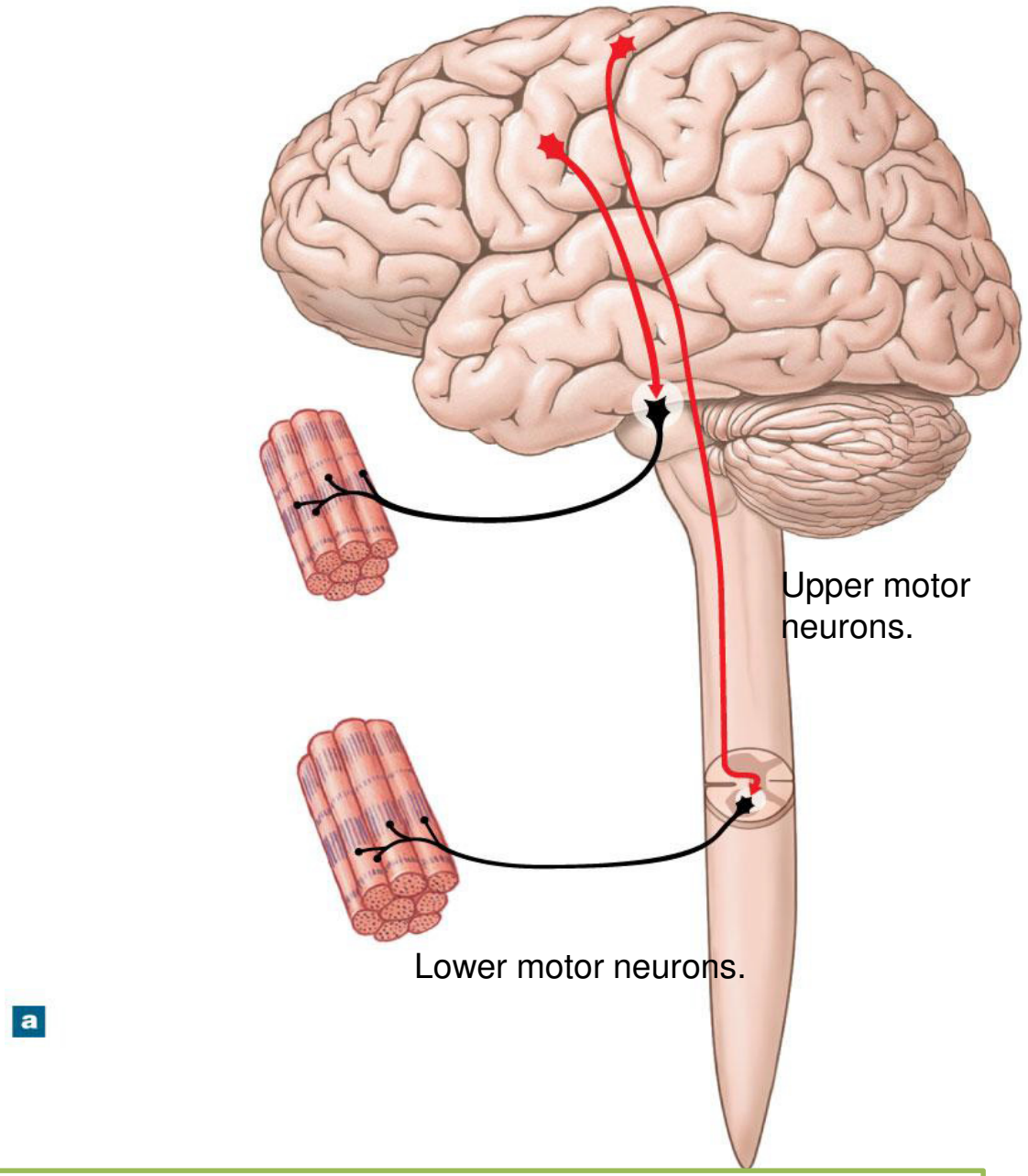
Motor tracts

- 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

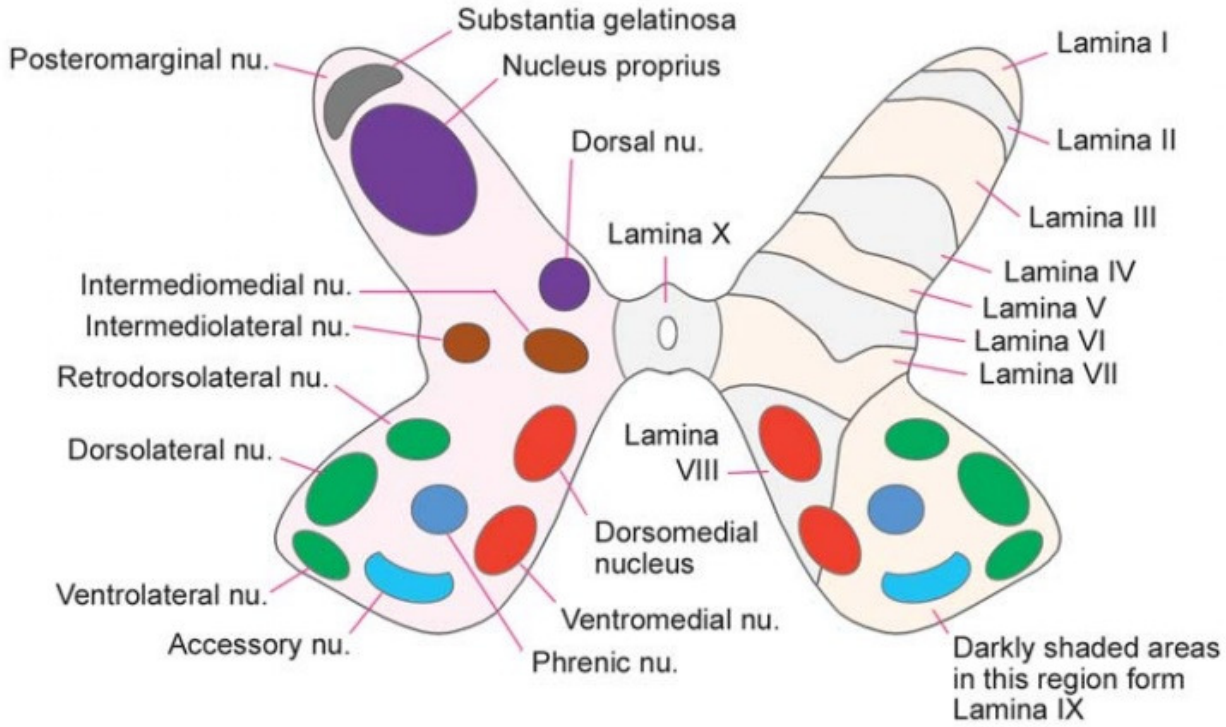
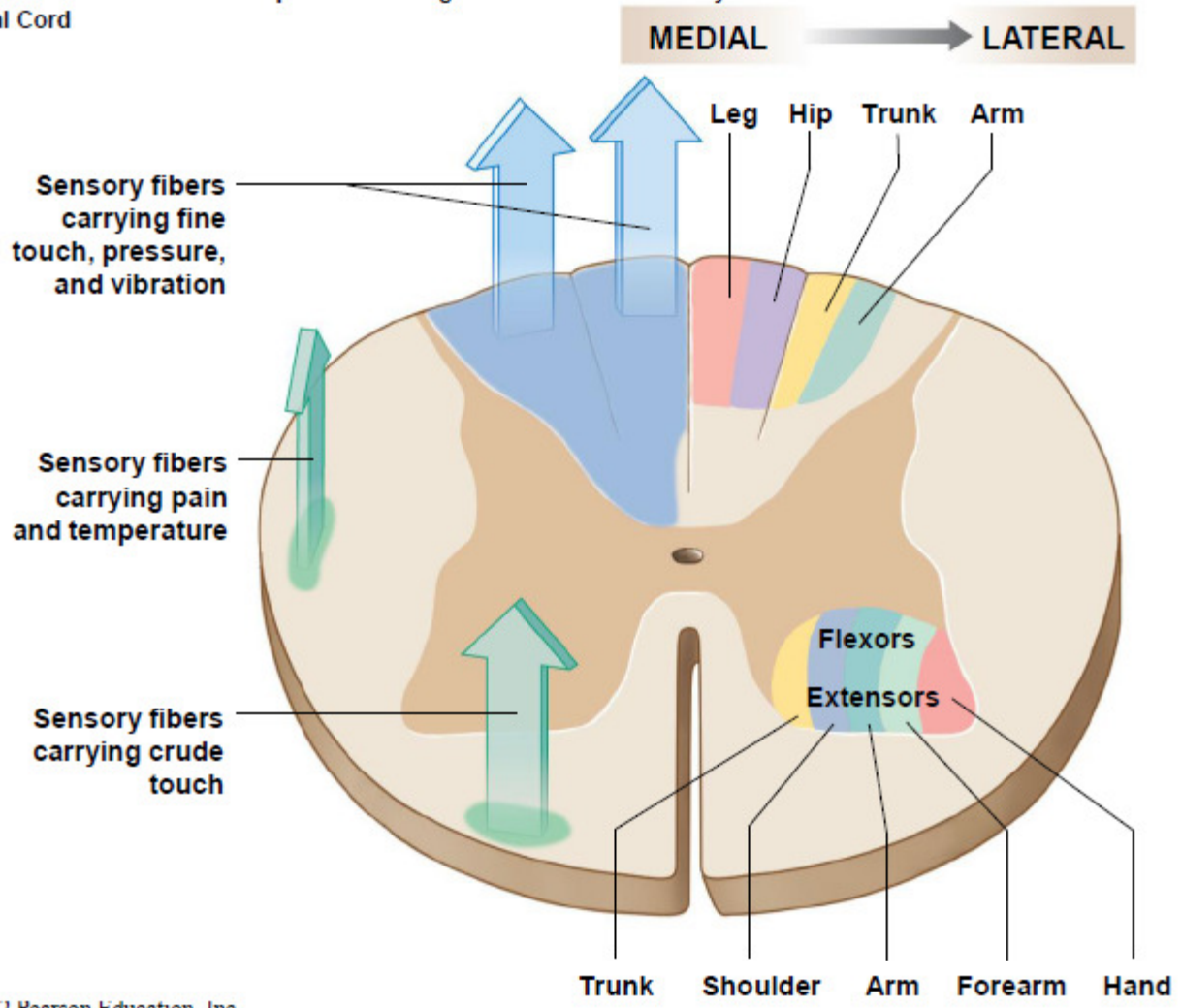


Fig. 5.2. Subdivisions of the grey matter of the spinal cord. The left half of the figure shows the cell groups usually described. The right half shows the newer concept of laminae.

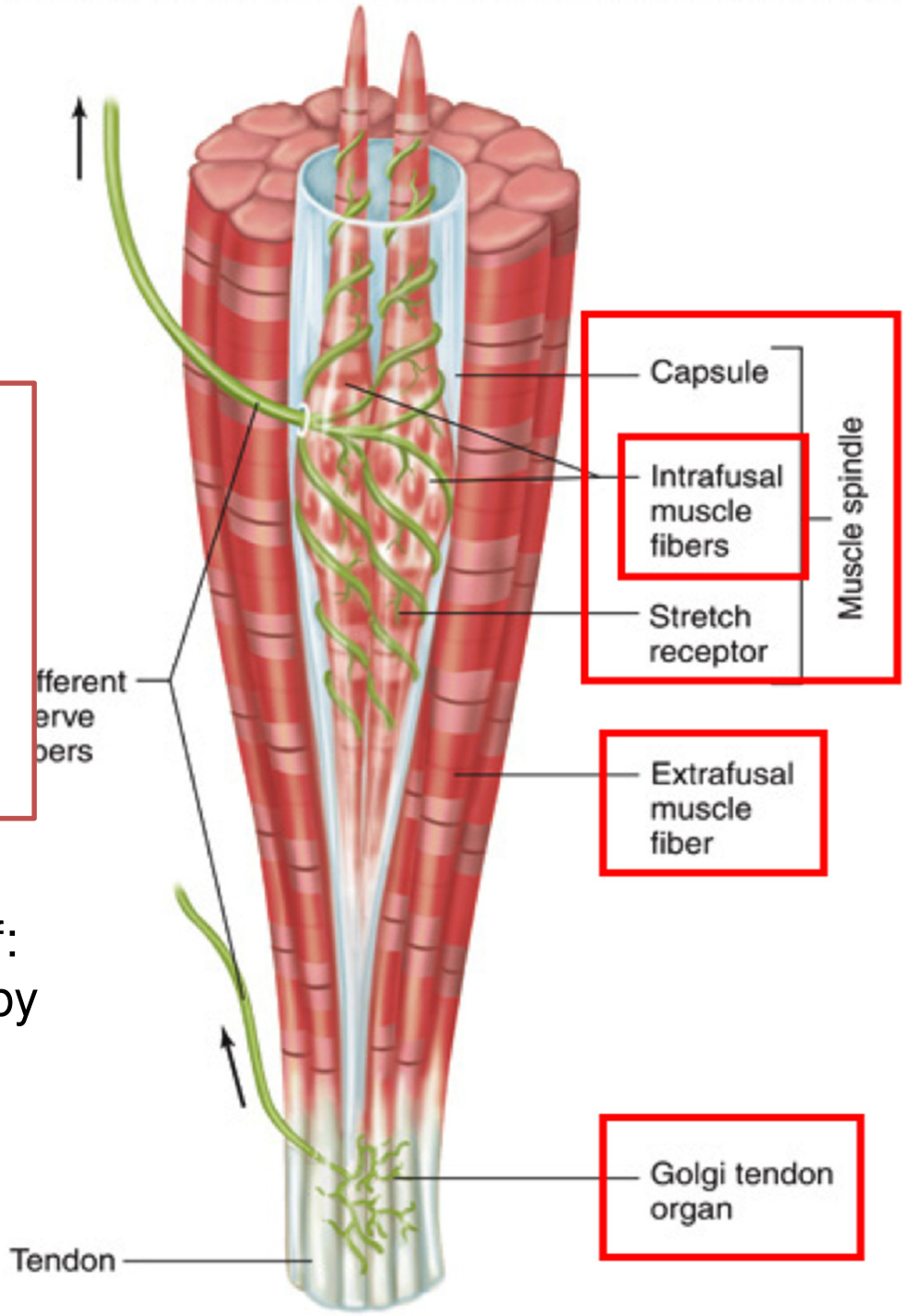
- Motor neurons of anterior horn
  - **Medial group:** (All segments)
  - **Lateral group:** only enlargements

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

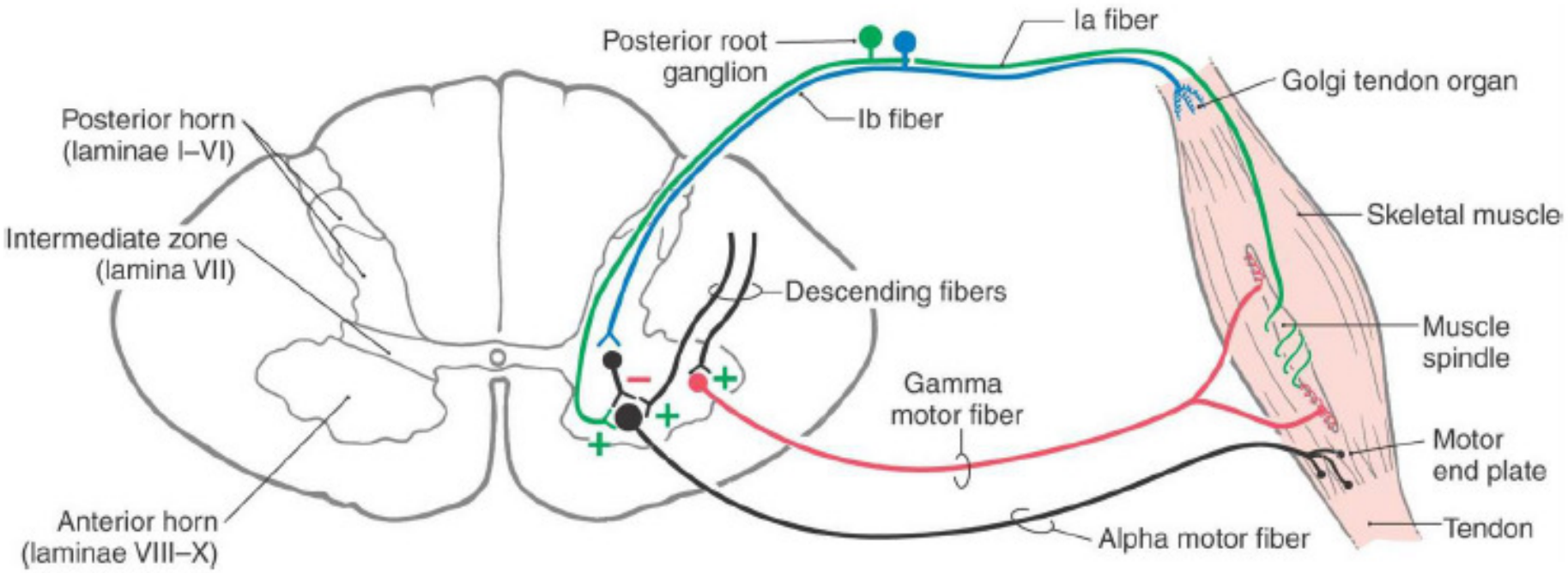


Muscle spindles are sensory receptors within the belly of a muscle that primarily detect changes in the length of this muscle.

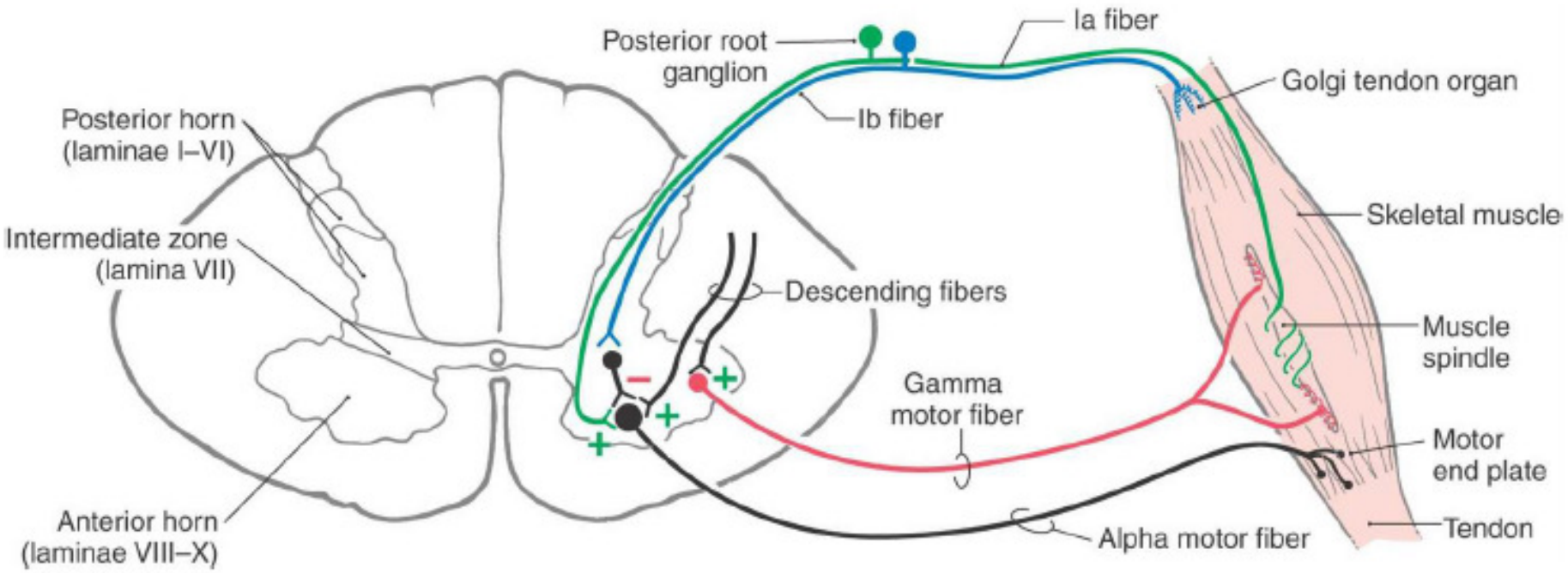
Each muscle spindle consists of an encapsulated cluster of small striated muscle fibers ("**intrafusal muscle fibers**") with somewhat unusual structure (e.g., nuclei may be concentrated in a cluster near the middle of the fiber's length).



- The skeletal muscle is composed of:
  - Extrafusal fibers (99%): innervated by **alpha motor neurons**.
  - Intrafusal fibers (1%): innervated by **gamma motor neurons**. depend on the muscle spindle receptors

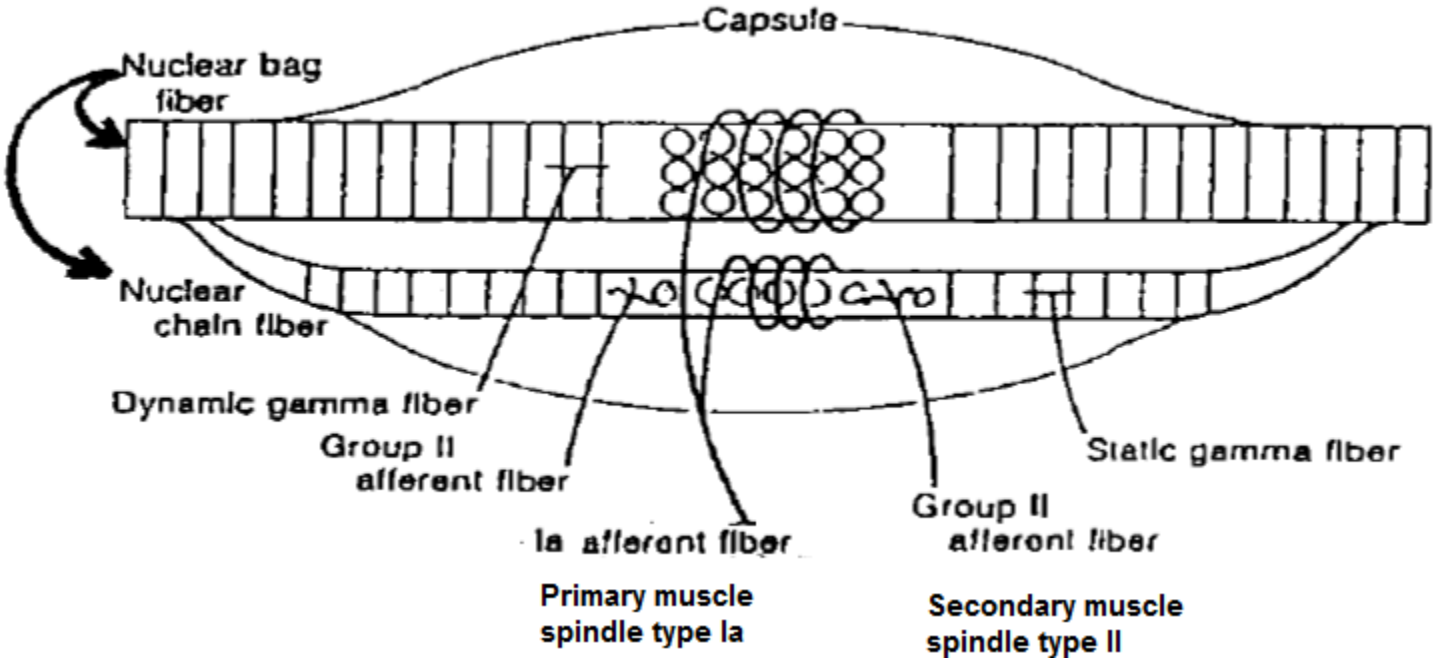


- **Activating alpha motor neurons**
- Directly through supraspinal centers: Descending motor pathways (UMN)
- Indirectly through Muscle spindles
  - Stretch reflex: skeletal muscles are shorter than the distance between its origin and insertion
  - Gamma loop



- Gamma fibers activate the muscle fibers indirectly, while alpha fibers do it directly.
- Alpha fibers give faster but short contraction
- Gamma fibers give slow but long contraction.
- For fast contraction: stimulate alpha.
- For muscle tone: stimulate gamma.
- For continuous contraction and a certain movement: stimulate both.

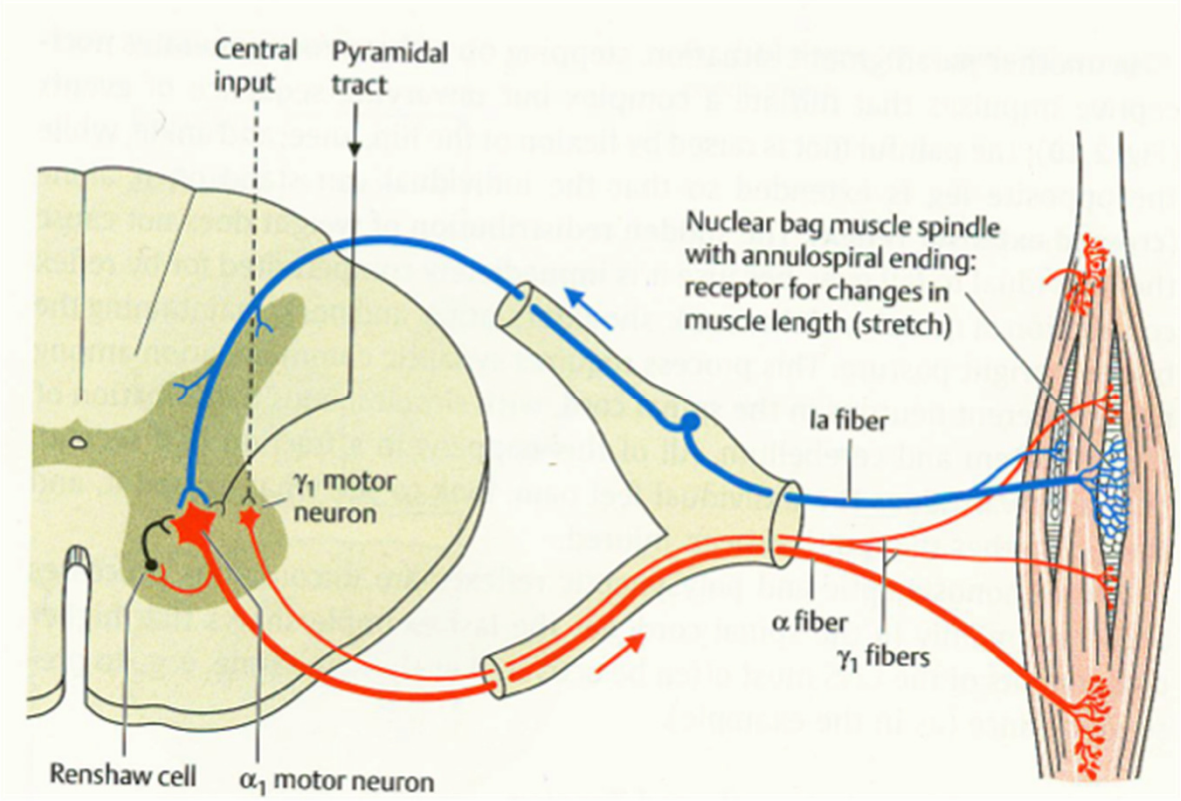
- Intrafusal fibers
  - **Nuclear Bag** Fibers: supplied by dynamic Gamma
  - **Nuclear chain** fibers: supplied by static Gamma



- ***Both Nuclear bag and chain Don't contain sarcomeres***

- **Primary afferent**: **type Ia**,
  - Around both nuclear bag and chain fibers
  - Rapidly adapting
  - Dynamic stretch reflex: e.g jerk (Knee, ankle quadriceps)
- **Secondary afferent**: **type II**
  - Found only in nuclear chain fibers.
  - Slowly adapting
  - Static stretch reflex. Important for muscle tone

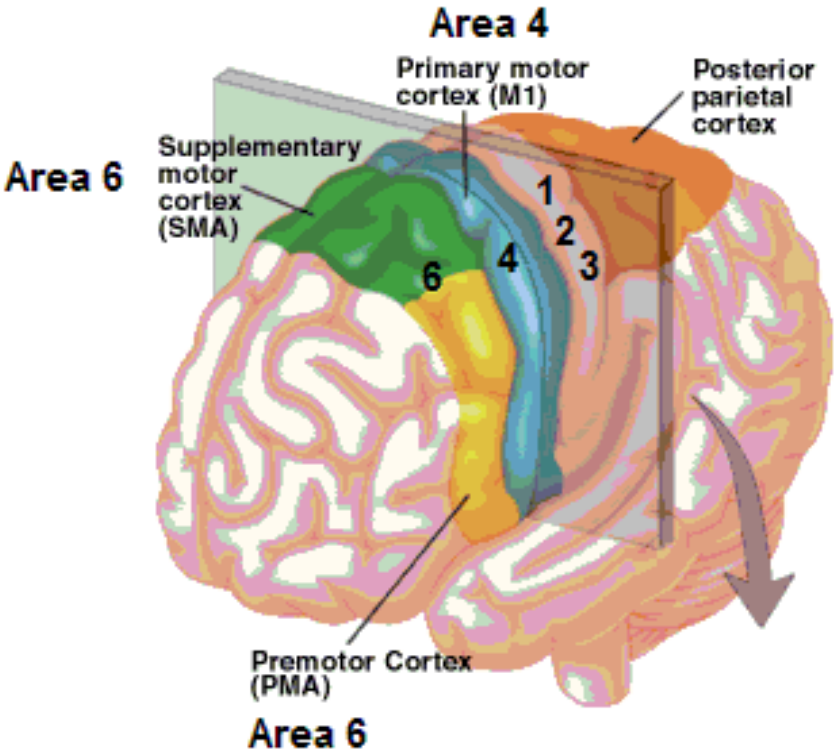
- Alpha motor neuron activity It is controlled by inhibitory cells in **lamina 7** called renshaw cells
- The renshaw cells secrete glycine and inhibit the alpha motor neuron
- **Strychnine poisoning**
  - inhibits the renshaw cells and prevents them from secreting glycine
  - Alpha motor neuron will cause excessive firing (contractions and convulsions)



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

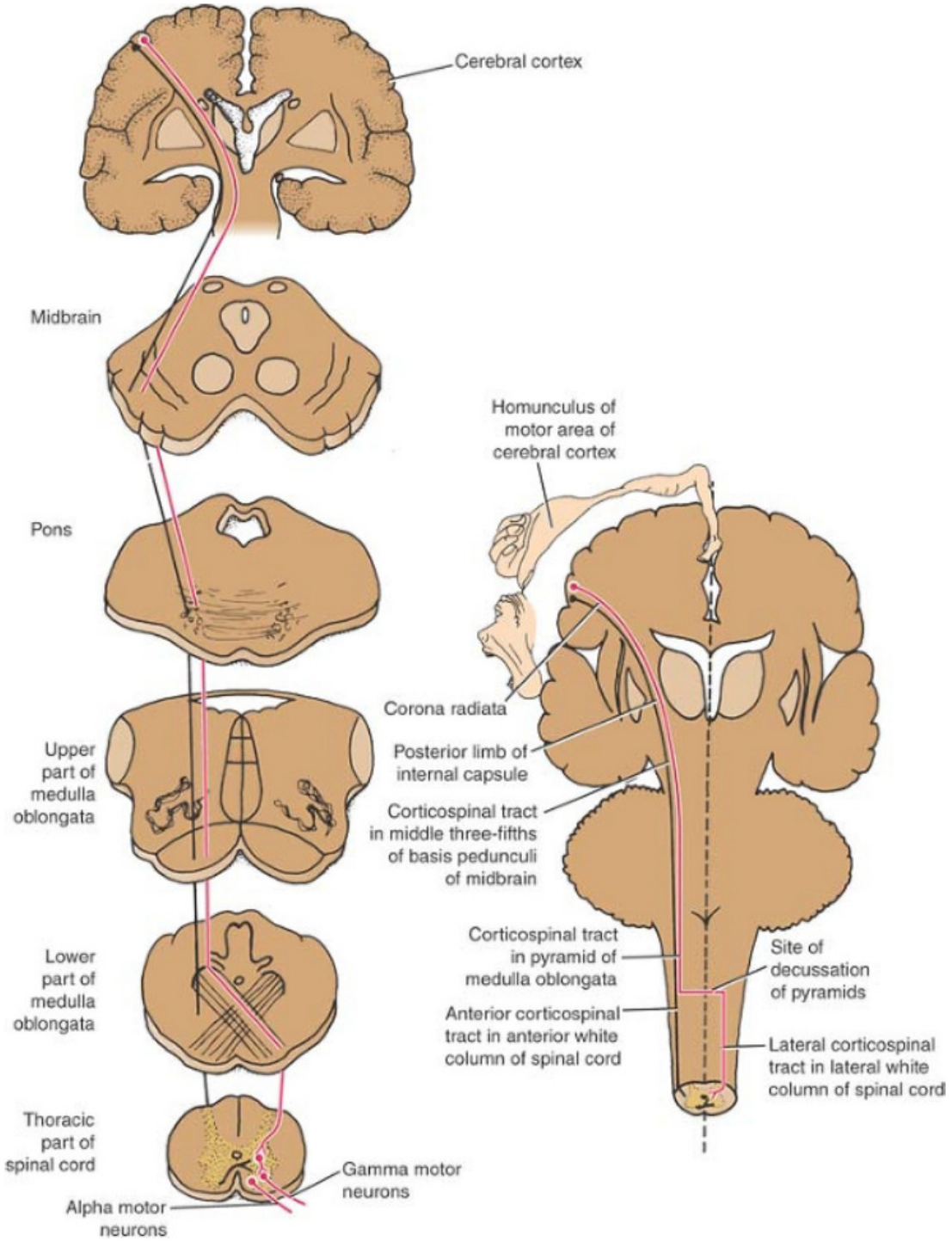
Motor tracts

- 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

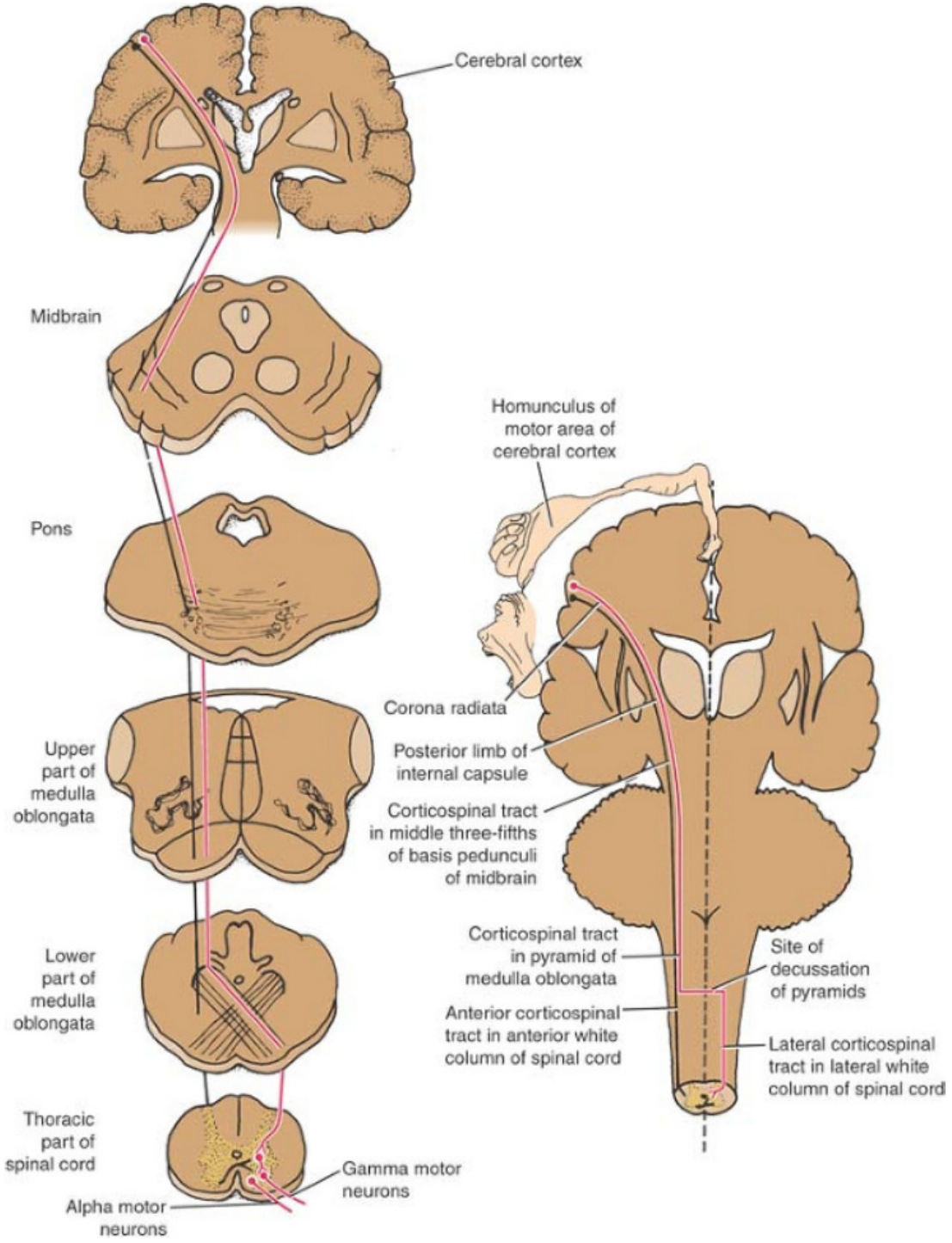


Lateral corticospinal tract

- 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).

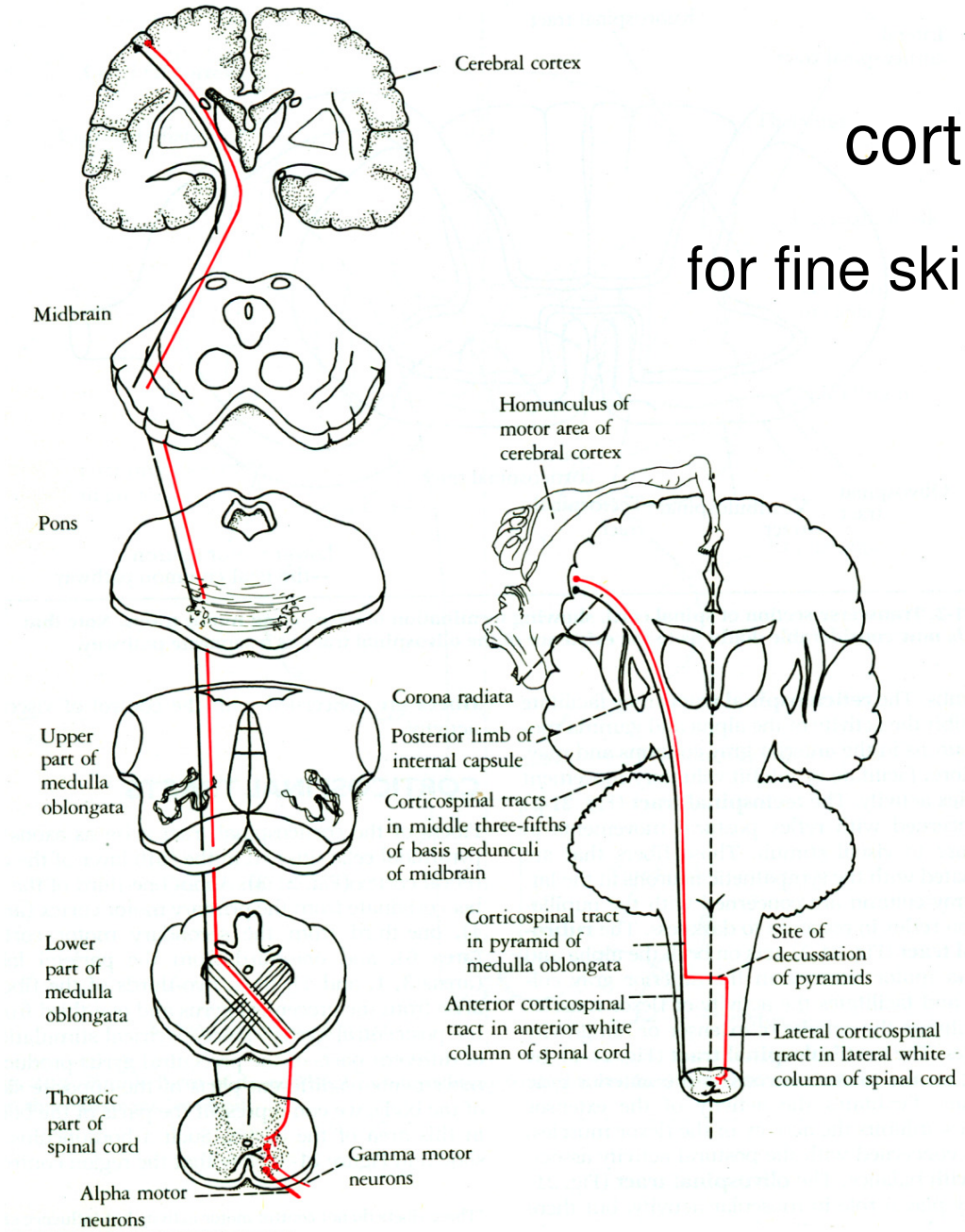


- The tract descends all the way of spinal cord with fibers continually leaving it in order to synapse on interneurons in the anterior gray horn. (Some even synapse directly on alpha and gamma motor neurons)
- *Those corticospinal fibers which do not decussate in the medulla continue descending on the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



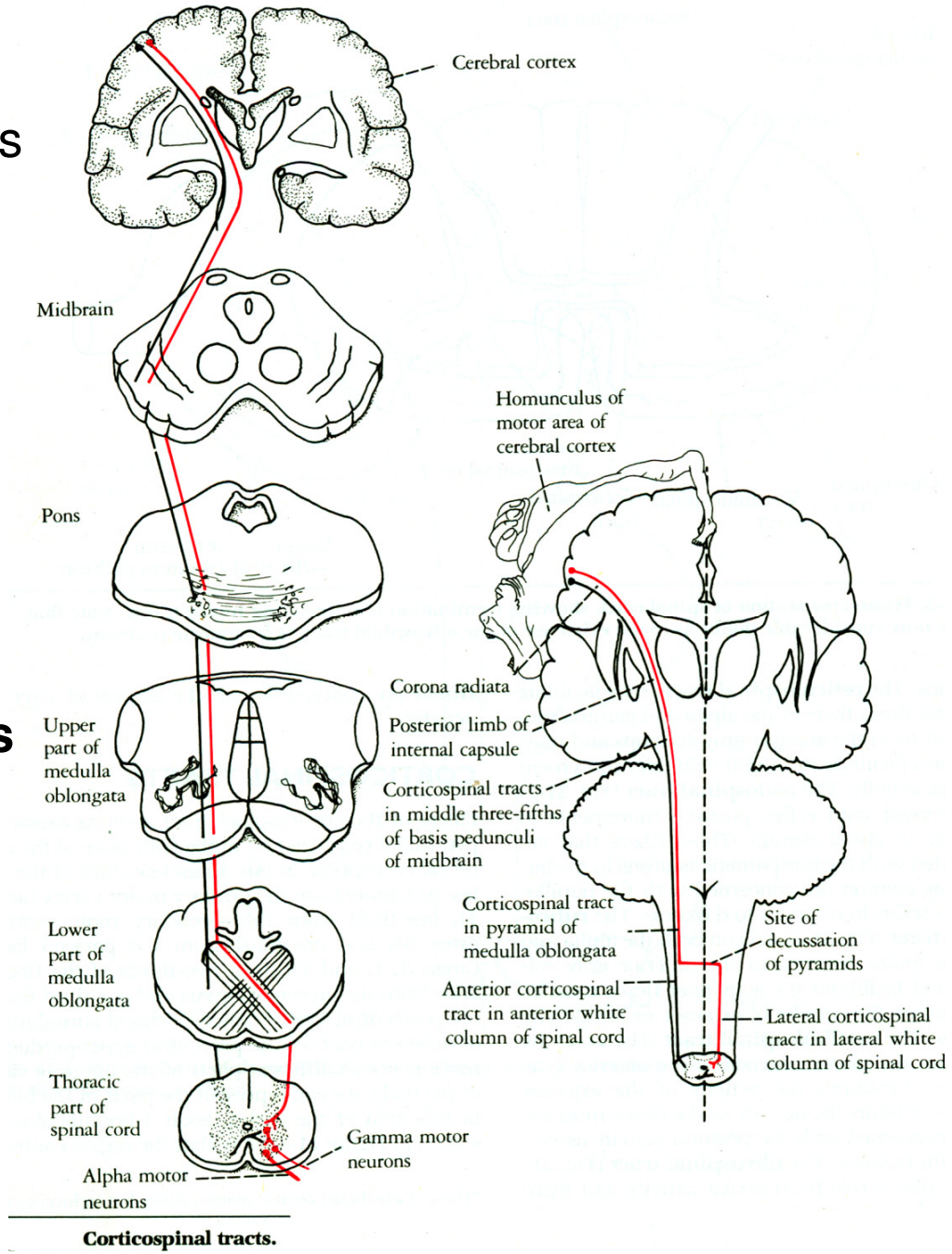
corticospinal tract

for fine skilled movements

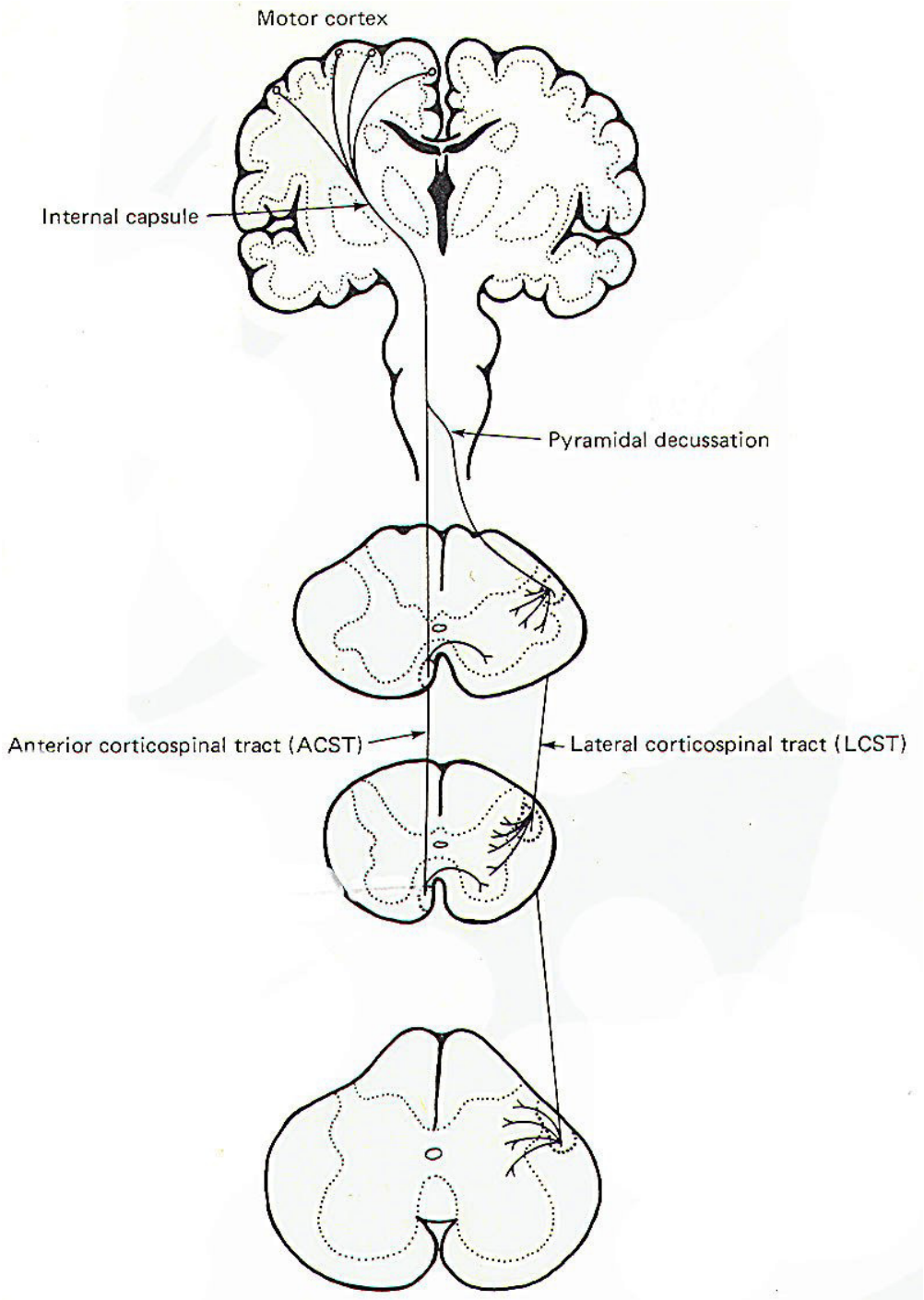


Corticospinal tracts.

- 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.



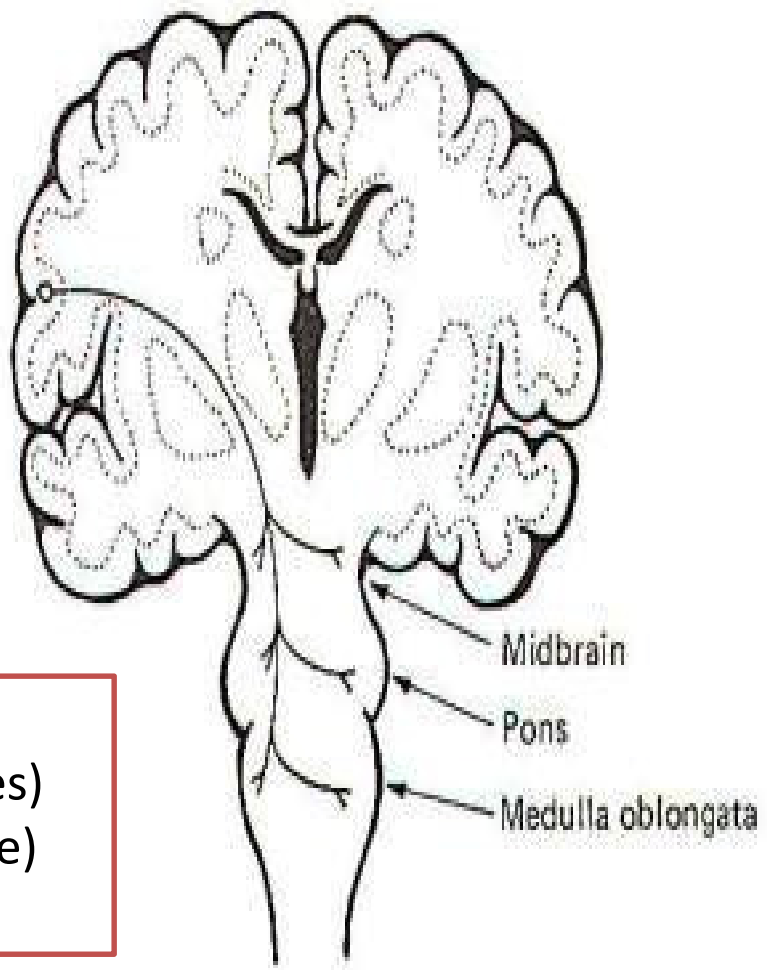
The anterior corticospinal tract

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

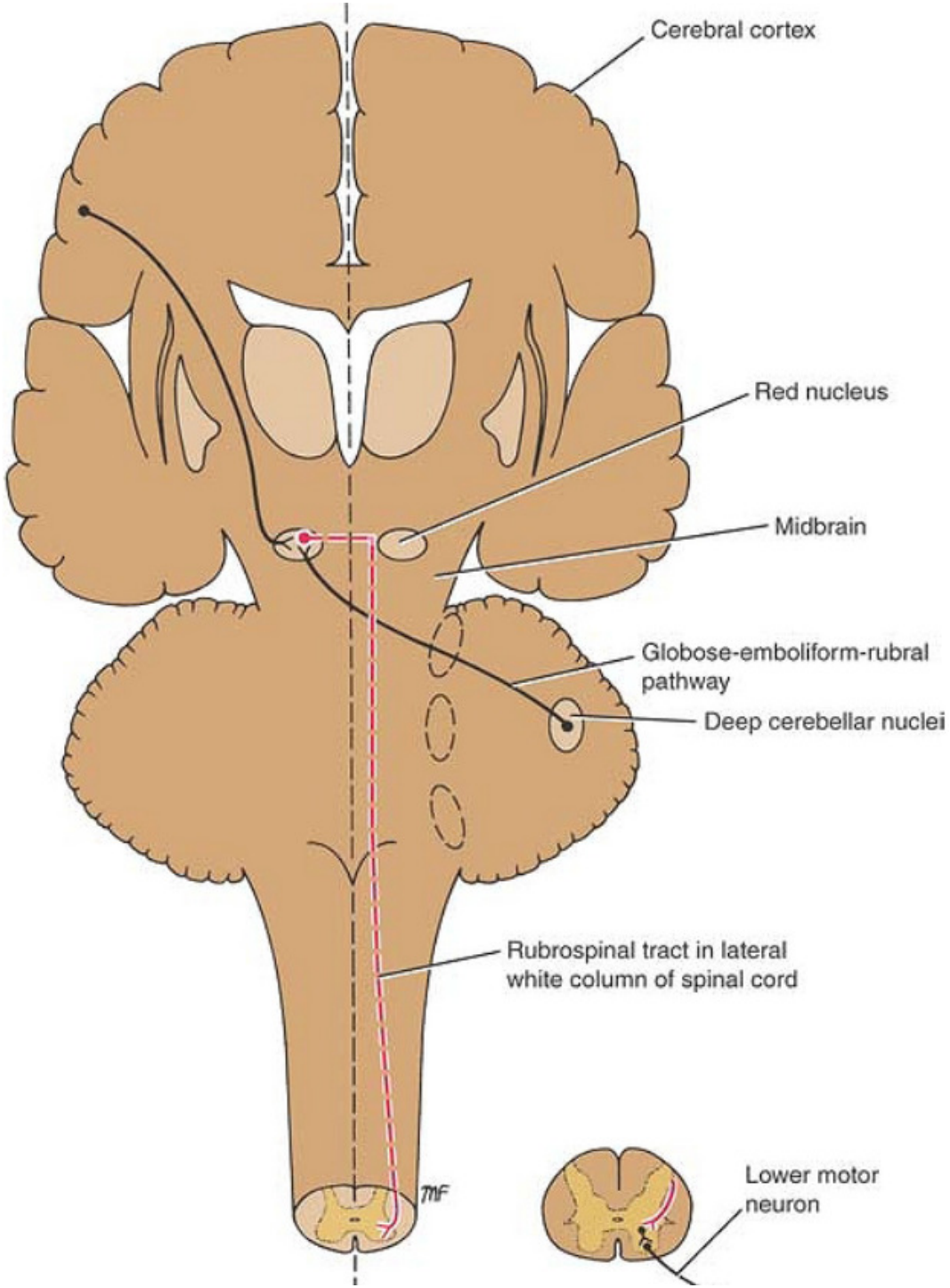
These motor pathways are complex and multisynaptic, and regulate:

- 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)

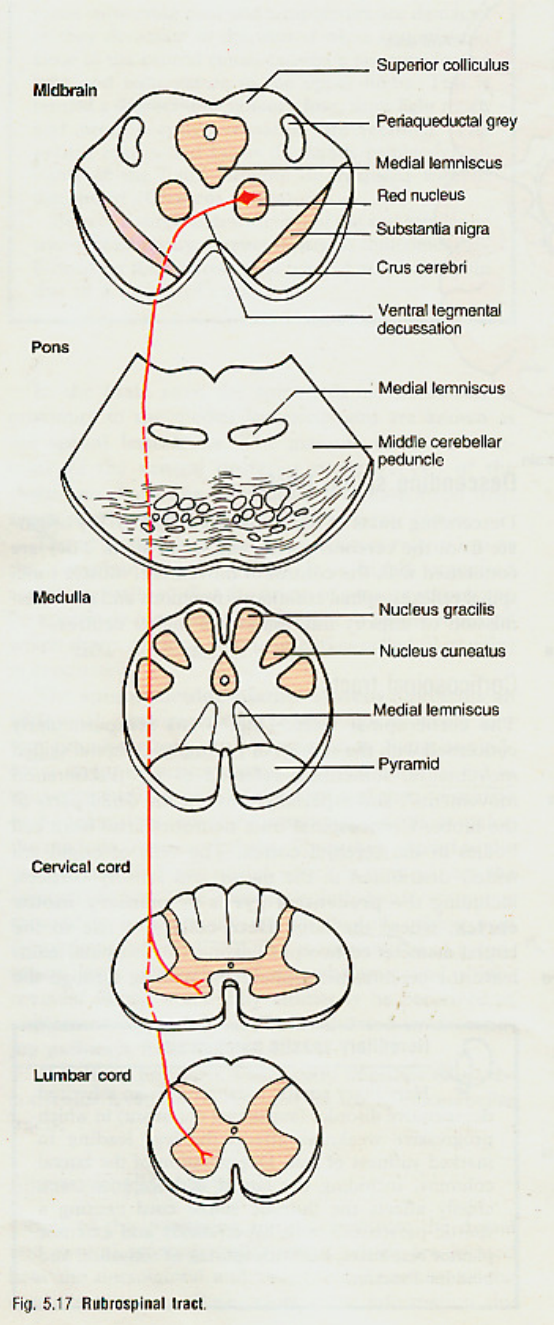
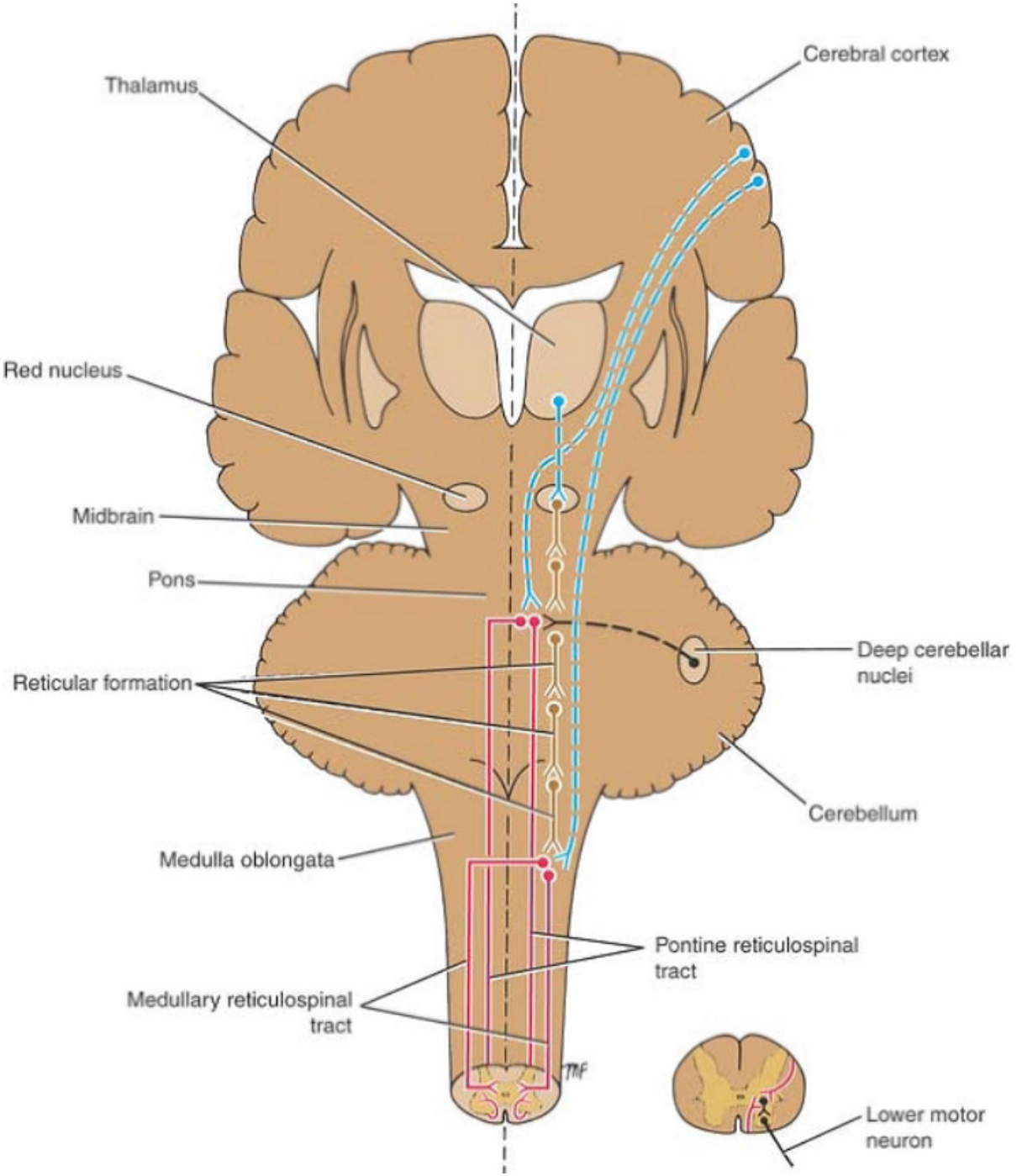


Fig. 5.17 Rubrospinal tract.

Pontine reticulospinal tract

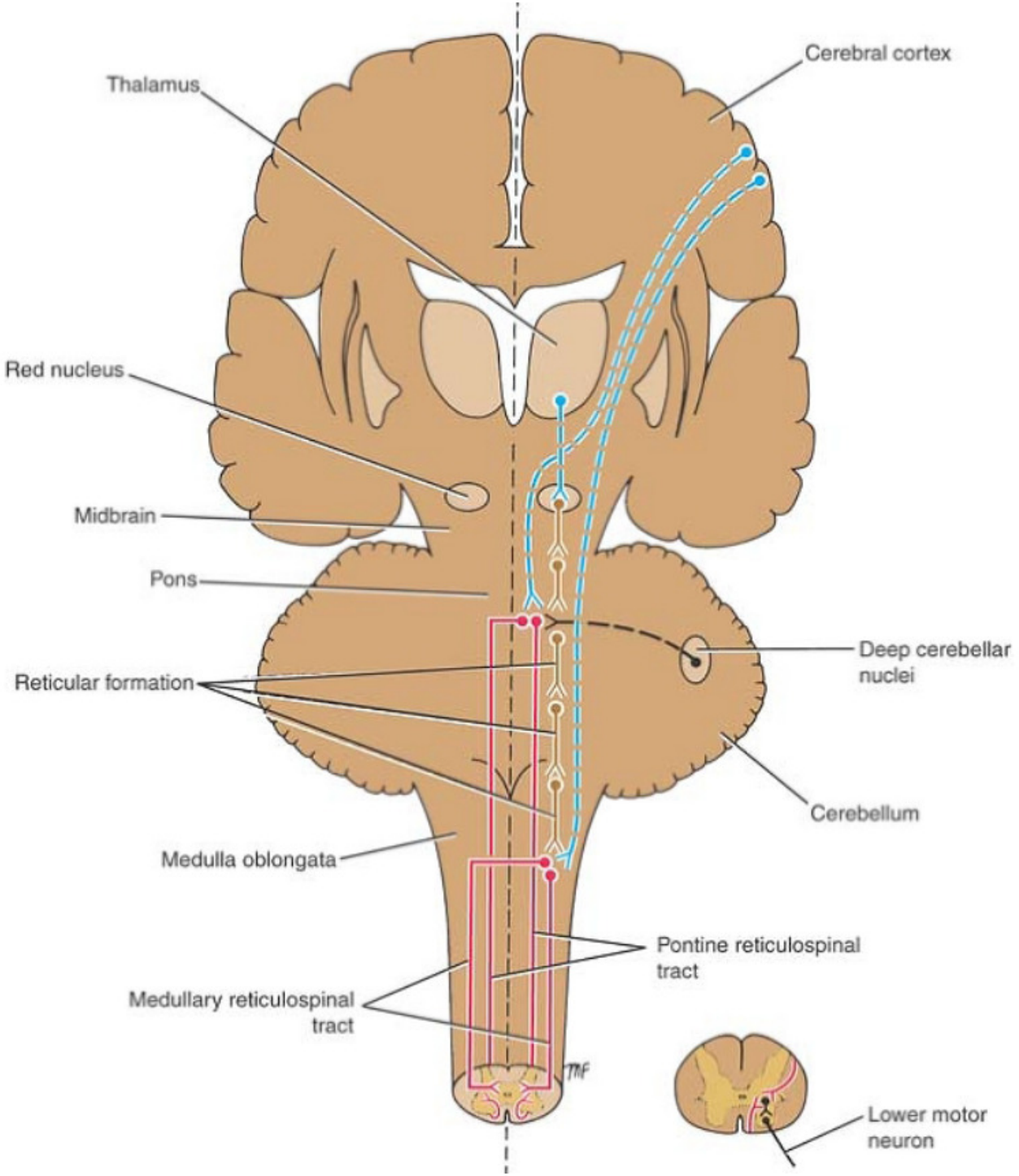
- From pons:
- axons of RF neurons descend **uncrossed** into the spinal cord
- Anterior white column
- medial reticulospinal tract (MRST)
- **tonically active**
- normally under **inhibition from cortex**
- **Function:**
- activate the axial and proximal limb extensors



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:**

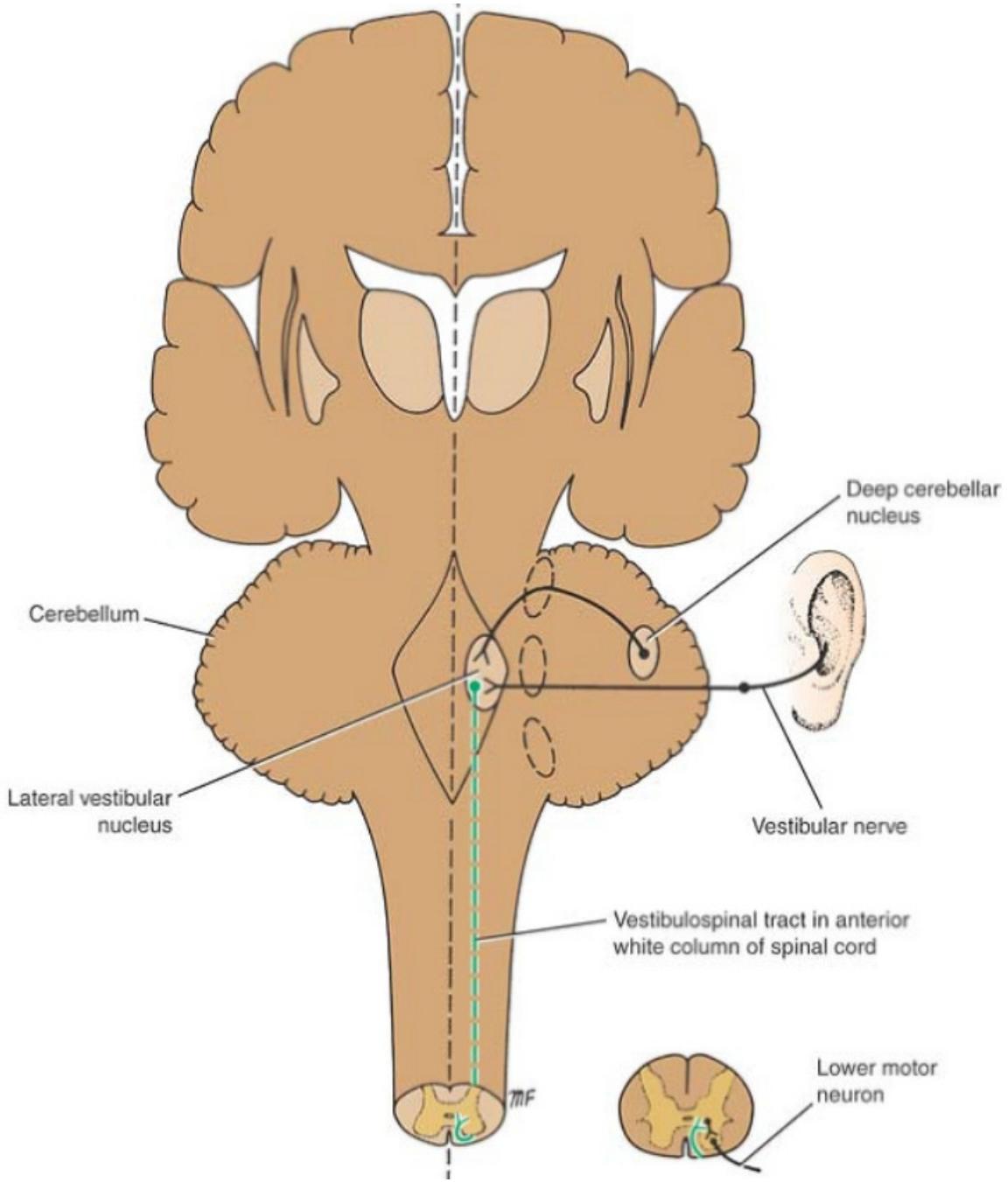
  Inhibit the axial and proximal limb extensors



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)

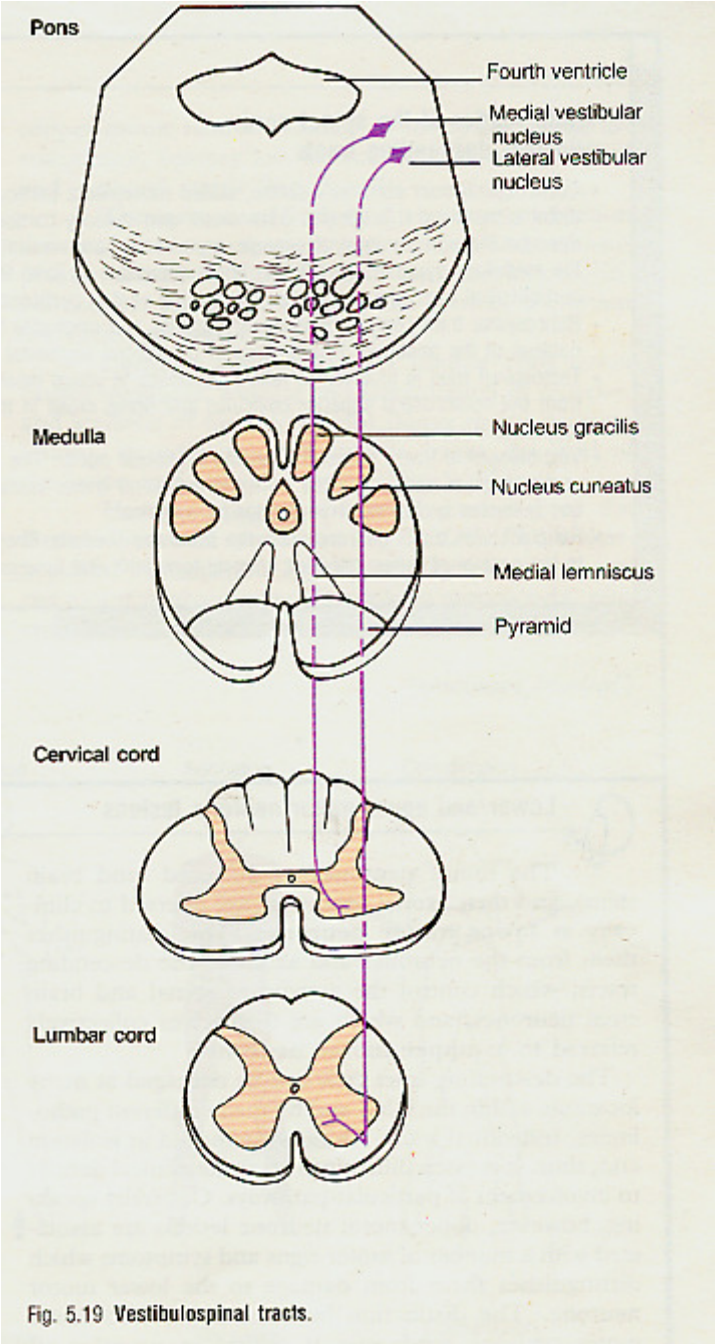
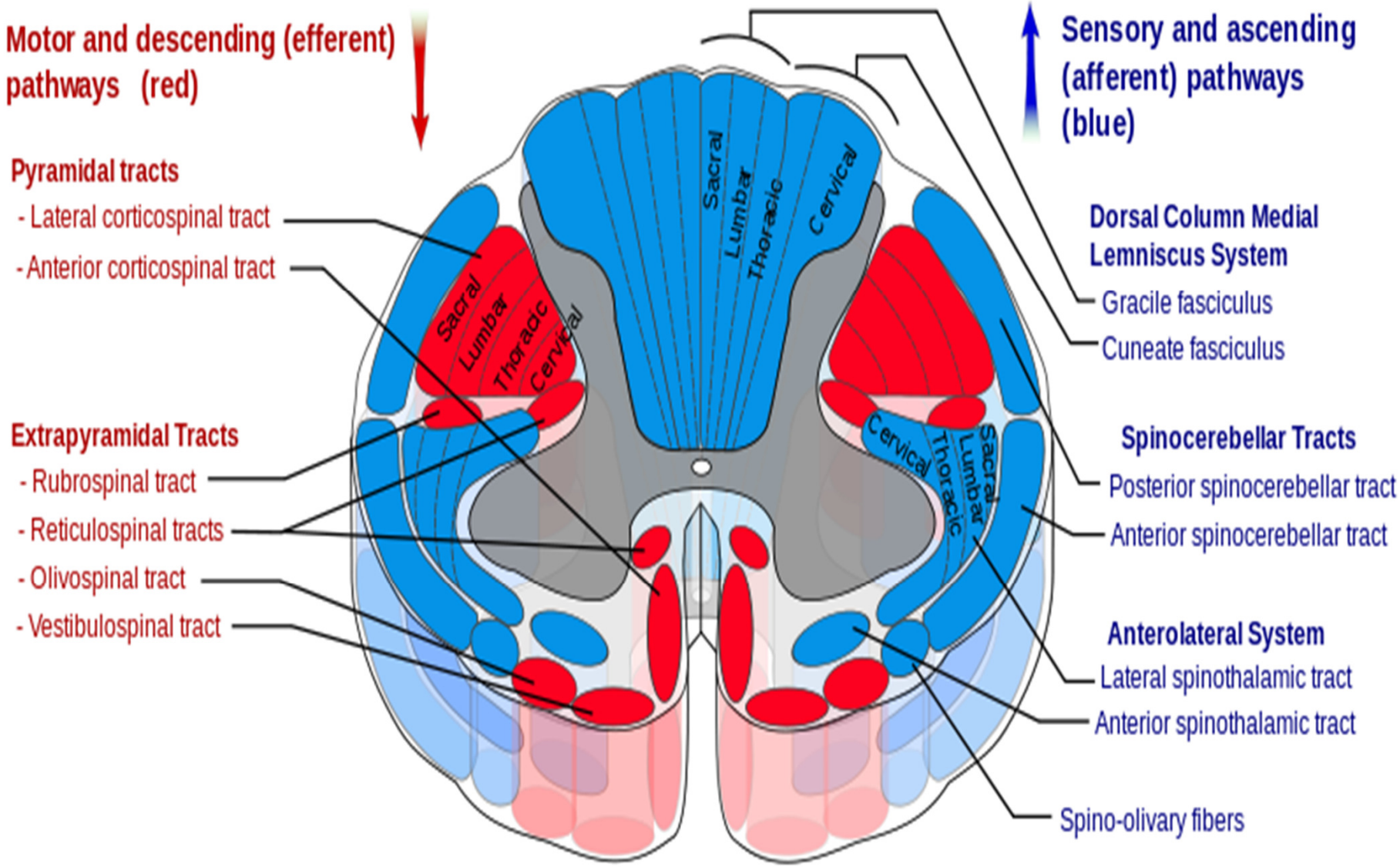
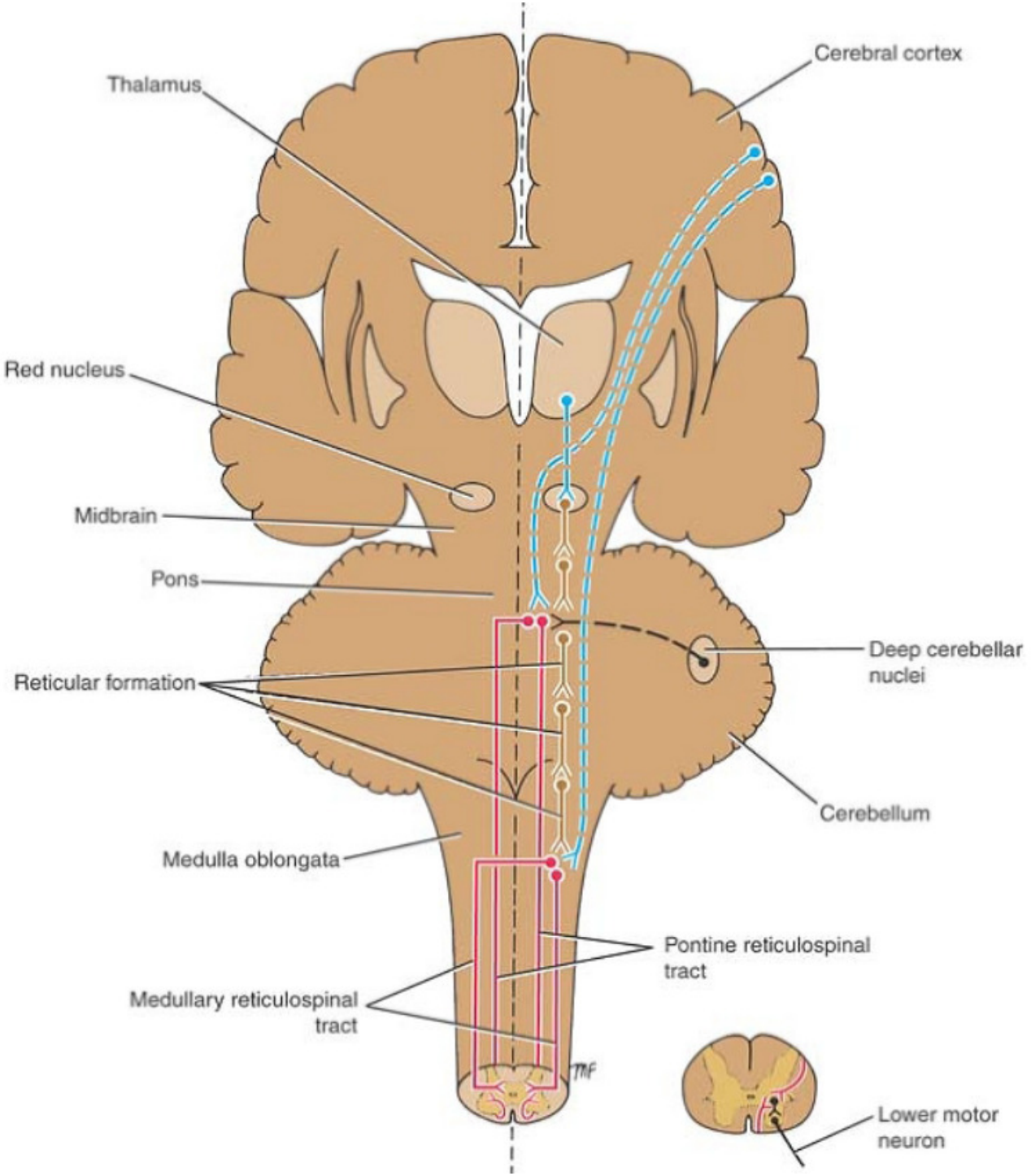


Fig. 5.19 Vestibulospinal tracts.


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*

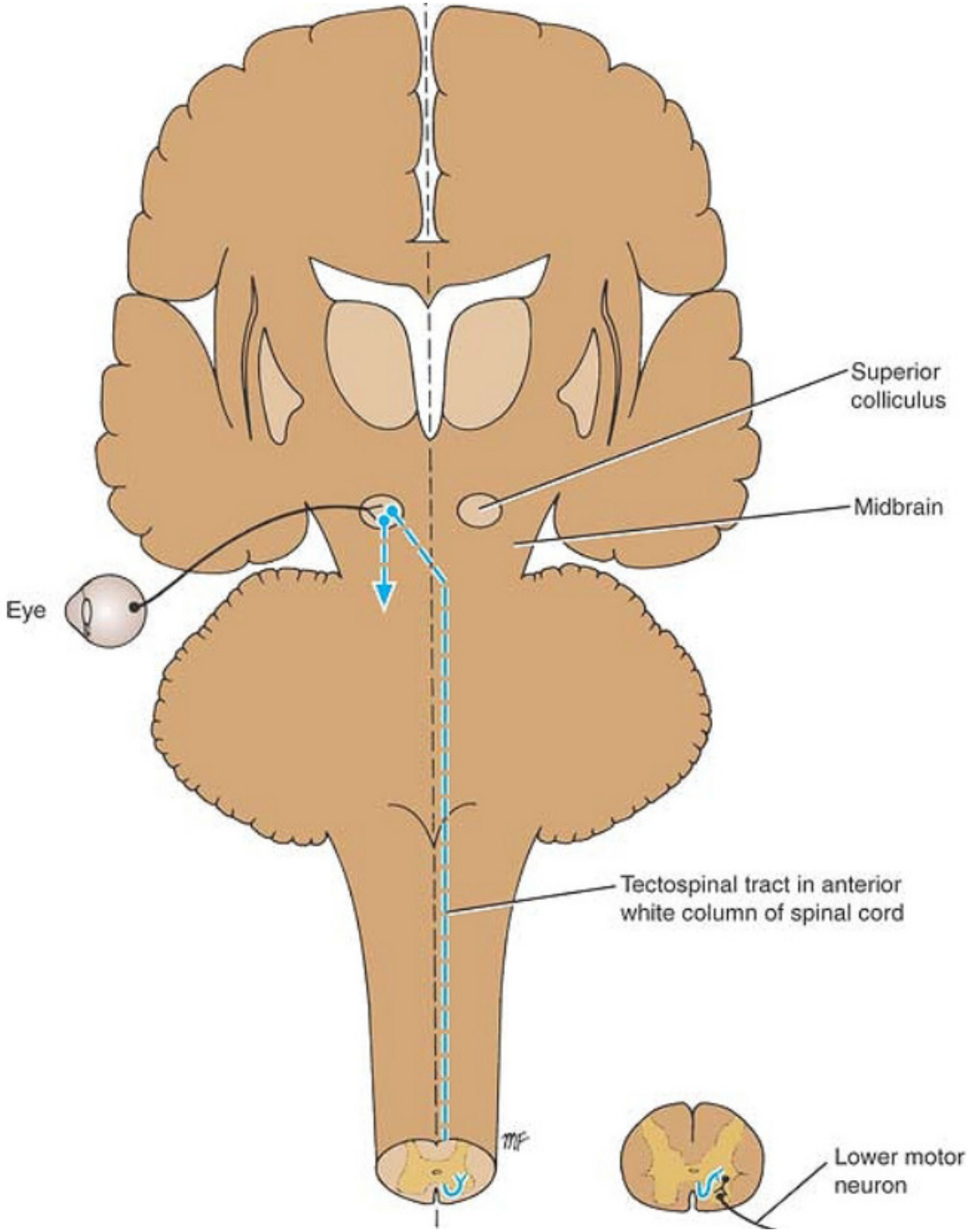


Tectospinal tract

- 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 Spastic/ clasp knife	Individual muscles is paralyzed 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

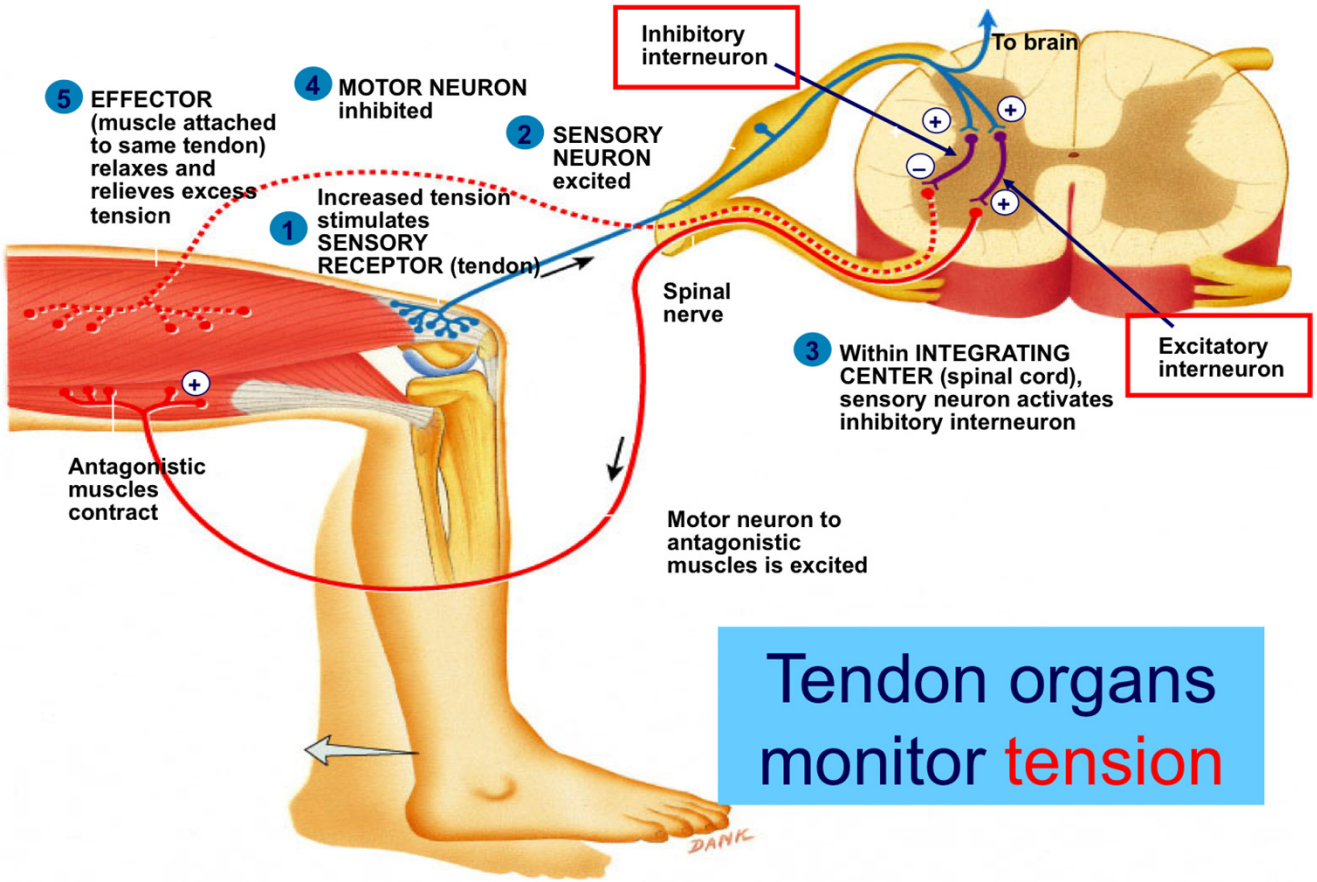
hypertonia and hyperreflexia, is the result of an increase in gamma motor neurons activity

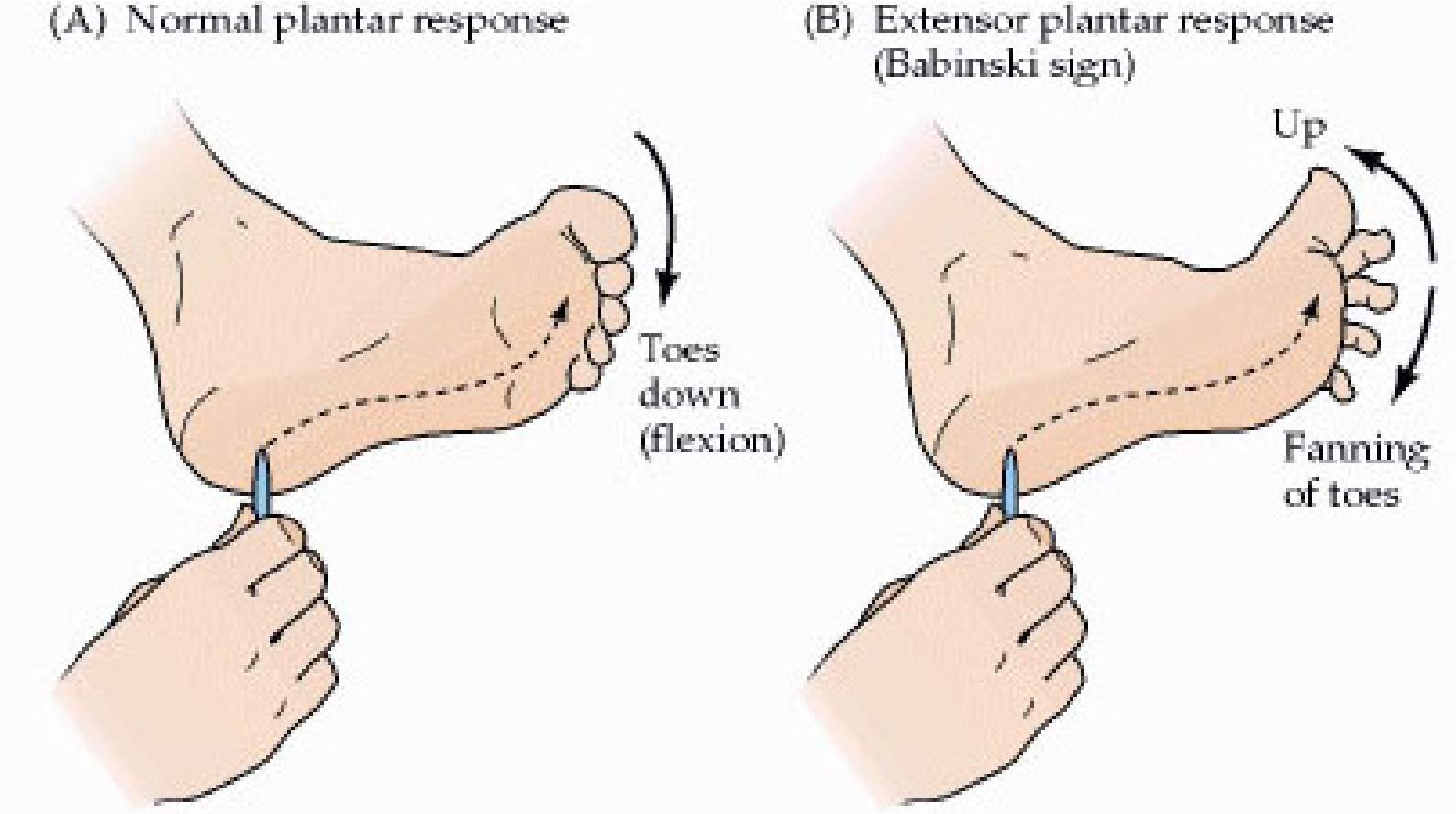
Clasp knife reaction

- 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

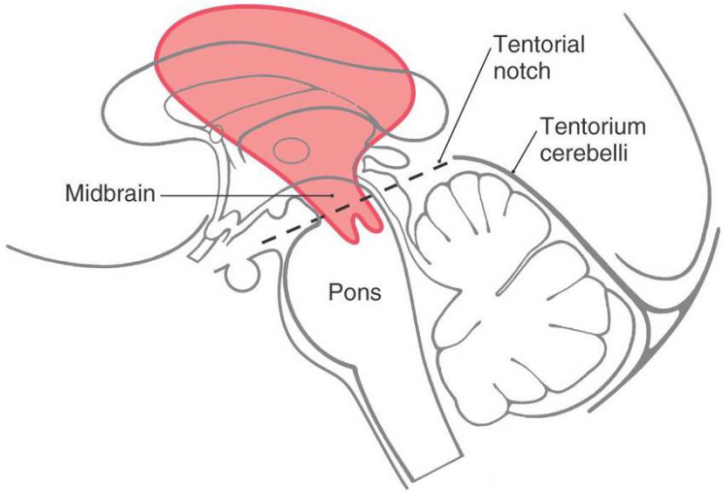
- Polysynaptic reflex arc
- law of reciprocal innervation

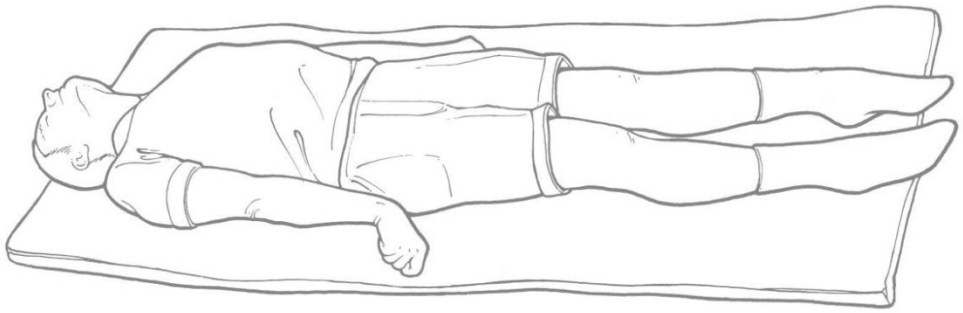




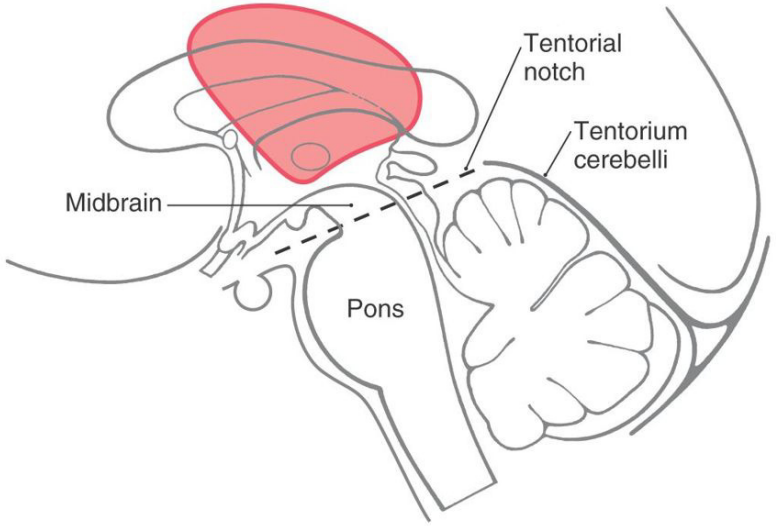
When the corticospinal tracts are nonfunctional, the influence of the other descending tracts on the toes becomes apparent, and a kind of withdrawal reflex takes place in response to stimulation of the sole, with the great toe being dorsally flexed and the other toes fanning out.

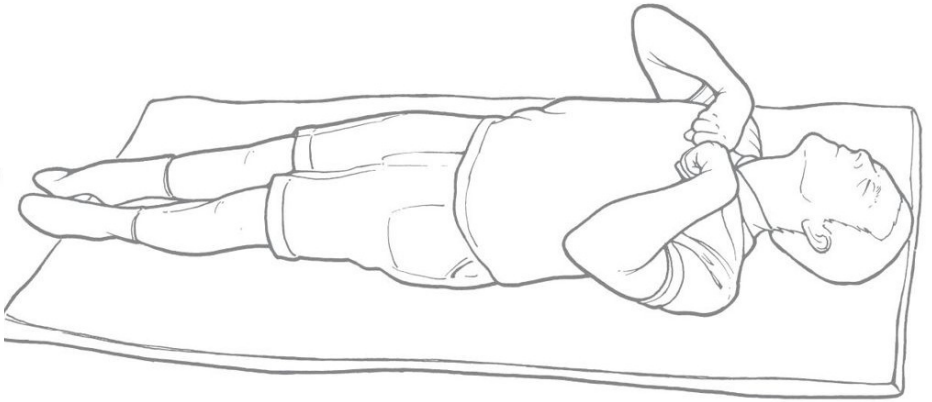
Decerebrate rigidity



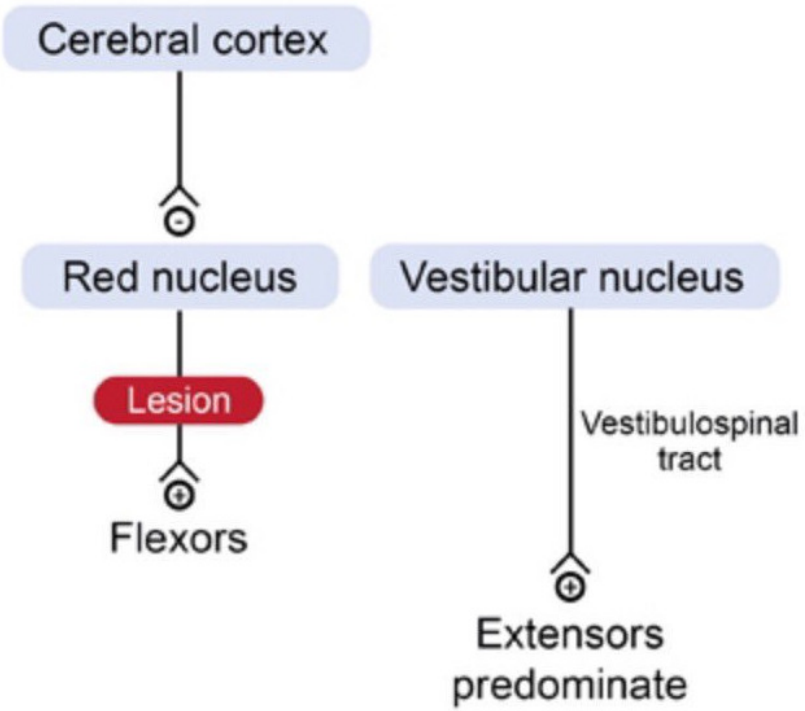


Decorticate rigidity

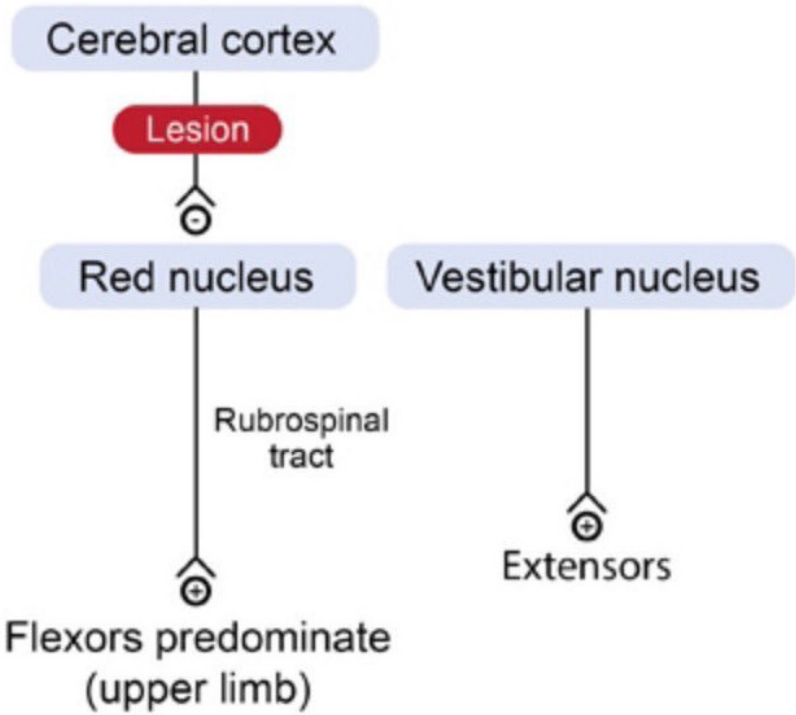




Decerebrate posture



Decorticate posture



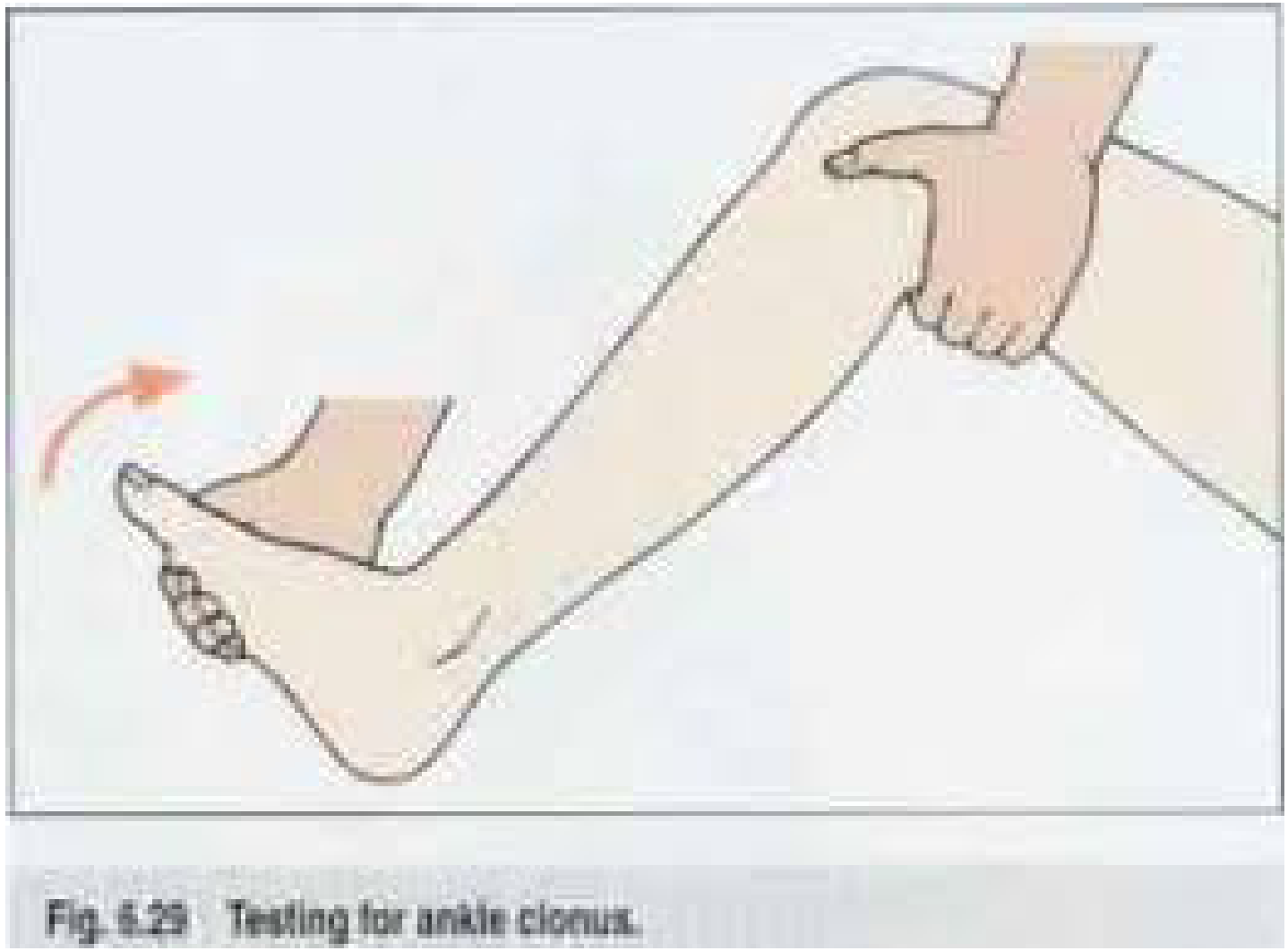


Fig. 6.29 Testing for ankle clonus.

Rhythmic contractions and relaxation of muscles when they are subjected to sudden sustained stretch

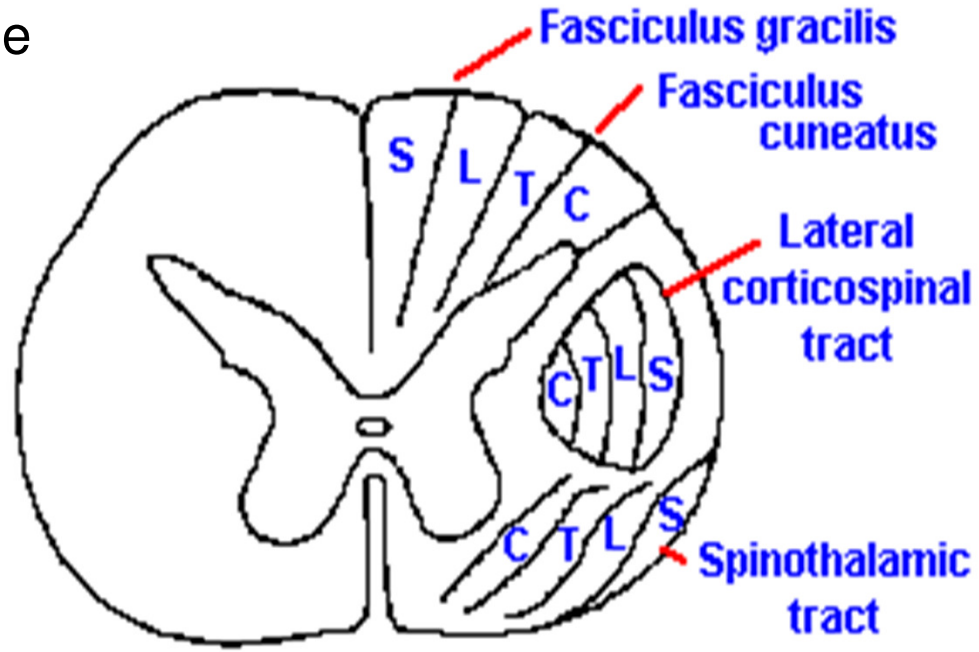
Clinical significance of lamination of the ascending tracts

- 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



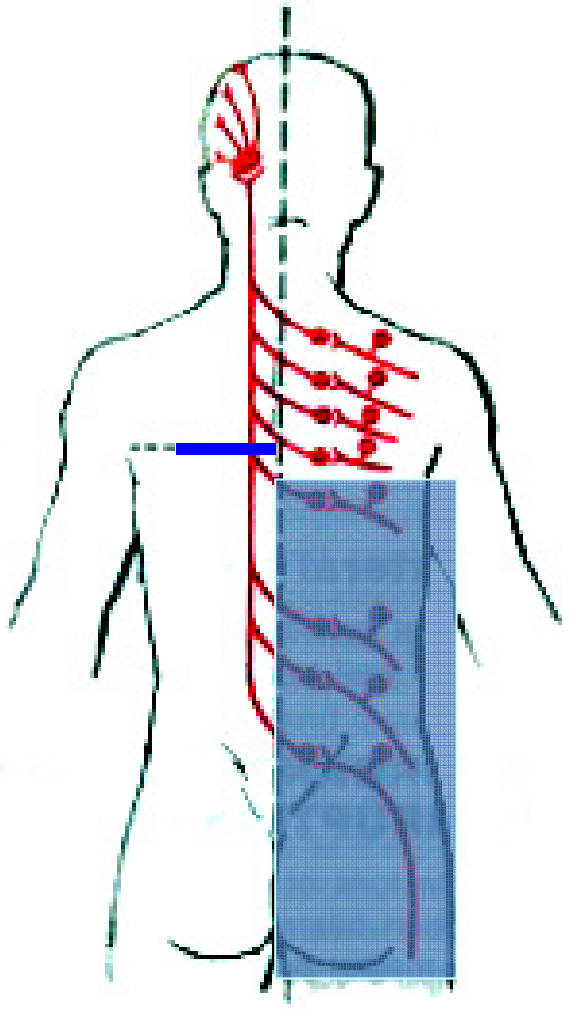
Clinical application

destruction of LSTT

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

patient will not

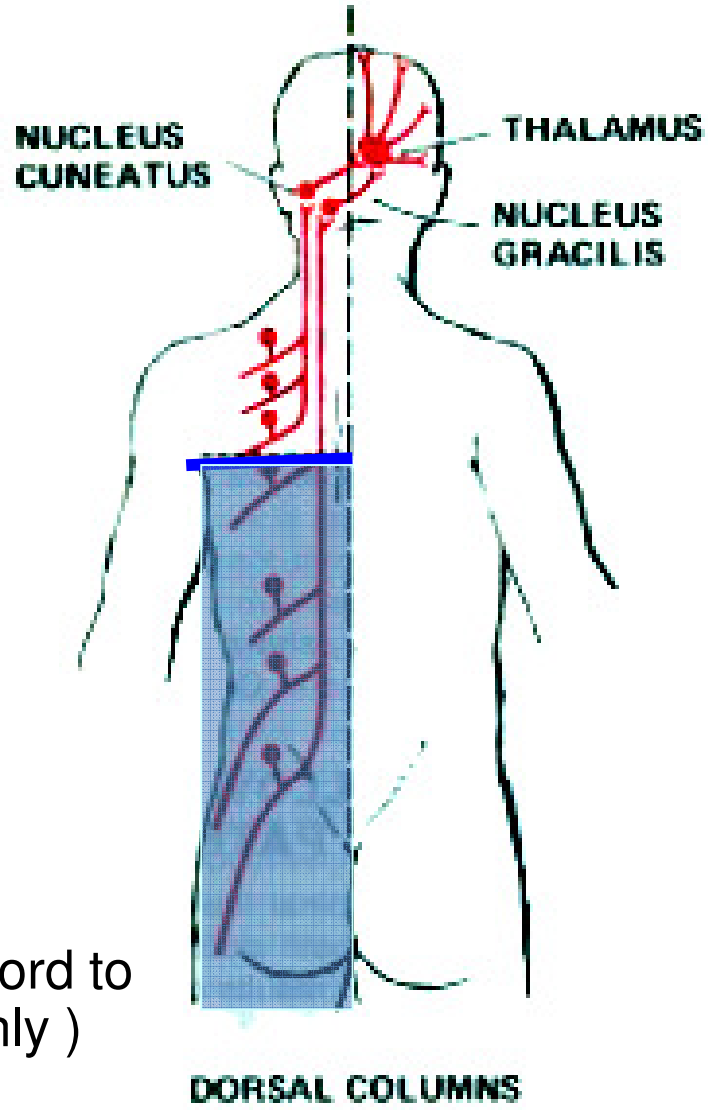
recognize hot and cold



Clinical application
destruction of
fasciculus gracilia and cuneatus

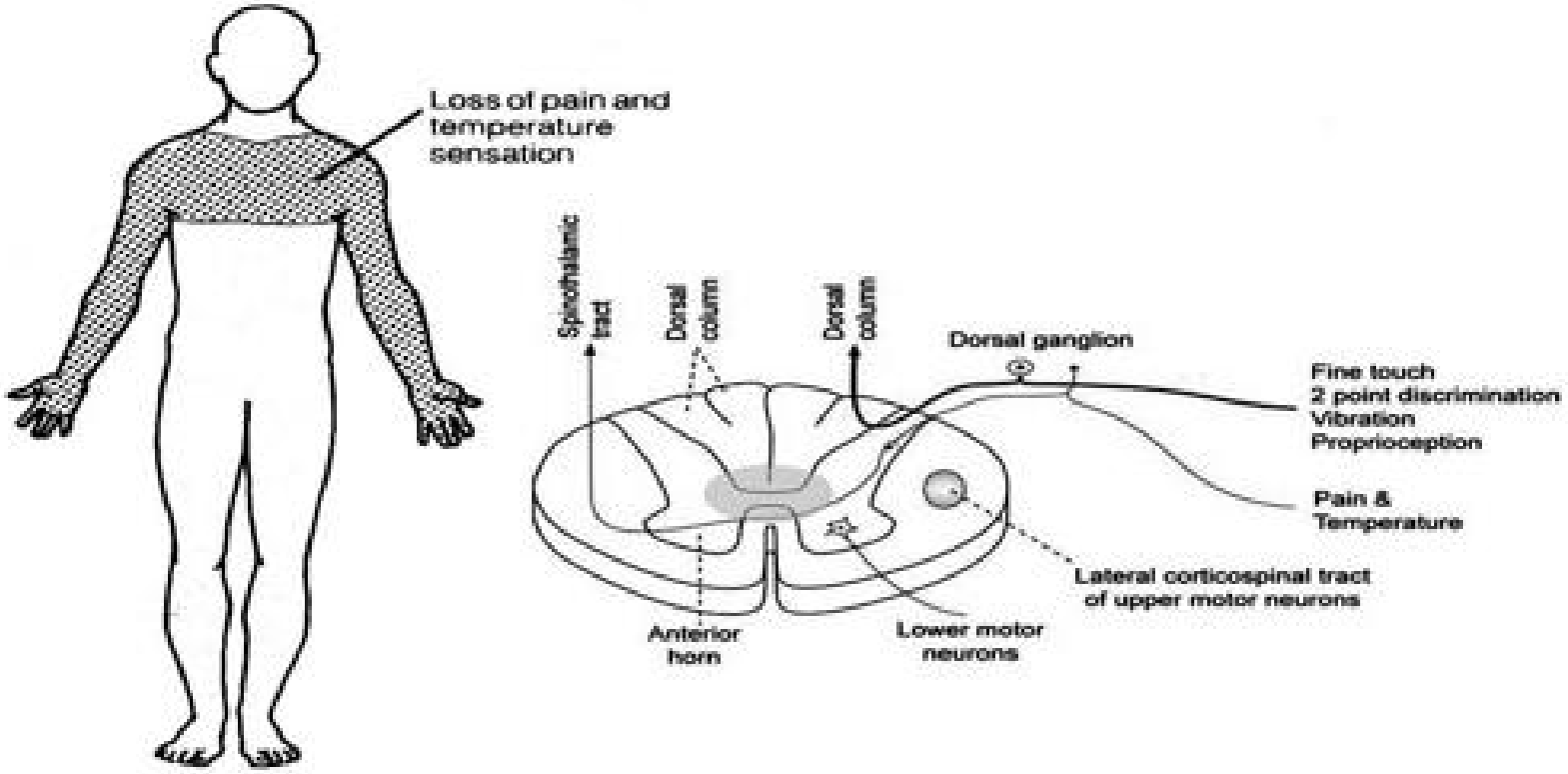
- loss of muscle joint sense, position sense, vibration sense and tactile discrimination
- on the same side
- below the level of the lesion

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



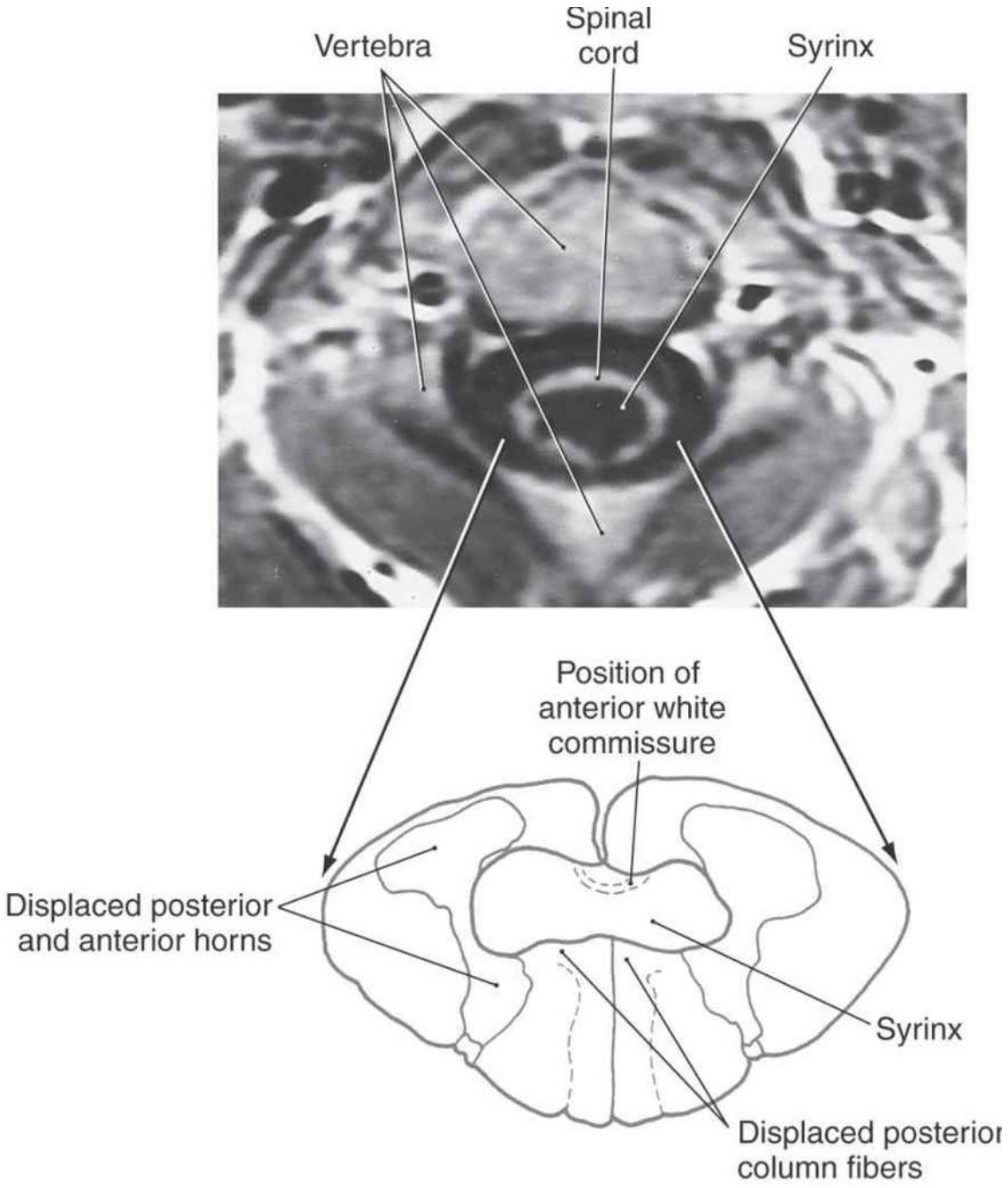
Syringomyelia

- Cavitation of the central regions of the spinal cord
- Damage fibers crossing in the anterior white commissure in both directions
- Bilateral loss of pain and thermal sensations
- When it is located at the C4 to C5 levels of the spinal cord sensory losses in the configuration of a cape draped over the shoulders and extending down to nipple level



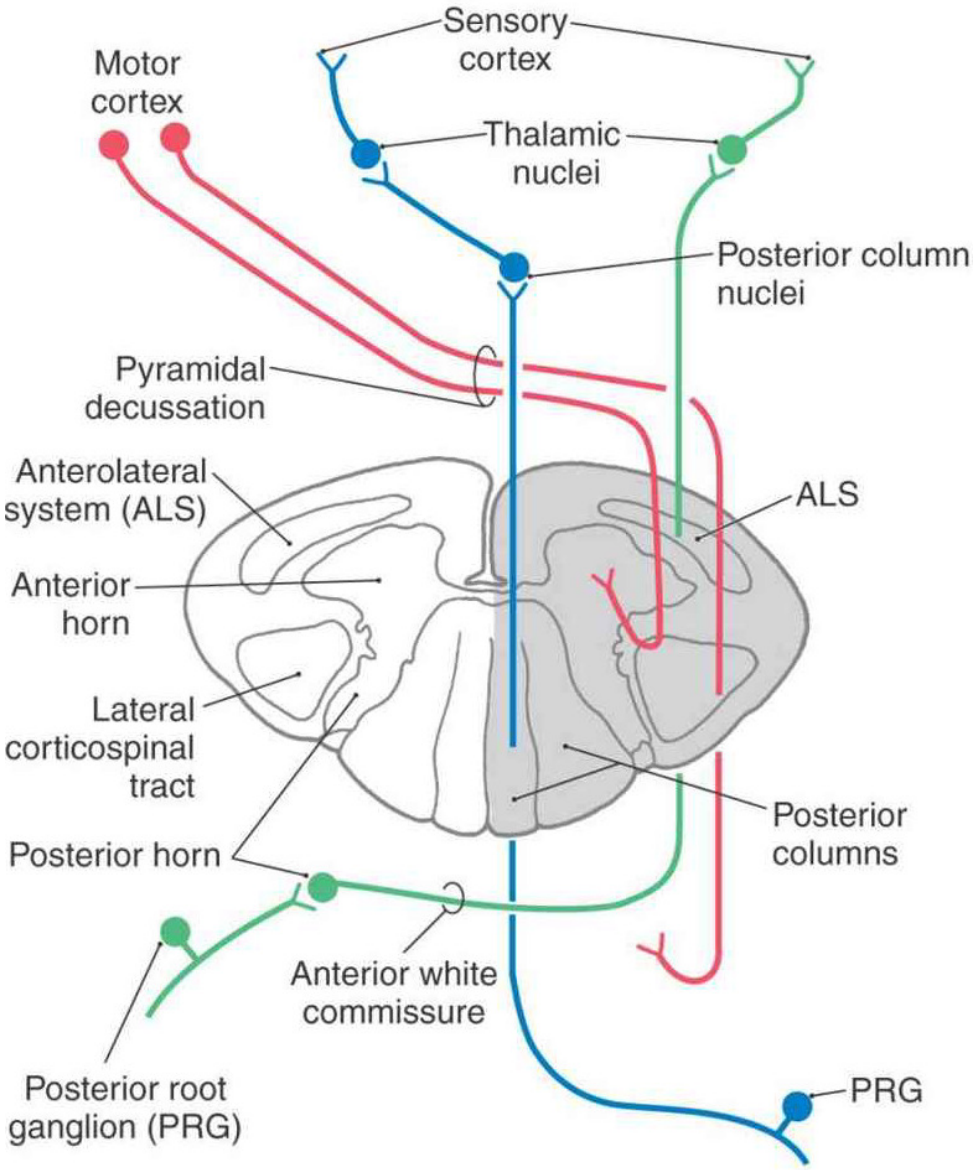
Syringomyelia

- If tit **extends into** the anterior horn results it will cause:
  - bilateral sensory loss
  - weakness of the corresponding extremity
- extension of the syrinx into one anterior horn results in an ipsilateral weakness of the upper extremity
- if both anterior horns are involved, the weakness is bilateral



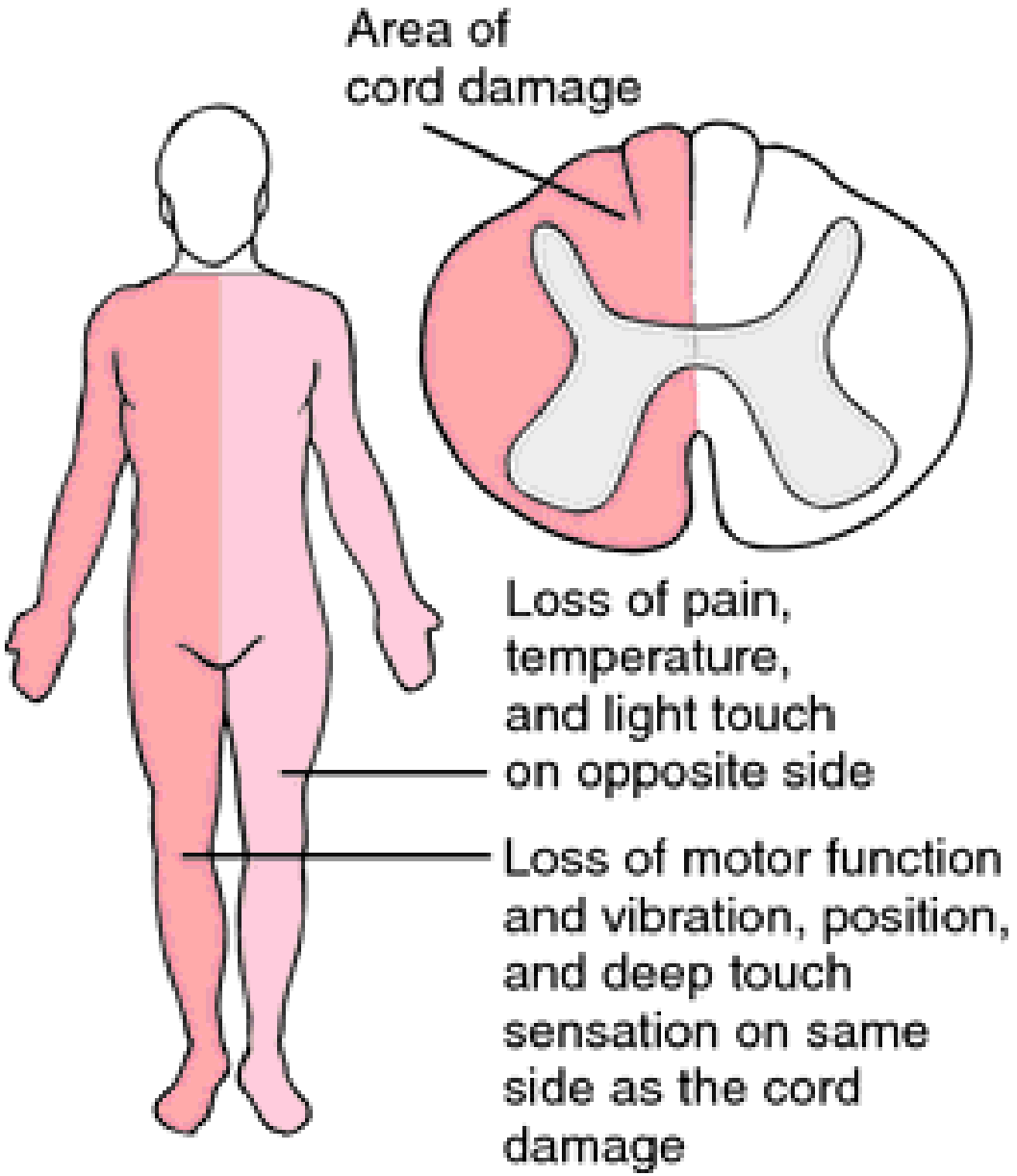
Brown-Séquard Syndrome

- Functional hemisection of the spinal cord results in:
  - damage to the lateral corticospinal tract, ALS, posterior columns
- Example: A lesion on the right at C4 to C5 will result in:
  - muscle weakness or paralysis (hemiparesis, hemiplegia) on the right side
  - loss of pain and thermal sensations on the left side
  - loss of proprioception, vibratory sense, and discriminative touch on the right

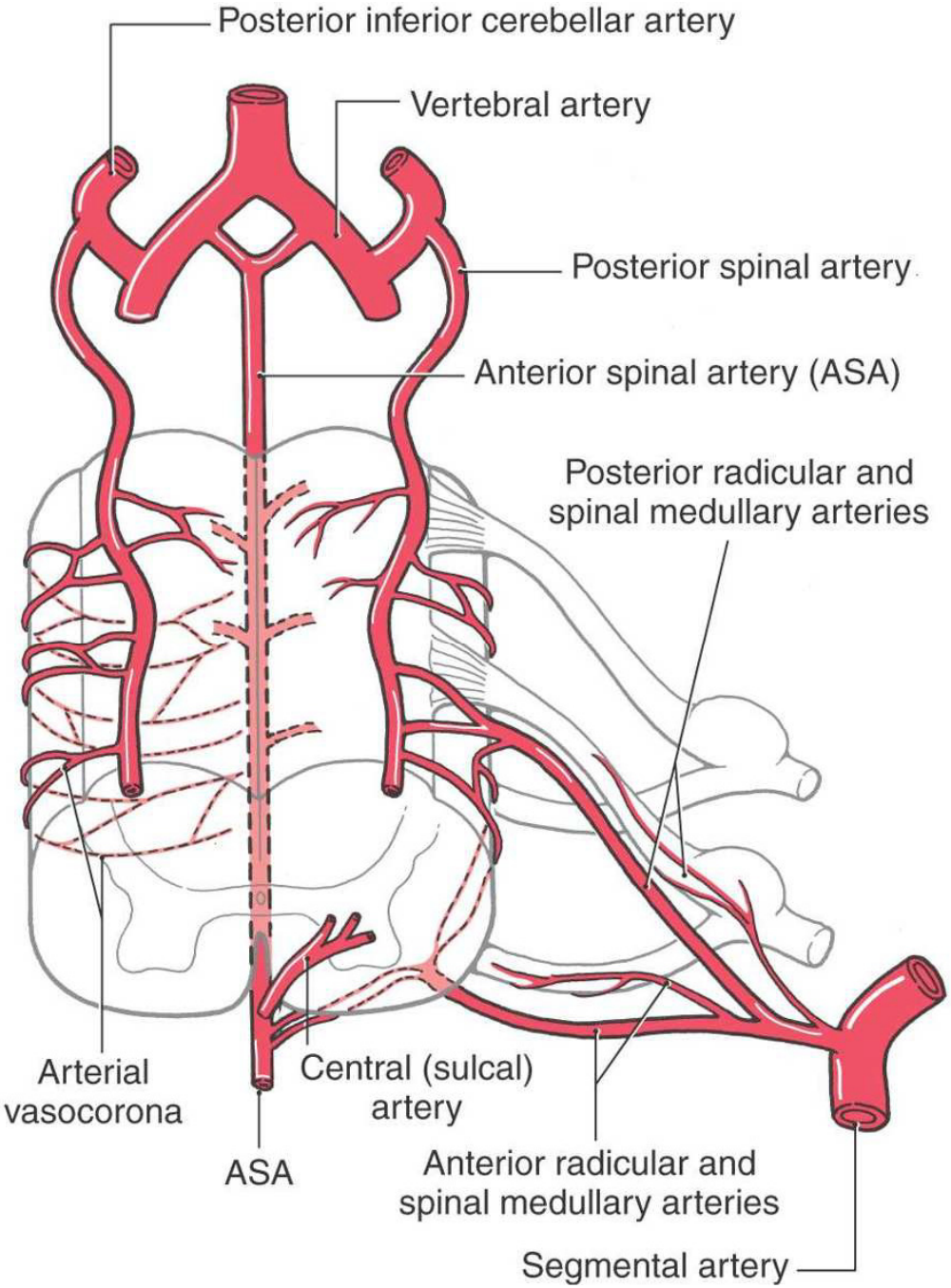


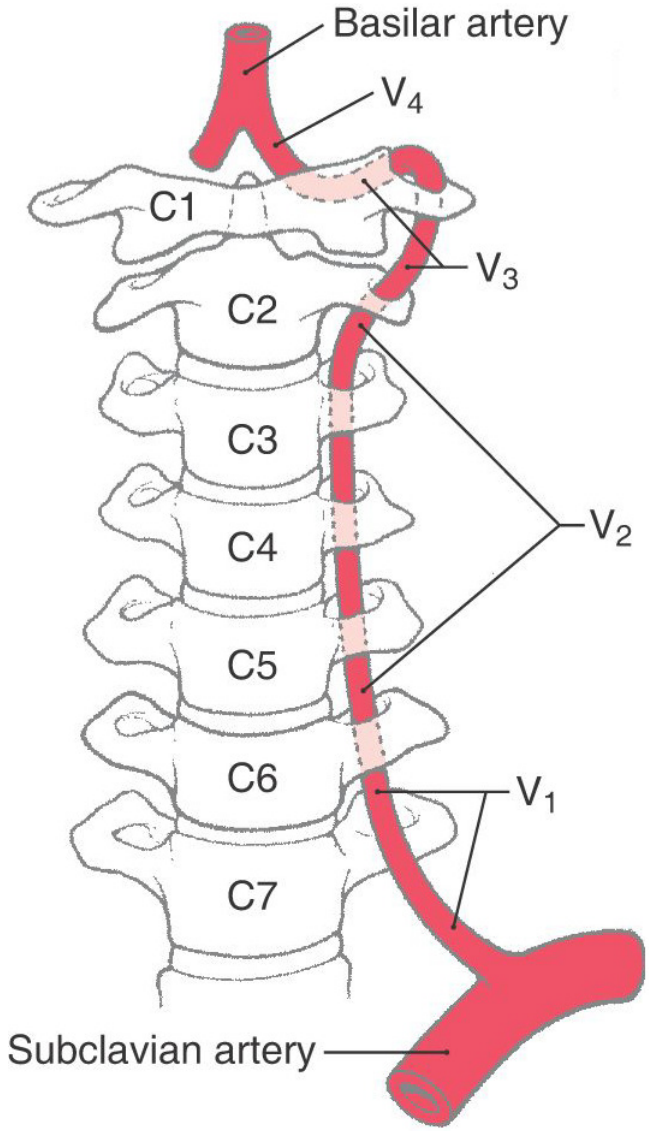
Brown-Séquard Syndrome

- **Contralateral** loss of nociceptive and thermal sensations over the body below the level of the lesion
- **Ipsilateral** loss of discriminative tactile, vibratory, and position sense over the body below the level of the lesion
- **Ipsilateral** paralysis of the leg or leg and arm, depending on the level of the hemisection



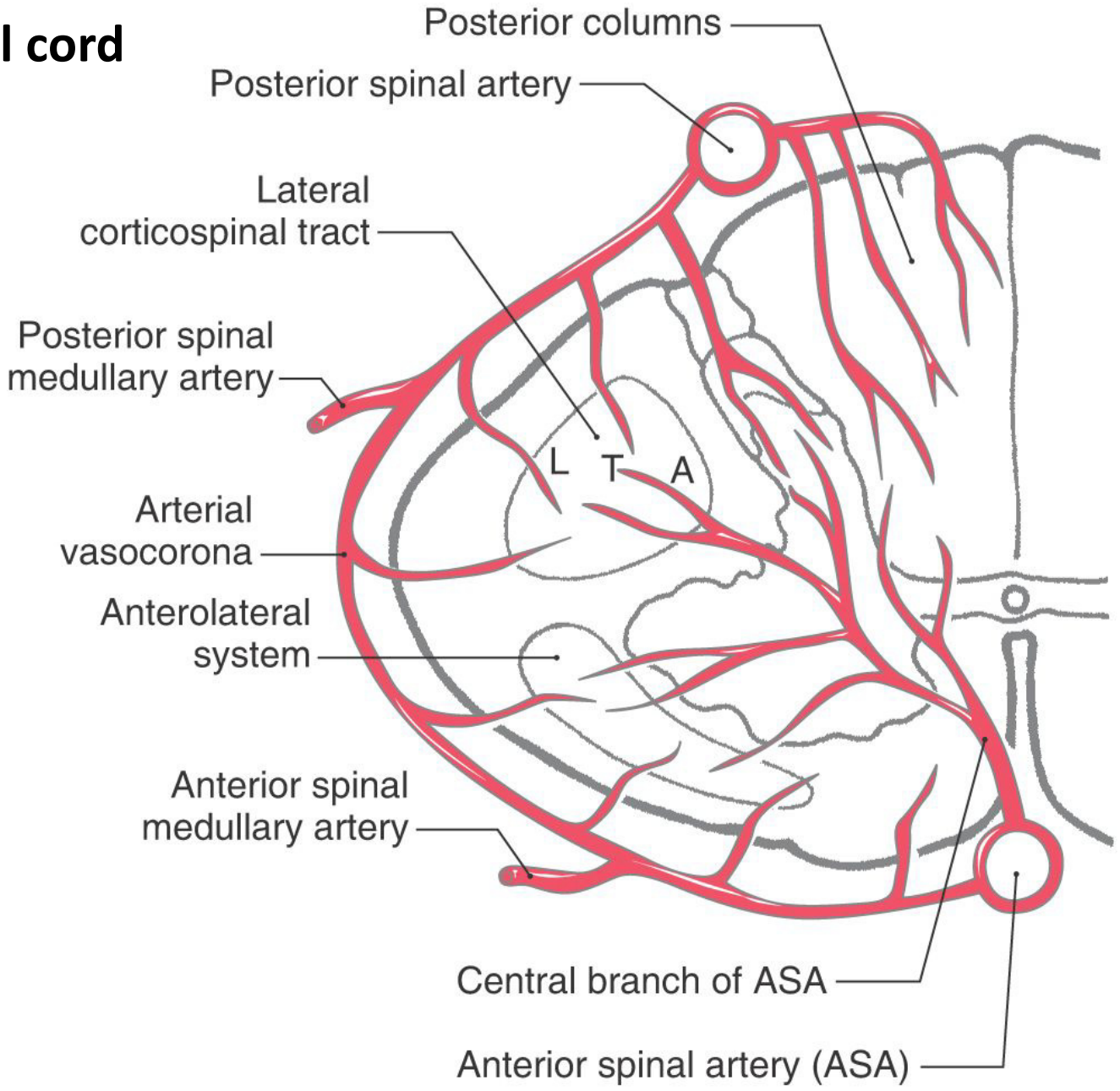
Blood supply of spinal cord





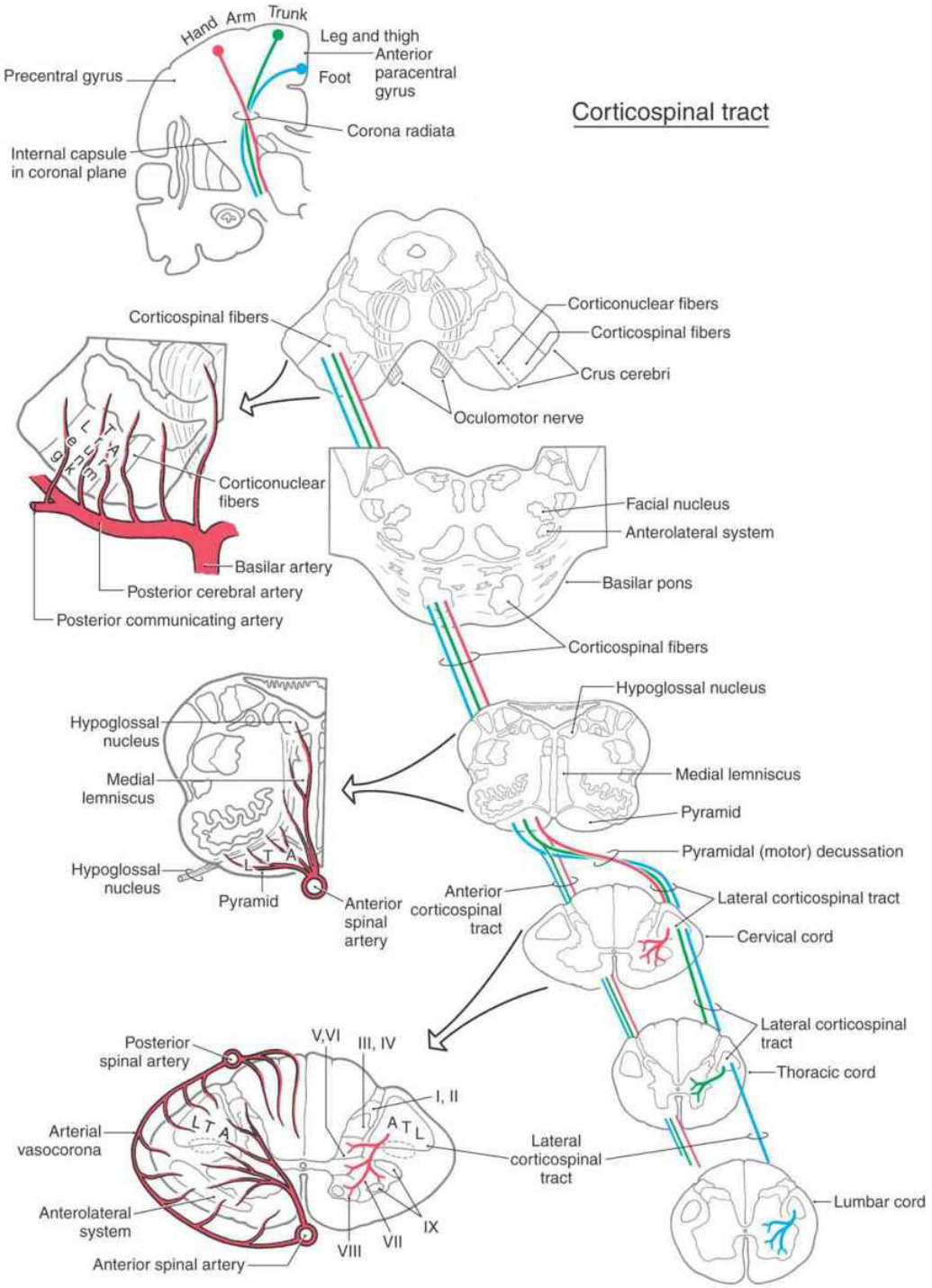
Blood supply of spinal cord

- 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**