

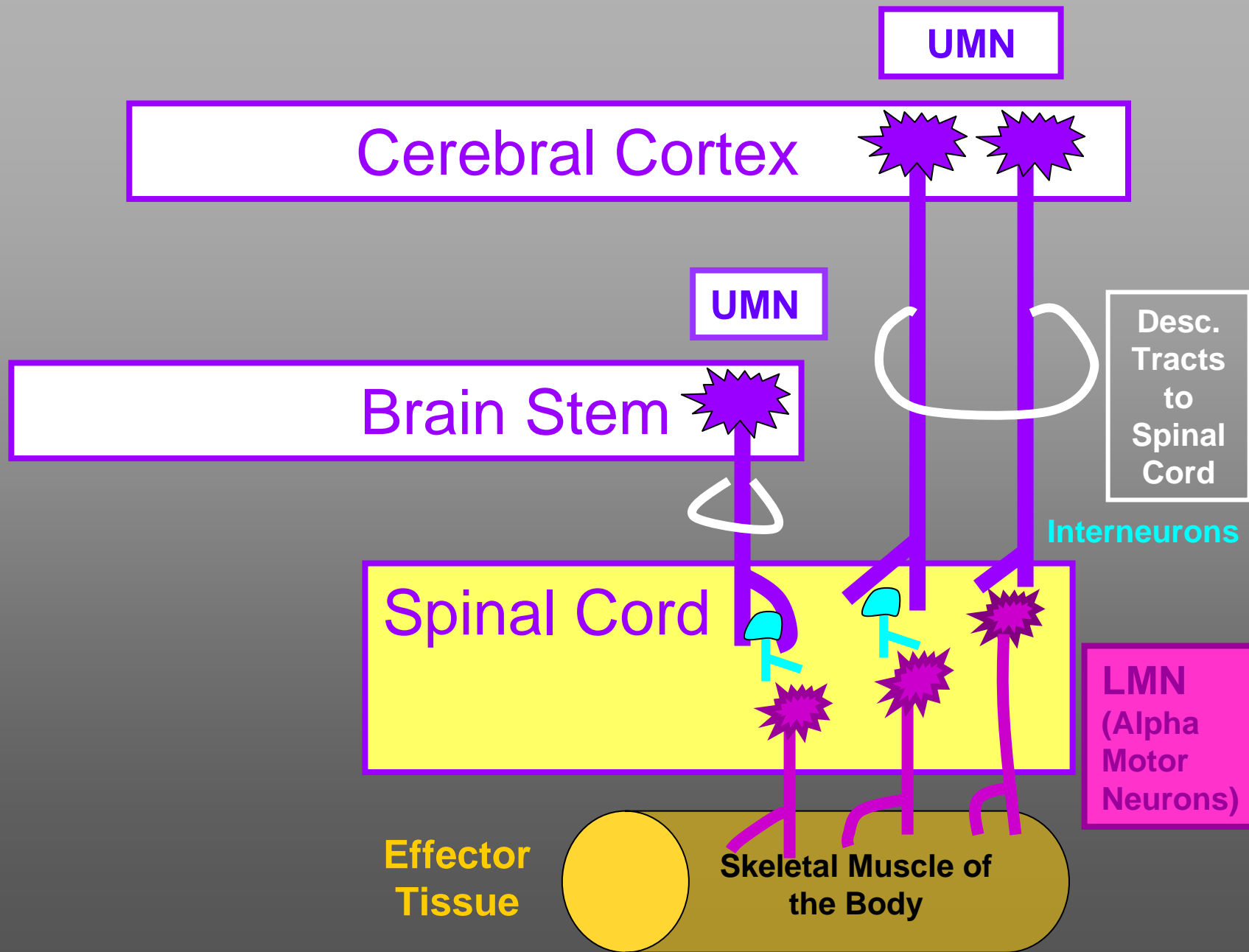
Mechanisms & Neural Substrate of Spasticity

Dr. Sharon L. Juliano

❖ Definition

- ❖ **Spasticity** - A velocity dependent increase in muscle tone (hypertonia) with exaggerated increase in reflexes (hyperreflexia).
- ❖ Hypertonia is associated with an increased resistance to passive stretch.
- ❖ Also associated with the clasp knife phenomenon and clonus.

- ❖ Caused by damage to descending pathways that influence gamma or alpha motor neurons.



LOWER MOTOR NEURON LESIONS

UPPER MOTOR NEURON LESIONS

CAUSES:

-
-
- 1) Degeneration of Anterior Horn Cells
- 2) Transection of Ventral Roots
- 3) Transection of Spinal Nerves

CAUSES:

- 1) Degeneration of Nerve Cell Bodies in the Motor / Somatosensory Cortices
- 2) Damage to Axons of Descending Systems particularly Corticospinal Fibers

SYMPTOMS:

-
- 1) Flaccid Paralysis
- 2) Loss of Myotatic Reflexes
- 3) Hypotonia
- 4) Muscle Fasciculations
- 5) Atrophy of Denervated Muscles

SYMPTOMS:

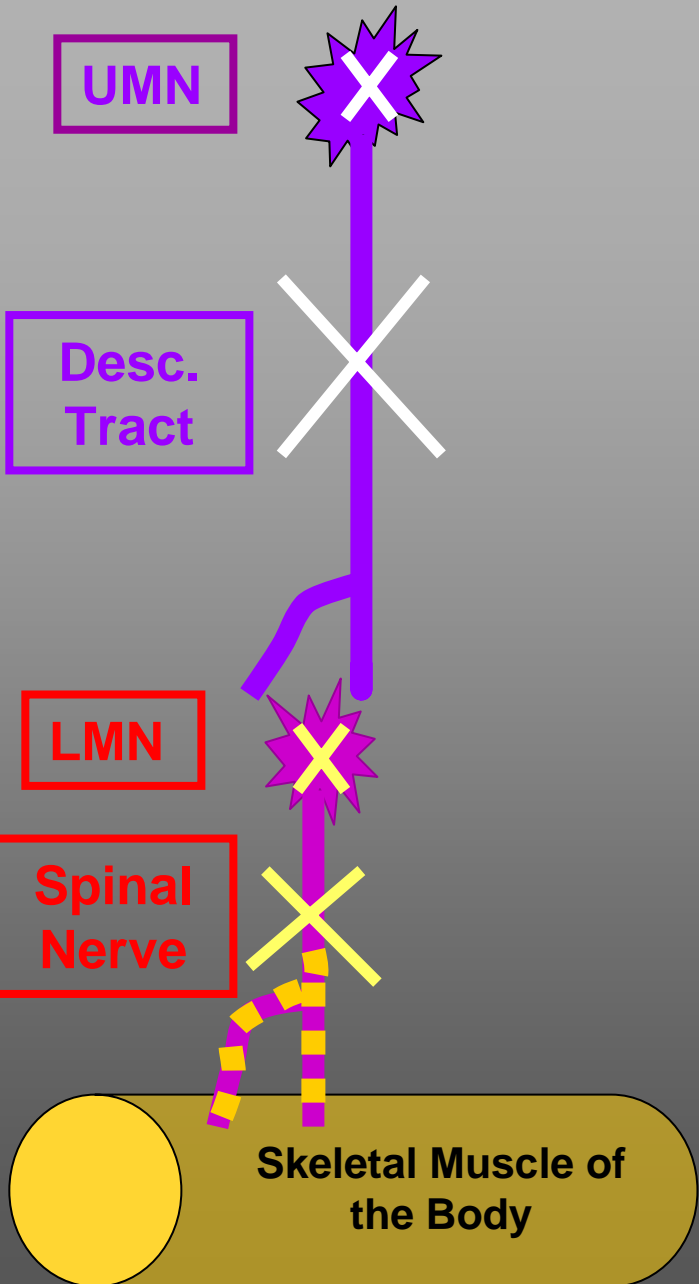
- 1) Spastic Paralysis
- 2) Hyperactive Myotatic Reflexes
- 3) Hypertonia
- 4) Clonus
- 5) Muscle Atrophy--if it occurs, it is very late and results from disuse
- 6) Babinski Sign (Corticospinal Damage)
- 7) Loss of Superficial Abdominal Reflex and Cremasteric Reflex (males)

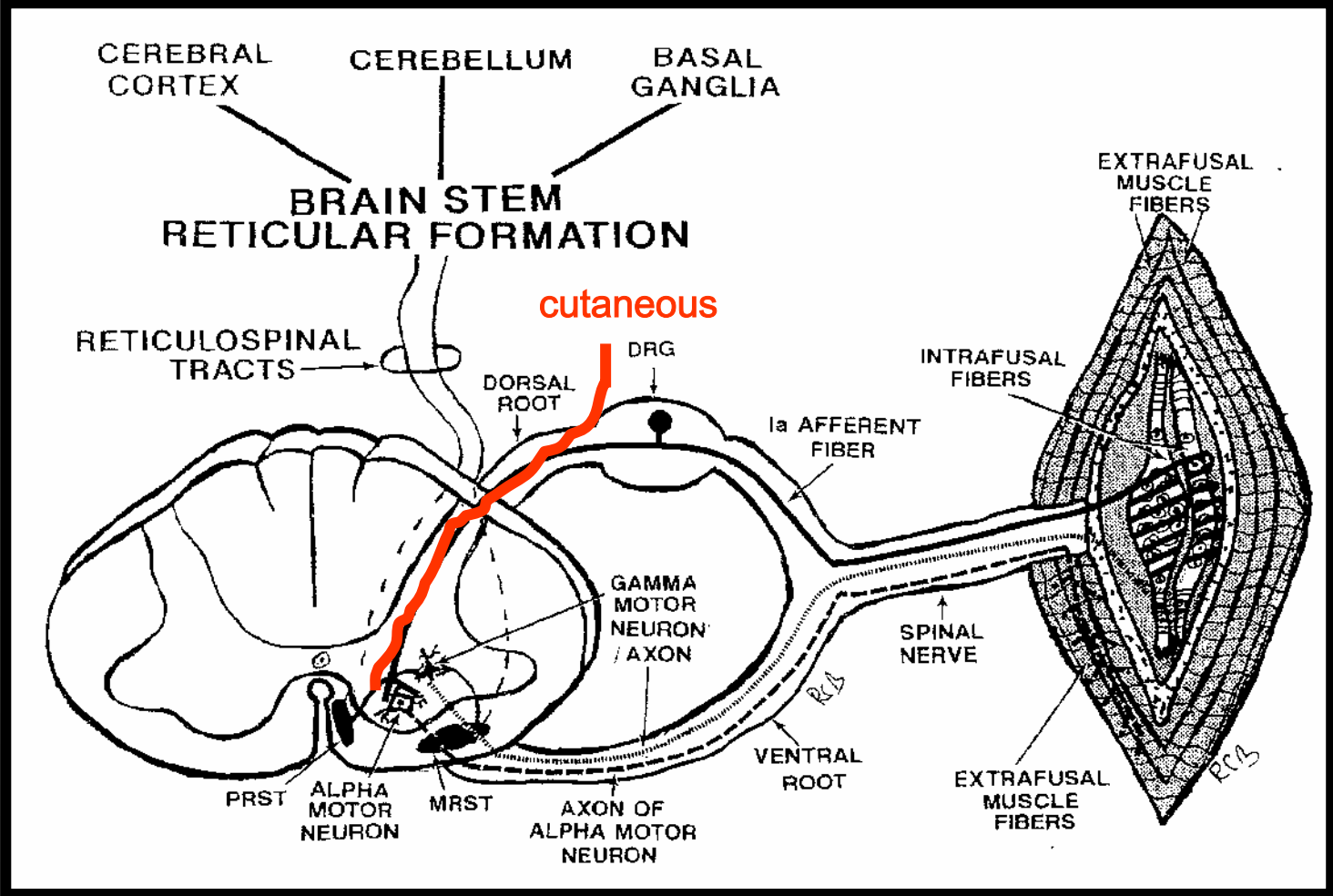
UMN/Descending Tracts Lesion

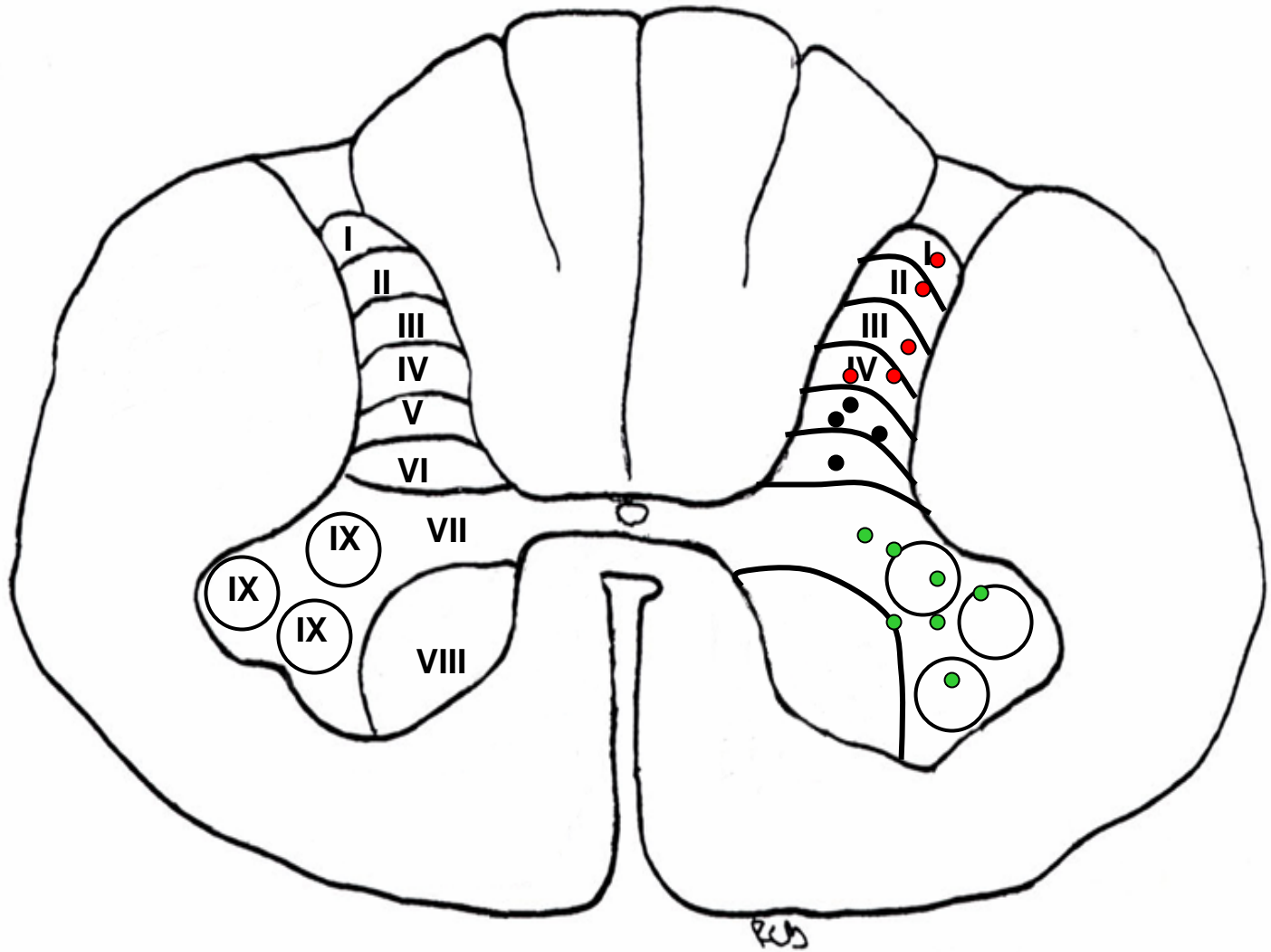
- A. does NOT denervate target muscle
- B. results in spastic paralysis
 1. resting tension of muscle is ↑ (hypertonia)
 2. hyperactive myotatic reflexes
 3. atrophy, if occurs, is a late event-from disuse of spastic muscle

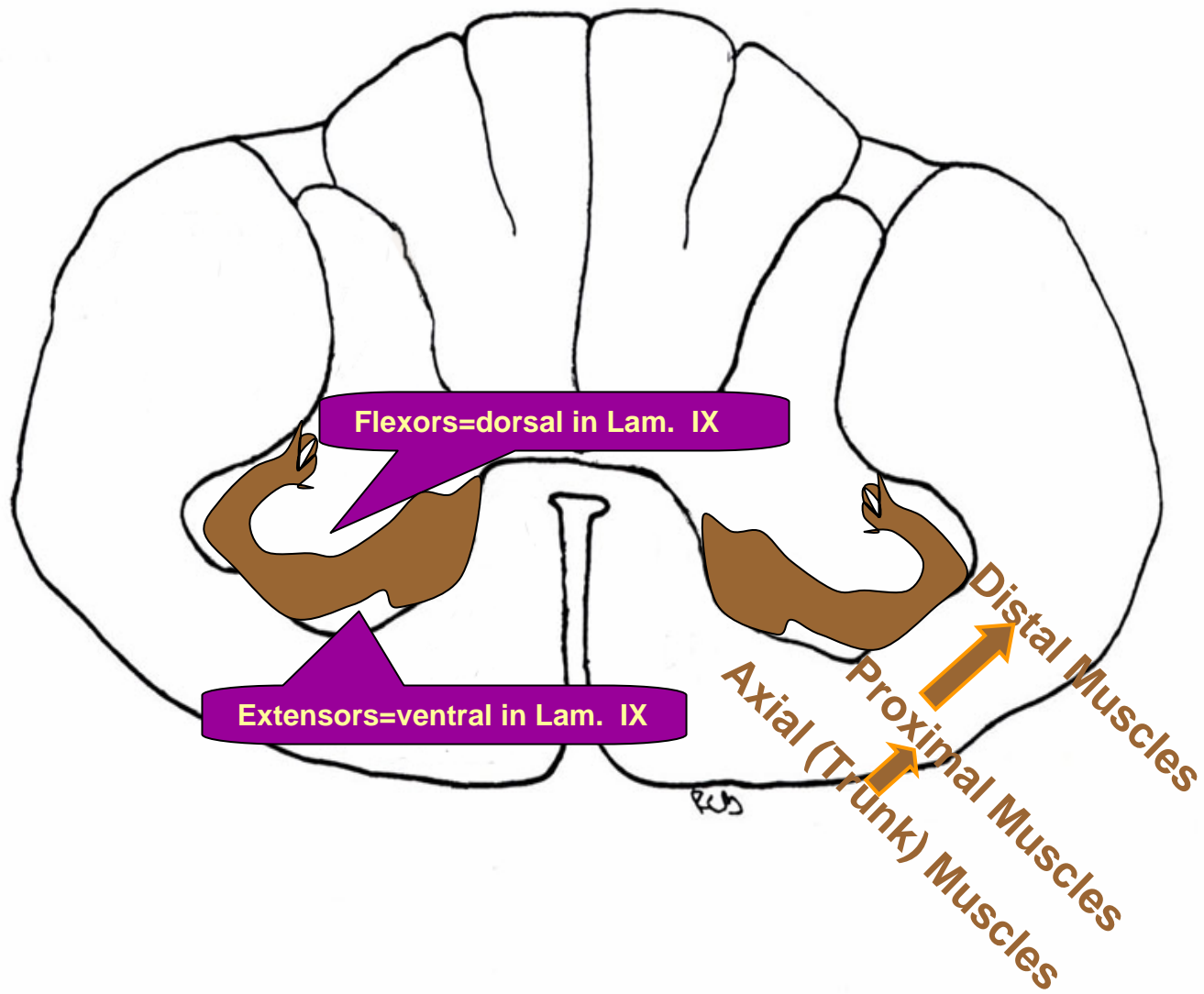
LMN/Spinal Nerve Lesion

- A. does denervate target muscle
- B. results in flaccid paralysis
 1. absent or diminished muscle tone (hypotonia)
 2. loss of myotatic reflex
 3. atrophy of denervated muscle/s









**MEDIAL
AND
LATERAL
DESCENDING SYSTEMS**

Medial Descending Tracts

Anterior Funiculus

Synapse in Lam. VII, VIII & IX (one tract)

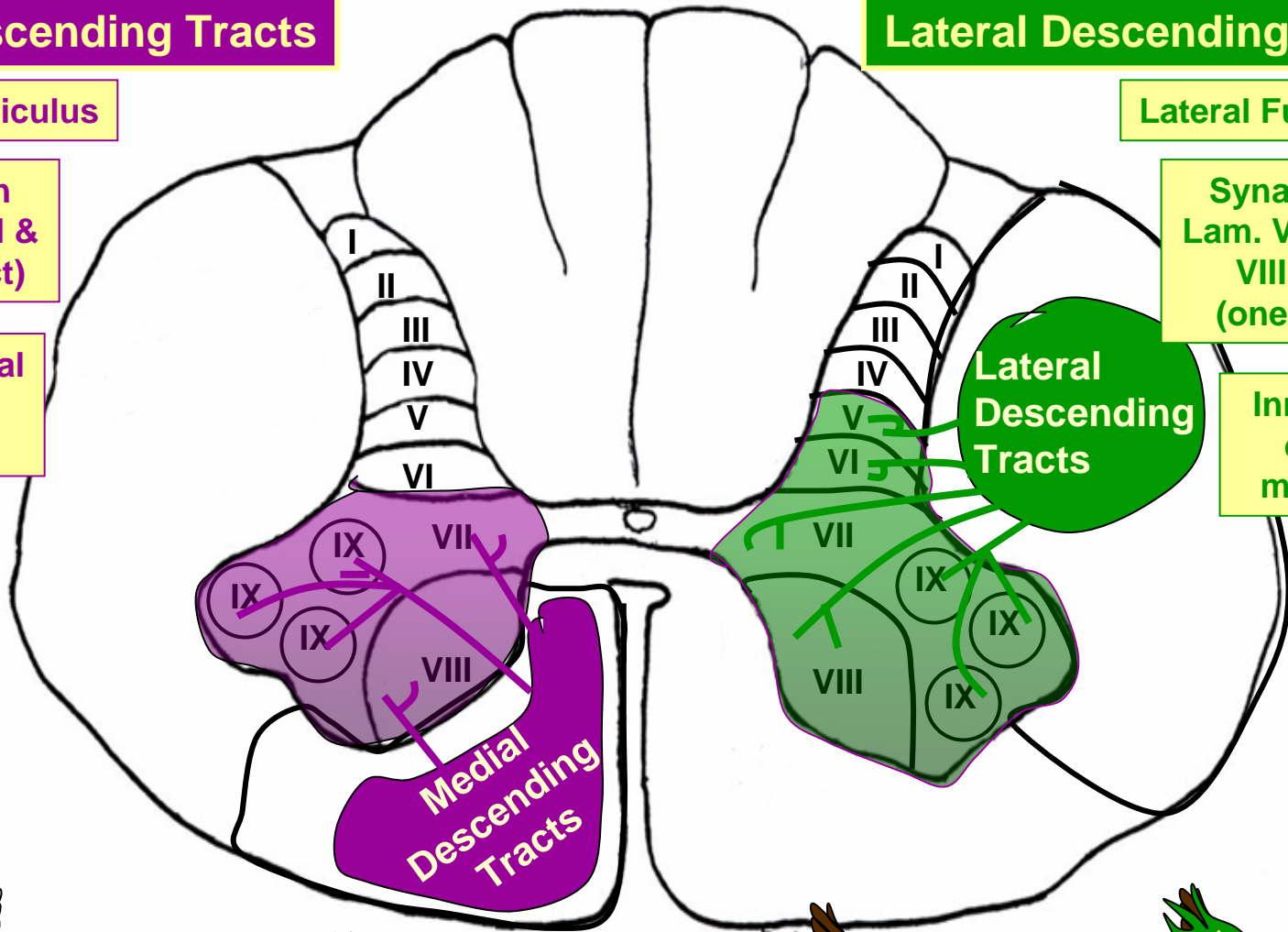
Innervate axial & proximal muscles

Lateral Descending Tracts

Lateral Funiculus

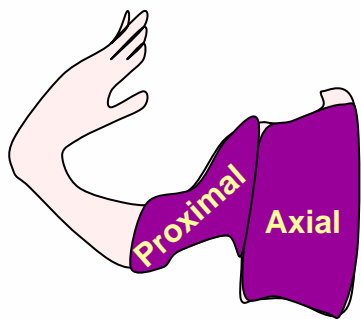
Synapse in Lam. V, VI, VII, VIII & IX (one tract)

Innervate distal muscles



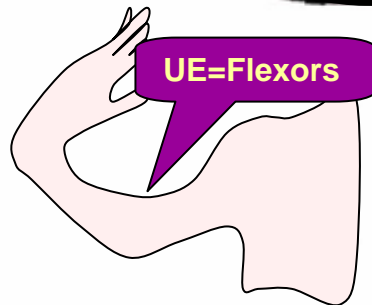
Medial Descending Tracts

Lateral Descending Tracts

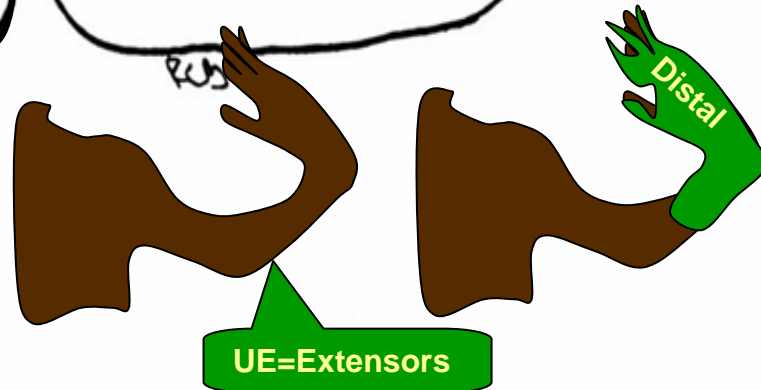


Proximal

Axial



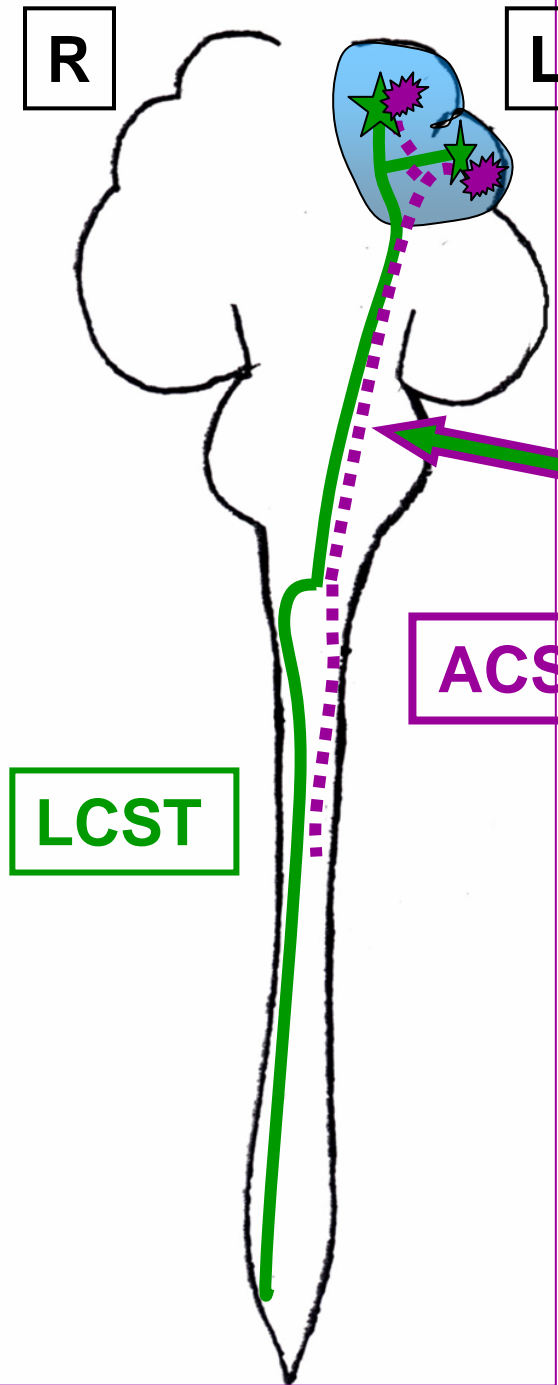
UE=Flexors



UE=Extensors

Distal

CORTICOSPINAL TRACTS

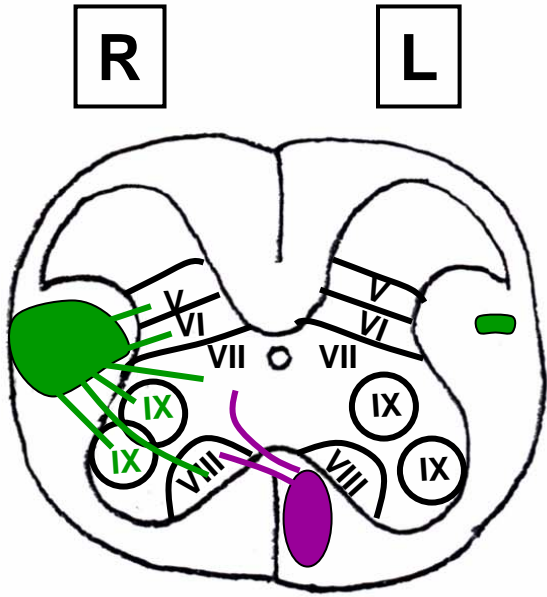


Motor & Sensory Cortex

CST

ACST

LCST



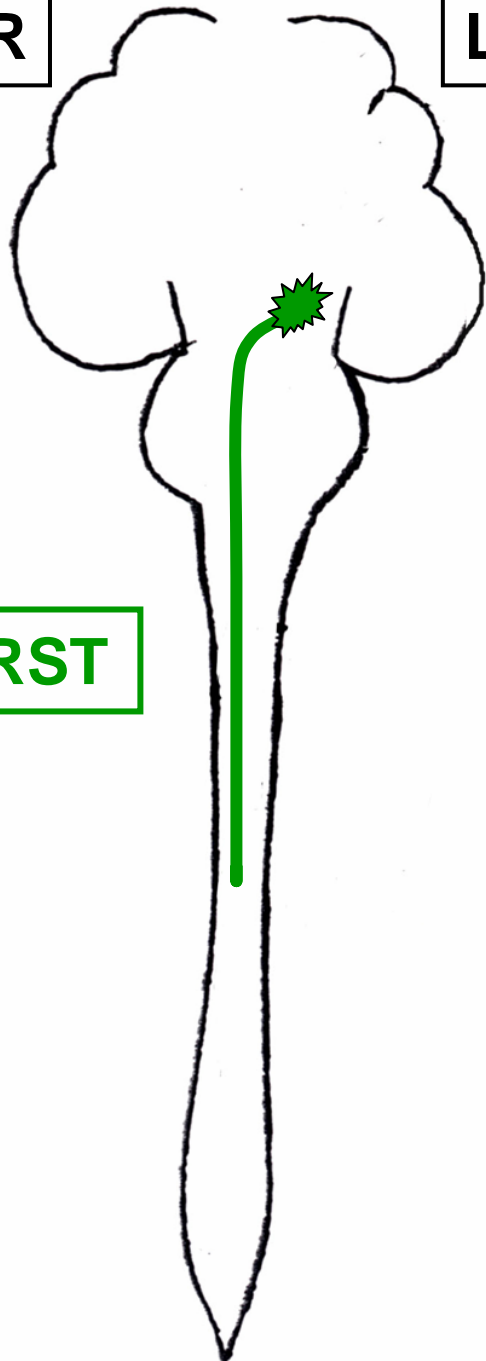
LCST

ACST

R

L

RUBROSPINAL TRACT

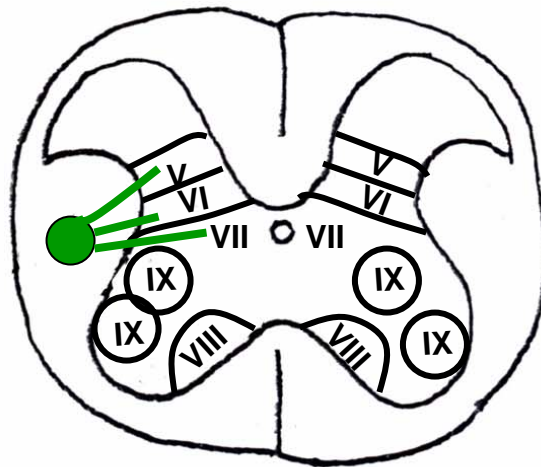


Red Nucleus-Midbrain

RST

R

L



R

L

L. VESTIBULOSPINAL TRACT

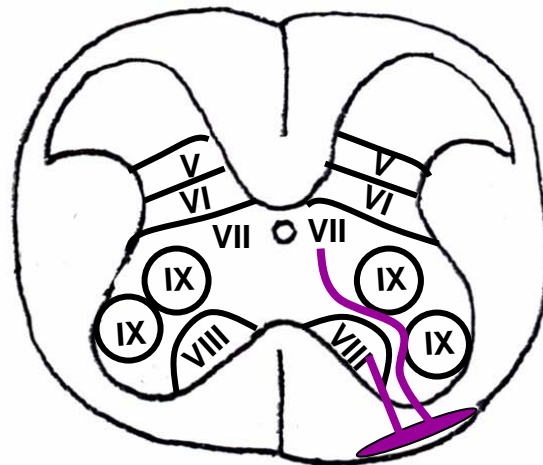
Function: facilitates extension of all 4 extremities

Lateral Vestibular Nucleus (Pons)

LVST

R

L



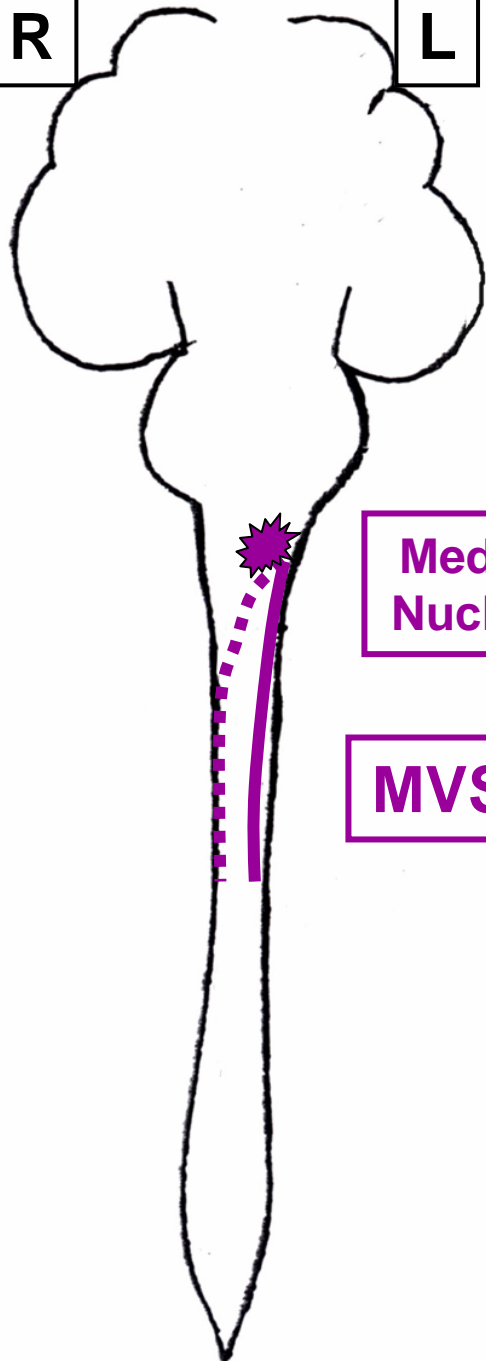
LVST

R

L

M. VESTIBULOSPINAL TRACT

Function: controls neck movements to stabilize head for eye gaze movements

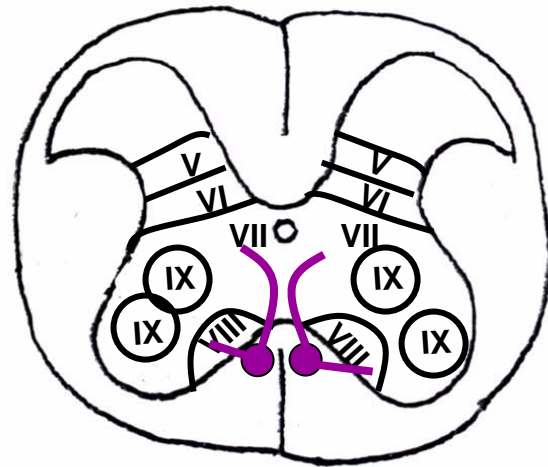


Medial Vestibular Nucleus (Medulla)

MVST

R

L



R

L

M. RETICULOSPINAL TRACT

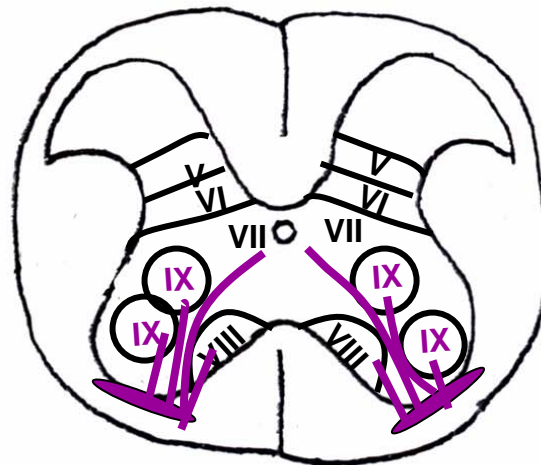
Function: controls muscle atonia during sleep

Reticular Formation (Medulla)

MRST

R

L



MRST

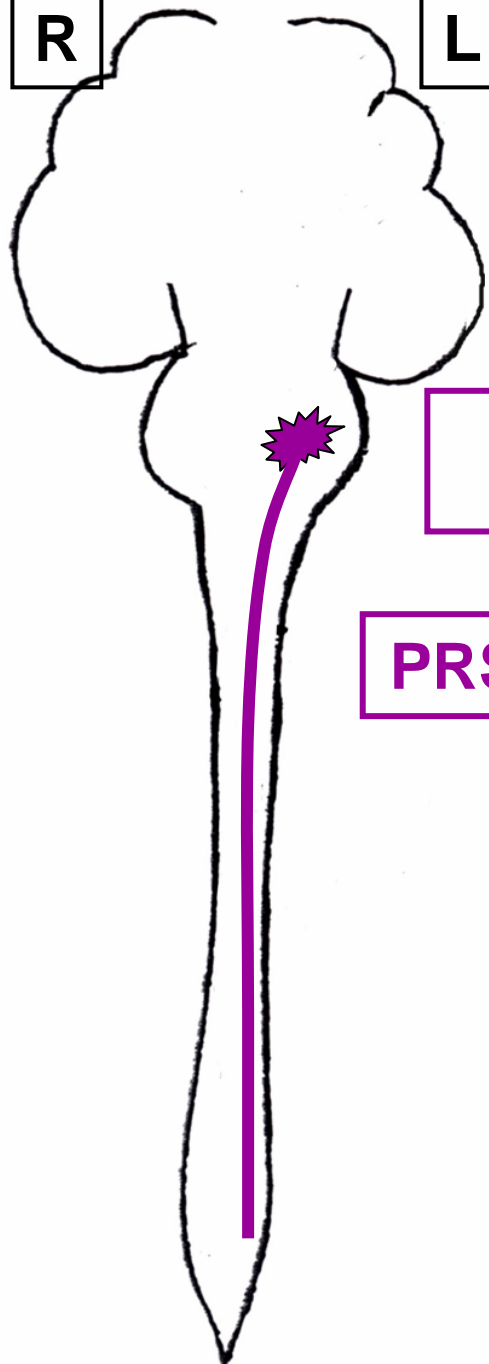
MRST

R

L

P. RETICULOSPINAL TRACT

Function: facilitates axial/proximal muscles

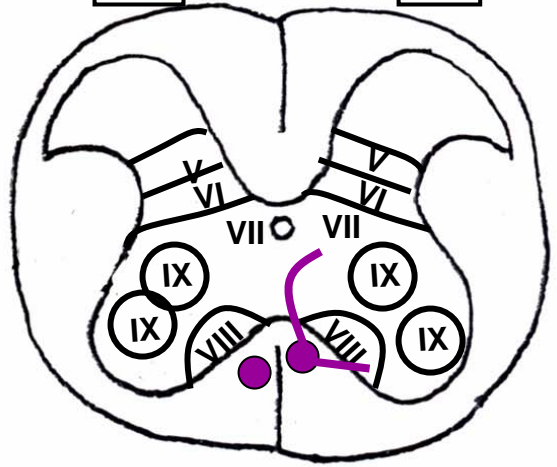


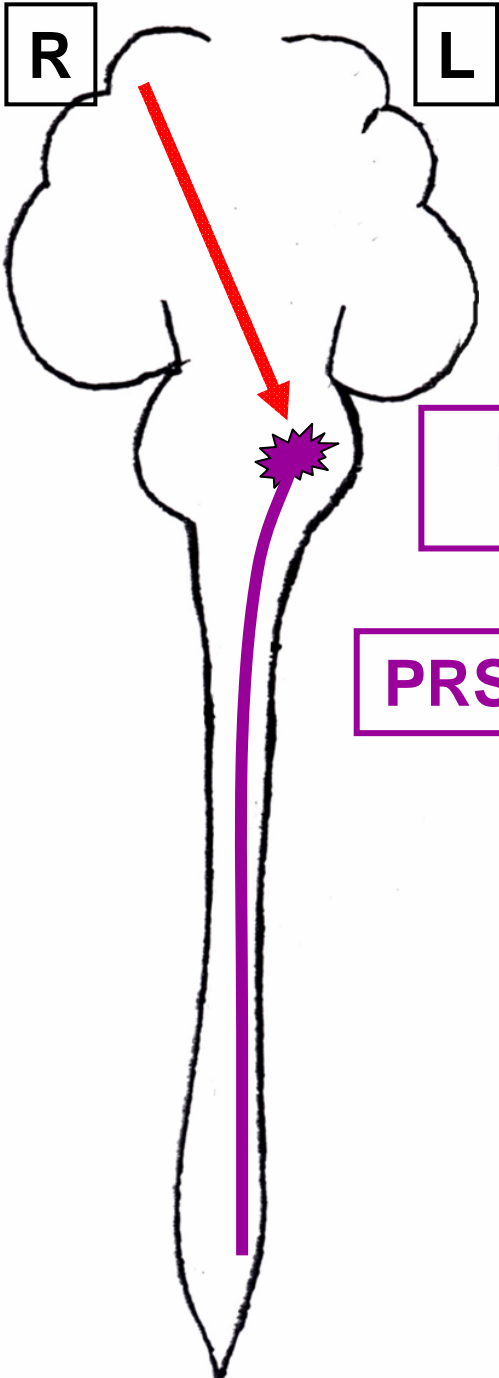
Reticular Formation (Pons)

PRST

R

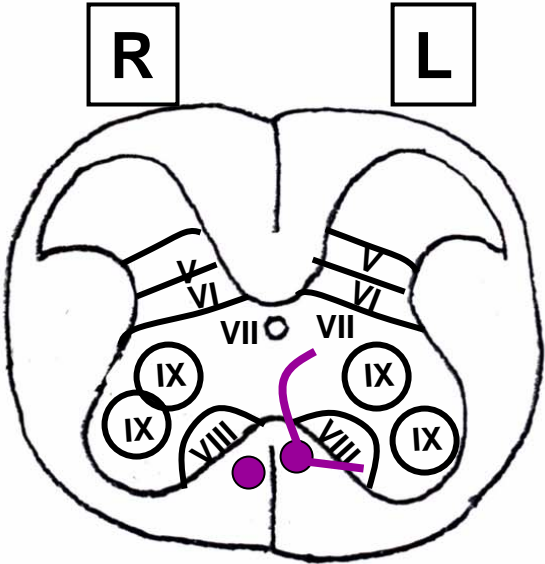
L





Reticular Formation
(Pons)

PRST



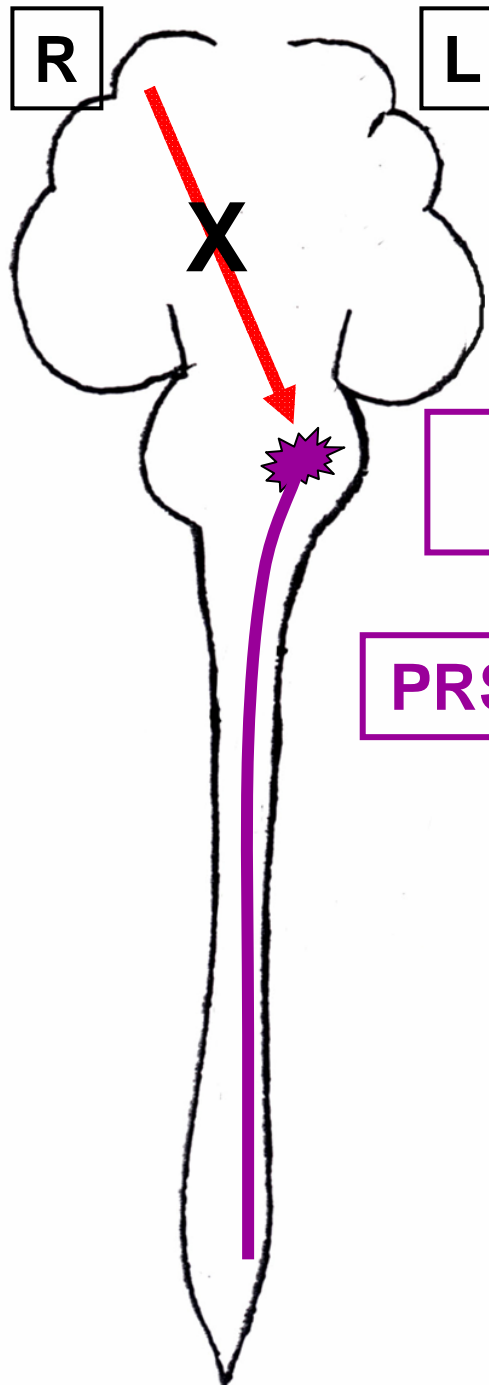
R

L

R

L

P. RETICULOSPINAL TRACT

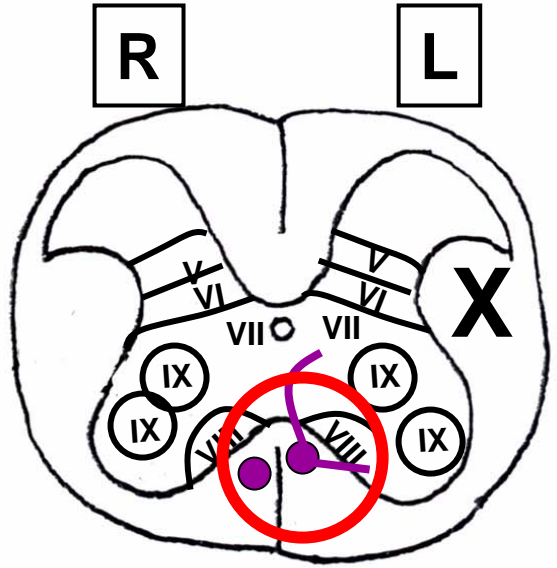


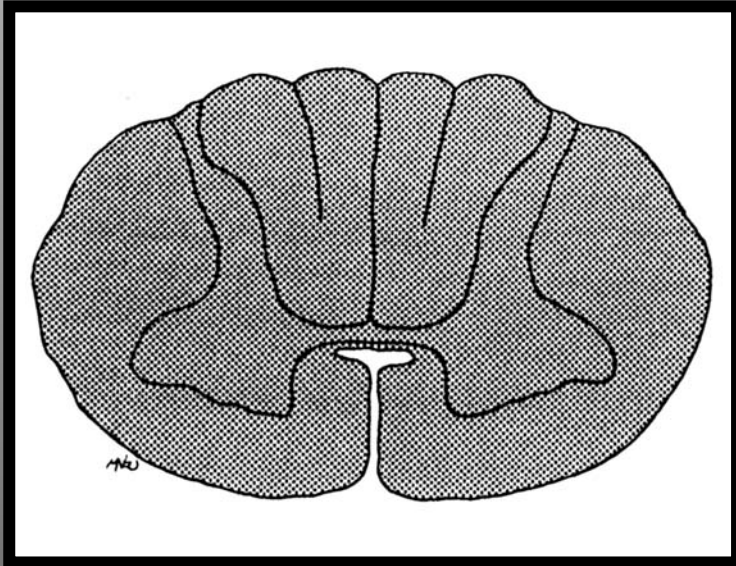
Reticular Formation
(Pons)

PRST

R

L





SPINAL CORD TRANSECTION

•**AREA DAMAGED:** Transection of the Spinal Cord

•**STRUCTURES & TRACTS INVOLVED:**

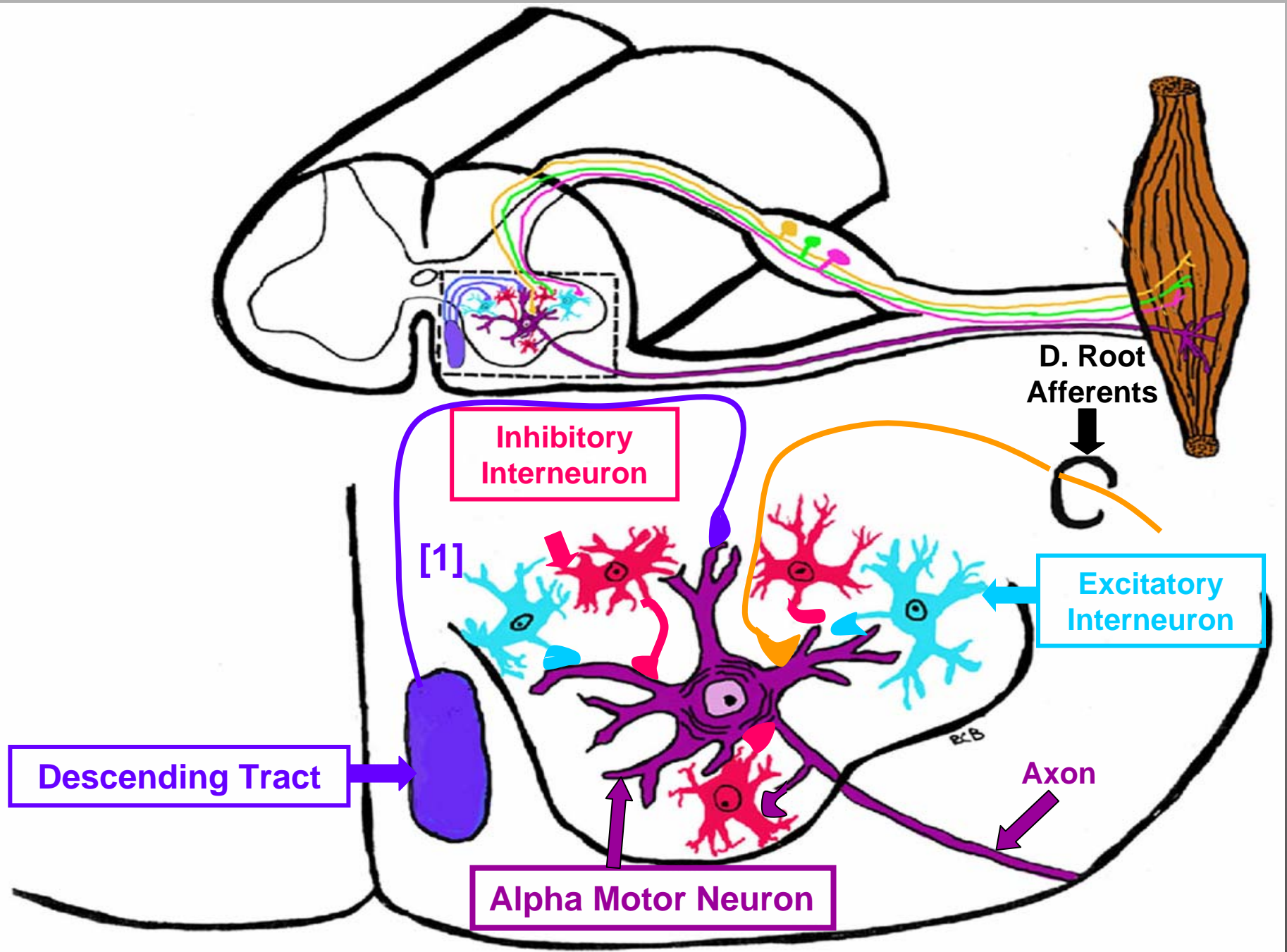
- 1) Disruption of all Spinal Cord Tracts

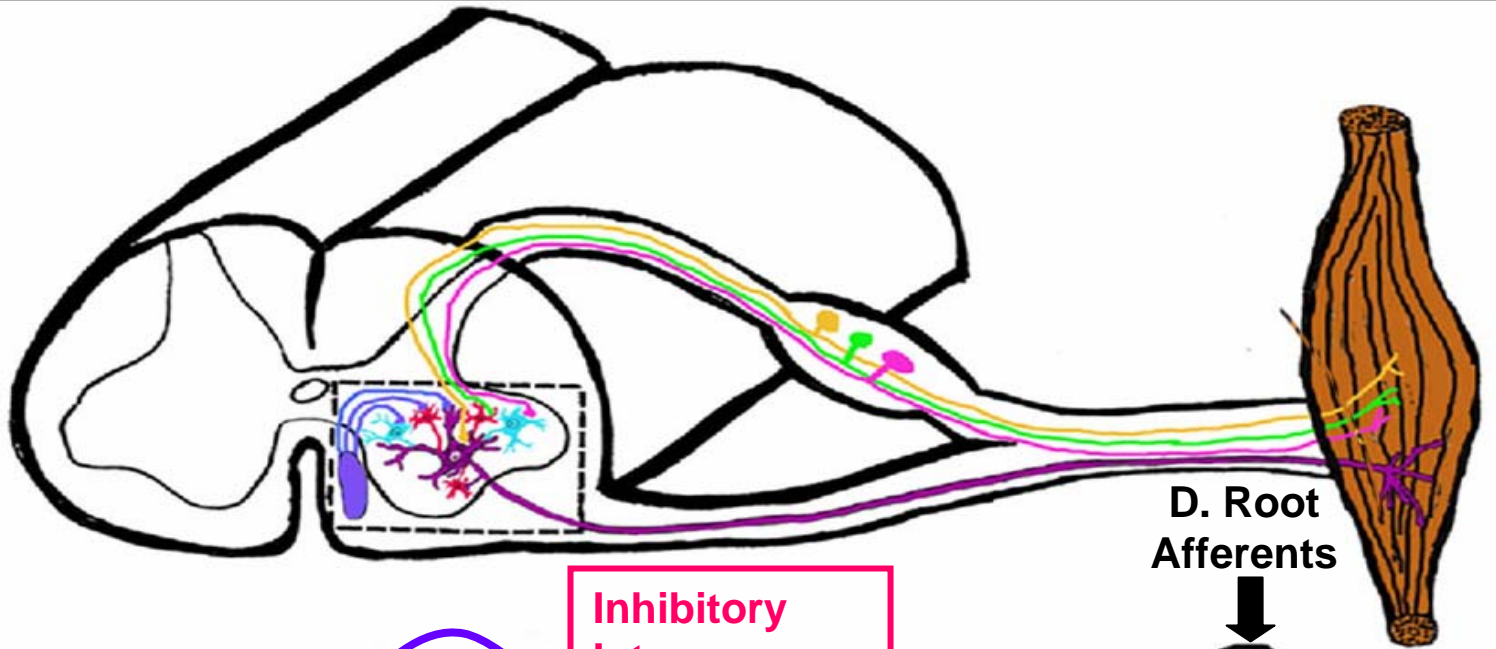
•**NEUROLOGICAL DEFICITS:**

- 1) Period of Spinal Shock (Avg = 3 wks)
- 2) Termination of Spinal Shock = Appearance of bilateral Babinski signs at ~ 3 wks
- 3) Period of Minimal Reflex Activity (3-6 wks)
 - a) muscles flaccid, no myotatic reflexes
 - b) weak flexor responses that begin distally in response to nociceptive stimuli
- 4) Flexor Spasms (6-16 wks)
 - a) Increasing tone in flexors and stronger flexor responses involving more proximal muscles in response to nociceptive stimuli
 - b) Triple Flexion Response is first seen and consists of flexion of the lower extremity at the hip, knee and ankle in response to mild nociceptive stimulus
 - c) Mass Reflex--powerful triple flexion reflex in response to non-specific stimulus
 - d) Paradoxical sweating below lesion level
- 5) Alternate Flexor & Extensor Spasms (4 mo-1 yr)
- 6) Predominant Extensor Spasms (> 1 yr)
 - a) marked extensor tone (spasticity & clasp-knife phenomenon)
 - b) clonus
 - c) bilateral Babinski signs
 - d) loss of sensation below the lesion level
 - e) increased myotatic reflexes
 - f) bowel, bladder and sexual function disturbances
 - g) reflex spinal sweating

Changes at the level of the spinal cord:

- Alpha motor neurons appear to be the most involved.
- Decrease in the amount of presynaptic inhibition of 1a afferents.
- Post activation depression of 1a afferents is decreased.
- Reciprocal 1a inhibition is reduced.
- Control of inhibitory interneurons impaired.
- Intraspinal sprouting.





D. Root Afferents

C

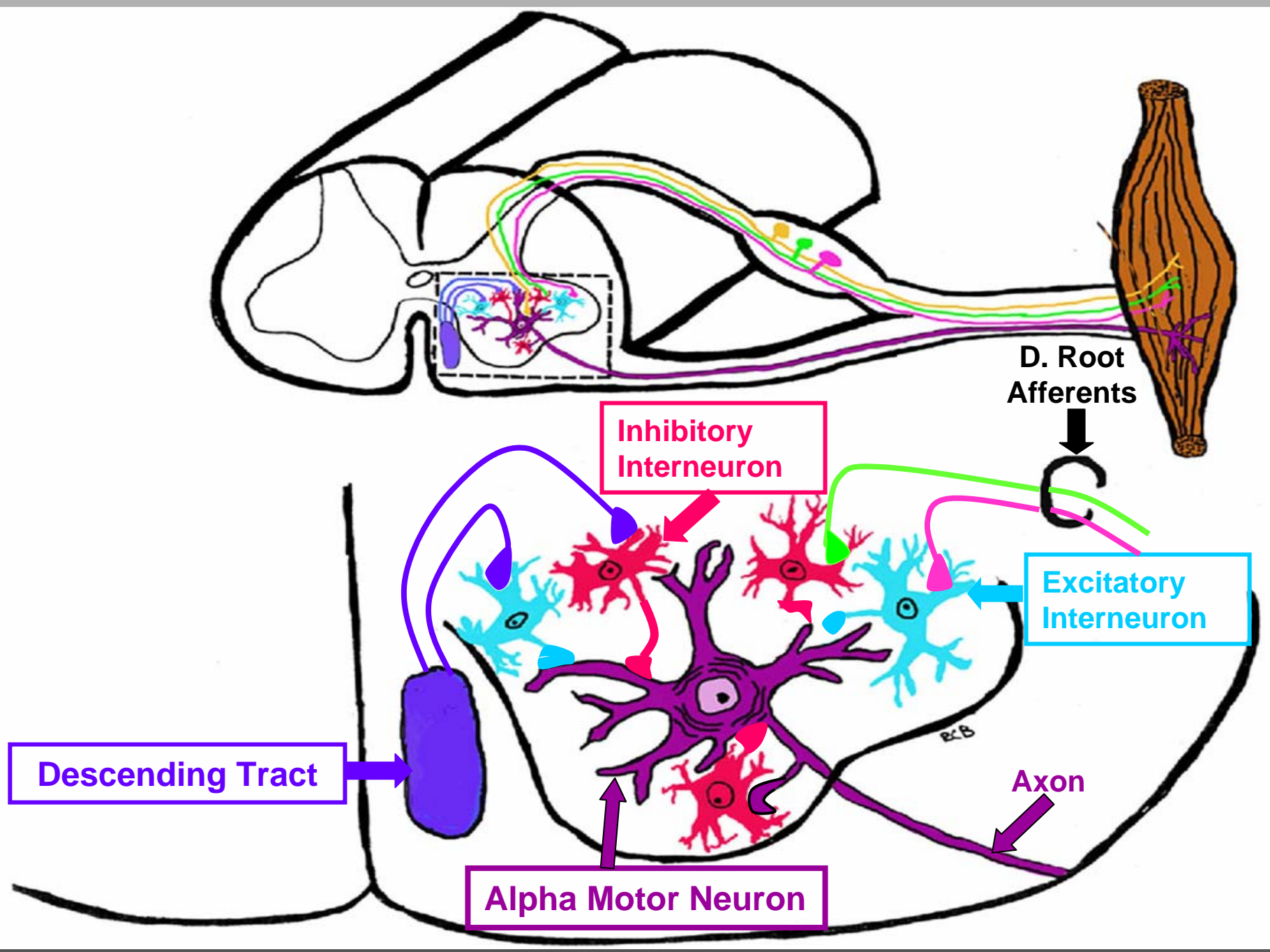
Inhibitory Interneuron

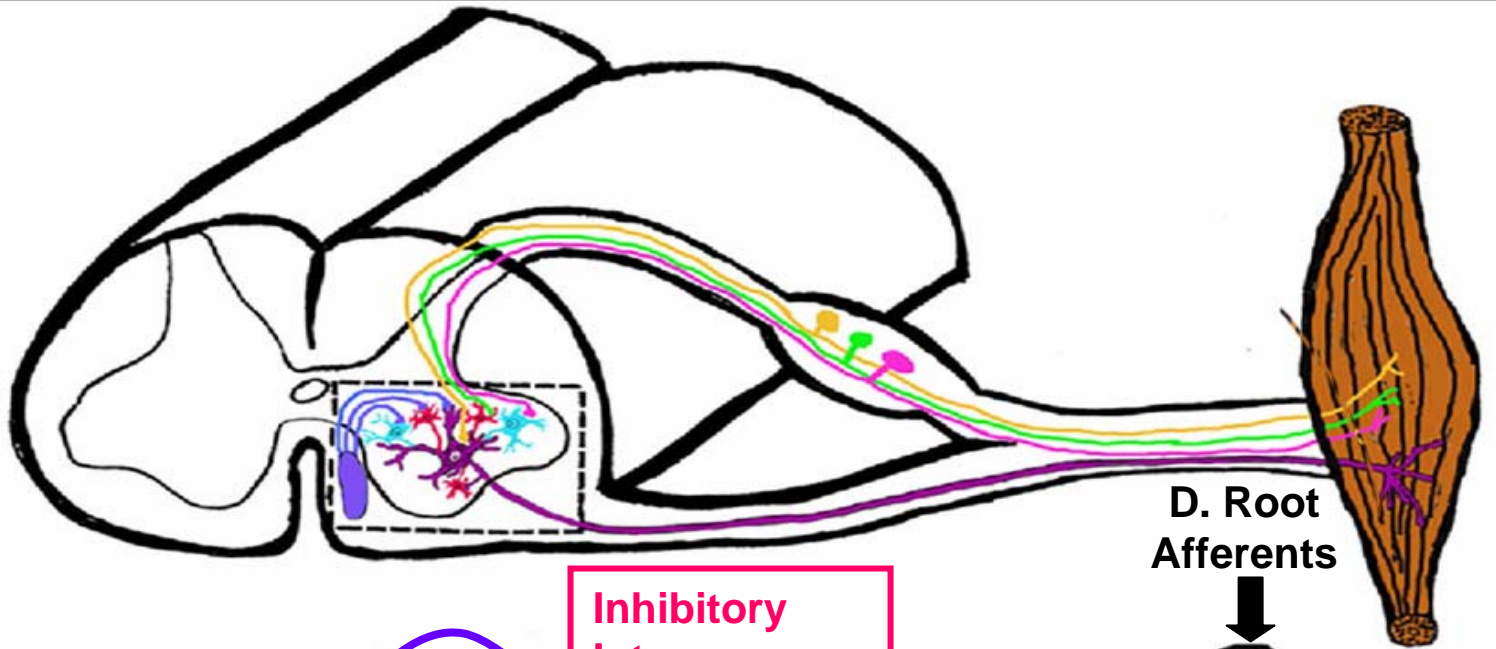
Excitatory Interneuron

Descending Tract

Alpha Motor Neuron

Axon





D. Root
Afferents

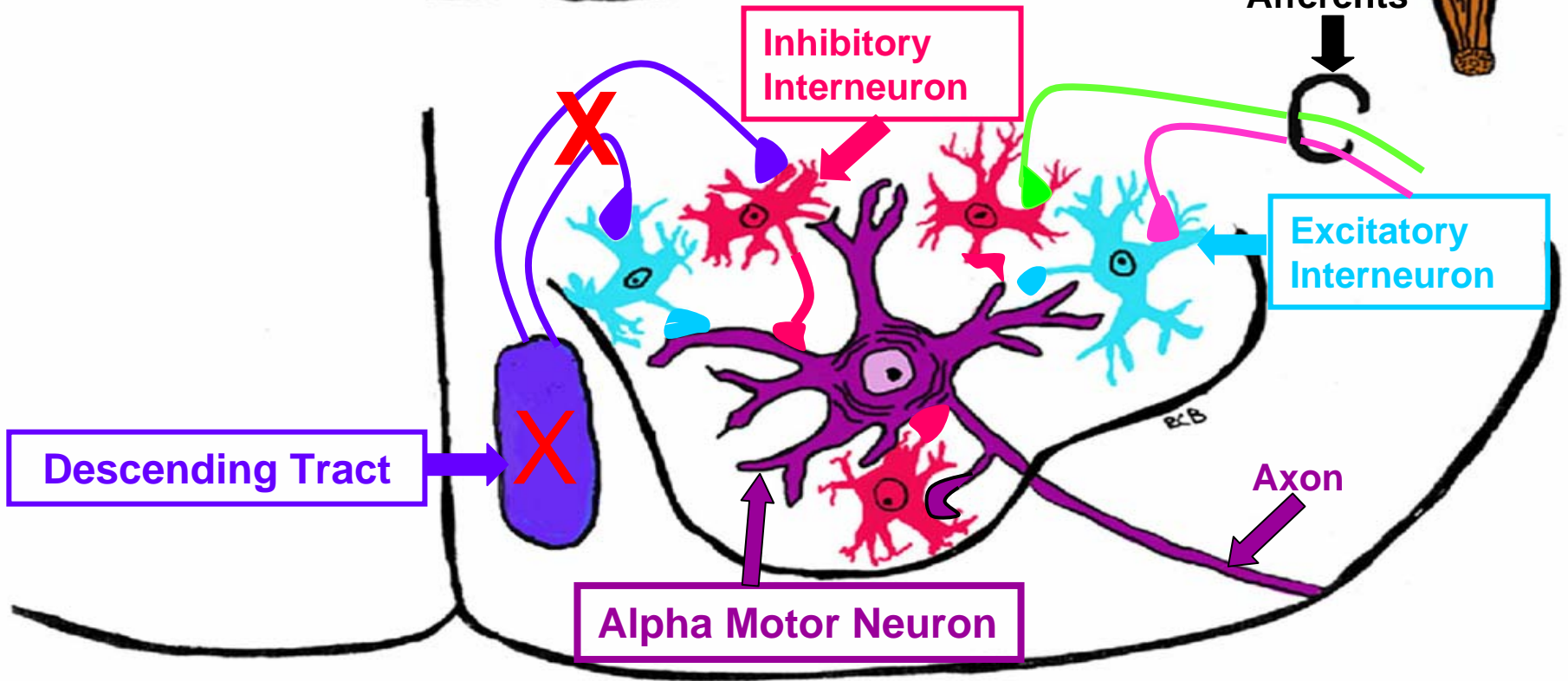
Inhibitory
Interneuron

Excitatory
Interneuron

Descending Tract

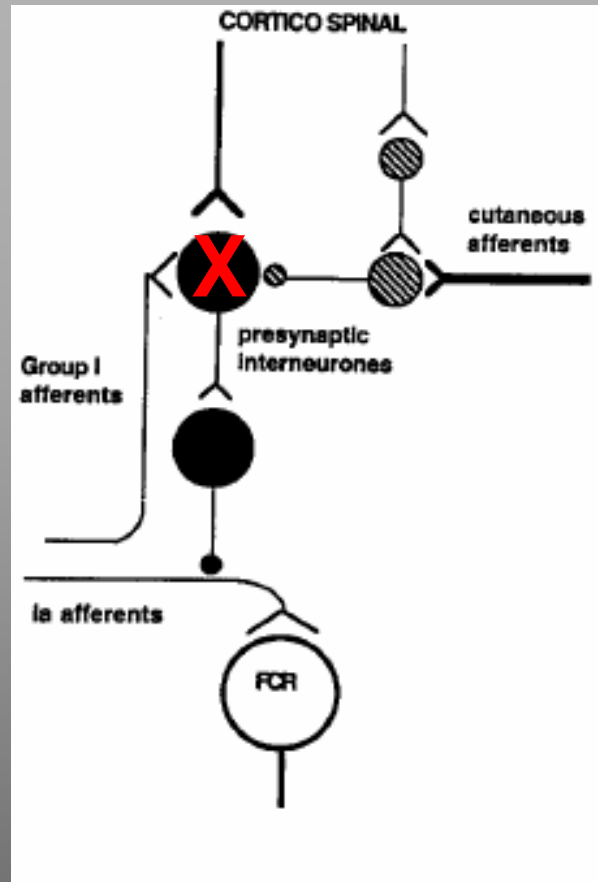
Alpha Motor Neuron

Axon



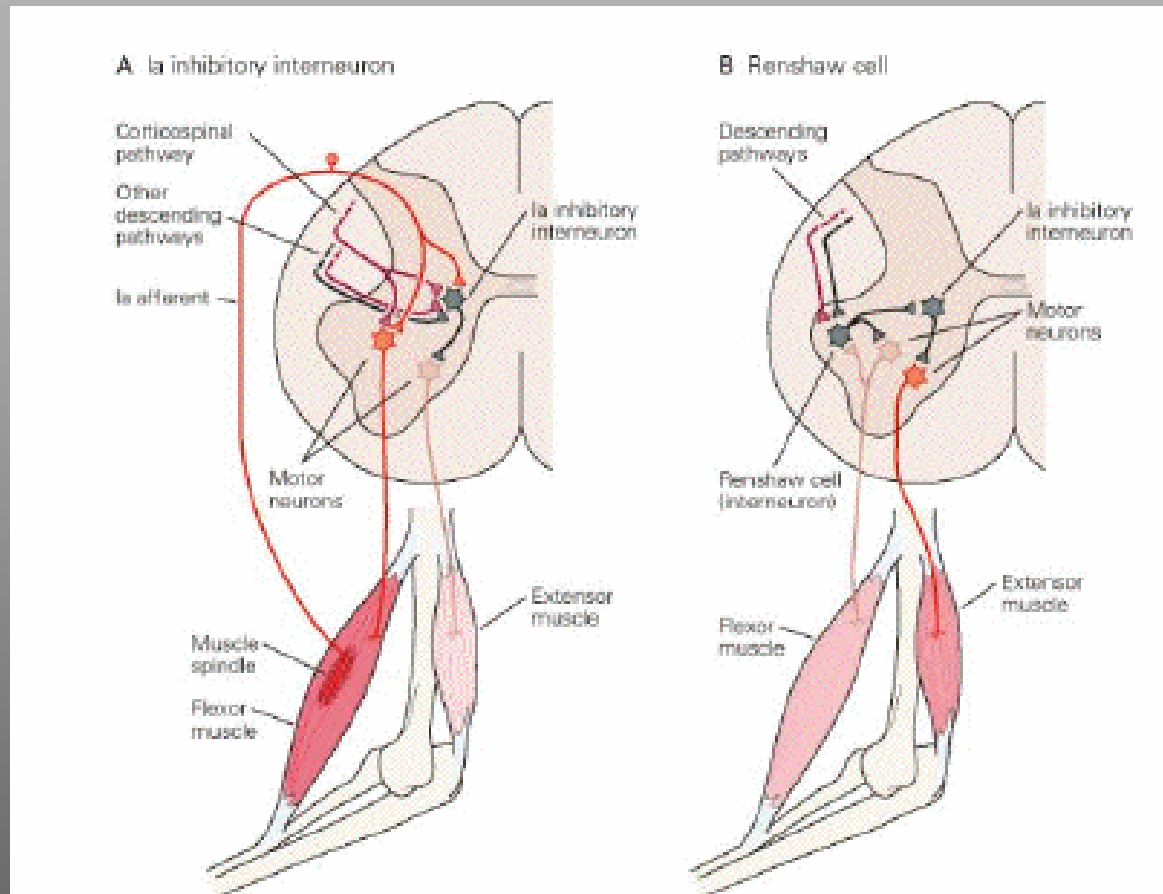
Changes at the level of the spinal cord:

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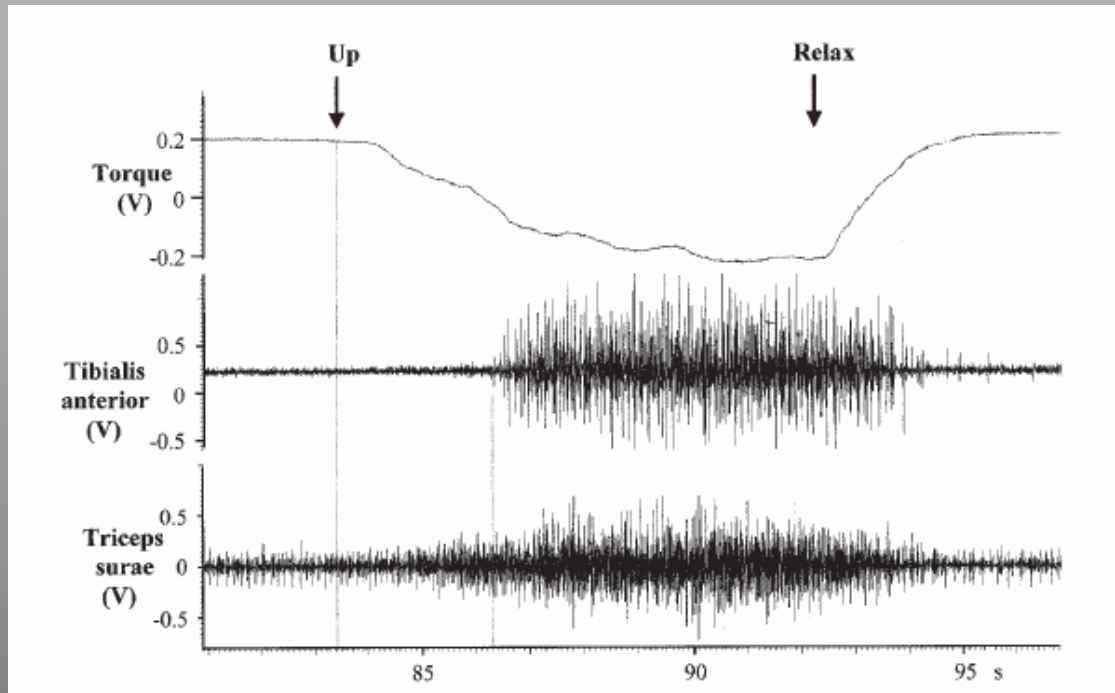


Katz, 1999

Decrease in the amount of presynaptic inhibition of 1a afferents.
Lack of this inhibition can contribute to increased stretch reflexes.

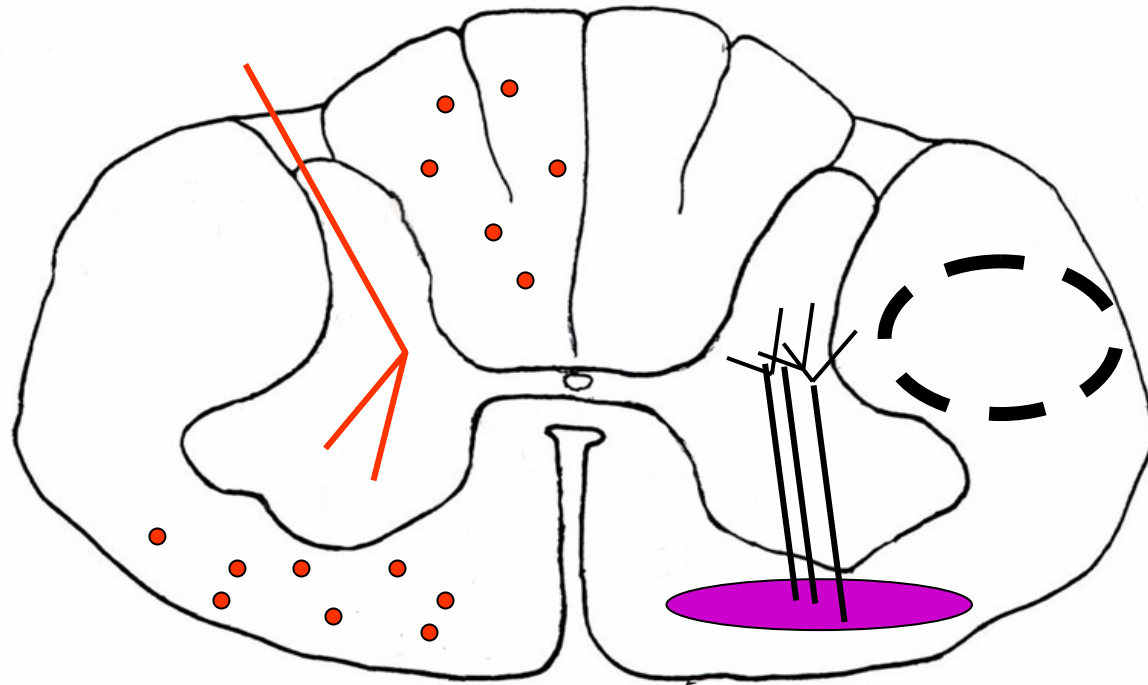


Reciprocal Ia inhibition is reduced



Gracies, 2005

Reciprocal 1a inhibition is reduced.



Lesion at Spinal Cord

Lesion above
Spinal Cord

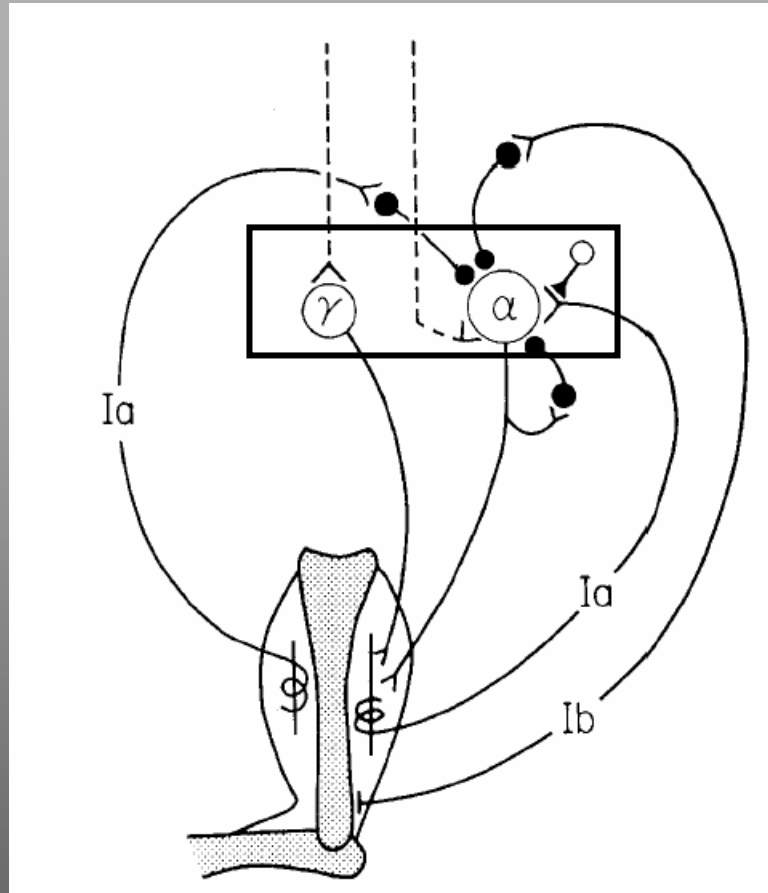
Intraspinal sprouting.



Lack of corticospinal control
Abnormal descending influence
Abnormal afferent influence
Changes in inhibitory circuitry

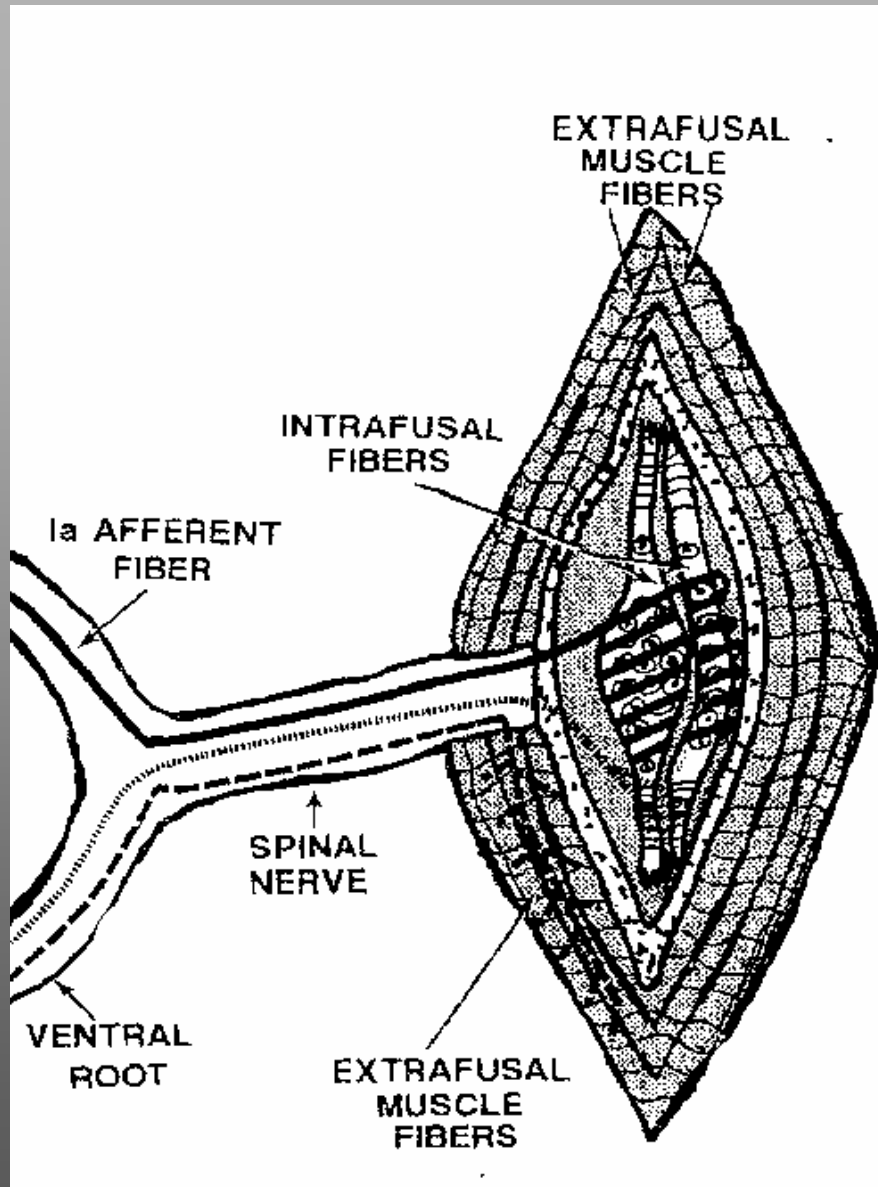
- Lack of corticospinal control
- Abnormal descending influence
- Abnormal afferent influence
- Changes in inhibitory circuitry

The End!



Reciprocal 1a inhibition is reduced

Muscle Spindles



Muscle spindles consist of intrafusal fibers & specialized sensory and motor nerve fibers. These specialized fibers are anchored to the extrafusal muscle fibers and are stretched when the muscle is stretched. Responsible for the myotatic reflex.

Types of intrafusal fibers:

Nuclear bag – responds to velocity & changes in muscle length (dynamic).

Nuclear chain – responds to changes in muscle length (static).

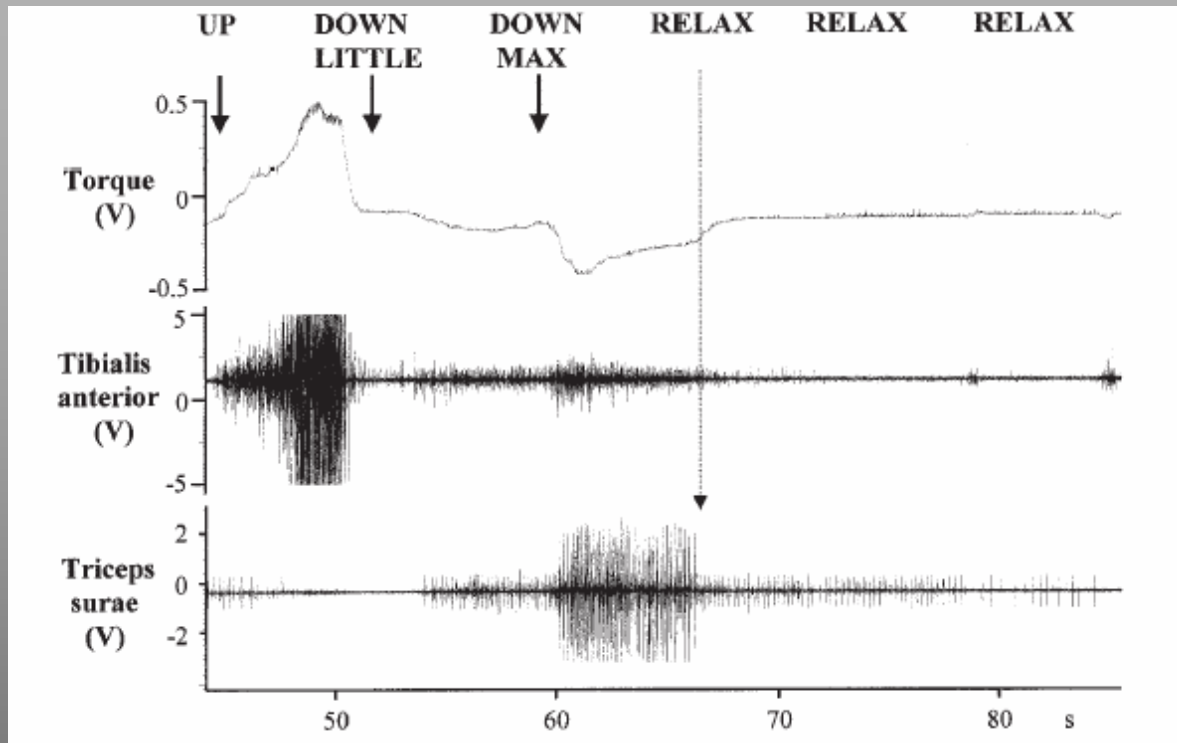
Nerve supply:

Sensory – Group 1a -Bag & Chain (dynamic).

Group II – Bag & Chain – static

Motor – Gamma motor neurons – innervate ends of intrafusal fibers.

DIFFERENCES	MEDIAL DESCENDING SYSTEM	LATERAL DESCENDING SYSTEM
FUNICULUS	ANTERIOR FUNICULUS	LATERAL FUNICULUS
TARGET CELLS	MEDIAL VII-IX	LATERAL V-IX
PATTERN OF INTERNEURON PROJECTIONS	LONG AXONS	SHORT AXONS
	MANY SC SEG.	FEW SC SEG.
	MUSC. GROUPS	INDIV. MUSC.
MUSCLES INNERVATED	AXIAL & PROXIMAL	DISTAL LIMB MUSCLES
MUSCLE ACTION	FL.=UE;EXT.=LE	EXT.=UE;FL.=LE
FUNCTIONS	POSTURE	SKILLED MOVE.



Gracies, 2005

Post activation repression of 1a afferents is decreased.