4- Spinal Cord Reflexes

BY

Dr. Nour A. Mohammed

Associate professor of physiology

Faculty Of Medicine , Mutah University

2024-2025

Classification of human reflexes

- **A. Peripheral reflexes**

Center outside CNS

Most of these reflexes are found in the GIT

1) Local **enteric** reflex: **e.g.** peristalsis and gastrin release.

2) Local **ganglionic** reflex: **e.g.** gastro-colic reflex.

3) Local **axon** reflex: (anti-dromic response) **e.g.** primary hyperalgesia

B. Central reflexes: Center inside CNS

They are further subdivided into:

Conditioned or Cortical reflexes	Unconditioned or Inborn reflexes
They are so called because they need: 1. Previous education or training (learning). 2. Intact cerebral Cortex (Consciousness). 3. Specific stimulus must be present.	They are so called because: 1. Need no education. 2. Center is subcortical. 3. Present since birth (fixed stimulus).
They are not essential for life Needed for Civilization.	They are essential for life. Have vital & protective functions.

Inborn reflexes are classified according to the site of CENTER into:

1) Spinal reflexes: their centers lie in the spinal cord.

2) Brain stem reflexes: their centers lie in the brain stem.

As vomiting & Cardiovascular reflexes (centers in medulla) visual reflexes (center in midbrain) .

3) Hypothalamic reflexes: their centers lie in the hypothalamus.

As VC on exposure to cold.

- ***Spinal reflexes***

- They are **central unconditioned** spinal reflexes.

- Divided into 3 main groups according to site of **RECEPTORS**:

1) **Superficial (Cutaneous) reflexes :** receptors lie in the skin.

2) **Deep reflexes:** receptors lie in the deep structures as muscles.

3) **Visceral reflexes:** receptors lie in the viscera.

The most important superficial reflexes:

- **1. Planter reflex**

Stimulus	Scratch in lateral side of planter aspect of foot by blunt object.
Response	Reflex **planter** flexion of the big toe and other toes.
Center	S1 or S1&2.
Importance	Normal response means intact pyramidal & extrapyramidal tracts.
Abnormal response	It is called "**Babiniski's sign**": a) Dorsiflexion of the big toe (indicates pyramidal lesion). b) Fanning in other toes (indicates extra pyramidal lesion).

Causes of Babiniski sign

A. Pathological:

1) Chronic stage of UMNL 2) Coma

B. Physiological:

1) Newborn (unmyelinated pyramidal tracts)
2) Deep sleep & anesthesia

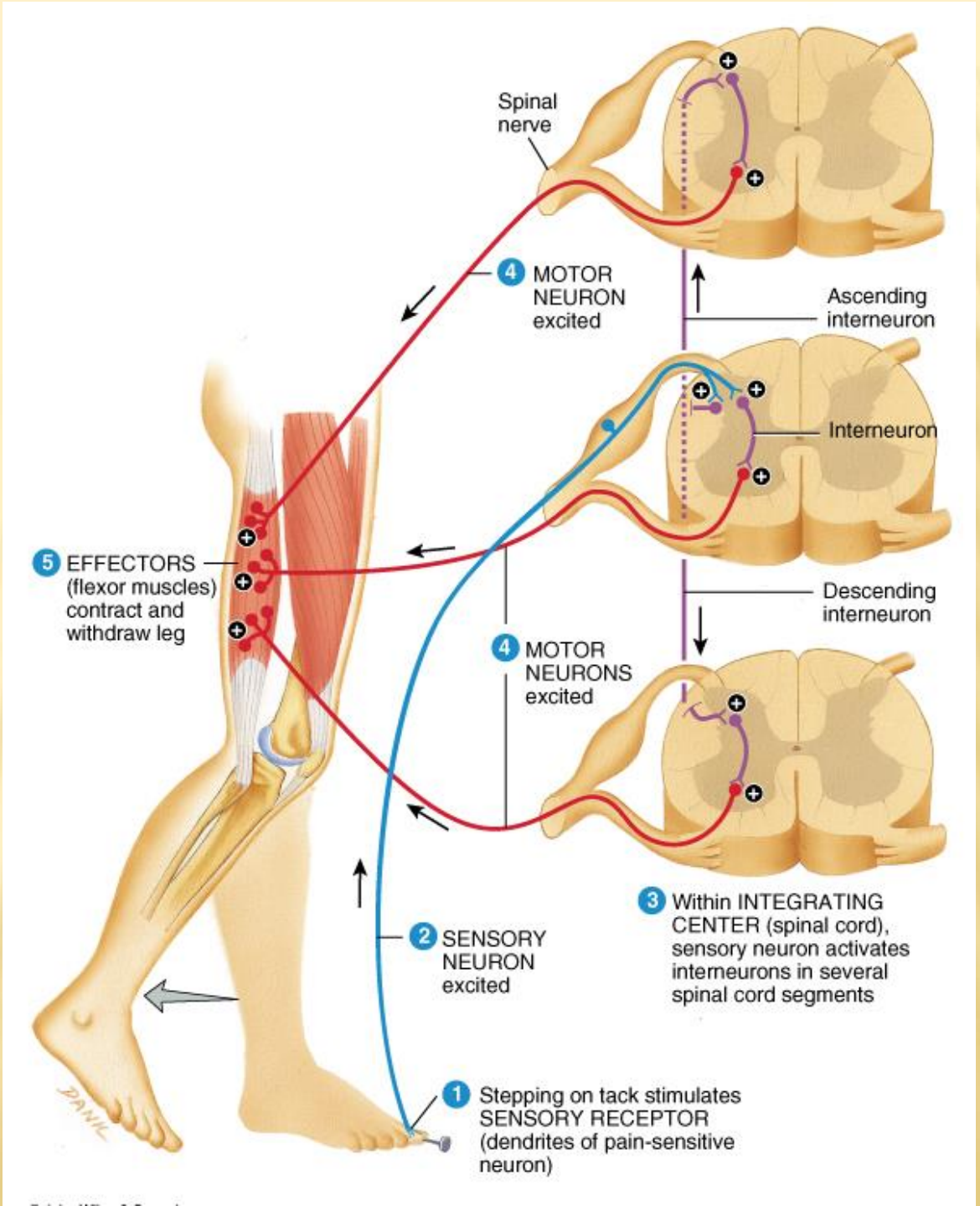
N.B. Absent planter reflex: in tabes dorsalis & LMNL affecting its reflex arc & shock stage of UMNL

- **2. Abdominal reflex:**

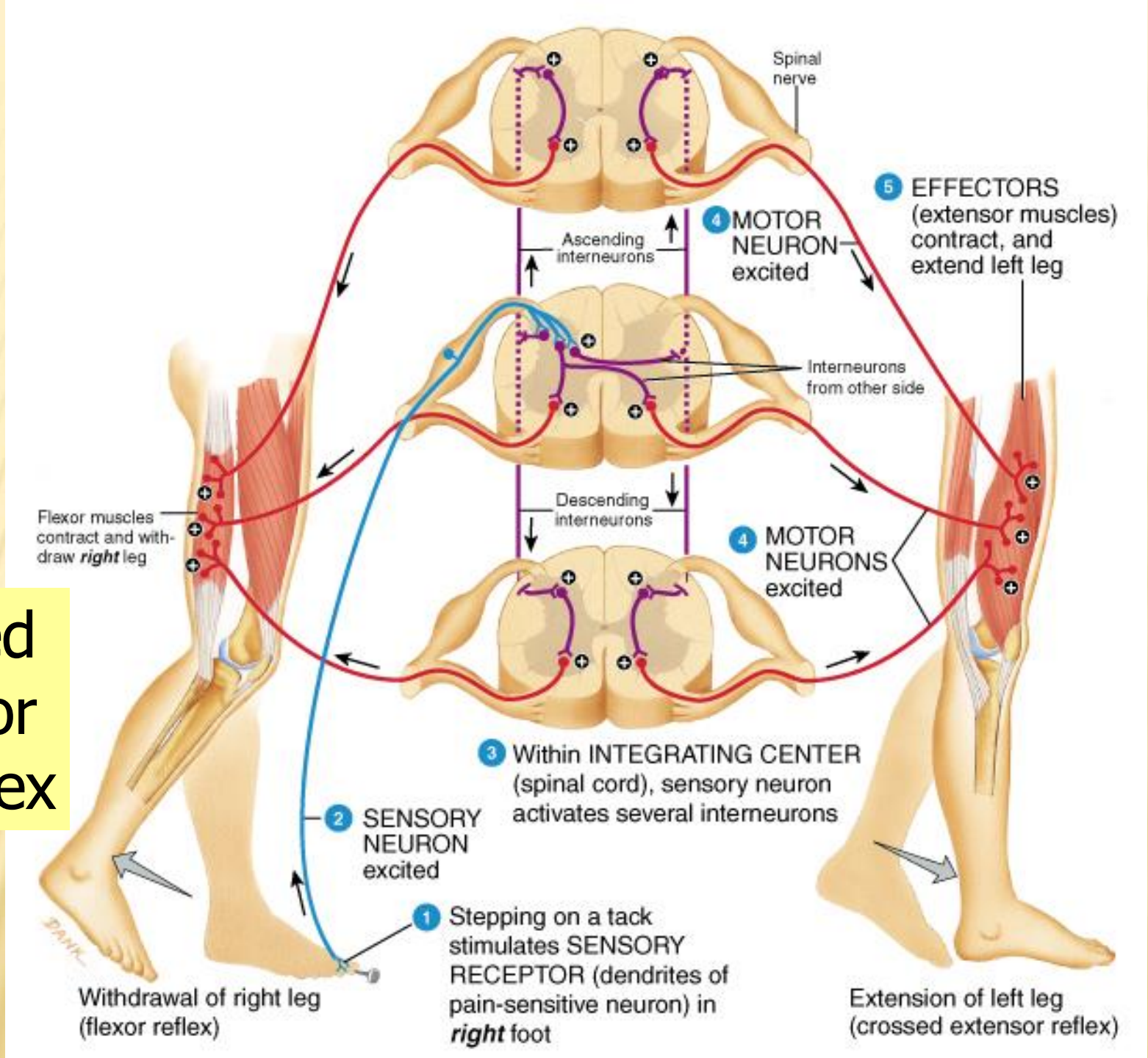
Stimulus	**Touching** abdominal **skin from outside toward umbilicus.**
Response	Reflex contraction of **abdominal** muscles ⇨ shift of umbilicus.
Center	- Upper abdomen (T7 – T10). - At umbilicus (T10). - Lower abdomen (T10 – T12)
Importance	a) To examine thoracic segment of spinal cord. b) May mask examination of abdominal organ.

3. Withdrawal reflex	**Injurious stimulus to the skin.** ⇨ **Reflex muscle contraction to withdraw body from harmful stimulus.**
4. Crossed Extensor Reflex	Very strong injurious stimulus at sole of the foot. ⇨ Withdrawal reflex in the stimulated limb & extension of other limb. Due to irradiation of impulse.
5. Positive Supporting Reflex L1:S1	**Equal** pressure on the sole of the foot by body weight. ⇨ Reflex contraction of both flexors and extensors of lower limb. Not obey reciprocal innervations.
6. Cremasteric Reflex (L1&2)	Scratch in medial side of the thigh. ⇨ Reflex contraction of cremasteric muscle & elevation of the testis.
7. Anal Reflex (S3 &4)	Scratch around anus. ⇨ Reflex contraction of external anal sphincter.

Flexor (Withdrawal) Reflex



Crossed Extensor Reflex



The most important deep reflexes

1) Stretch reflex.

2) Stepping reflexes: (by 1 or 2 or 4 limbs)

a) Direct: each flexion stimulates the following extension (in 1 limb) -ve successive spinal induction.

b) Indirect: flexion of limb → extension of other limb (in 2 limbs).

c) Diagonal: flexion of fore-limb with contra-lateral hind-limb.

The most important visceral reflexes

1) Micturition **2)** Defecation

3) Erection **4)** Autonomic reflexes (VC & sweating)

Stretch reflex and skeletal muscle tone

Definition of stretch reflex

Stretch of skeletal muscle leads to reflex contraction.

- It is **central, unconditioned, spinal, deep reflex**
- It is the only **monosynaptic** reflex in humans

Pathway of stretch reflex (reflex arc)

1. The receptor (Muscle Spindle)

- It is capsulated **M**echanoreceptors. **Very Slowly** adapting receptors
- Present between the muscle fibers & parallel to them
- Spindle in shape and contains **3-10** intra-fusal fibers
  - The central part of intra-fusal fibers is called **sensory area**
  - The ends of intra-fusal fibers are **contractile**
- There are **two types** of intra-fusal fibers in the muscle spindle

Nuclear Bag fibers (NB)	Nuclear Chain fibers (NC)
Thick & 2 – 3/spindle & **S**tretched.	Thin & 4 – 6/spindle & Lax.
Nuclei form a central bag.	Nuclei form a **C**hain.
Stimulated maximal by: **S**udden stretch.	Stimulated maximal by: **C**ontinuous stretch.
Main receptors for **tendon jerk**.	Main receptors for **muscle tone**.

2. Afferent innervations from muscle spindle

Annulo spiral or Type-Ia (1ry)	Flower spray or Type-II (2ry)
Rapid myelinated. Aα, 16 µ in diameter 100 meter/second	Slower. Aβ, 8 µ , 40 meter/second.
Arise from: Central part of **both** NB & NC.	Arise from: Peripheral part of NC **only**.
Main afferent for **tendon jerk**.	Main afferent for **muscle tone**.

3. Center of stretch reflex

- Afferent fibers enter the spinal cord through the dorsal roots to synapse directly with the alpha cells of the **AHCs**.
- Stretch reflex is **the only Monosynaptic reflex** (No interneurons)

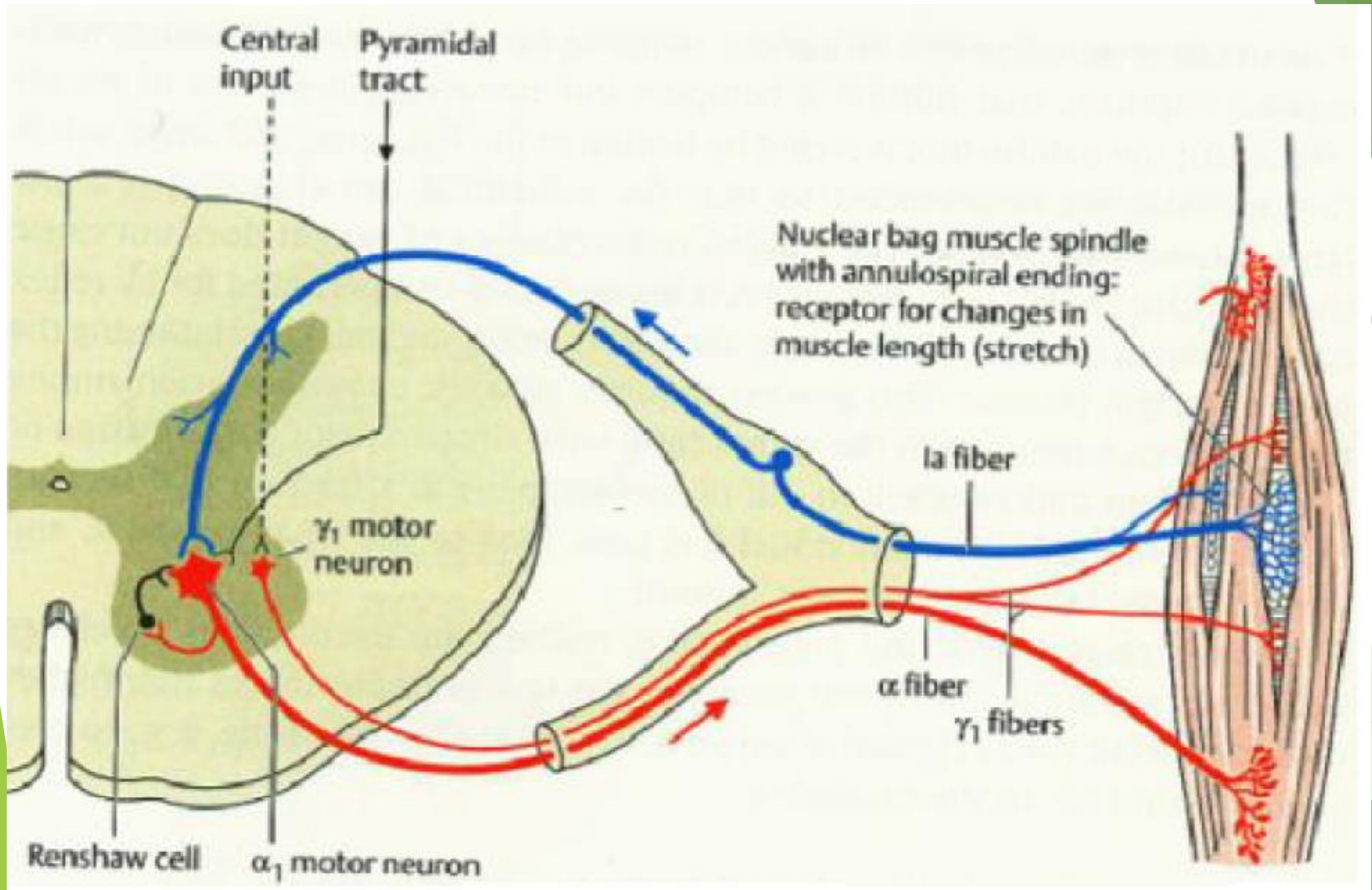
So, Central delay = Synaptic delay = 0.5 msec.

4. Efferent of stretch reflex

- Alpha fibers from large alpha cells in the **AHCs.**
- Innervate the extra-fusal muscle fibers.

5. Effector organ in stretch reflex

- Extra-fusal muscle fibers which are the ordinary muscle fibers around the stimulated muscle spindle.


Central input
Pyramidal tract
Nuclear bag muscle spindle with annulospiral ending: receptor for changes in muscle length (stretch)
Ia fiber
γ_1 motor neuron
α fiber
γ_1 fibers
Renshaw cell
α_1 motor neuron

Gamma (γ) efferent innervations of muscle spindle

- In the AHCs of spinal cord there are small γ- efferent motor fibers.

(4 μ, 4 m/sec)

- γ Fibers supply the peripheral contractile parts of the muscle spindle

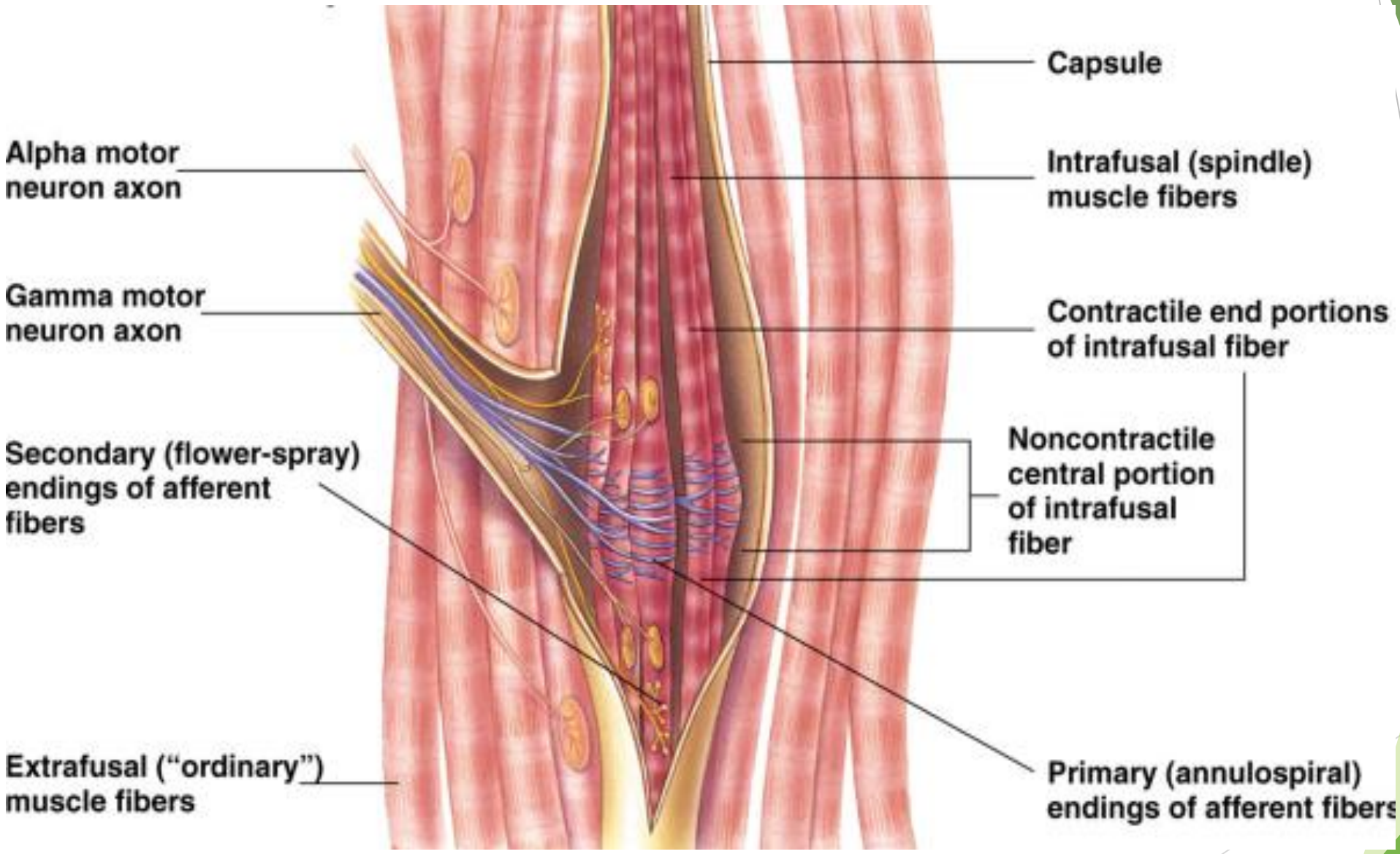
- Stimulation of γ- efferent motor fibers ⇨ contraction of peripheral contractile parts of the muscle spindle ⇨ stretching of the central receptor part of the muscle spindle ⇨ stimulation of the stretch reflex.

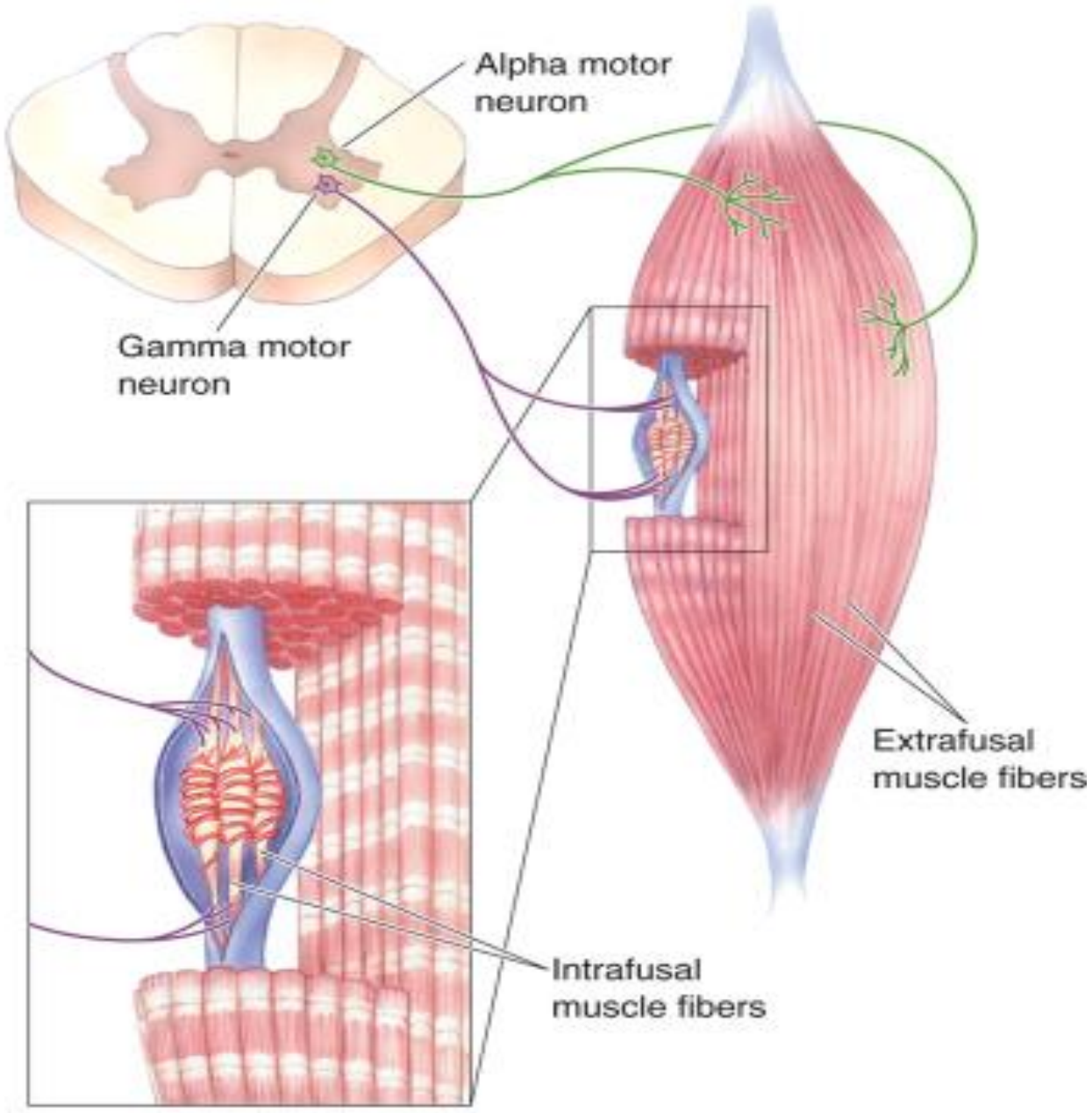
- Stimulation of γ ⇨ strengthening of muscle contraction & muscle tone

- Gamma static (γ- S) to nuclear chain & Gamma dynamic (γ- D) to nuclear bag

(γ) Cells are controlled by many higher centers through descending tracts:

Supraspinal facilitatory centers	Supraspinal inhibitory centers
Primary motor area "4" of cerebral cortex.	Suppressor areas "4s" of cerebral cortex.
Neocerebellum.	Paleocerebellum.
Caudate nucleus of basal ganglia.	Lentiform nucleus of basal ganglia.
Vestibular nucleus & Olivary nucleus.	Red nucleus.
Facilitatory pontine reticular formation. (has **intrinsic activity**)	Inhibitory medullary reticular formation.


Capsule
Alpha motor neuron axon
Intrafusal (spindle) muscle fibers
Gamma motor neuron axon
Contractile end portions of intrafusal fiber
Secondary (flower-spray) endings of afferent fibers
Noncontractile central portion of intrafusal fiber
Extrafusal ("ordinary") muscle fibers
Primary (annulospiral) endings of afferent fibers


Alpha motor neuron
Gamma motor neuron
Extrafusal muscle fibers
Intrafusal muscle fibers

Mode of stimulation of muscle spindle

1) Sudden stretch: like during tapping on muscle tendon (tendon jerk)

⇨ stimulate nuclear bag. Then, via annulospiral ⇨ **Dynamic** response

2) Continuous stretch: helped by pulling effect of gravity (muscle tone)

⇨ stimulate nuclear chain. Then, via flower spray ⇨ **Static** response

3) Contraction of the periphery of the intra-fusal fibers:

Due to efferent discharge from gamma (γ) fibers

N.B: Maximal stimulation of muscle spindle: when muscle is passively stretched (like during tapping its tendon).

Minimal stimulation of muscle spindle: during voluntary contraction.

Types of stretch reflex

1) Dynamic stretch reflex: (monosynaptic)

2) Static stretch reflex: (monosynaptic)

	Dynamic phase	Static phase
Stimulus	Sudden stretch.	Continuous stretch.
Response	Sudden contraction.	Continuous contraction.
Proper stimulus	Sudden tapping on tendon.	Pulling effect of gravity.
Receptors	Nuclear bag.	Nuclear chain.
Afferent	Only 1ry.	Both 1ry & 2ry.
Importance	Tendon jerk.	Muscle tone.

3) Negative stretch reflex: (monosynaptic)

- Shortening of the muscle by its contraction ⇨ reflex relaxation (or reflex inhibition of further contraction)

4) Inverse stretch reflex: (**poly**synaptic)

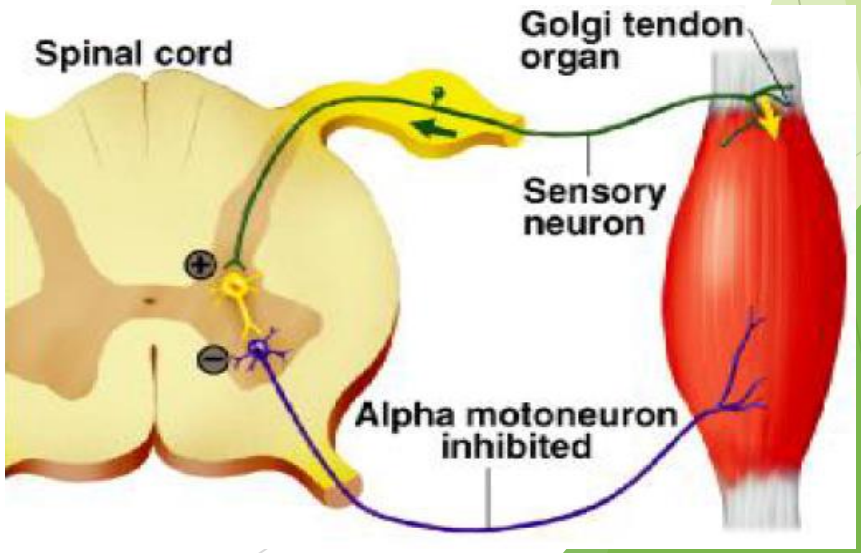
-Overstretch of the muscle → reflex relaxation

- Receptors are **Golgi tendon organ(GTO)**

- Relaxation due to either: a) Inhibitory interneurons at spinal level
  b) Inhibitory cerebellar impulses

Differences between MS & GTO

	Muscle spindle	Golgi tendon organ
Site	Between fleshy muscle fibers.	In tendon of muscle.
Stimulus	Muscle stretch.	Overstretch.
Response	Muscle contraction. "Stretch reflex".	Muscle relaxation. "Inverse stretch reflex".
Connection	Monosynaptic.	Polysynaptic.
Afferent	2 types of afferent fibers to spinal cord (primary & secondary endings).	Only one afferent rapidly conducting fibers (diameter = 16 µ).



5) Cerebellar stretch reflex = Load reflex (polysynaptic)

- When your arm is flexed, your biceps muscle is contracted.
- If we suddenly apply an extra weight on your hand, your arm remains flexed by the assist of this reflex.

(to elevate the load)

- Here the proprioceptive impulses reach cerebellum, which responds by sending strong facilitatory impulses to the **gamma** motor neurons leading to increase in muscle tone & strengthen contraction.

Functions of stretch reflex

1) Signal averaging function (Damping function):

- ***Definition:*** **It prevents skeletal muscle oscillations. (damp = prevent)**

- ***Mechanism:*** **motor cortex sends unequal discharge to AHCs.**

➢ **With weak impulses ⇨ the muscle tone becomes strong.**

➢ **With strong impulses ⇨ the muscle tone becomes weak.**

- **Thus, all the contractions become equal which prevent oscillations.**

2) Skeletal muscle tone:

- ***Definition:*** **Continuous mild sub-tetanic contraction of skeletal muscles.**

- ***Mechanism:*** **Static type of stretch reflex.**

(distance between origin and insertion > true muscle length).

- ***Site:*** **All muscles of the body. But, more in the antigravity muscles.**

- ***Functions:***

1. Keeping equilibrium & adjust body position.

2. Tone of the abdominal muscle keeps viscera in position.

3. Prevents drop of the head & mandible.

4. Help venous & lymphatic return.

5. Heat production & regulates body temperature. (by shivering)

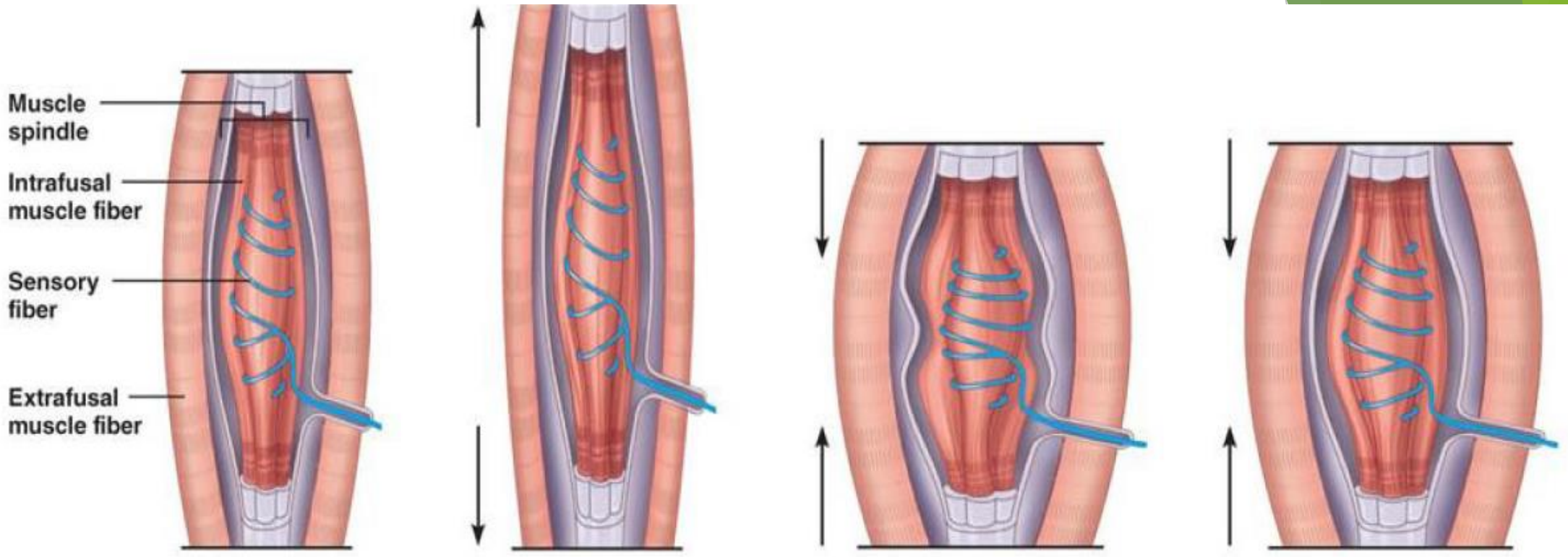
3) Prevent avulsion of tendon: by **inverse stretch reflex**, prevent muscle tear.

4) Servo - assist function (α - γ Co-activation):

- Stimulation of γ ⇨ stimulation of α ⇨ increasing force of contraction.
- This occurs without increasing discharge from higher motor areas with minimal energy consumption.
- Present especially in "**load reflex**" when the muscle lifts a heavy weight against gravity. This weight all the time exerts stretching effect on the tendon of the muscle stimulating intra-fusal fibers.

The most-important characters of the stretch reflex are:-

1. Muscle tone is deep, spinal, monosynaptic reflex.
2. Muscle tone is the static phase of the stretch reflex.
3. Muscle tone **consumes little energy** , **never fatigued** and very **slowly adapting.**
4. When the tone is increased in a certain muscle, it is inhibited in its antagonistic.
5. Because there is **no interneuron** in the reflex arc of the stretch reflex, there is **no after discharge** and the reflex is extremely localized.



Unstretched muscle. Action potentials (APs) are generated at a constant rate in the associated sensory fiber.

Stretched muscle. Stretching activates the muscle spindle, increasing the rate of APs.

If only α motor neurons were activated. Only the extrafusal muscle fibers contract. The muscle spindle becomes slack and no APs are fired. It is unable to signal further length changes.

But normally α-γ coactivation occurs. Both extrafusal and intrafusal muscle fibers contract. Tension is maintained in the muscle spindle and it can still signal changes in length.

THANK YOU