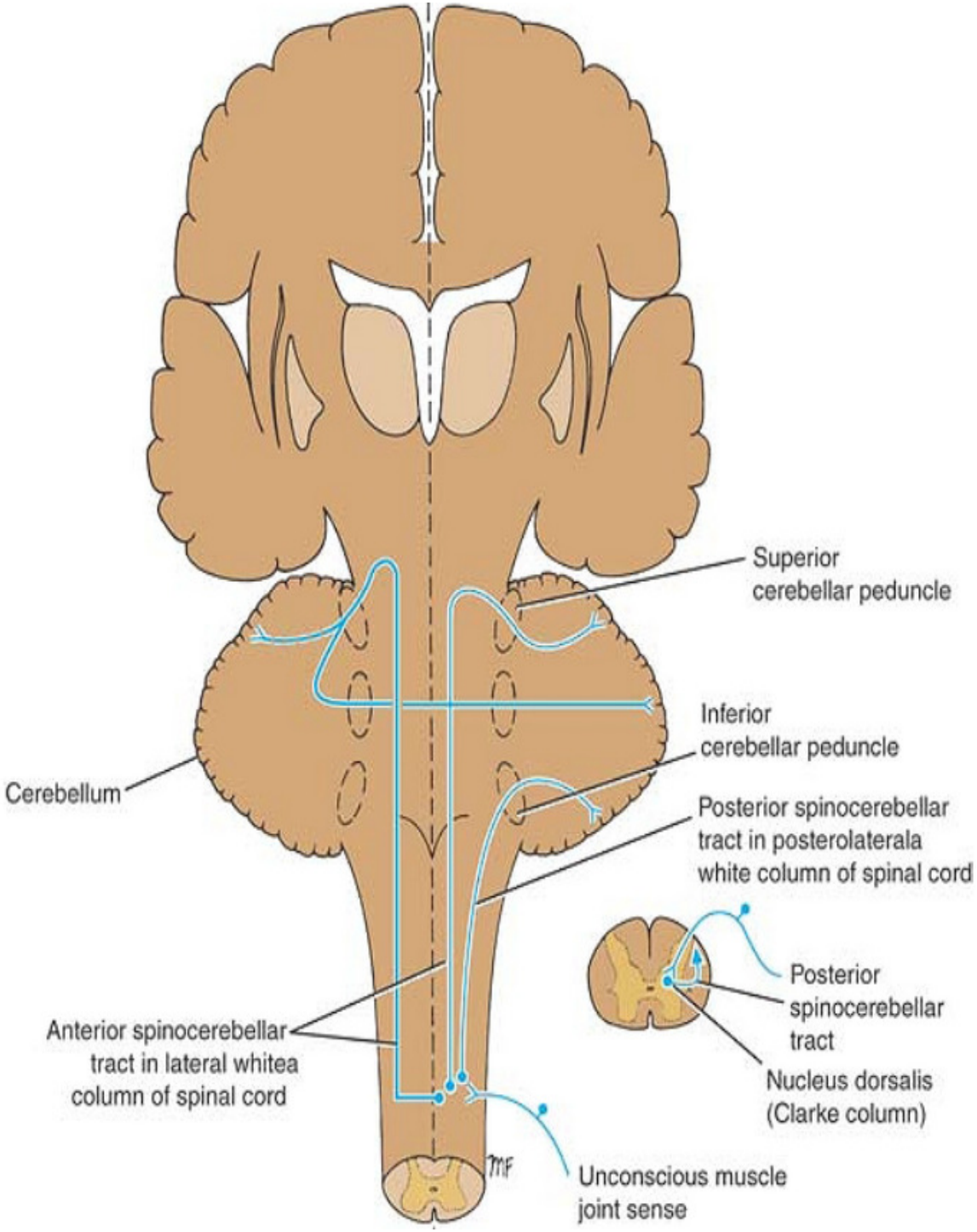
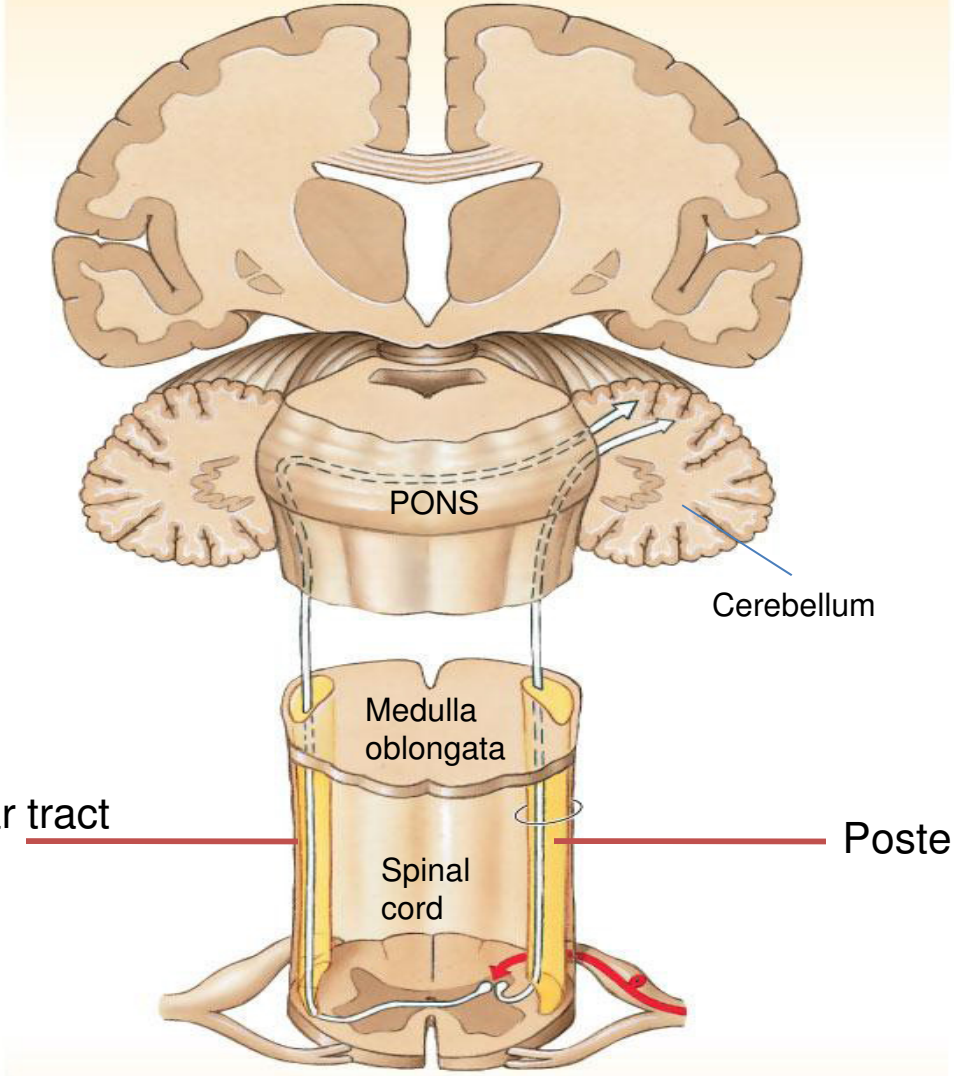
# Anterior spinocerebellar tract

- muscle and joint sensation
- 1st order neuron axons terminate at the base of post gray column (nucleus dorsalis)
- the majority of axons of 2nd order neurons cross to opposite side and ascend as anterior spinocerebellar tract in the contralateral white column
  - ➢ *the minority of axons ascend as anterior spinocerebellar tract in the lateral white column Of the same side*
- ascend as anterior spinocerebellar tract to medulla oblongata and pons
- Terminates in cerebellar cortex (through superior cerebellar peduncle)
  - ➢ *the fibers that **crossed over** in spinal cord **cross back** within cerebellum*



## Spinocerebellar Tracts




Anterior spinocerebellar tract

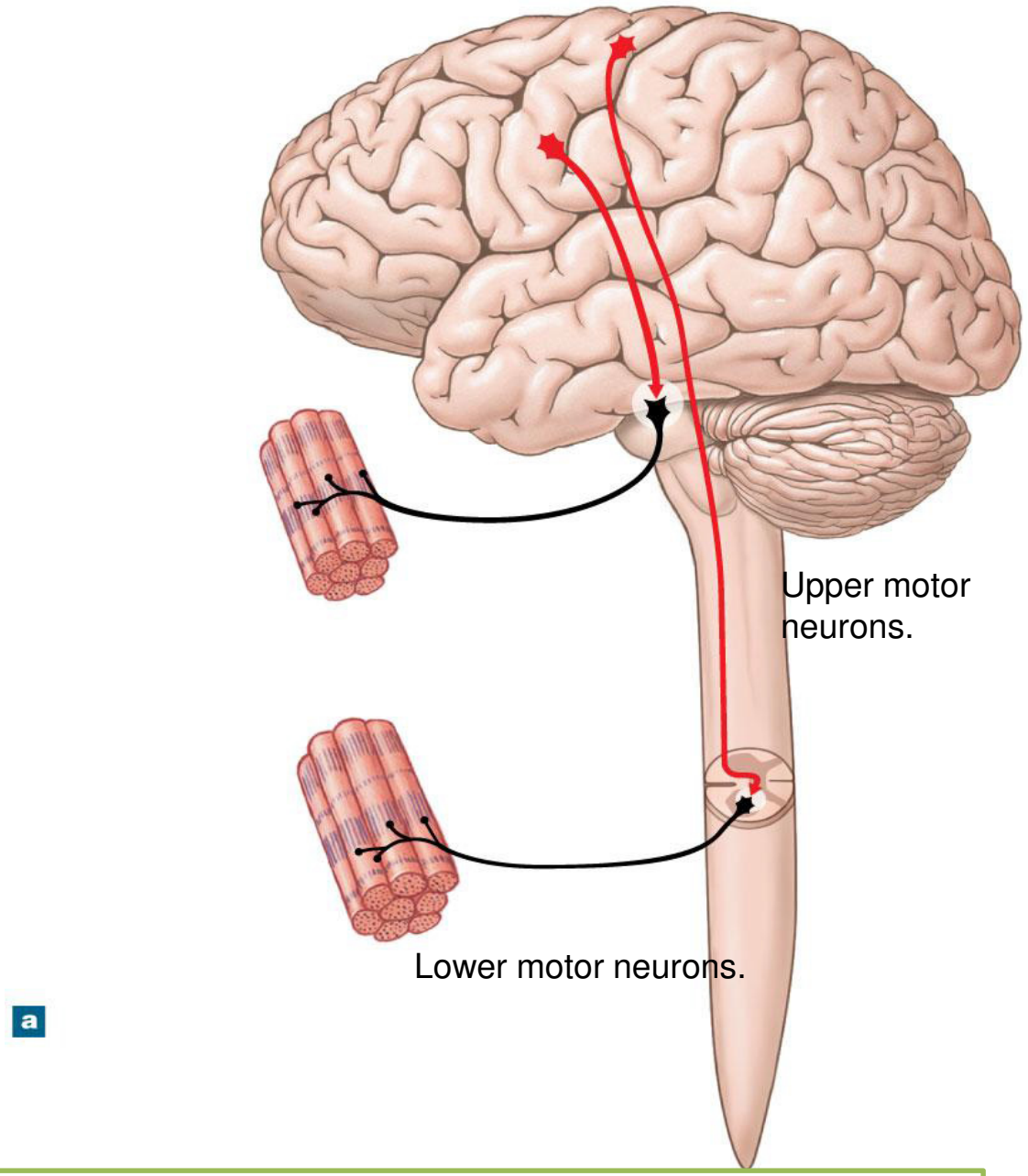
Posterior spinocerebellar tract

**Proprioceptive input from Golgi tendon organs,**
**muscle spindles, and joint capsules**

d

# Motor tracts

- There are two major descending tracts
- **Pyramidal tracts** (Corticospinal ) : Conscious control of skeletal muscles
- **Extrapyramidal:** Subconscious regulation of balance, muscle tone, eye, hand, and upper limb position:
  - **Vestibulospinal tracts**
  - **Reticulospinal tracts**
  - **Rubrospinal tracts**
  - **Tectospinal tracts**




**Extrapyramidal tracts arise in the brainstem, but are under the influence of the cerebral cortex**

# Rexed laminae

- **Lamina 8:** motor interneurons, Commissural nucleus
- **Lamina 9:** ventral horn, LMN, divided into nuclei:
  - **Ventromedial**: all segements (extensors of vertebral coloumn)
  - **Dorsomedial**: (T1-L2) intercostals and abdominal muscles
  - **Ventrolateral:** C5-C8 (arm) L2-S2 (thigh)
  - **Dorsolateral:** C5-C8 (Forearm), L3-S3 (Leg)
  - **Reterodorsolateral:** C8-T1 (Hand), S1-S2 (foot)
  - **Central:** Phrenic nerve (C3-C5)
- **Lamina X**: Surrounds the central canal – the grey commissure

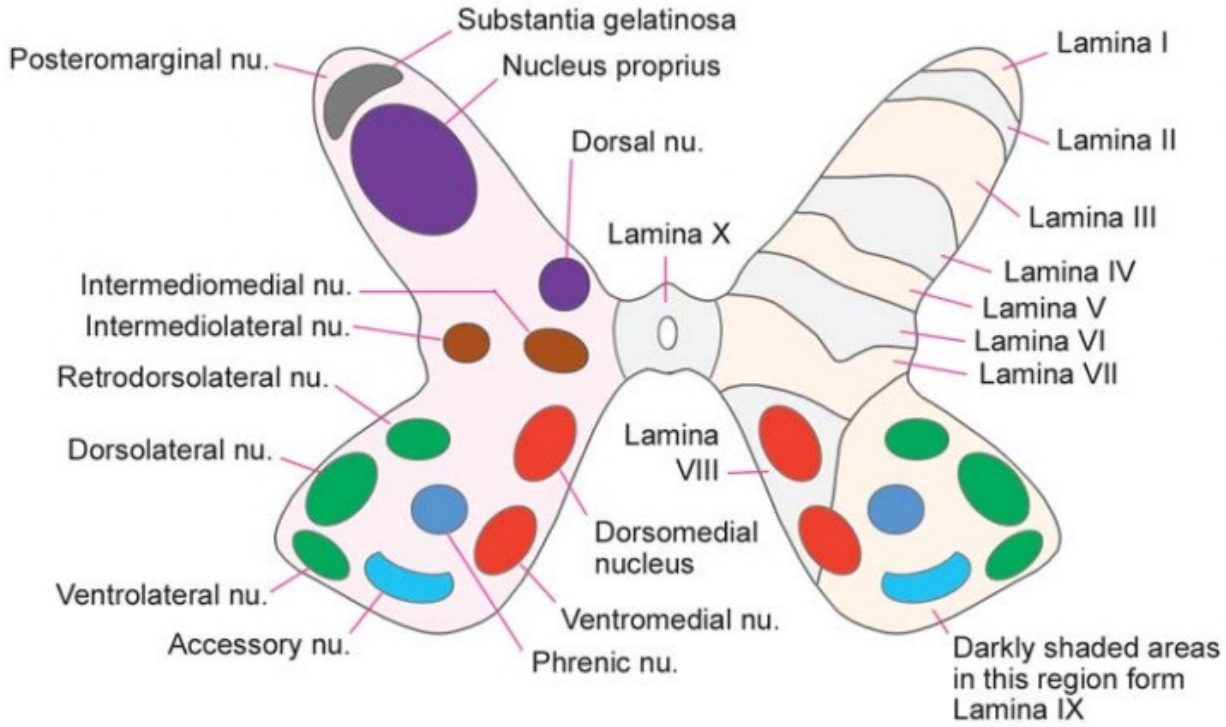
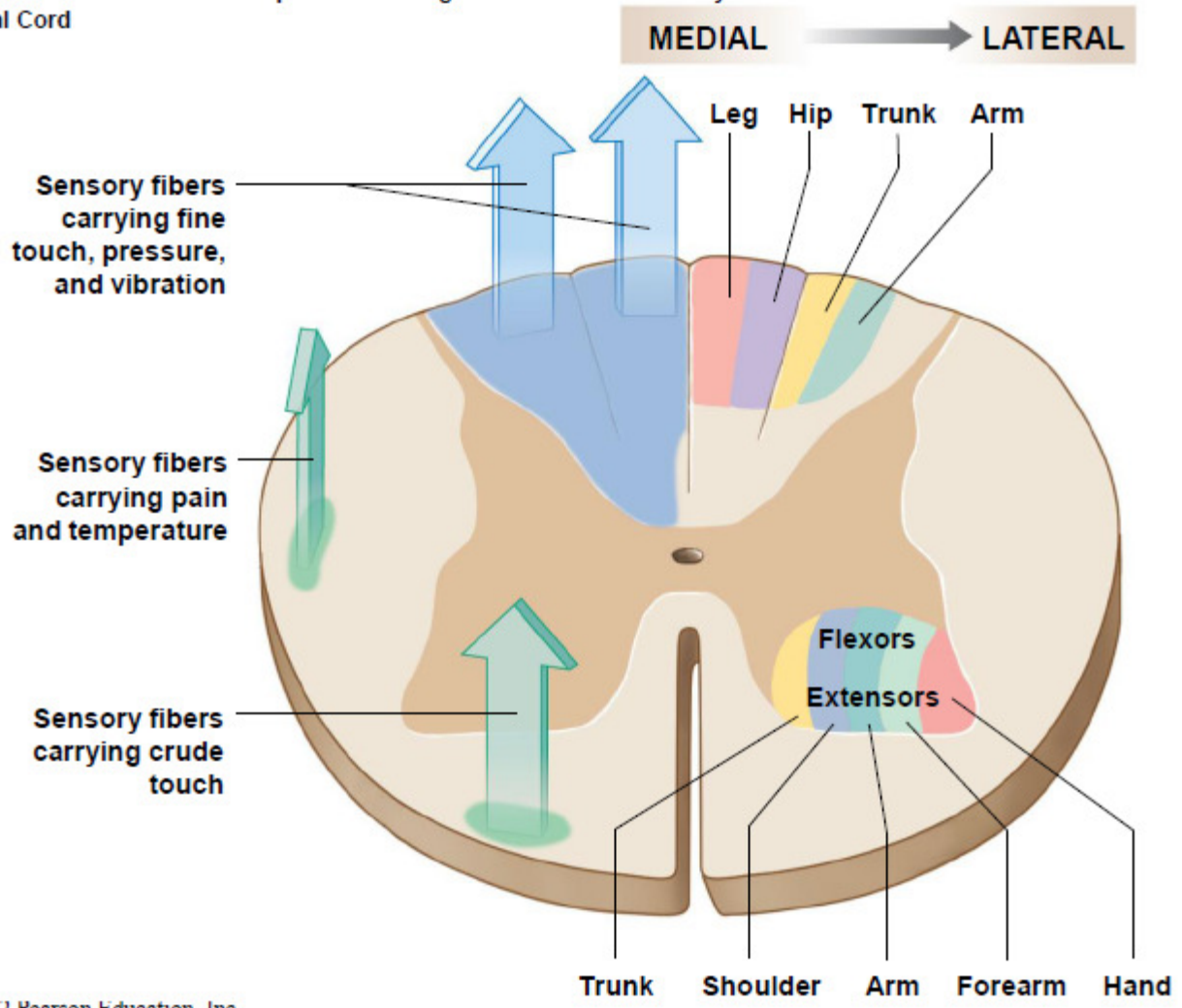



Fig. 5.2. Subdivisions of the grey matter of the spinal cord. The left half of the figure shows the cell groups usually described. The right half shows the newer concept of laminae.

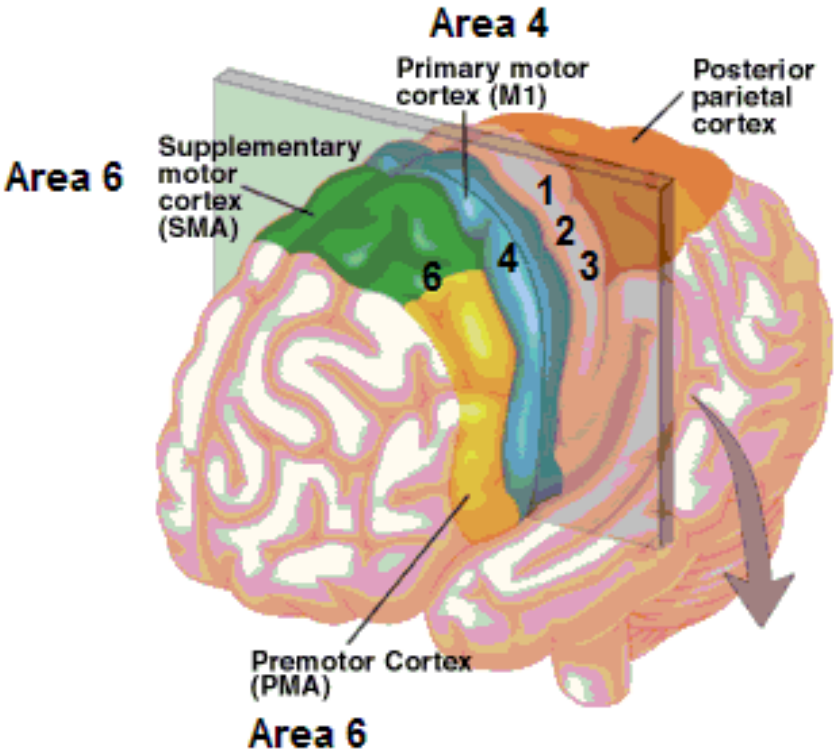
- Motor neurons of anterior horn
  - **Medial group:** (All segments)
  - **Lateral group:** only enlargements

Figure 15.1 Anatomical Principles for the Organization of the Sensory Tracts and Lower–Motor Neurons in the Spinal Cord



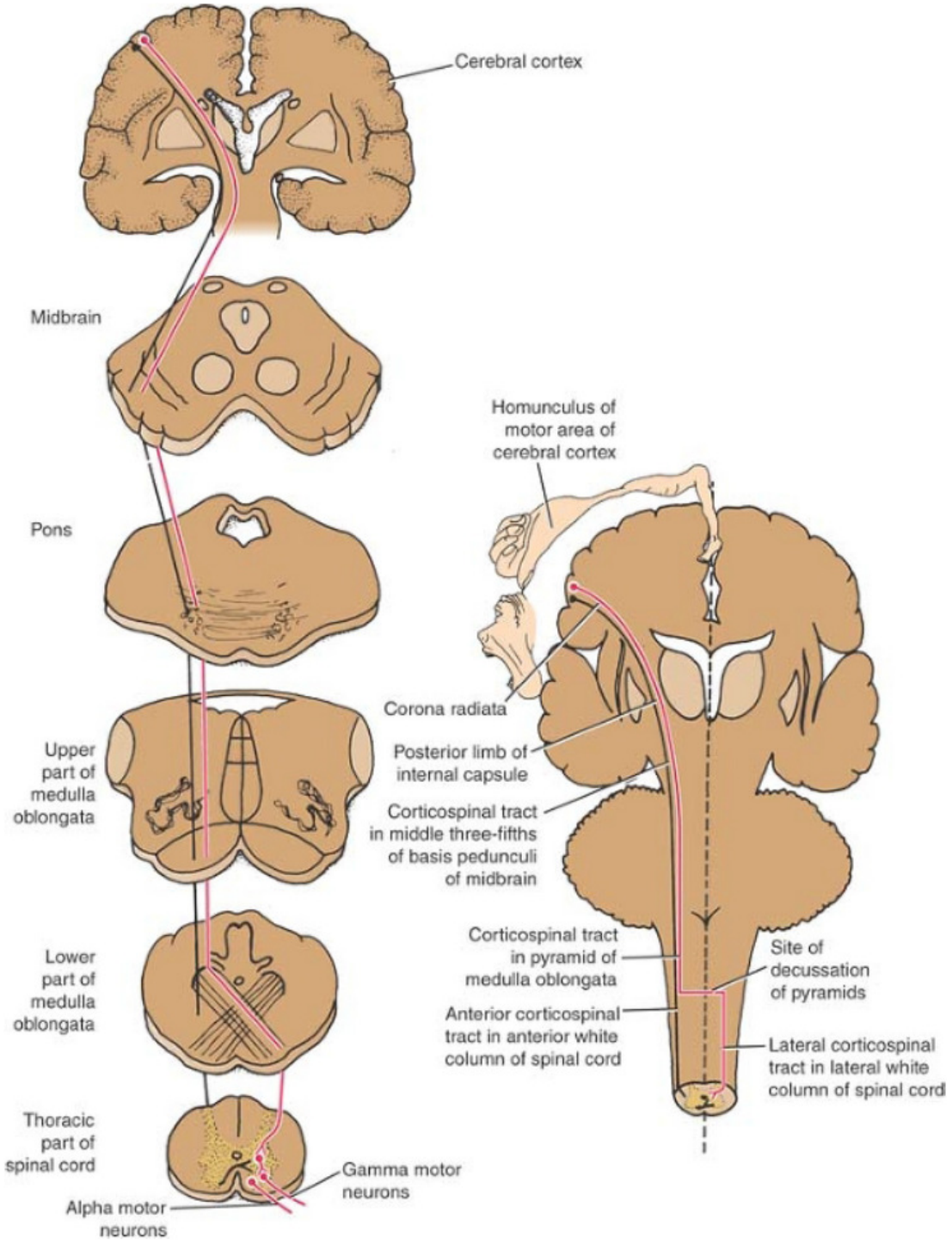
## Motor tracts

- Both pyramidal tracts and extrapyramidal both starts from cortex:
  - Area 4
  - Area 6
  - Area  312
- Pyramidal: mainly from area 4
- Extrapyramidal: mainly from area 6
  - area 6
  - **Premotor area:** uses external cues
  - **Suplemantary motor area:** uses internal cues

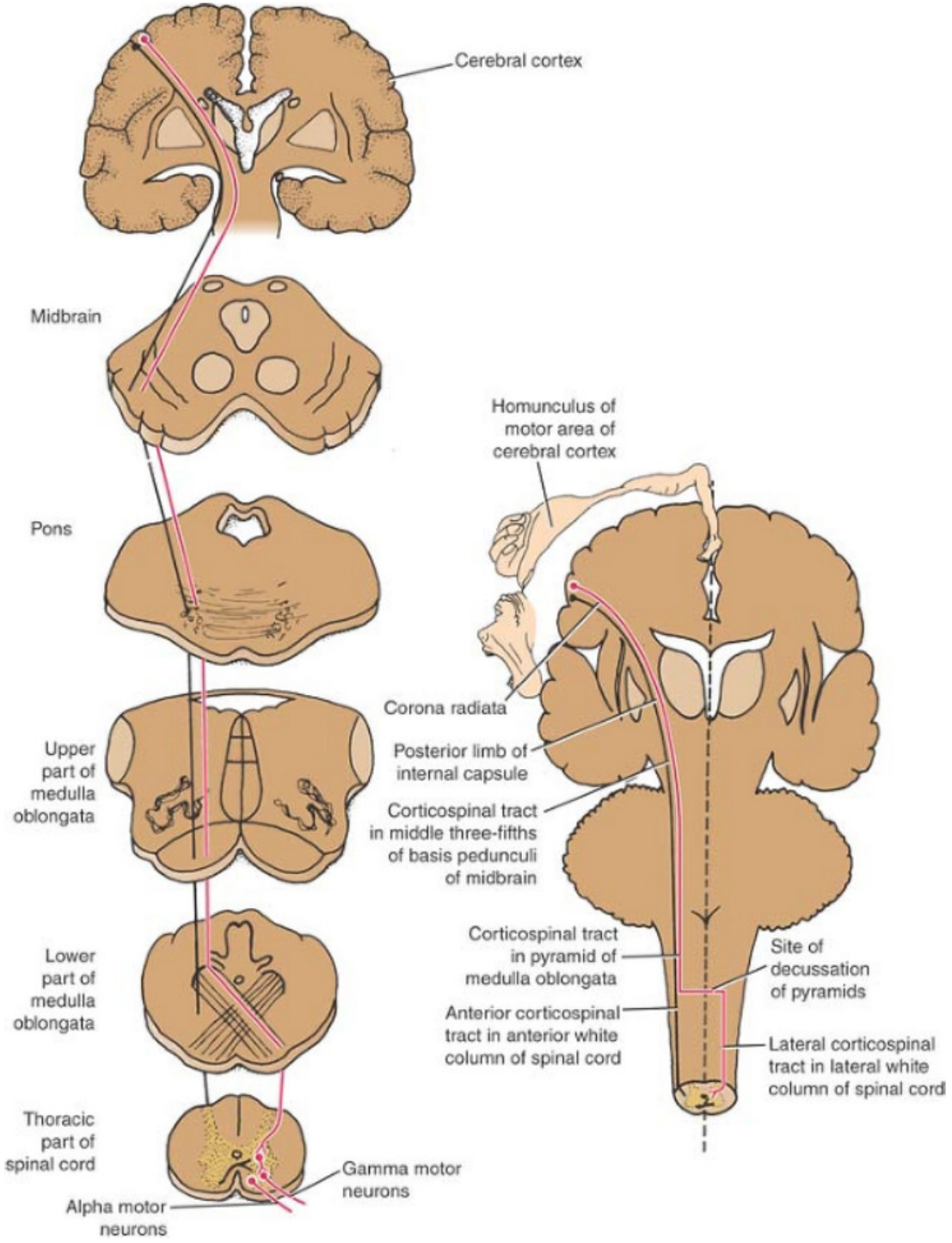


## Lateral corticospinal tract

- The upper motor neurons of these tracts originate in the precentral gyrus of the cerebral cortex
- In midbrain:middle three-fifths of the **basis pedunculi of the midbrain**
- In medulla oblongata: pyramids
- Most of the fibers (85 percent) cross over (decussate) to the opposite side in the pyramidal decussation, where they continue to descend in the **lateral funiculus** of the spinal cord as the **lateral corticospinal tract** (LCST).

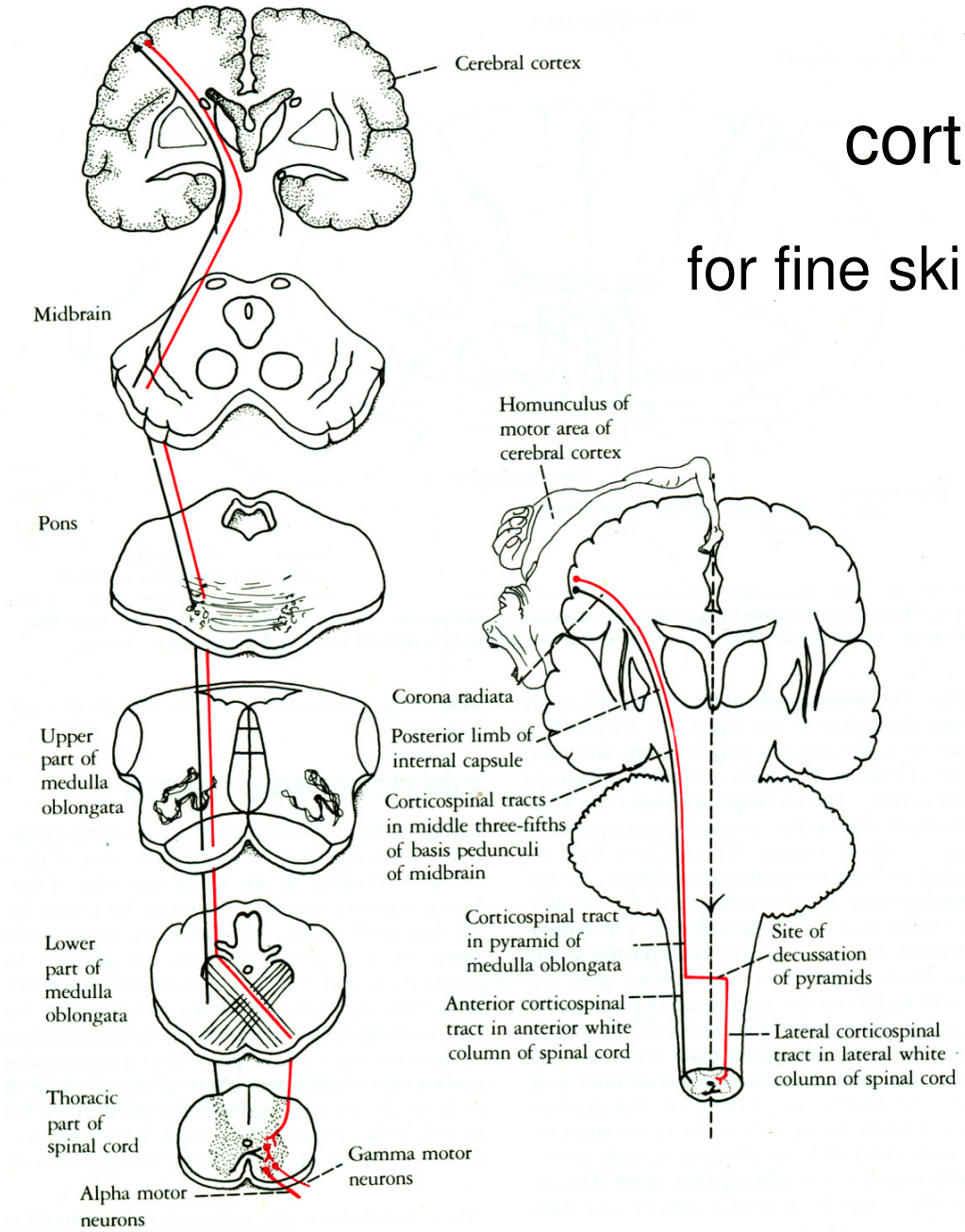


- The tract descends all the way of spinal cord with fibers continually leaving it in order to synapse on interneurons in the anterior gray horn. ( Some even synapse directly on alpha and gamma motor neurons)
- *Those corticospinal fibers which do not decussate in the medulla continue descending on the same (ipsilateral) side of the cord and become the anterior corticospinal tract (ACST).*



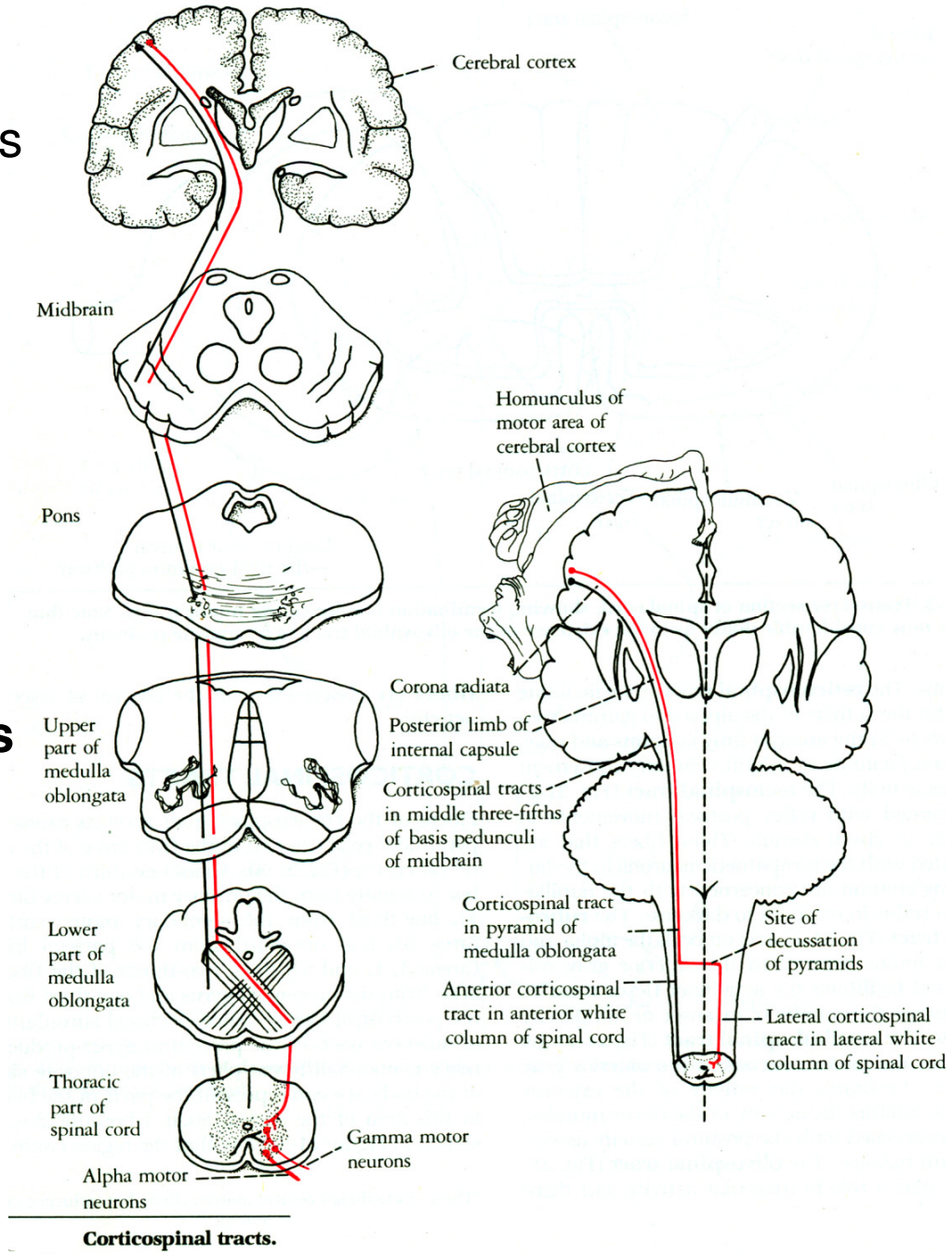
# corticospinal tract

## for fine skilled movements

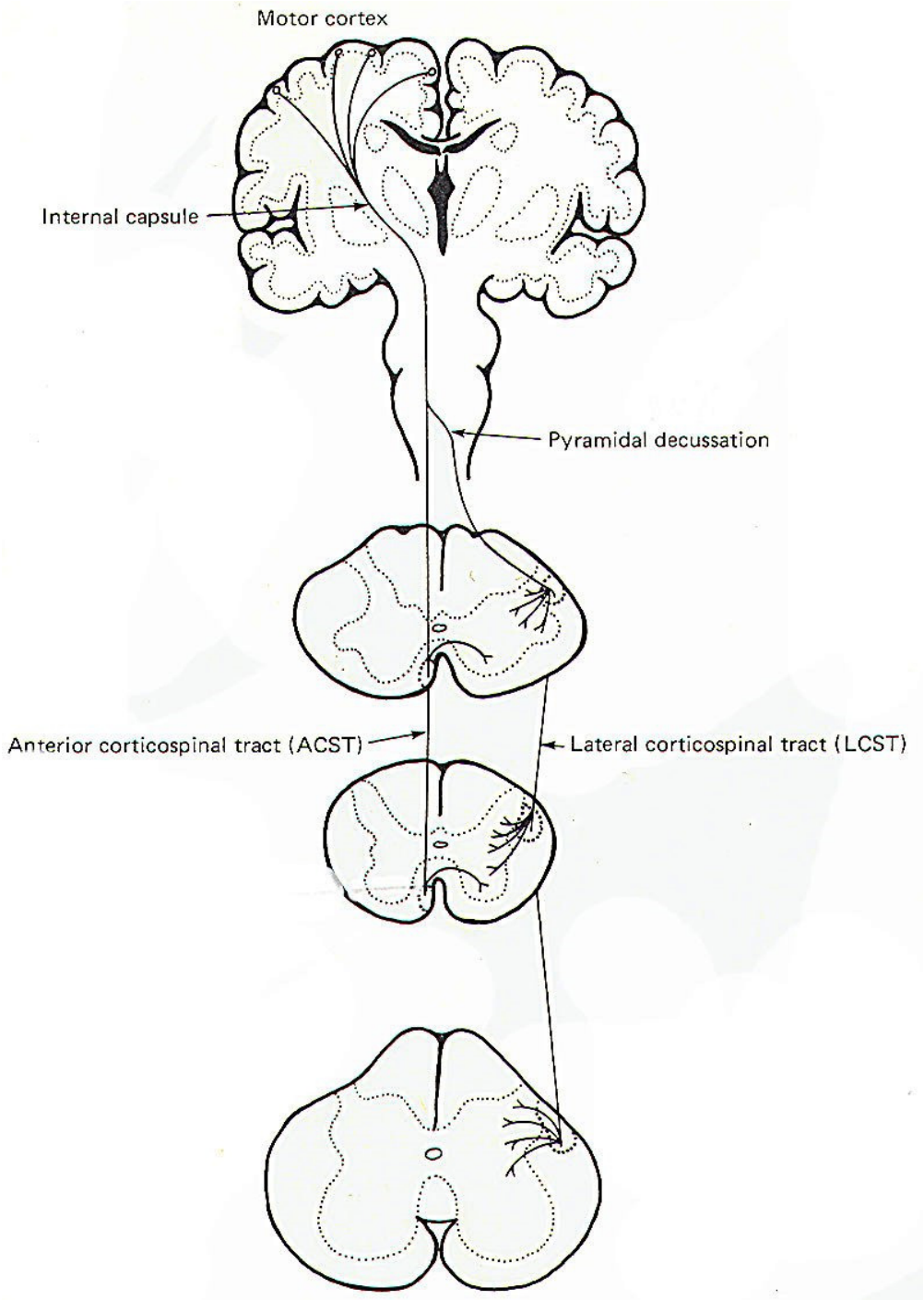



**Corticospinal tracts.**

- Lateral corticospinal tract descends the full length of the spinal cord
- LCST fibers synapse with alpha and gamma nuclei of the
  - Cervical region **(55%)** (great effect on the upper limb)
  - Thoracic 20%
  - Lumbar and Sacral 25%
- The lateral corticospinal tract synapses **mainly by interneurons** In lamine IV, V, VI, VII, VIII
- **Exception:** 3% originate from the fifth layer of area 4 (giant cells of betz) synapse directly. (Accurate movements)



**Corticospinal tracts.**



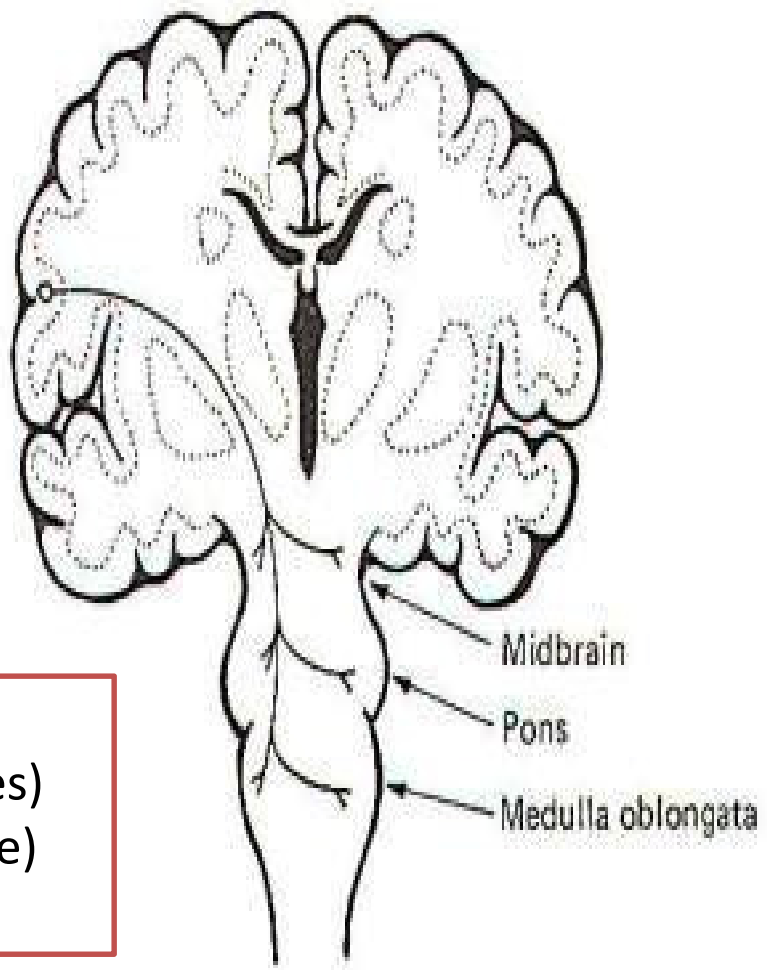

**The anterior corticospinal tract**

acts on the proximal muscles of upper limb (shoulder muscle) of the ipsilateral and contralateral sides

*Fibers leave the tract at various levels to cross over in the anterior white commissure to synapse on interneurons in the anterior gray horn.*

**The Corticoneuclear Tract (fibers)**

- This tract is composed of fibers originating in the precentral gyrus of the lower quarter of the motor cortex.
- The descending fibers terminate in the motor nuclei of cranial nerves III and IV in the midbrain; V, VI. and VII in the pons; and IX, X, XI, and XII in the medulla.
- The corticobulbar fibers from one side of the brain project to the motor nuclei on both sides of the brainstem (bilateral input)




The corticoneuclear input is bilateral **Except** :

1- Part of 7th ( which supplies LOWER facial muscles)

2- Part of 12th (which supplies genioglossus muscle)

**The Subconscious Motor Tracts**

•Consists of four tracts involved in monitoring the subconscious motor control

•**Vestibulospinal tracts**

•**Tectospinal tracts**

•**Reticulospinal tracts**

•**Rubrospinal tracts**

Extrapyramidal tracts arise in the brainstem, but are under the influence of the cerebral cortex

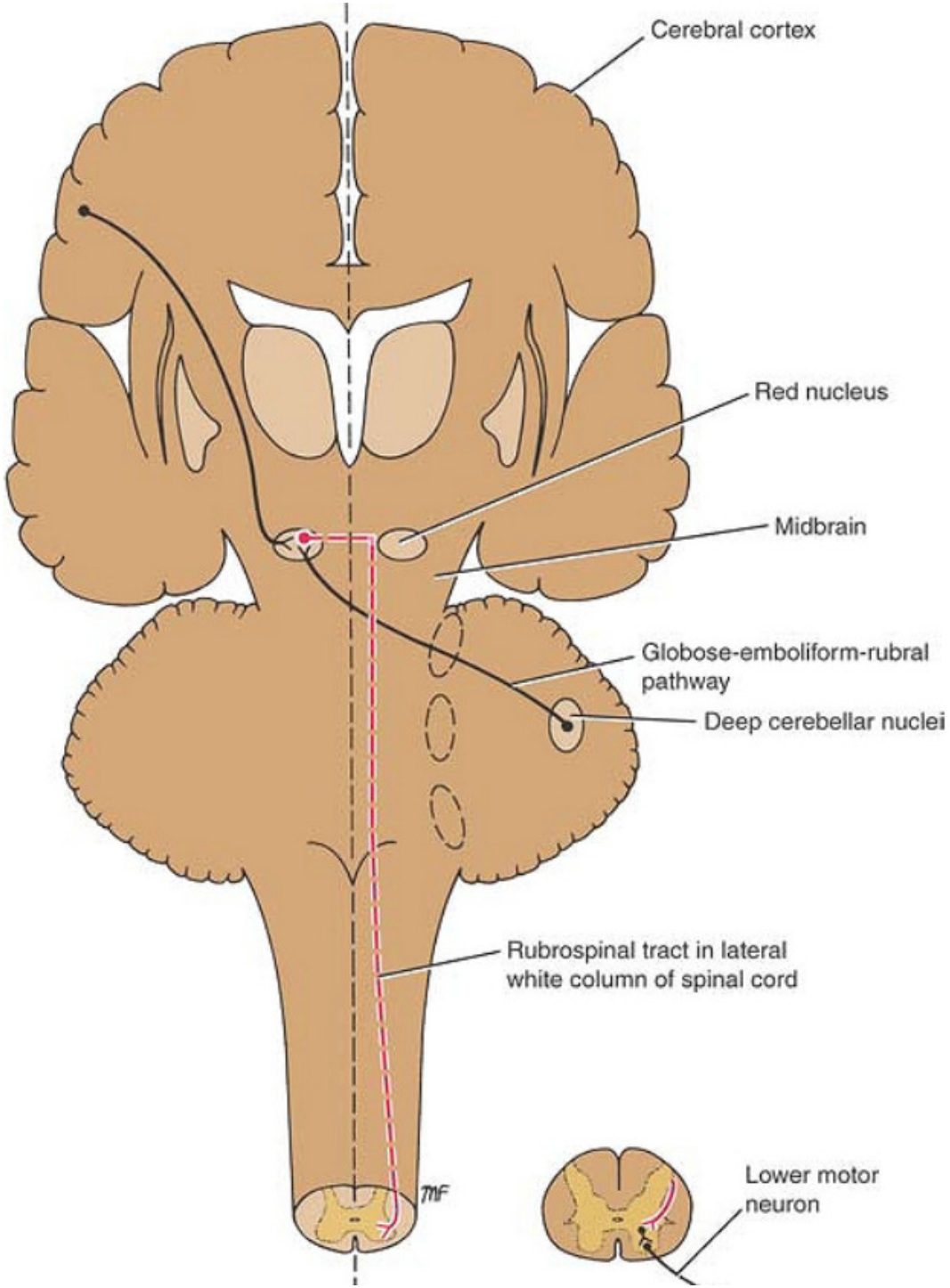
These motor pathways are complex and multisynaptic, and regulate:

- Axial muscles that maintain balance and posture
- Muscles controlling coarse movements of the proximal portions of limbs
- Head, neck, and eye movement

# Rubrospinal tract

- **Red nucleus**
  - In the midbrain at the level of superior colliculus
  - Recieves afferent fibers from cerebral cortex and the cerebellum
- **Crossed** (at the level of the nucleus)
- Lateral white column
- **Function:**

  facilitate the activity of flexors and inhibit the activity of extensors



# Rubrospinal tract

- rubrospinal tract is very close to the lateral corticospinal tract in the spinal cord. They form the **lateral motor system**
- synapses with alpha and gamma through interneurons
- Excitatory to flexors and inhibitory to extensors
- supply the distal flexors muscles mainly with little effect on the proximal muscles

( facilitate the activity of flexor muscles )

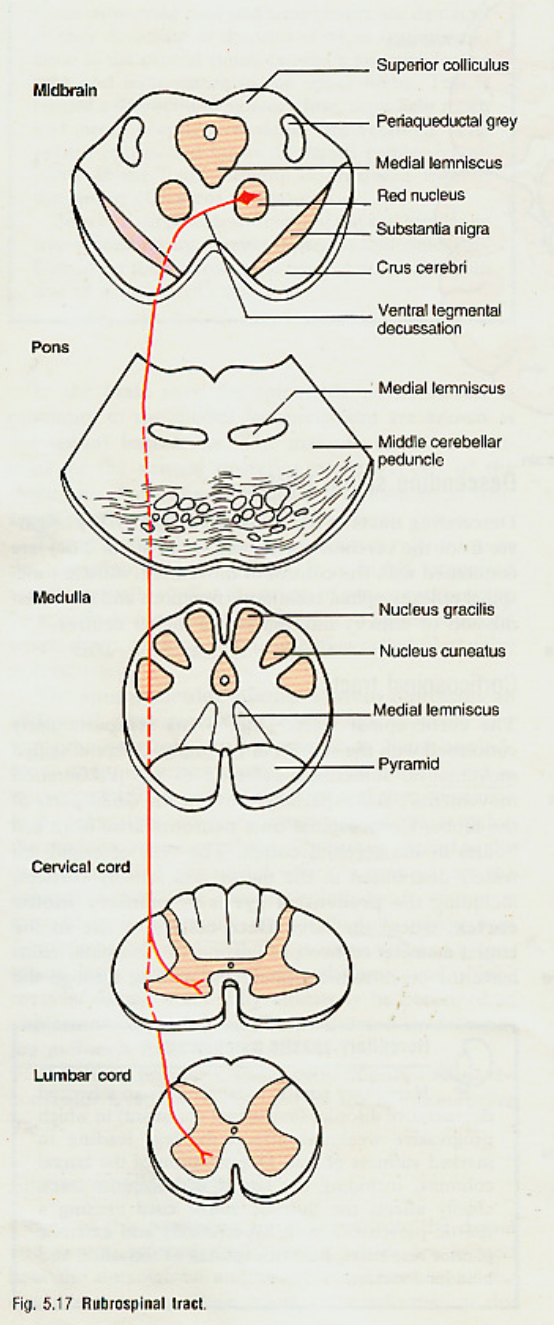
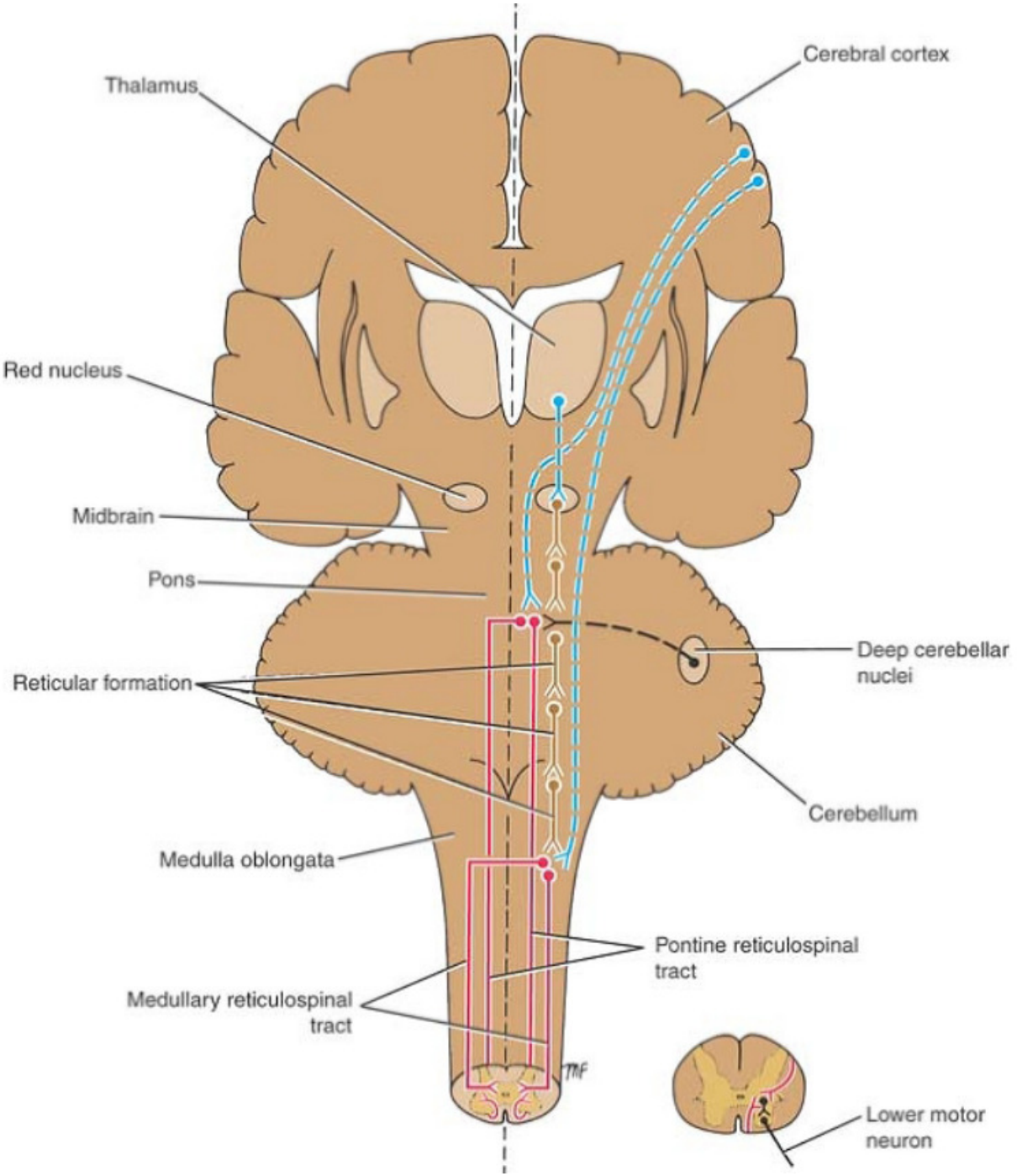


Fig. 5.17 Rubrospinal tract.

**Pontine reticulospinal tract**

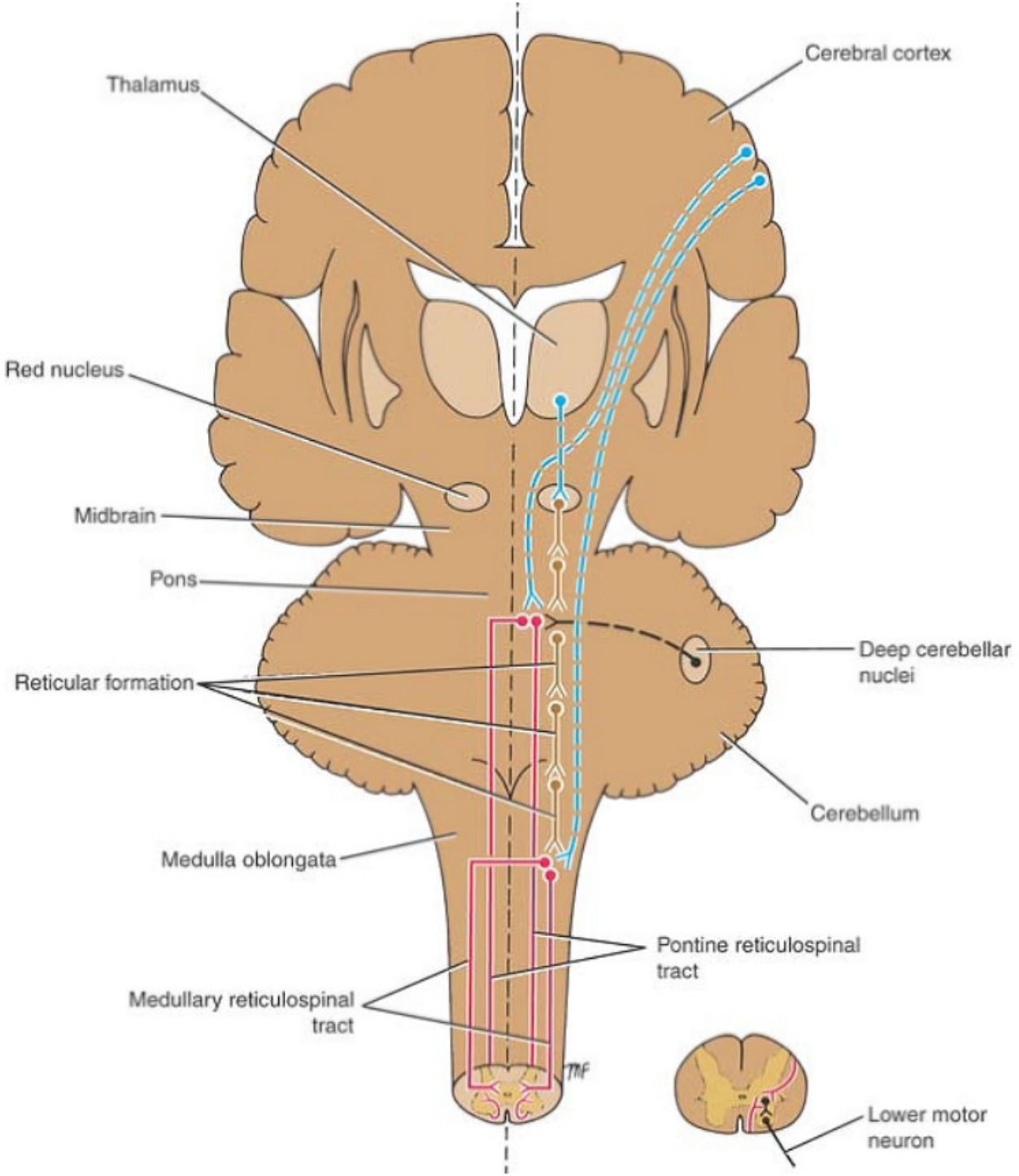
- From pons:
- axons of RF neurons descend **uncrossed** into the spinal cord
- Anterior white column
- medial reticulospinal tract (MRST)
- **tonically active**
- normally under **inhibition from cortex**
- **Function:**
- activate the axial and proximal limb extensors



# Medullary reticulospinal tracts

- From medulla
- axons of RF neurons descend **crossed and uncrossed** into the spinal cord
- Lateral white column
- Lateral reticulospinal tract (LRST)
- NOT tonically active
- normally under **stimulation**
- **Function:**

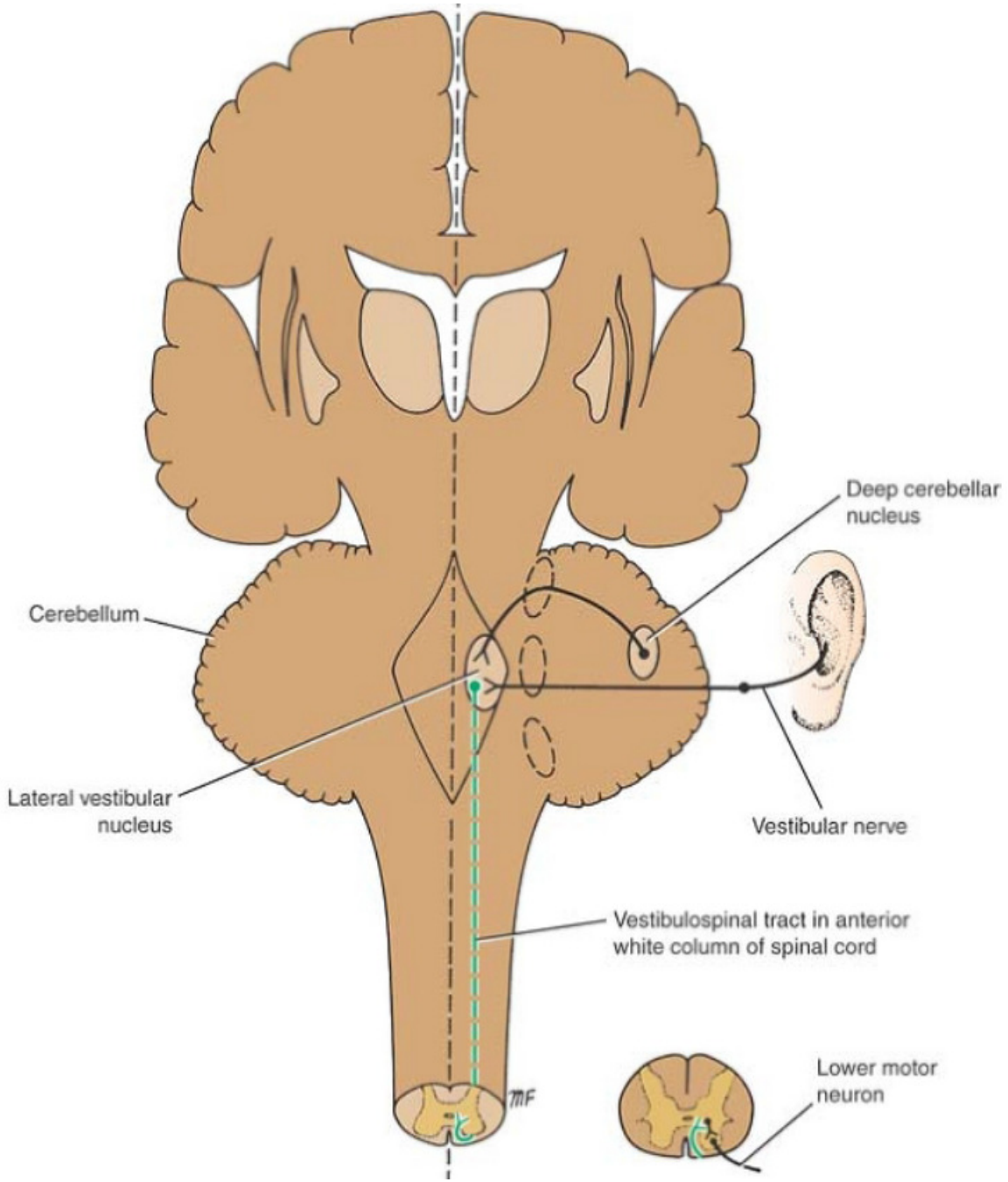
  Inhibit the axial and proximal limb extensors



Vestibulospinal Tract

- **Vestibular nuclei**
  - in the pons and medulla beneath the floor of 4th ventricle
  - Recieves afferent fibers from the inner ear throug the vestibular nerve and from the cerebellum
- **Uncrossed**
- Anterior white column
- **Function:**

  facilitate the activity of extensor muscles and inhib the activity of flexor muscles association with the maintenance of balance



# Vestibulospinal tract

- nerve cells in vestibular nucleus (in the pons and medulla oblongata
  - received afferents from inner ear and cerebellum

- axons descend <u>uncrossed</u>
  - through medulla and through the length of spinal cord

- synapse with neuron in the anterior gray column of the spinal cord

**( balance by facilitate the activity of the extensor muscles )**

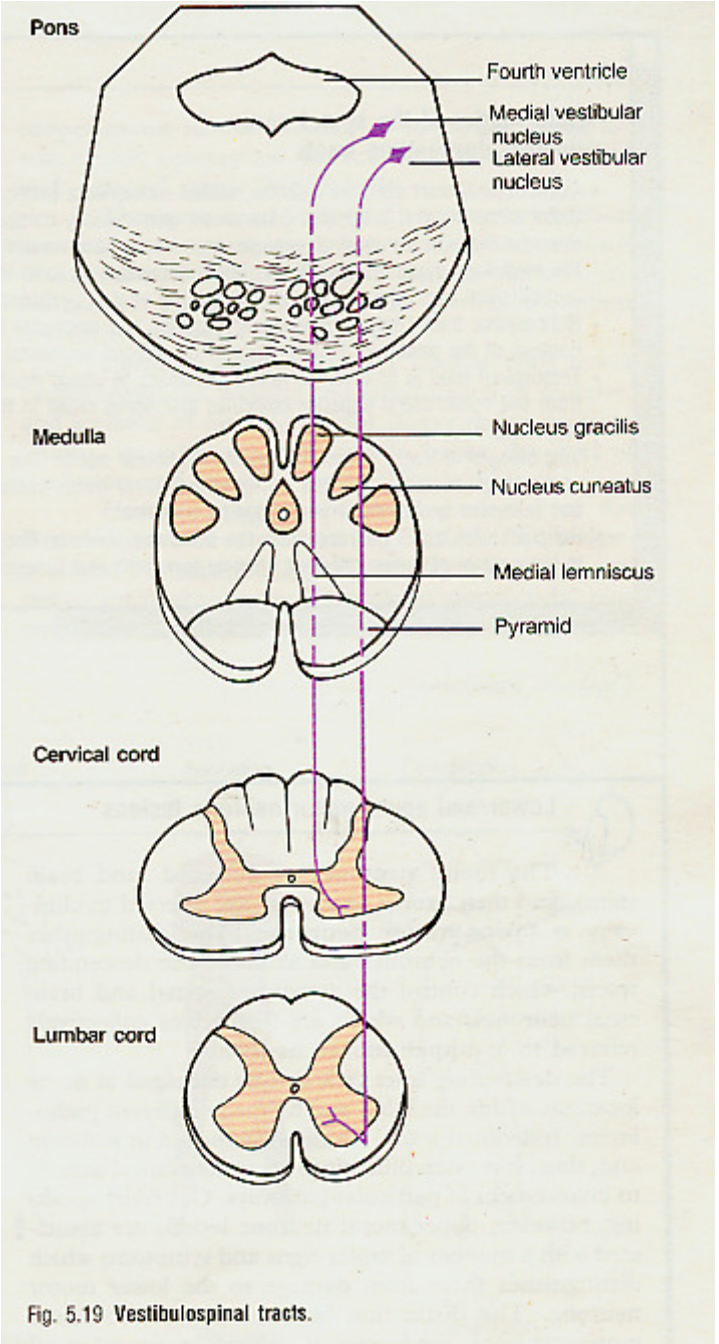
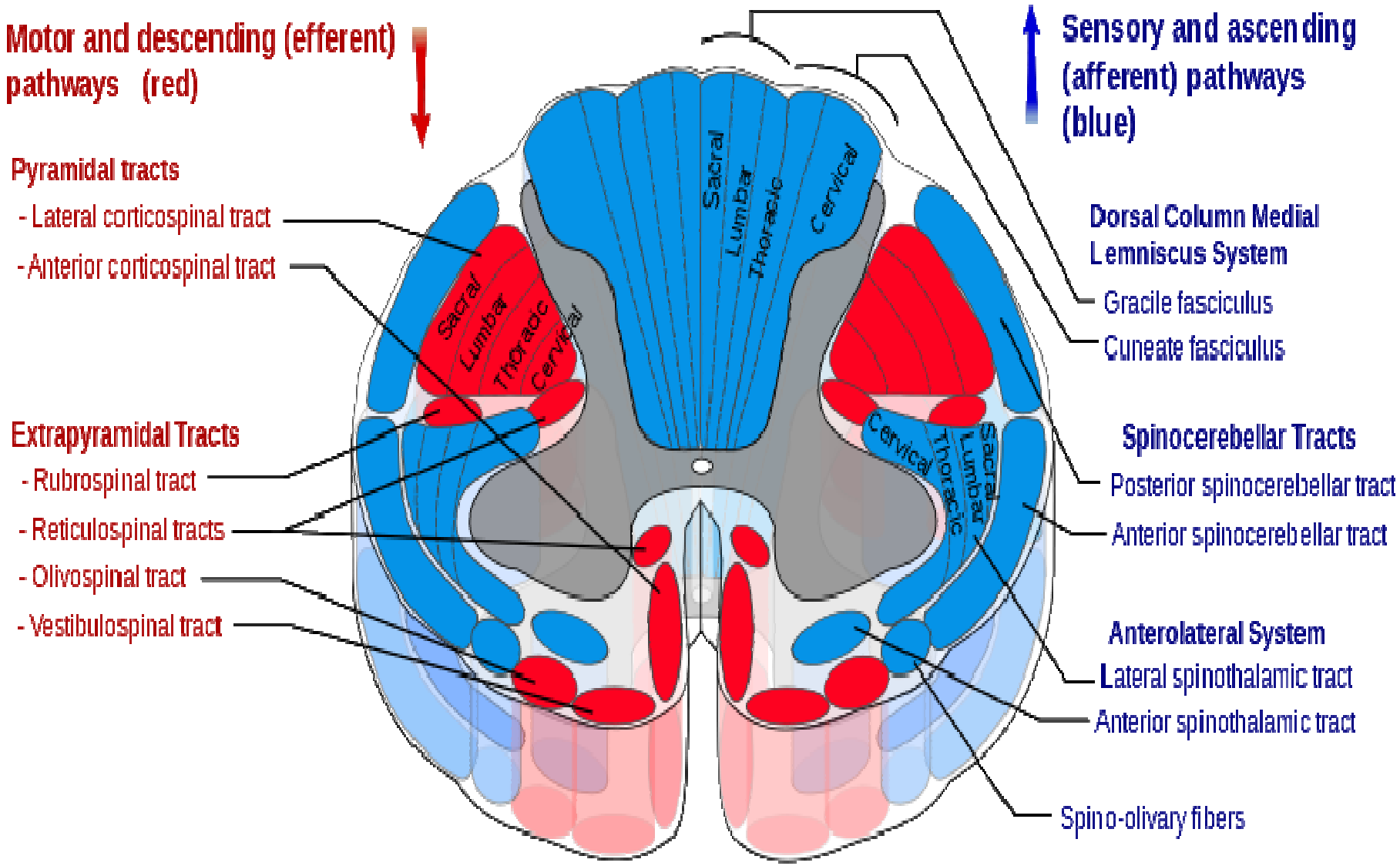
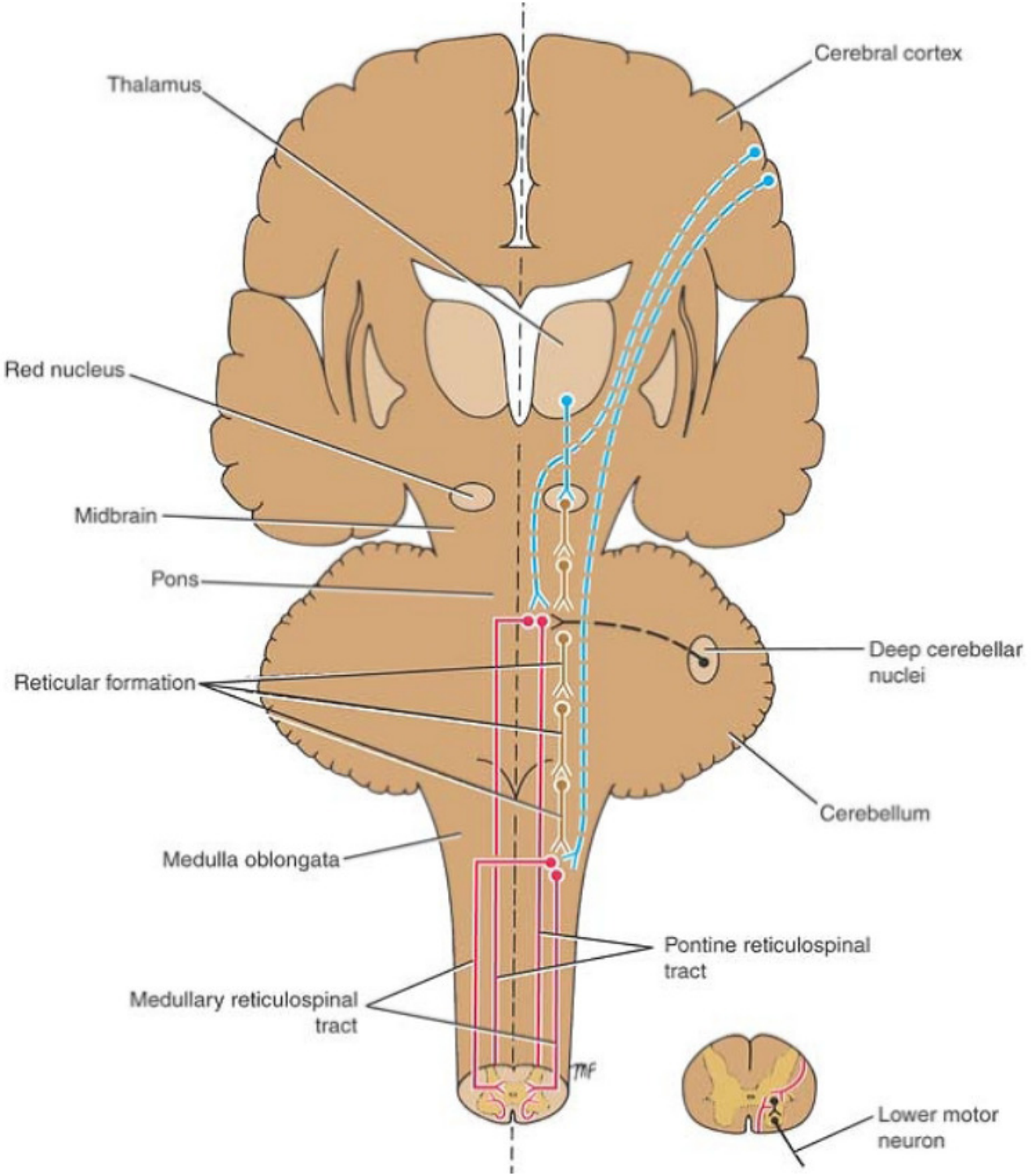


Fig. 5.19 Vestibulospinal tracts.


Motor and descending (efferent) pathways (red)
Pyramidal tracts
- Lateral corticospinal tract
- Anterior corticospinal tract
Extrapyramidal Tracts
- Rubrospinal tract
- Reticulospinal tracts
- Olivospinal tract
- Vestibulospinal tract
Sacral
Lumbar
Thoracic
Cervical
Sensory and ascending (afferent) pathways (blue)
Dorsal Column Medial Lemniscus System
Gracile fasciculus
Cuneate fasciculus
Spinocerebellar Tracts
Posterior spinocerebellar tract
Anterior spinocerebellar tract
Anterolateral System
Lateral spinothalamic tract
Anterior spinothalamic tract
Spino-olivary fibers

# Reticulospinal tracts

- Has also descending autonomic fibers providing a pathway by which the hypothalamus can control the sympathetic and sacral parasympathetic outflow.
- Most of these fibers are derived from *the lateral reticulospinal tract*

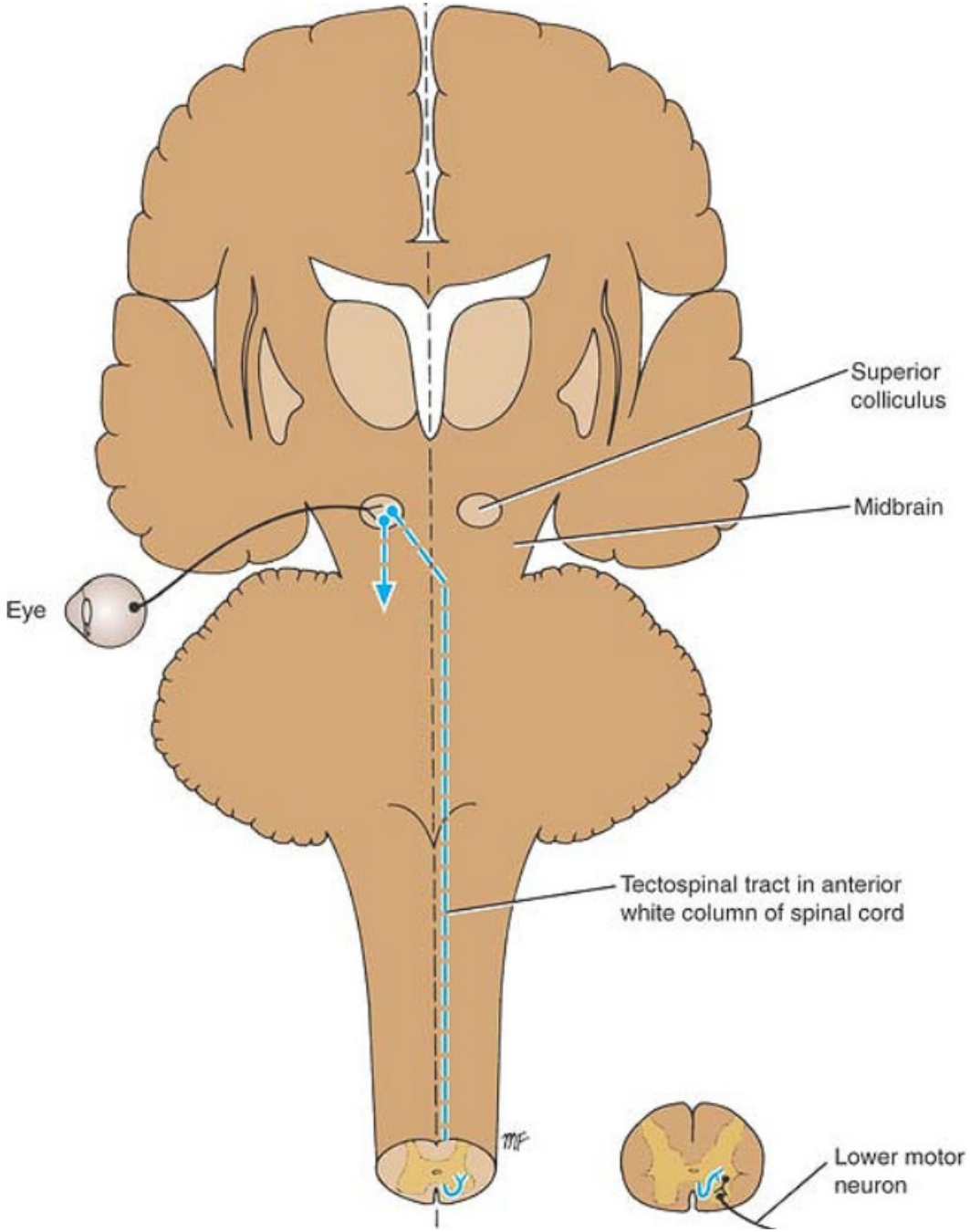


# Tectospinal tract

- nerve cells in superior colliculus of the midbrain
- **Crossed**
- The tract descends in the anterior white column close to Anterior median fissure
- Majority of fibers terminate in the anterior gray column of upper cervical segments of spinal cord

**( responsible for reflex movement of**

**head & neck in response to visual stimuli )**



## The motor pathways are classified into

- **Medial Motor system**: axial & proximal muscles. Medial Motor system include:
  - Anterior corticospinal tract.
  - Extrapyramidal pathway in general
- **Lateral Motor system**: distal muscles mainly, lateral Motor system include
  - lateral corticospinal tract
  - Rubrospinal tract distal muscles mainly (and proximal).

# COMPARISON BETWEEN UMN AND LMN

| Features | Upper motor neuron lesions(UMN) | Lower motor neuron lesion(LMN) |
|---|---|---|
| | UMN starts from motor cortex to the cranial nerve nuclei in brain and anterior horn cells in spinal cord | LMN is the motor pathway from anterior horn cell(or Cranial nerve nucleus)via peripheral nerve to the motor end plate |
| Bulk of muscles | No wasting | Wasting of the affected muscles (atrophy) |
| Tone of muscles | Tone increases (Hypertonia) | Tone decreases (Hypotonia) |
| Power of muscles | Paralysis affects movements of group of muscles<br>Spastic/ clasp knife | Individual muscles is paralyzed<br>Flaccid ( flaccid paralysis) |
| Reflexes | Exaggerated. (Hyperreflexia) | diminished or absent. (Hyporeflexia) |
| Fasciculation | Absent | Present |
| Babinski sign | Present | Absent |
| clasp-knife reaction | Present | Absent |
| Clonus | Present | Absent |

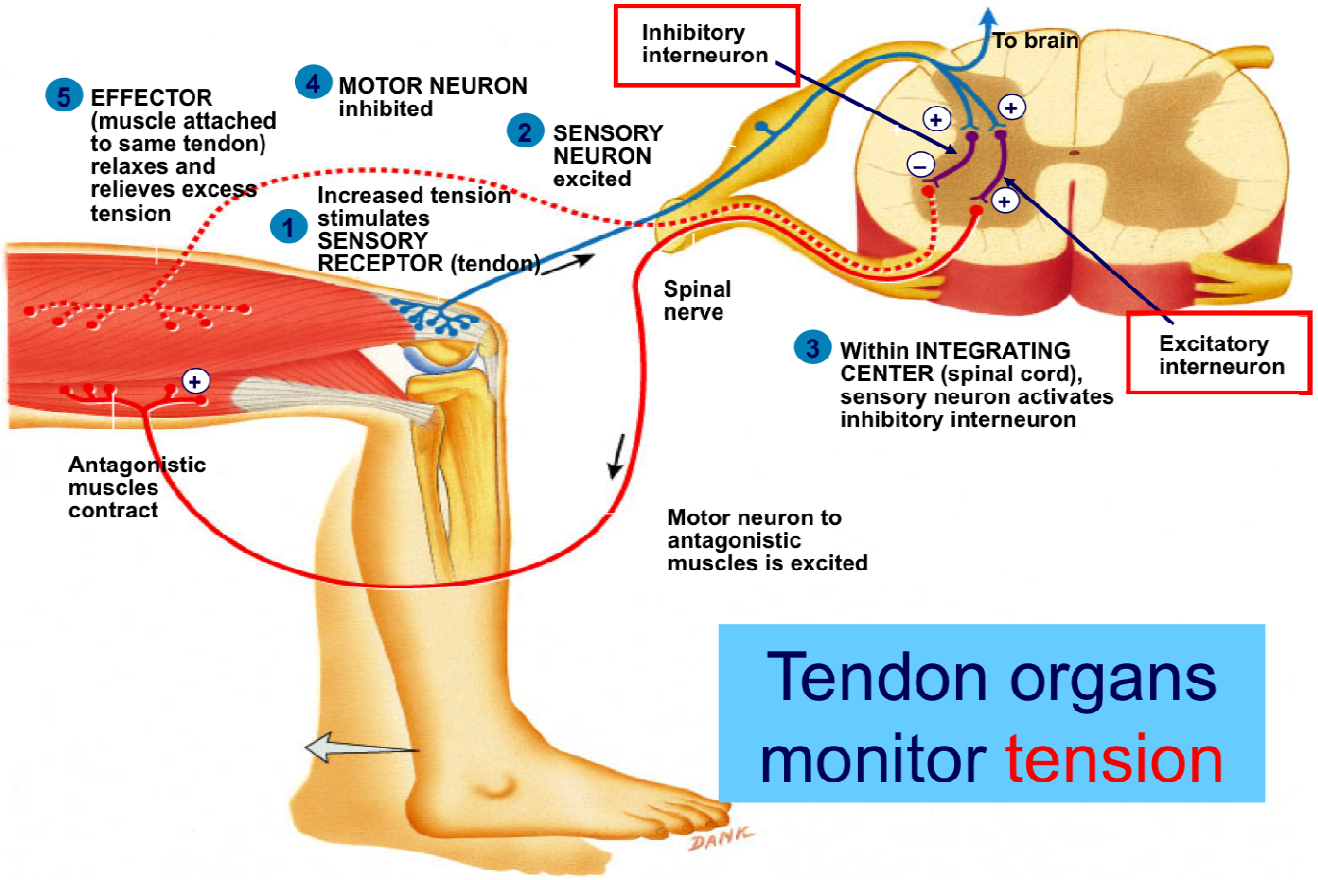
hypertonia and hyperreflexia, is the result of an increase in gamma motor neurons activity

# Clasp knife reaction

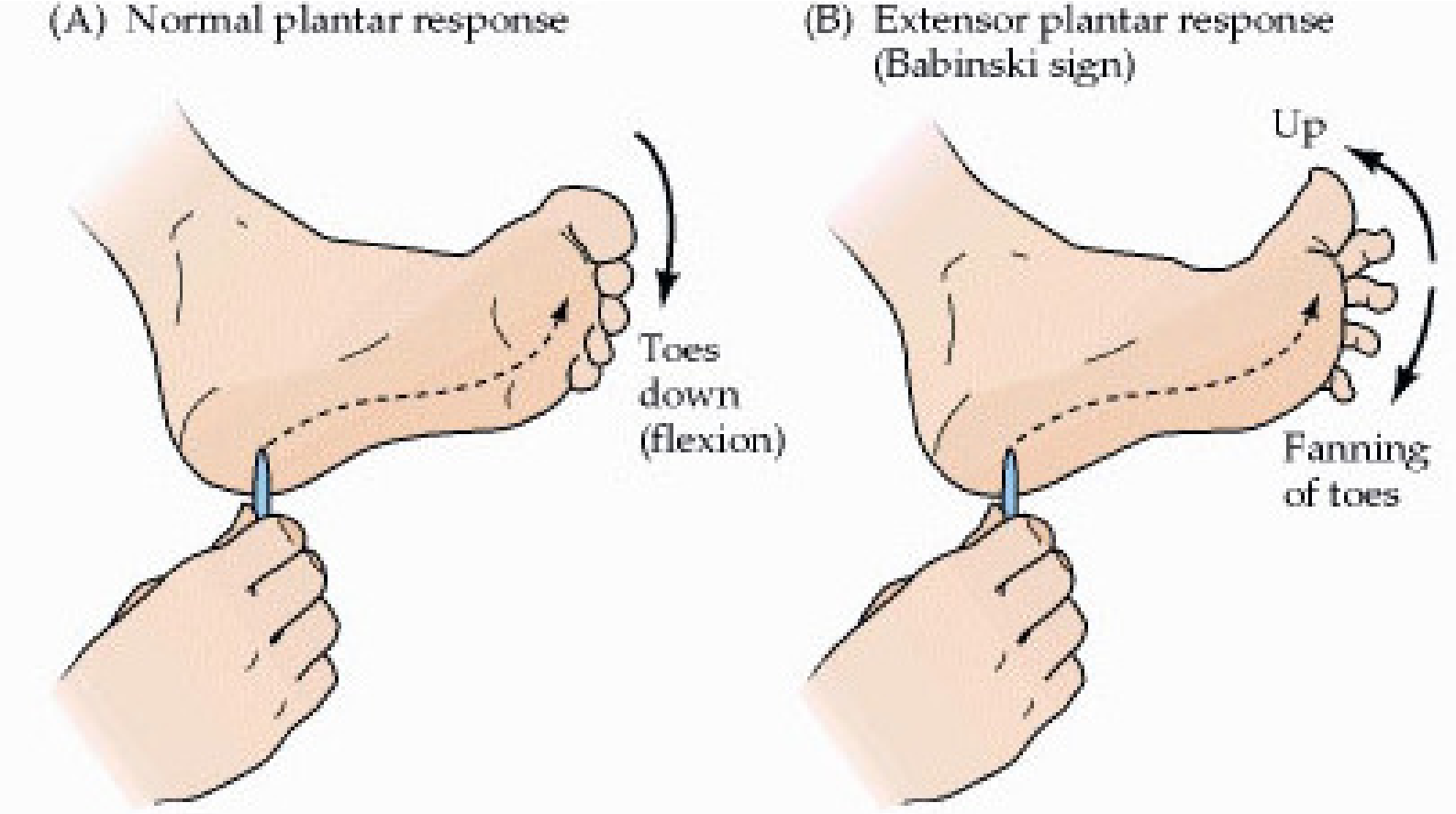
- Overactivity of the pointine excitatory system ( spasticity)
- **Initial resistance:** Exaggerated stretch reflex
- **Sudden release:** After applying pressure, the tension in the muscle will increase and will be enough to activate the **Golgi tendon organs** which will cause the relaxation

# Tendon reflex

- Polysynaptic reflex arc
- law of reciprocal innervation




Tendon organs monitor tension




When the corticospinal tracts are nonfunctional, the influence of the other descending tracts on the toes becomes apparent, and a kind of withdrawal reflex takes place in response to stimulation of the sole, with the great toe being dorsally flexed and the other toes fanning out.

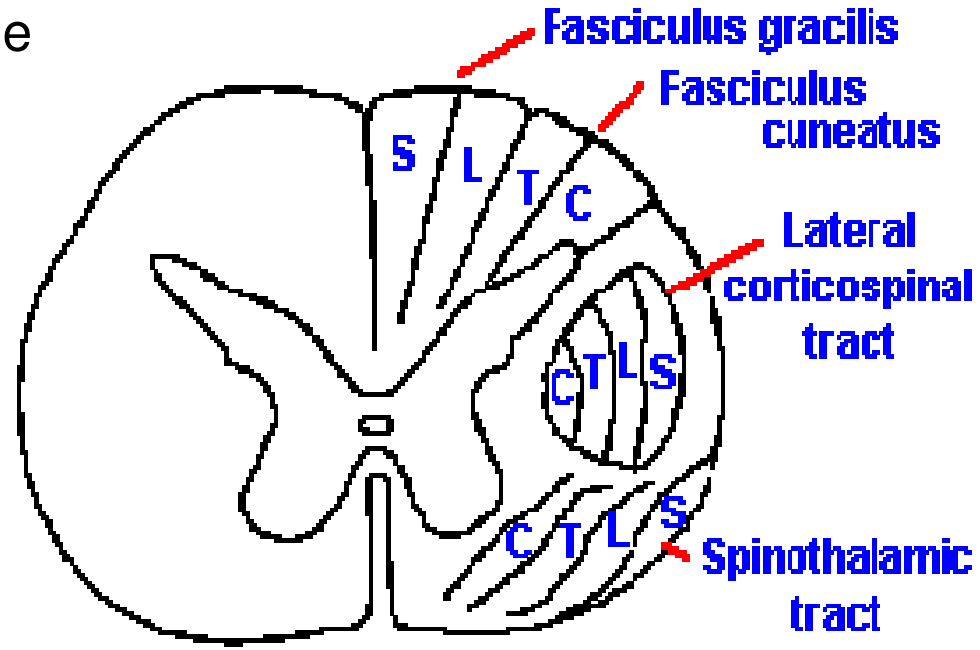
# Clinical significance of lamination of the ascending tracts

- Any external pressure exerted on the spinal cord in the region of the spinothalamic tracts will first experience a loss of pain and temperature sensations in the sacral dermatome of the body
- If pressure increases the other higher segmental dermatomes will be affected

❖**Remember that in the spinothalamic tracts the cervical to sacral segments are located medial to lateral**

- **Intramedullary tumor:** affect the cervical fibers (Medial)
- **Extramedullary tumor** would affect lower limb fibers (lateral).

❑ **Sacral sparing:** Occur at intramedullary tumor



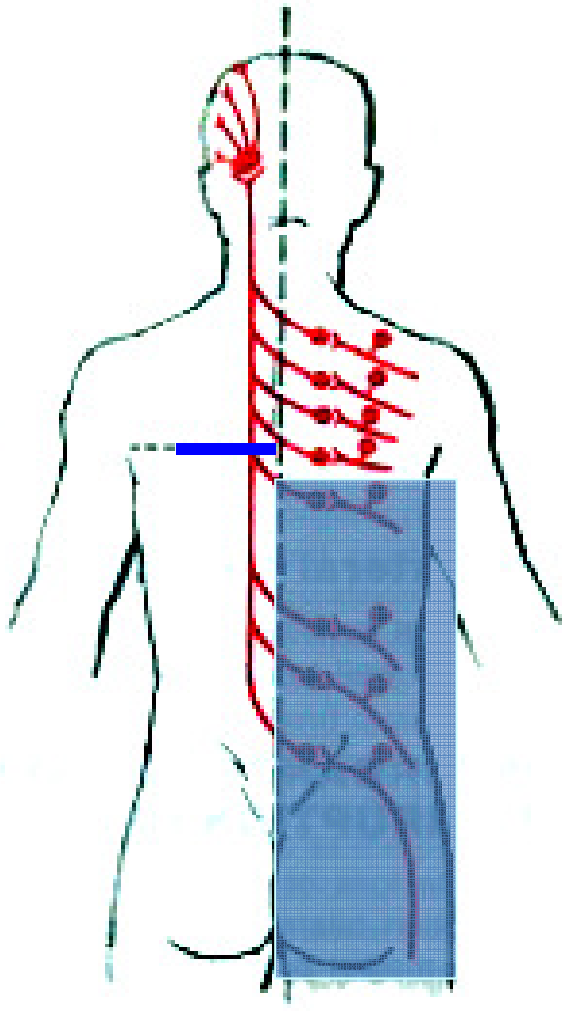
Clinical application

destruction of LSTT

- loss of
  - pain and thermal sensation
  - on the contralateral side
  - below the level of the lesion

patient will not

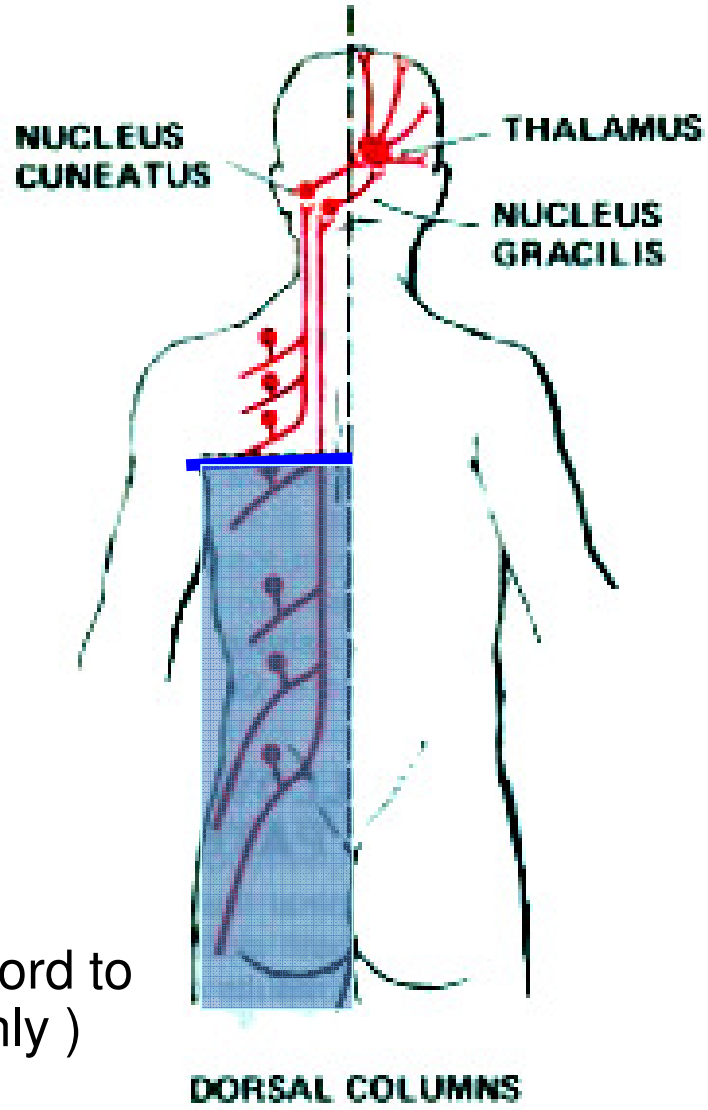
recognize hot and cold



Clinical application
destruction of
fasciculus gracilia and cuneatus

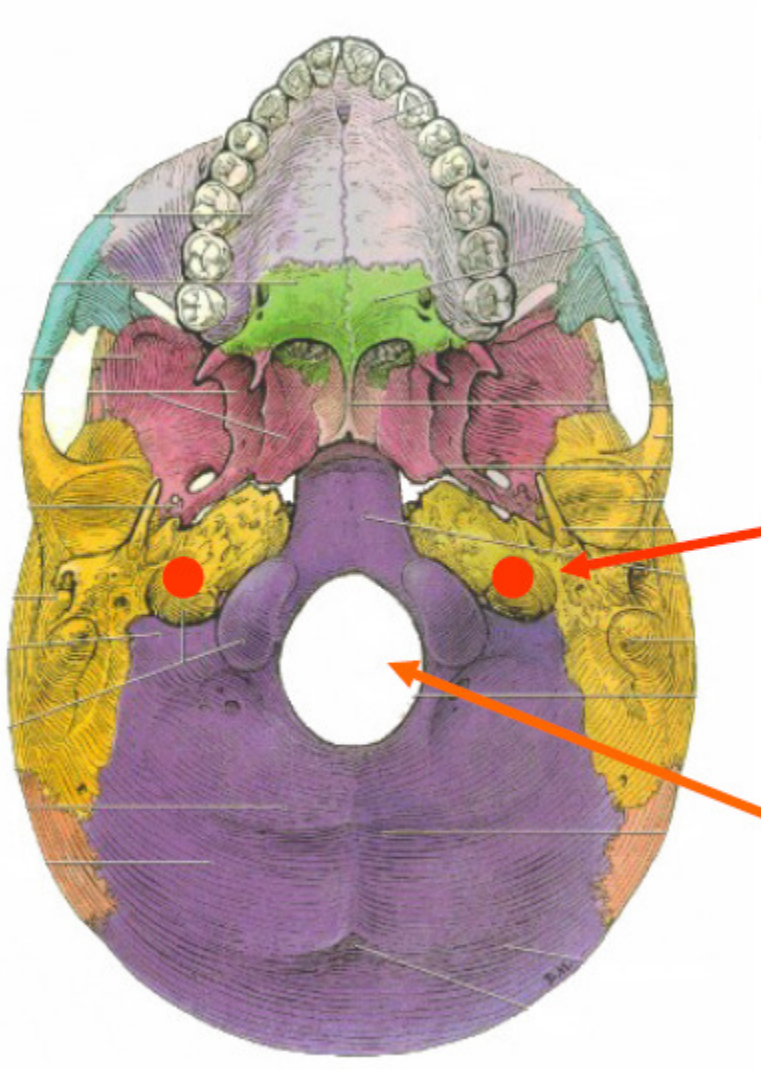
- loss of muscle joint sense, position sense, vibration sense and tactile discrimination
- on the same side
- below the level of the lesion

(extremely rare to have a lesion of the spinal cord to be localized as to affect one sensory tract only )



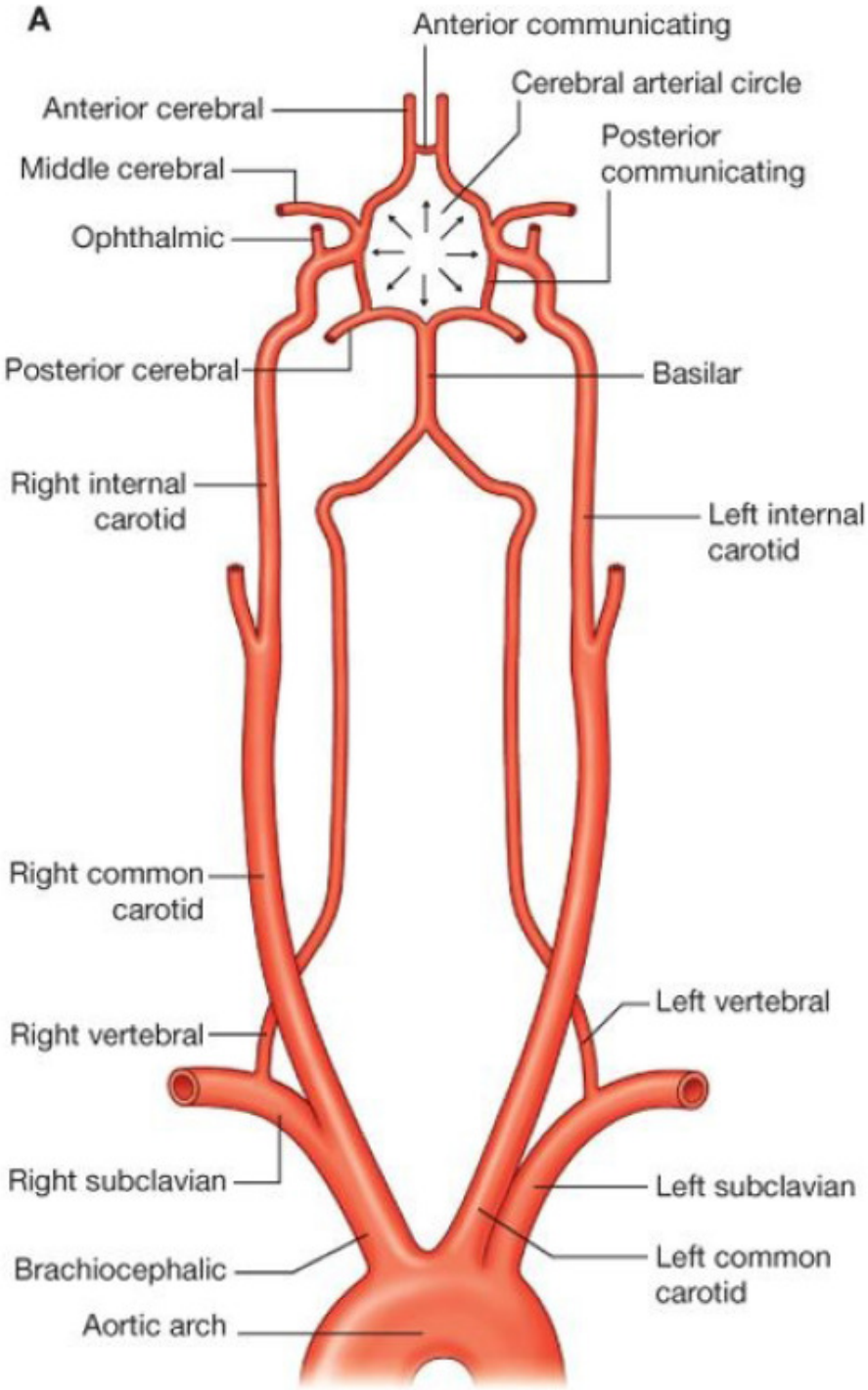
# Arterial Blood Supply

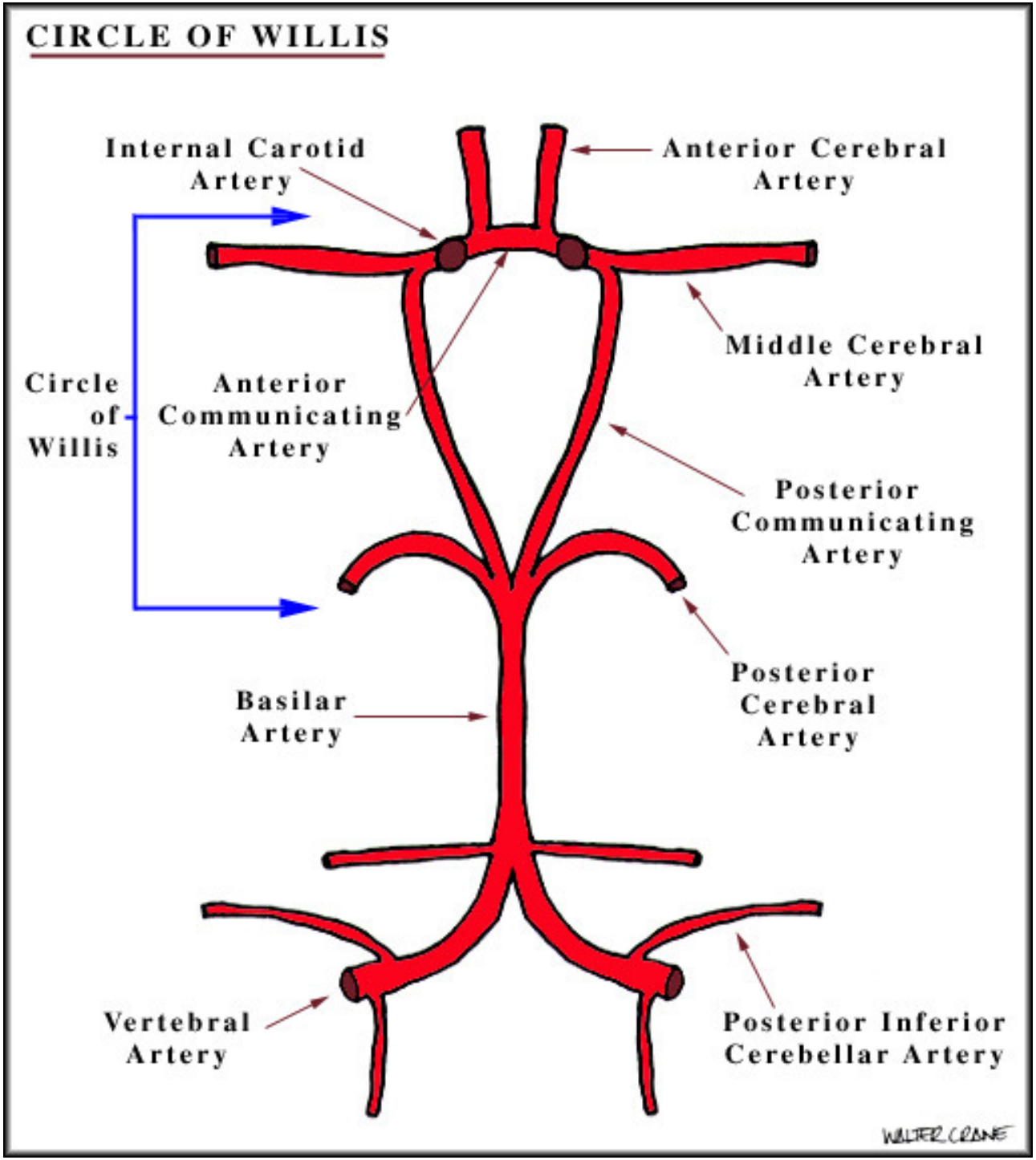
- Brain is supplied by pairs of internal carotid artery and vertebral artery.
- The four arteries lie within the subarachnoid space
- Their branches anastomose on the inferior surface of the brain to form the **circle of Willis**



A. Internal Carotid Artery- enters skull via Carotid Canal And Foramen Lacerum

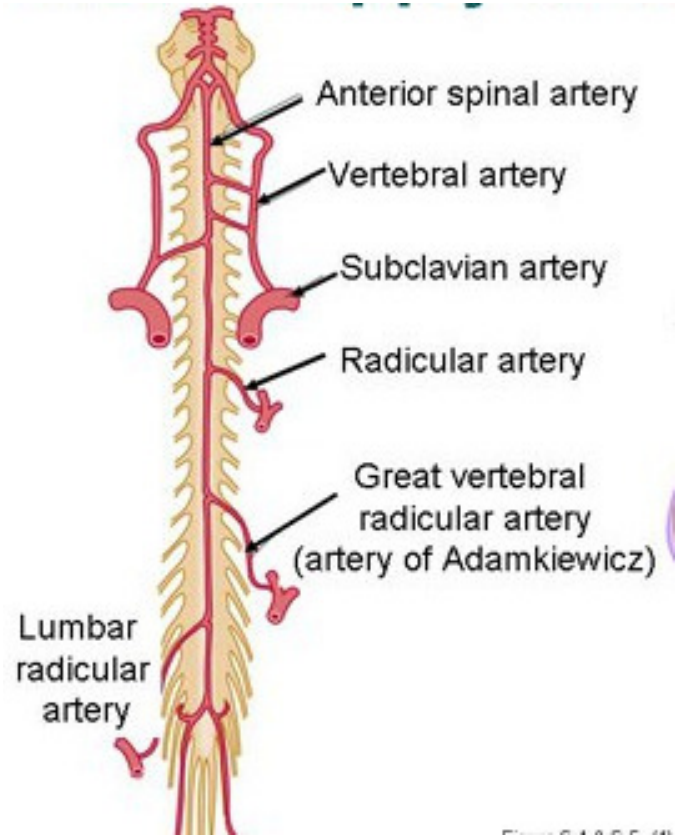
B. Vertebral artery- enters skull via Foramen Magnum

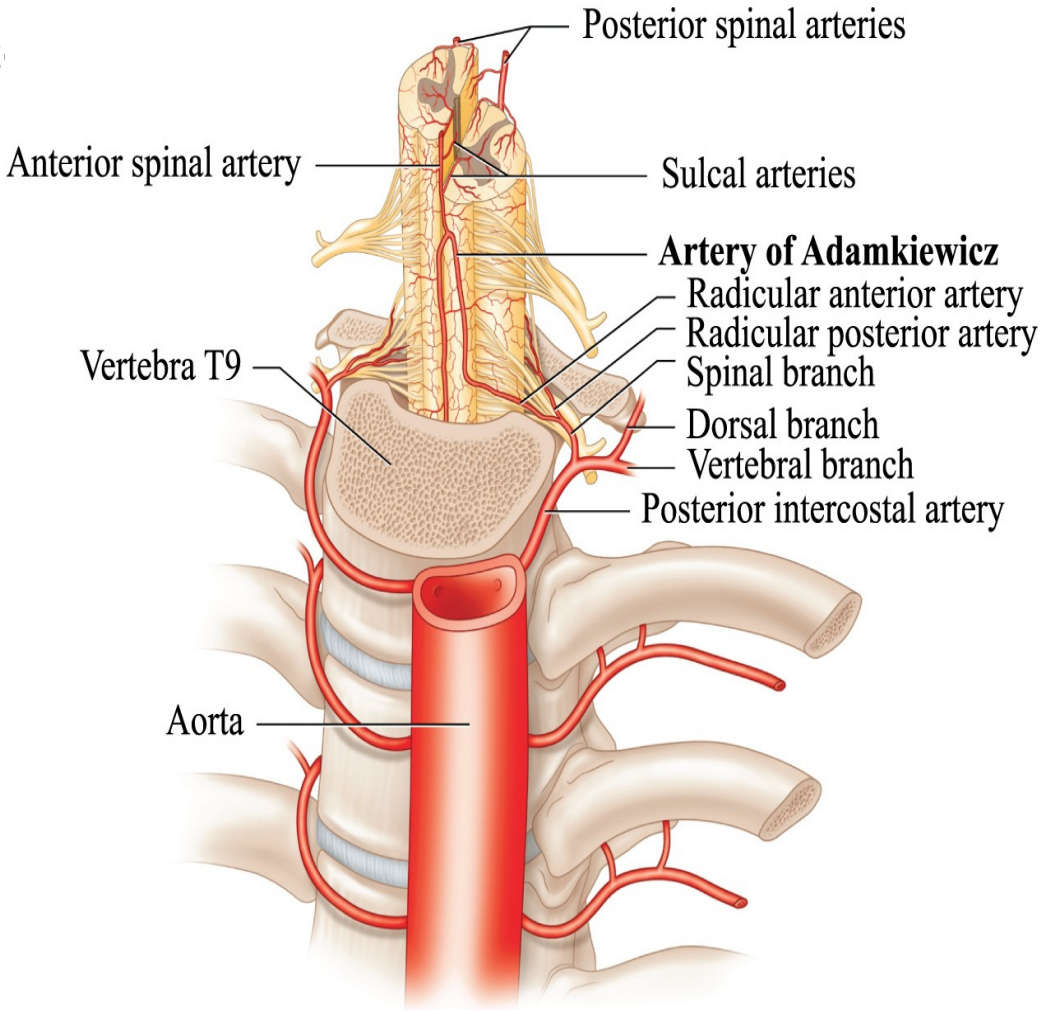

A
Anterior communicating
Cerebral arterial circle
Anterior cerebral
Posterior communicating
Middle cerebral
Ophthalmic
Posterior cerebral
Basilar
Right internal carotid
Left internal carotid
Right common carotid
Left vertebral
Right vertebral
Right subclavian
Left subclavian
Brachiocephalic
Left common carotid
Aortic arch


CIRCLE OF WILLIS
Internal Carotid Artery
Anterior Cerebral Artery
Middle Cerebral Artery
Circle of Willis
Anterior Communicating Artery
Posterior Communicating Artery
Posterior Cerebral Artery
Basilar Artery
Vertebral Artery
Posterior Inferior Cerebellar Artery
WALTER CRANE

# Blood supply of spinal c

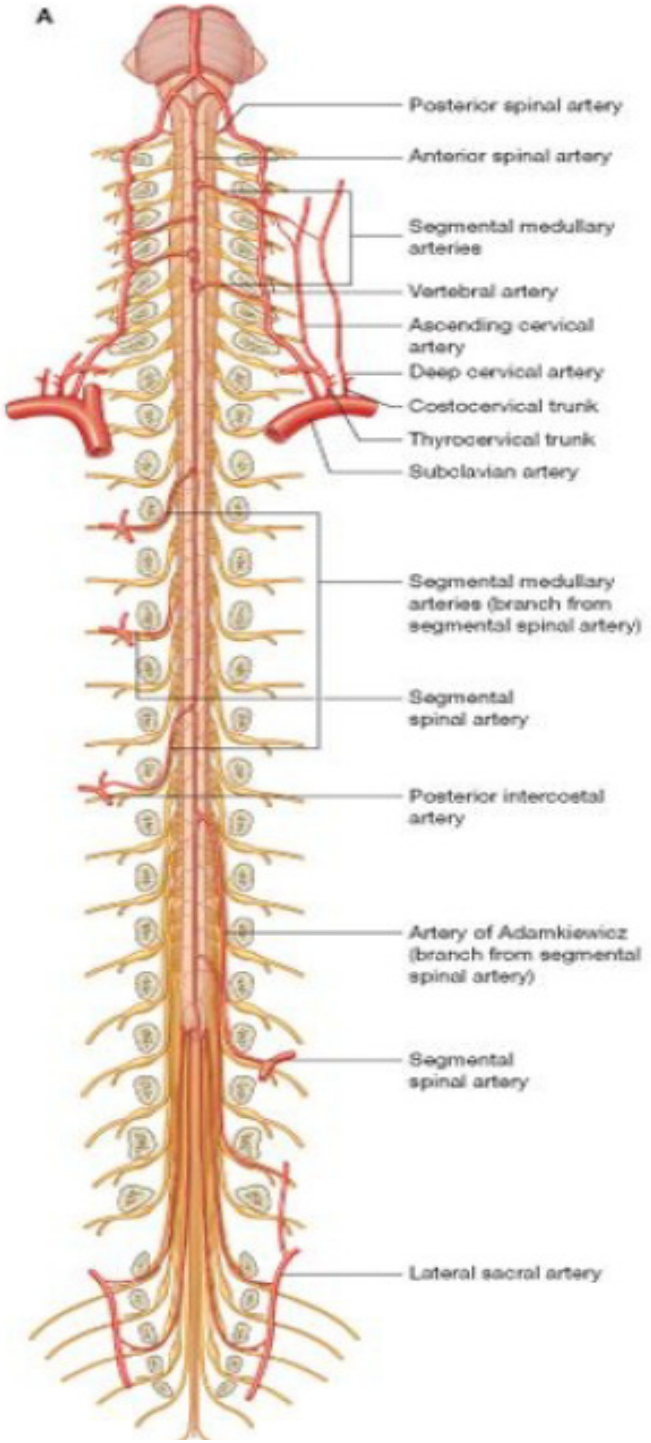
- **Longitudinal arteries:**
  - **One anterior spinal artery**: arise from the vertebral arteries (in anterior median fissure)
  - **Two posterior spinal arteries**: arise from the posterior inferior cerebellar artery (in the posterolateral sulcus)



# Blood supply of spinal cord

- **segmental spinal arteries,** arise from:
  - Vertebral arteries
  - Deep cervical arteries in the neck
  - Posterior intercostal arteries in the thorax
  - lumbar arteries in the abdomen
- Branches :
  - **Anterior radicular arteries**
  - **Posterior radicular arteries**
  - **Segmental medullary arteries**
- **Artery of Adamkiewicz**
  - usually on the left side,
  - reinforces the arterial supply to the lower portion of the spinal cord
  - From Left posterior intercostal artery at the level of the 9th to 12th intercostal artery, which branches from the aorta, and supplies the lower two thirds of the spinal cord
  - Anastomose with anterior spinal artery



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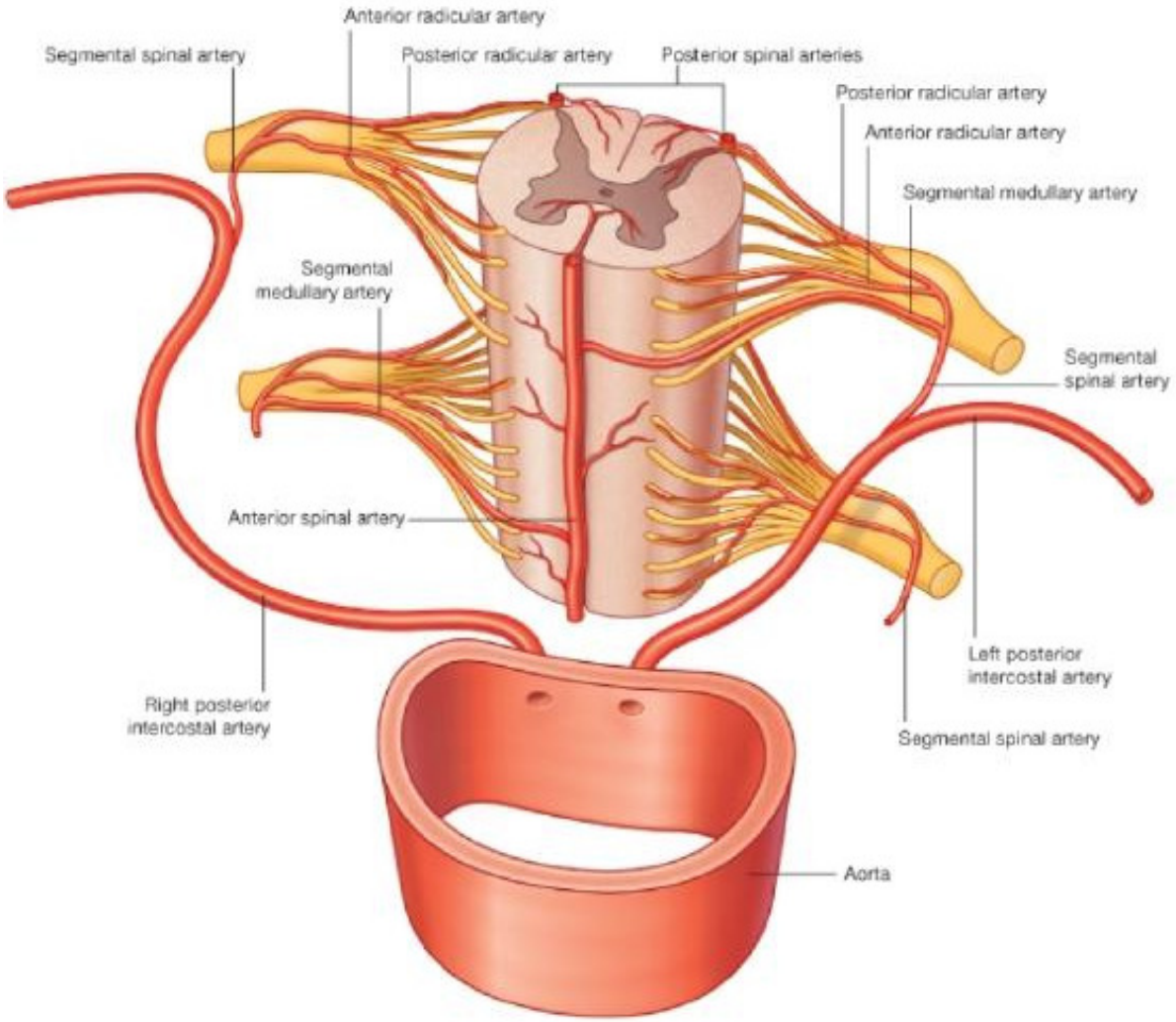
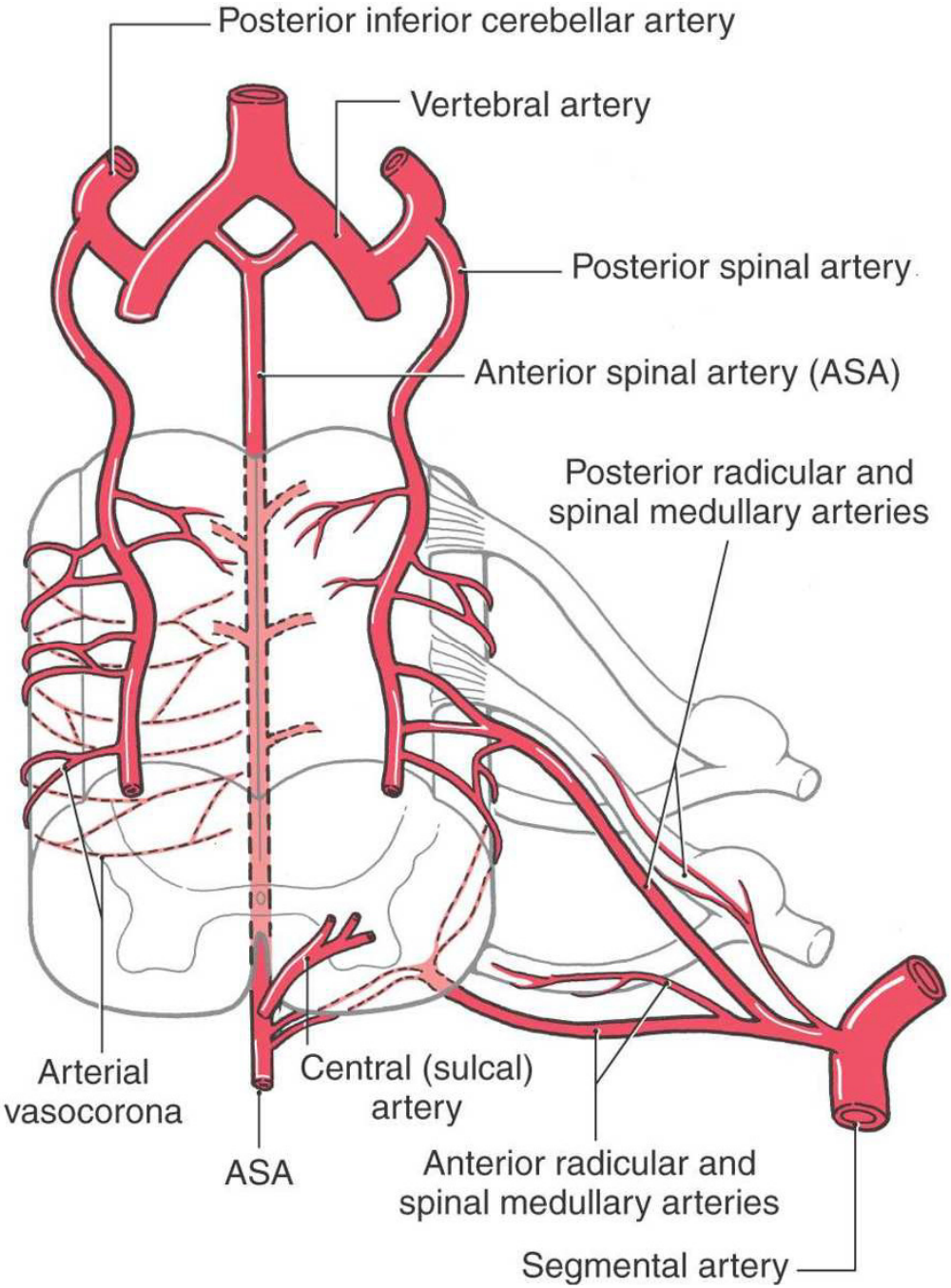
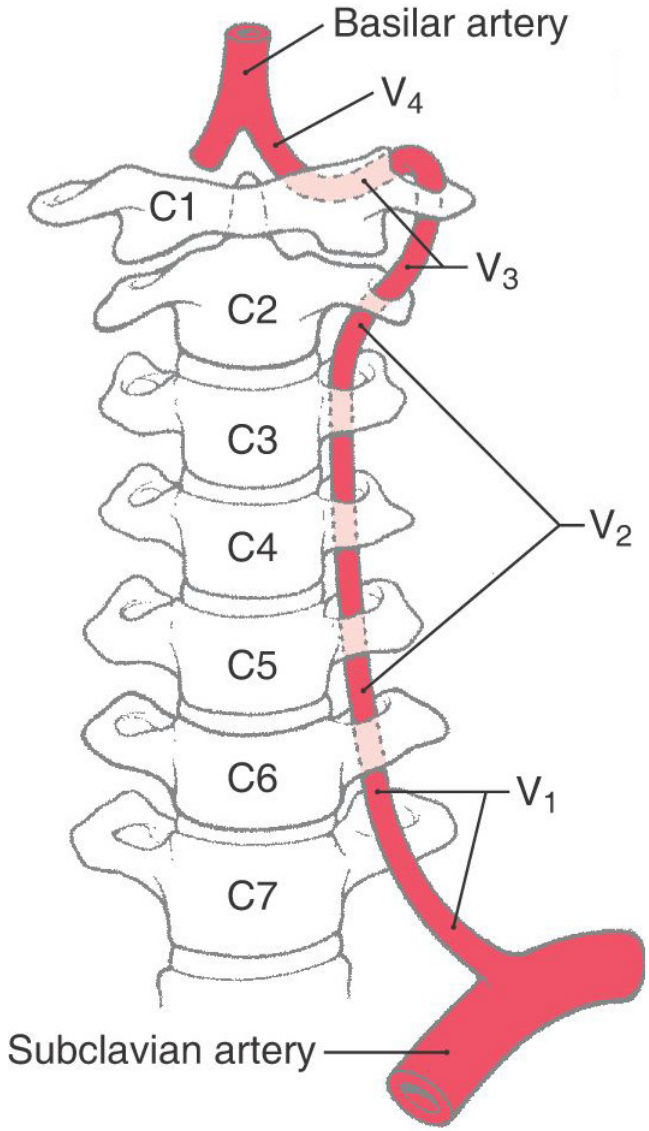


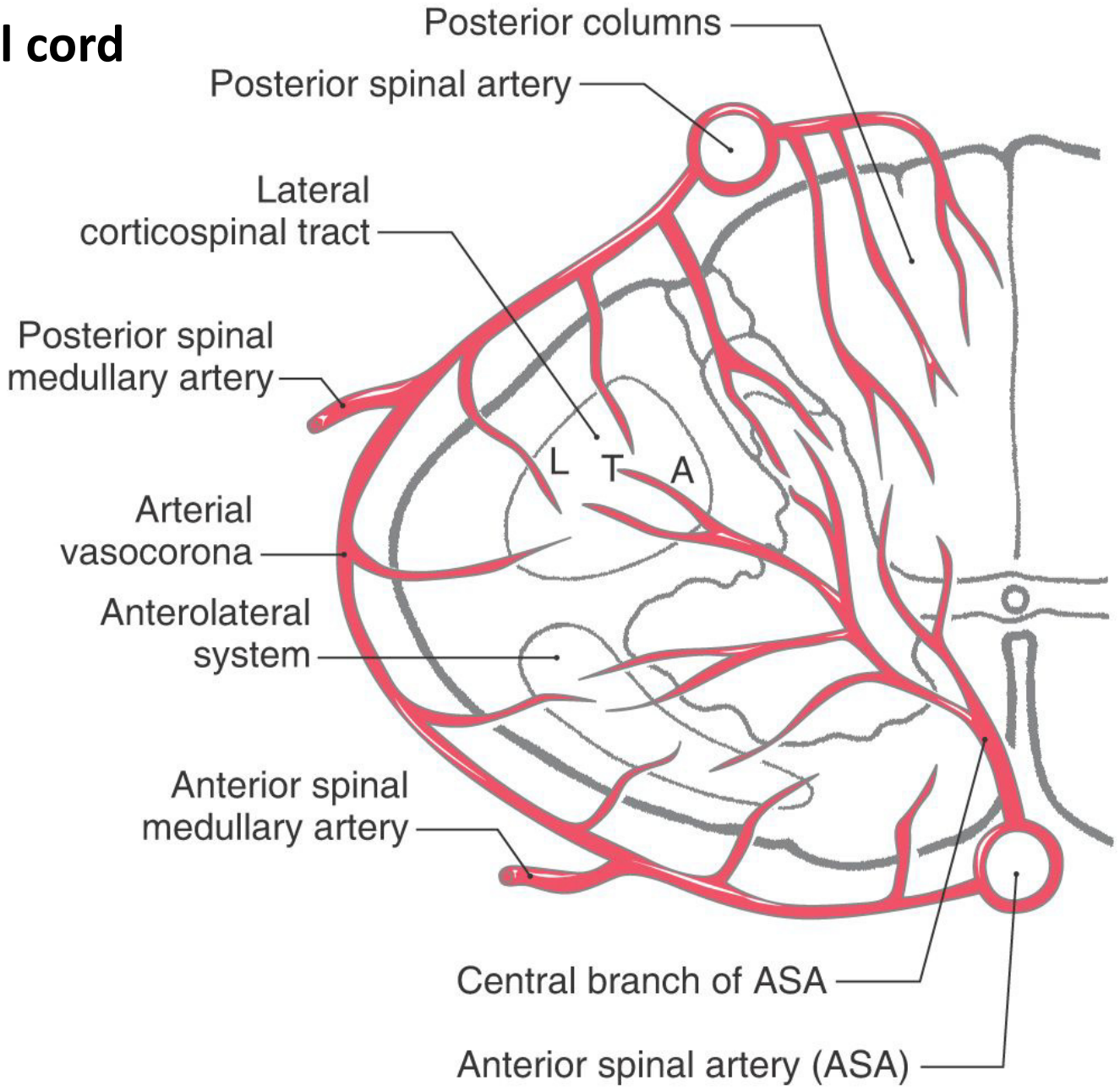
# Blood supply of spinal cord



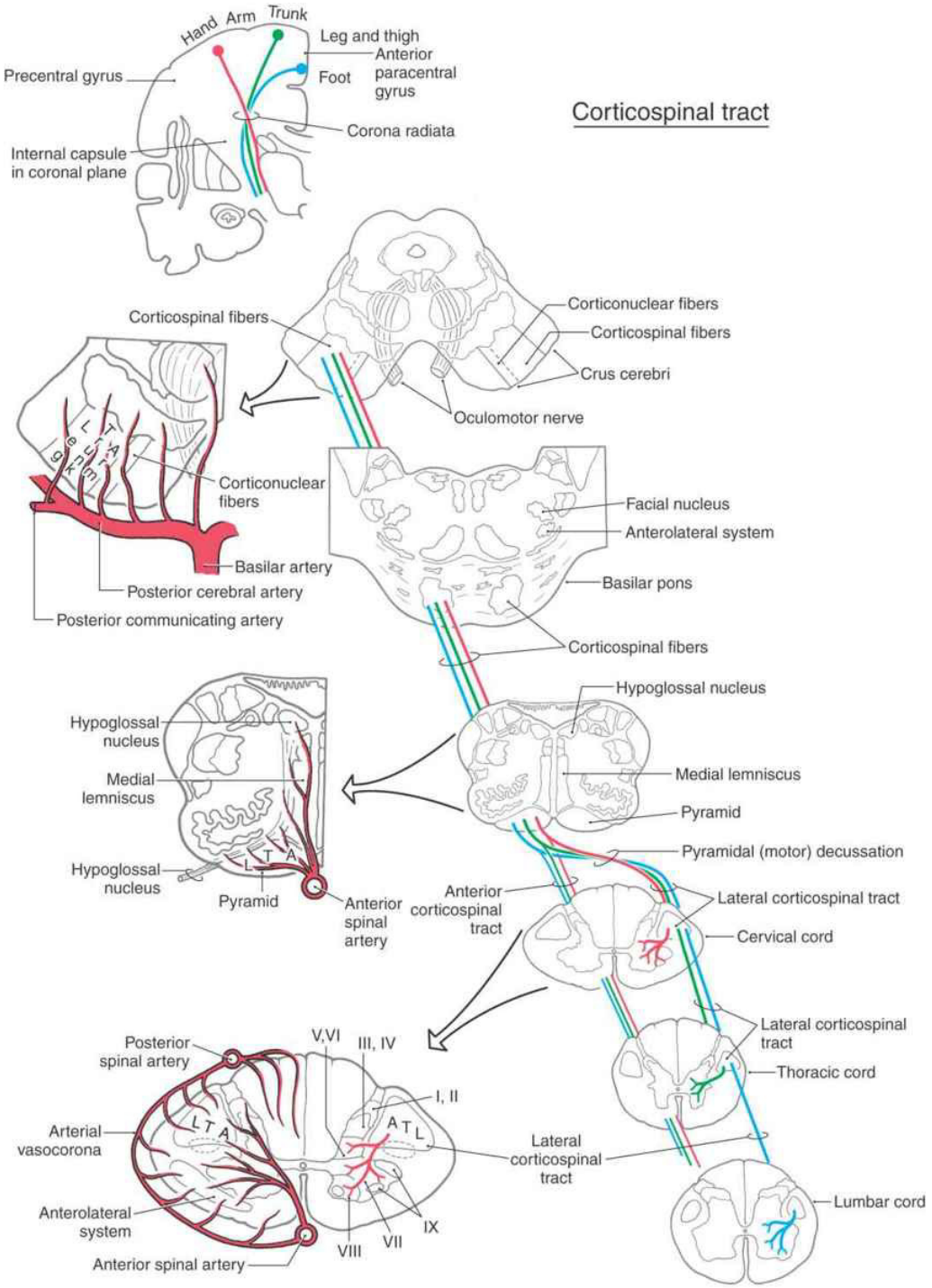
## Blood supply of spinal cord

- Terminal branches of the spinal medullary arteries join to form **arterial vasocorona.**
- **The posterior spinal arteries and arterial vasocorona :** The posterior columns and peripheral parts of the lateral and anterior funiculi
- **The anterior spinal artery**: Most of the gray matter and the adjacent parts of the white matter



# Central Cord Syndrome

- may result from hyperextension of the neck
- Occludes blood supply to the cord via the anterior spinal artery
- bilateral weakness of the extremities (more so of the upper than of the lower)
- pain and thermal sensation loss, and bladder dysfunction



- Compromise of blood flow in the **posterior spinal artery** results in:
- **Ipsilateral reduction or loss of discriminative, positional, and vibratory tactile sensations at and below the segmental level of the injury**