

# Stretch Reflex & Golgi Tendon Reflex

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# Neuropsychiatry Block

## Chapter 55

### Motor Functions of the Spinal Cord, The cord Reflexes

(**Guyton & Hall**)

Reference book/Ganong review of  
medical physiology

# Objectives

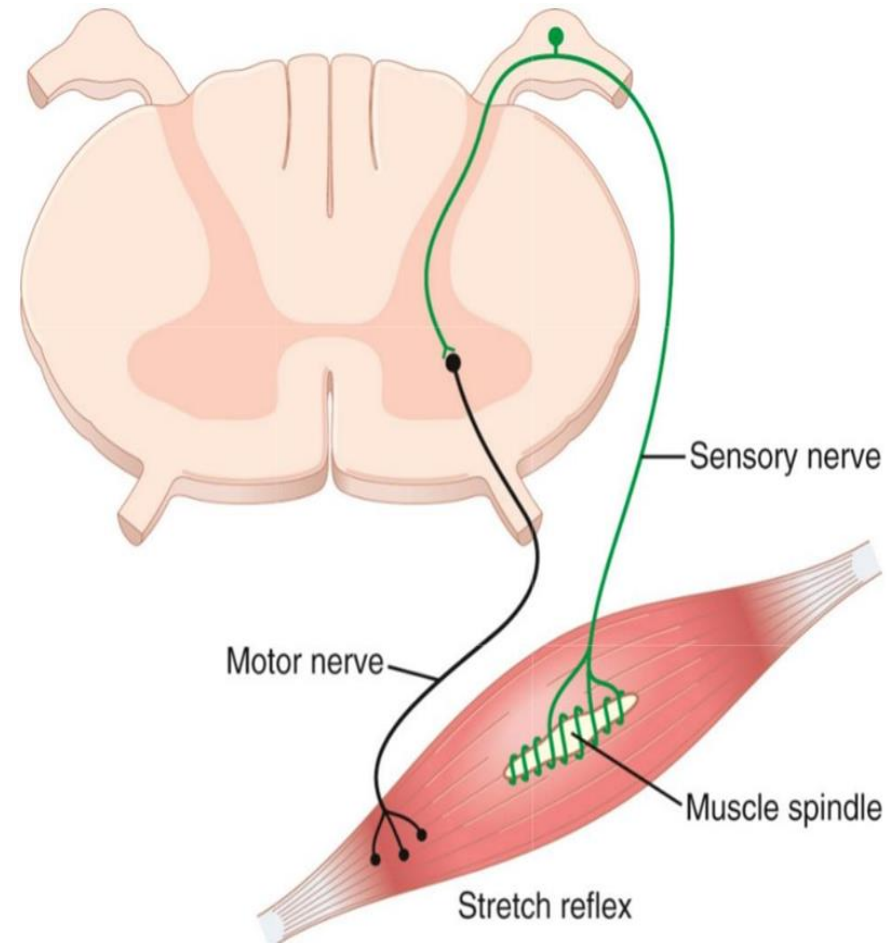
- By the end of this lecture students are expected to:
- Describe the components of stretch reflex and its function
- Describe the structure , innervations and function of the muscle spindle .
- Explain the roles of **alpha** and **gamma** motor neurons in the stretch reflex
- Describe and explain muscle tone
- Discuss the spinal and supraspinal regulation of stretch reflex
- Describe the inverse stretch reflex and its function

# What is a Stretch Reflex?

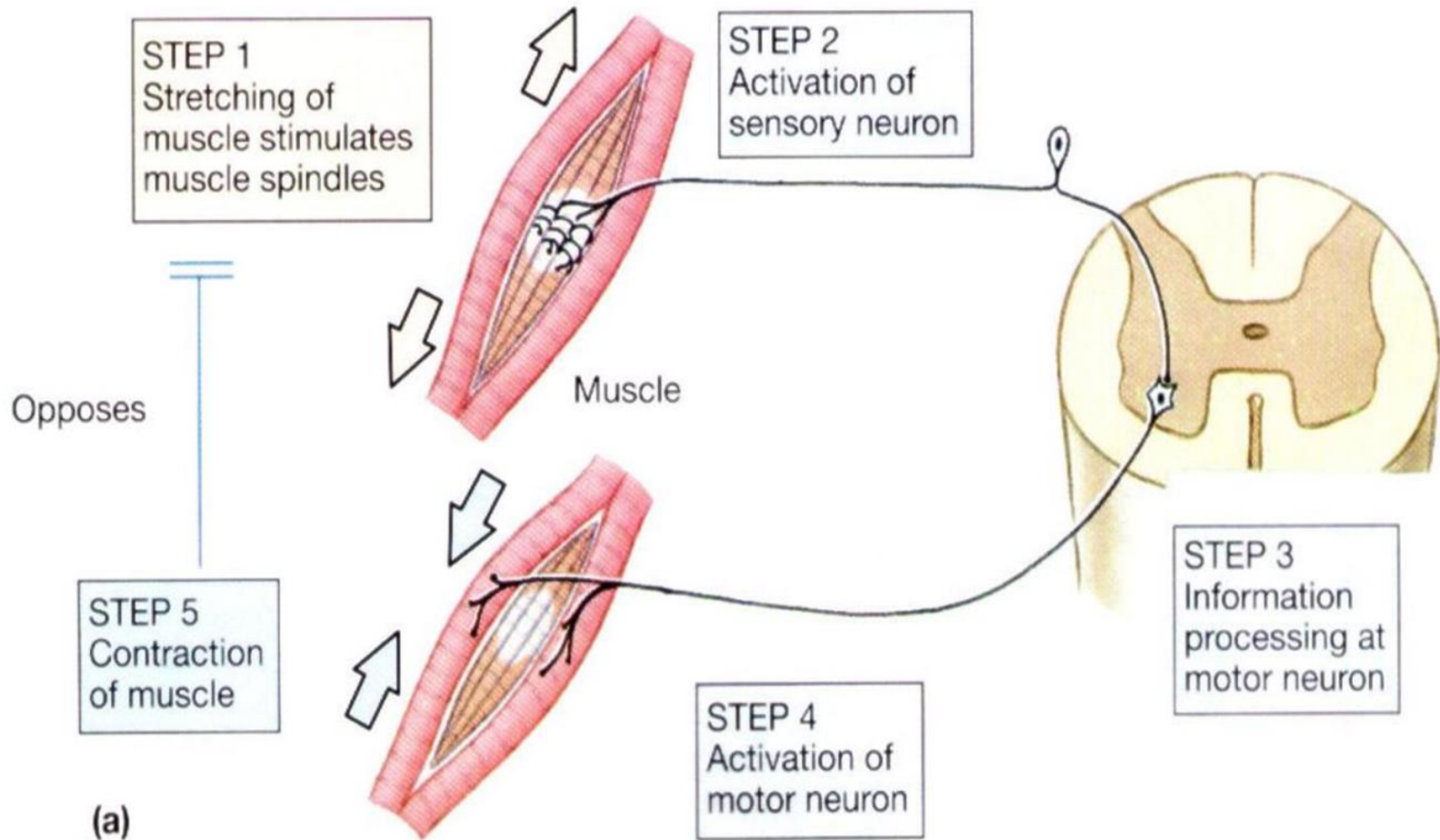
- It is a reflex contraction of a muscle when it is moderately stretched
- It is a monosynaptic reflex (also known as myotatic reflex)
- It has two components:
  - **dynamic** stretch reflex (**patellar-tendon** or **knee jerk** reflex)
  - **static** stretch ( muscle tone)

# Pathway of Stretch Reflex (*Reflex Arc*)

1. Sensory receptor (muscle spindles)
2. Afferent neuron (fast-conducting  $A\alpha$  (Ia) and  $A\beta$  (II) nerve fibers )
3. Integrating center (spinal cord)
4. Efferent (motor) neurons : axons of  $\alpha$ -motor neurons
5. Effector : extrafusal muscle fibers

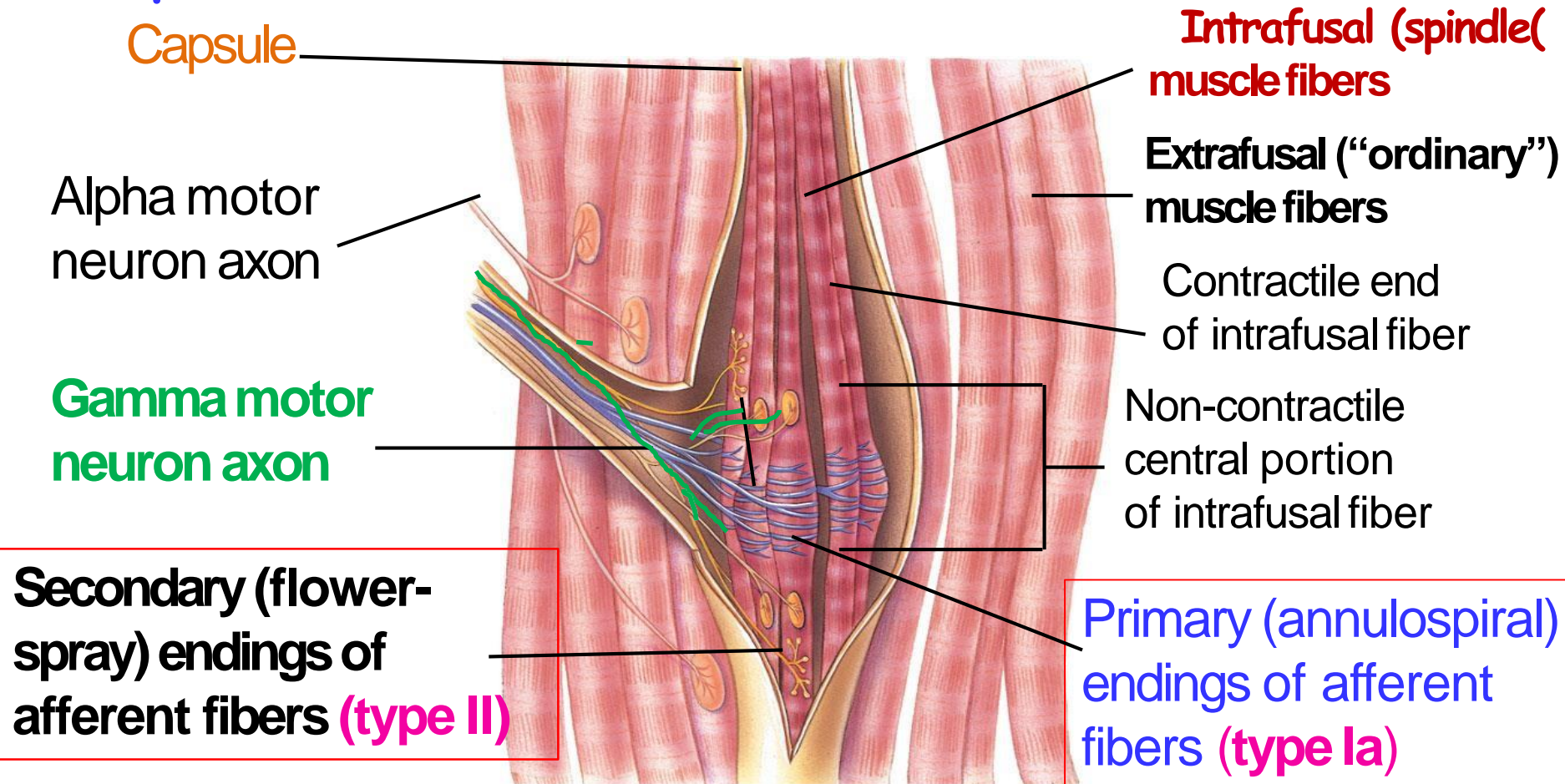


# *Pathway of Stretch Reflex*



# Muscle Spindles-1

- Is located in the fleshy part of the muscle
- Consists of 3-12 small **intrafusal fibers** within a capsule
- Each intrafusal fiber has a central (non-contractile) area (**receptor**), and a contractile area on each side.

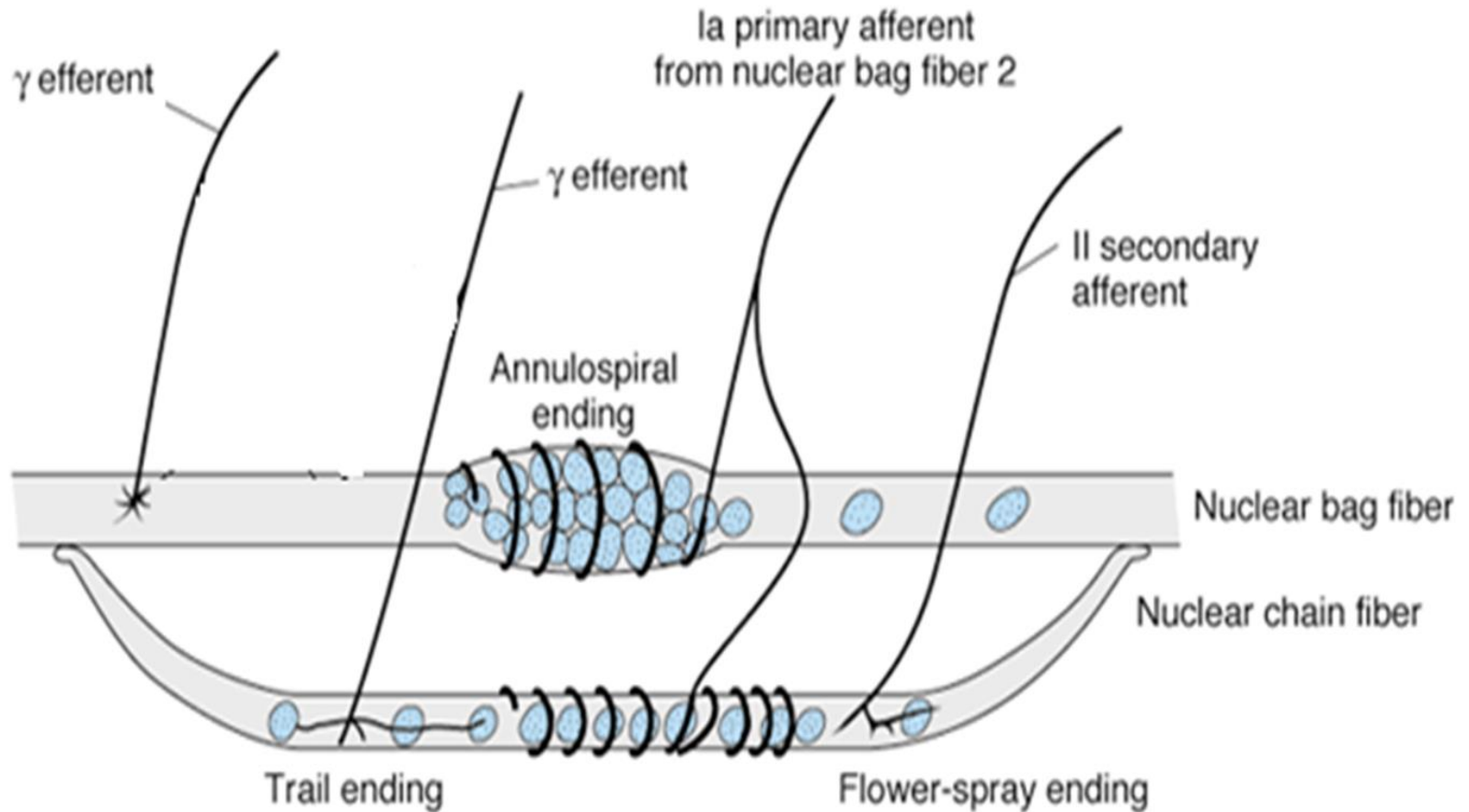


# Muscle Spindle-2

- There are 2 types of intrafusal muscle fibers:
- **1) Nuclear bag fibres;**
  - Have a dilated central area filled with nuclei.
  - Are 1-3 of these fibres per spindle.
- **2) Nuclear chain fibres;**
  - Have nuclei which are arranged as a chain in the receptor area.
  - Are 4-9 of these fibres per spindle.



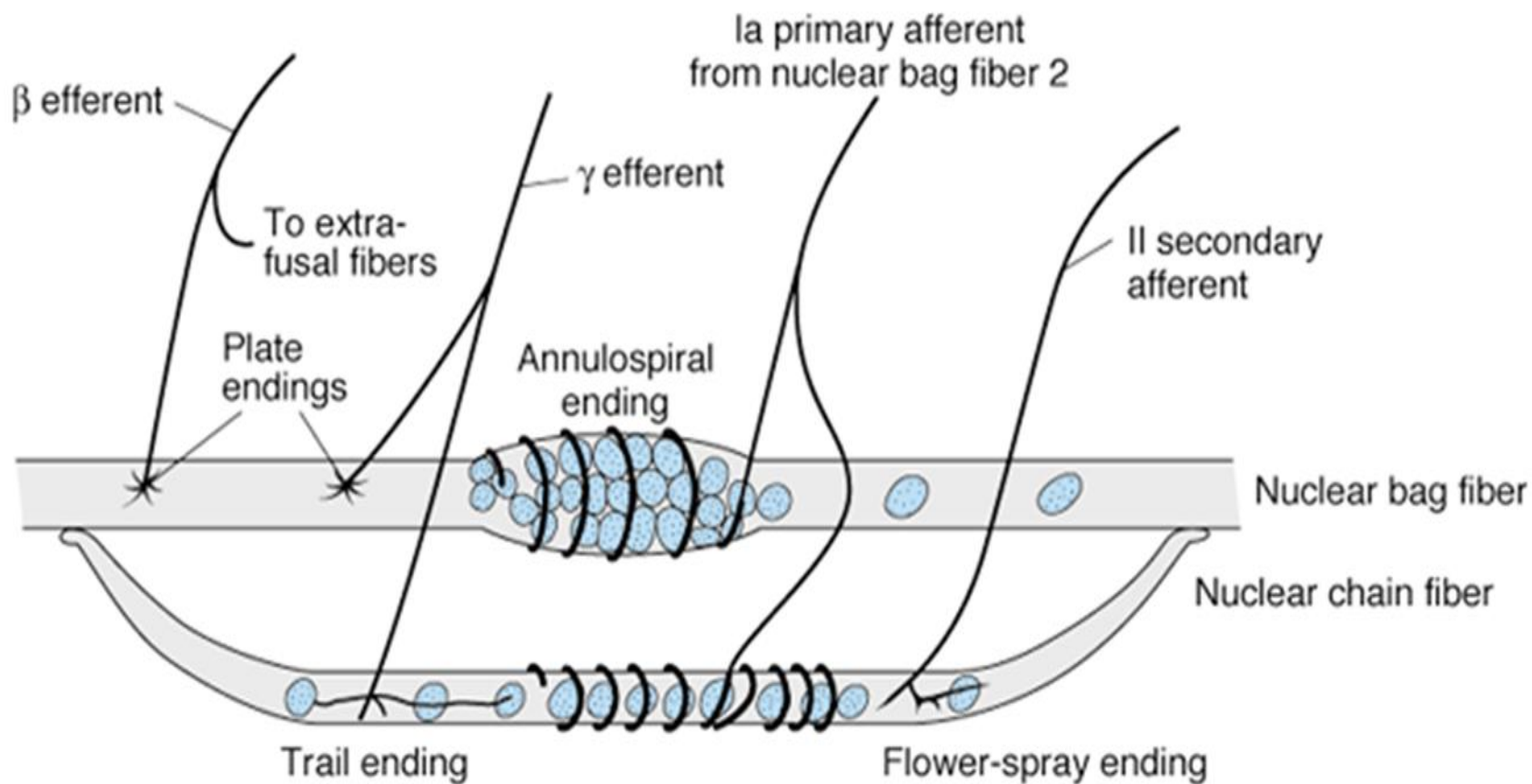
# Muscle Spindle-3



# Sensory ( Afferent ) Innervation of the Muscle Spindle

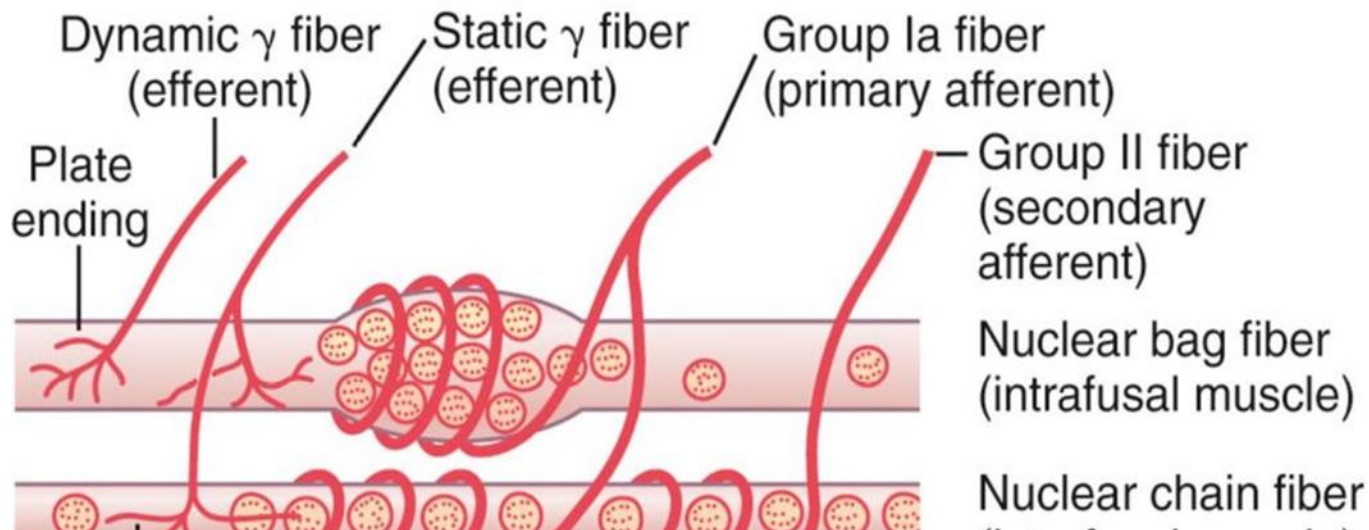
## A/The primary ( annulospiral ) ending:

- Group Ia endings(17 micrometers in diameter) encircle receptor areas of nuclear bag fibers mainly, but also nuclear chain fibres
- Send sensory signals to the CNS at the highest conduction velocity of 70 to 120 m/sec
- Discharge most rapidly if the muscle is suddenly stretched (dynamic response) and less rapidly (or not) during sustained stretch (static response)
- *Measures the rate or velocity of change - in muscle length .*



# Sensory ( Afferent ) Innervation of the Muscle Spindle-2

- **B/ Secondary ( Flower-spray ) Afferents**
  - Group II fibers ( 8 micrometers in diameter), innervate ONLY the nuclear chain receptor
  - Discharge at an increased rate throughout the period during which the muscle is being stretched, directly proportion to the degree of stretch (measure only muscle length, Static Response).



# Efferent Innervation of Muscle Spindle

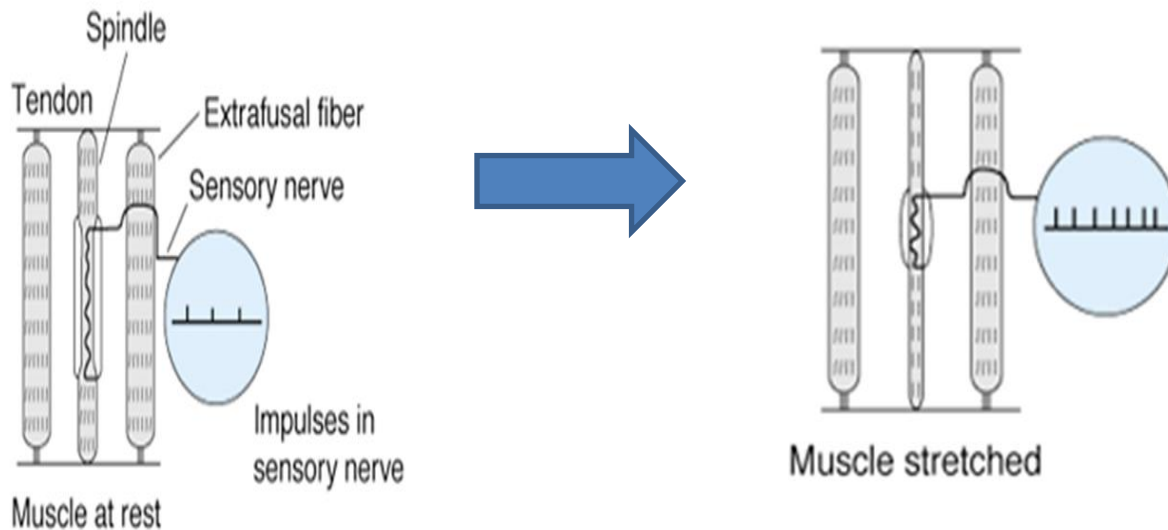
- Gamma ( $\gamma$ ) efferent endings terminate on the peripheral contractile parts of the intrafusal muscle fibres as:
  - **Plate endings:** end mainly on the nuclear bag fibres (called **dynamic gamma efferent**)
  - **Trail endings:** end mainly on nuclear chain fibres (called **static gamma efferent**)
- The function of  $\gamma$ - motor neurons is to regulate the sensitivity of the intrafusal muscle fibers, but **HOW?**

# Efferent Innervation of Muscle Spindle-2

- They adjust ms spindle sensitivity
- $\uparrow$   $\gamma$ -MNs cause contraction of the peripheral parts of intrafusal fibers  $\rightarrow$  stretch of central parts of ms spindle  $\rightarrow$   $\uparrow$ es the sensitivity of the ms spindle to stretch i.e. ms spindle needs a small amount of passive stretch to be stimulated

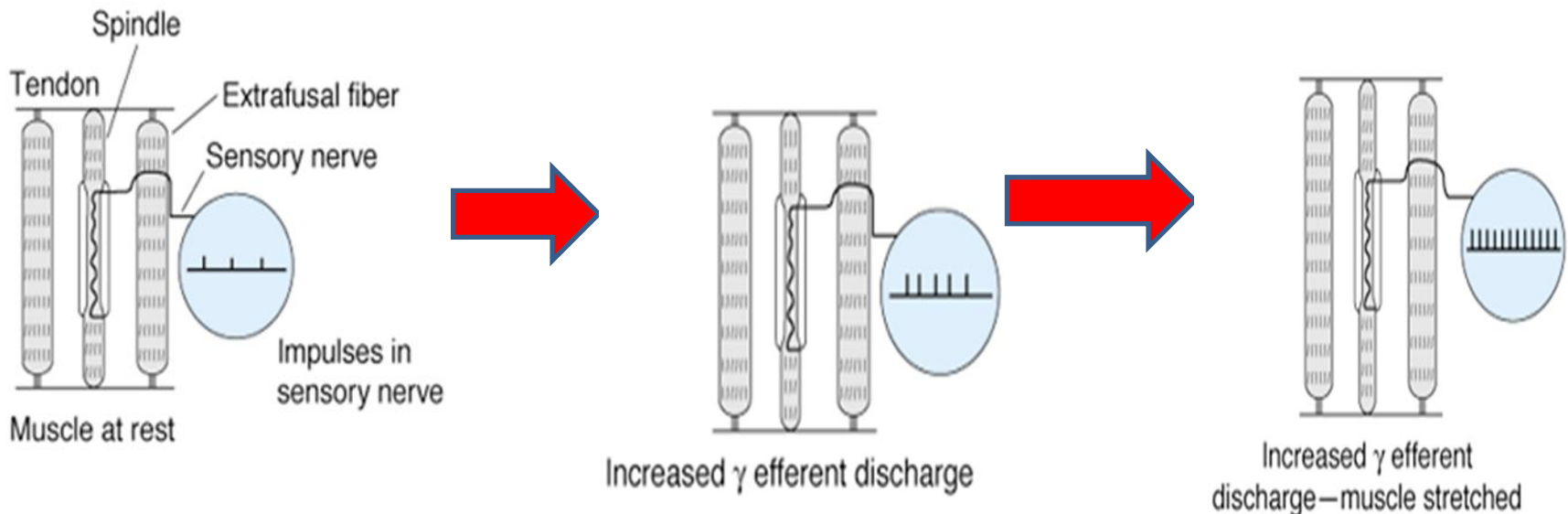
# How Are Muscle Spindles Stimulated?-1

- 1. **Passive stretch of the whole muscle:**
  - It causes stretch of the muscle spindle which lies parallel to muscle fibers.



# How Are Muscle Spindles Stimulated?-2

- **2) Activation of the  $\gamma$ -MNs:**
  - By supraspinal centers or reflexly
- It causes contraction of the peripheral part the intrafusal fibres  $\rightarrow$  stretch of receptor area





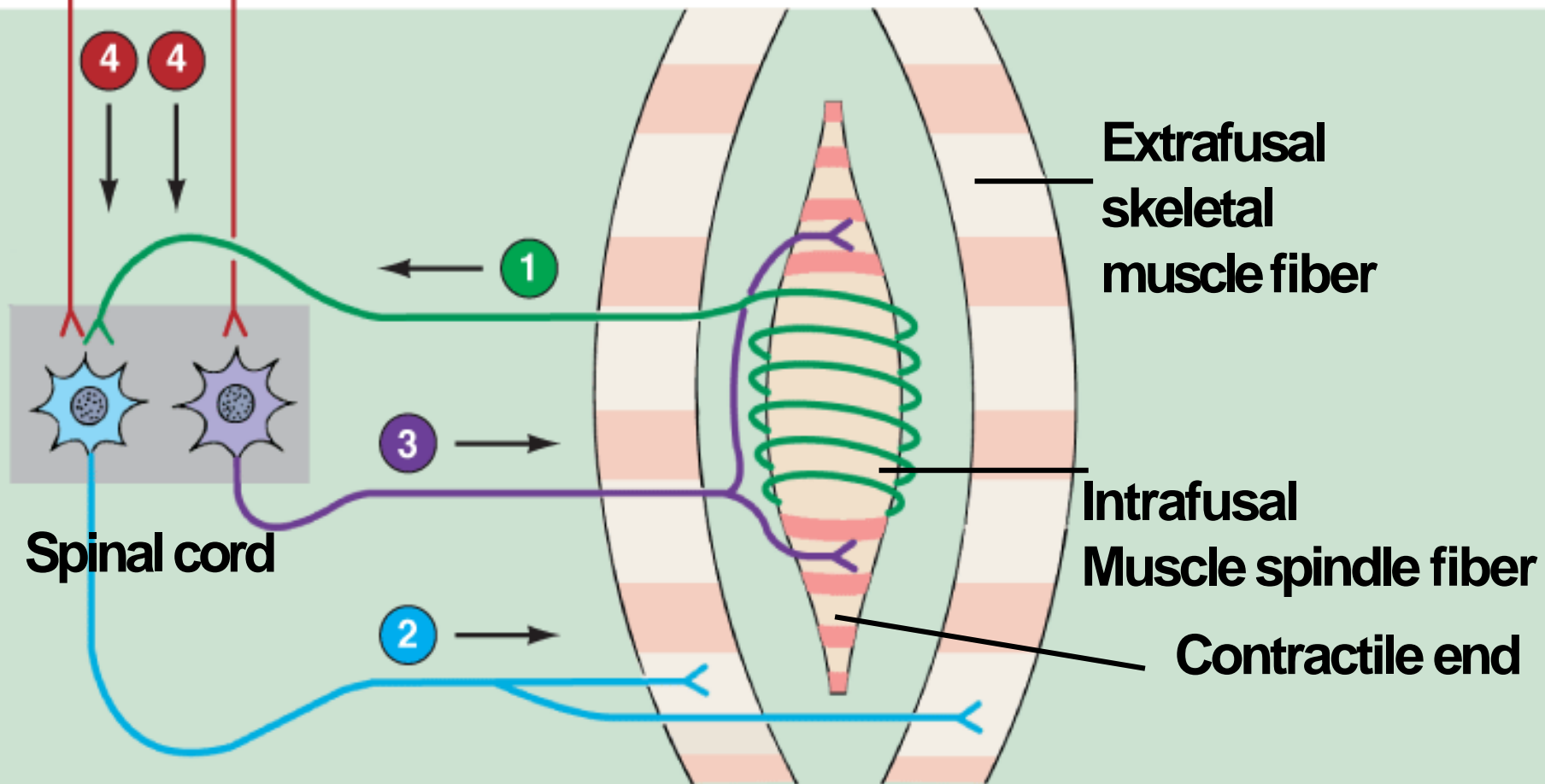
# How Are Muscle Spindles Stimulated?-3

## 3).Co-activation of $\alpha$ - and $\gamma$ - Motor Neurons:

- Signals from the motor cortex to the alpha motor neurons, mostly transmitted to the gamma motor neurons simultaneously, an effect called **coactivation**

## What is the significance of this coactivation?

- Regulate the sensitivity of the spindle by keeping its length constant
- Oppose sudden changes in muscle length



① Afferent input from sensory endings of muscle spindle fiber

② Alpha motor neuron output to regular skeletal-muscle fiber

① → ② Stretch reflex pathway (Arc)

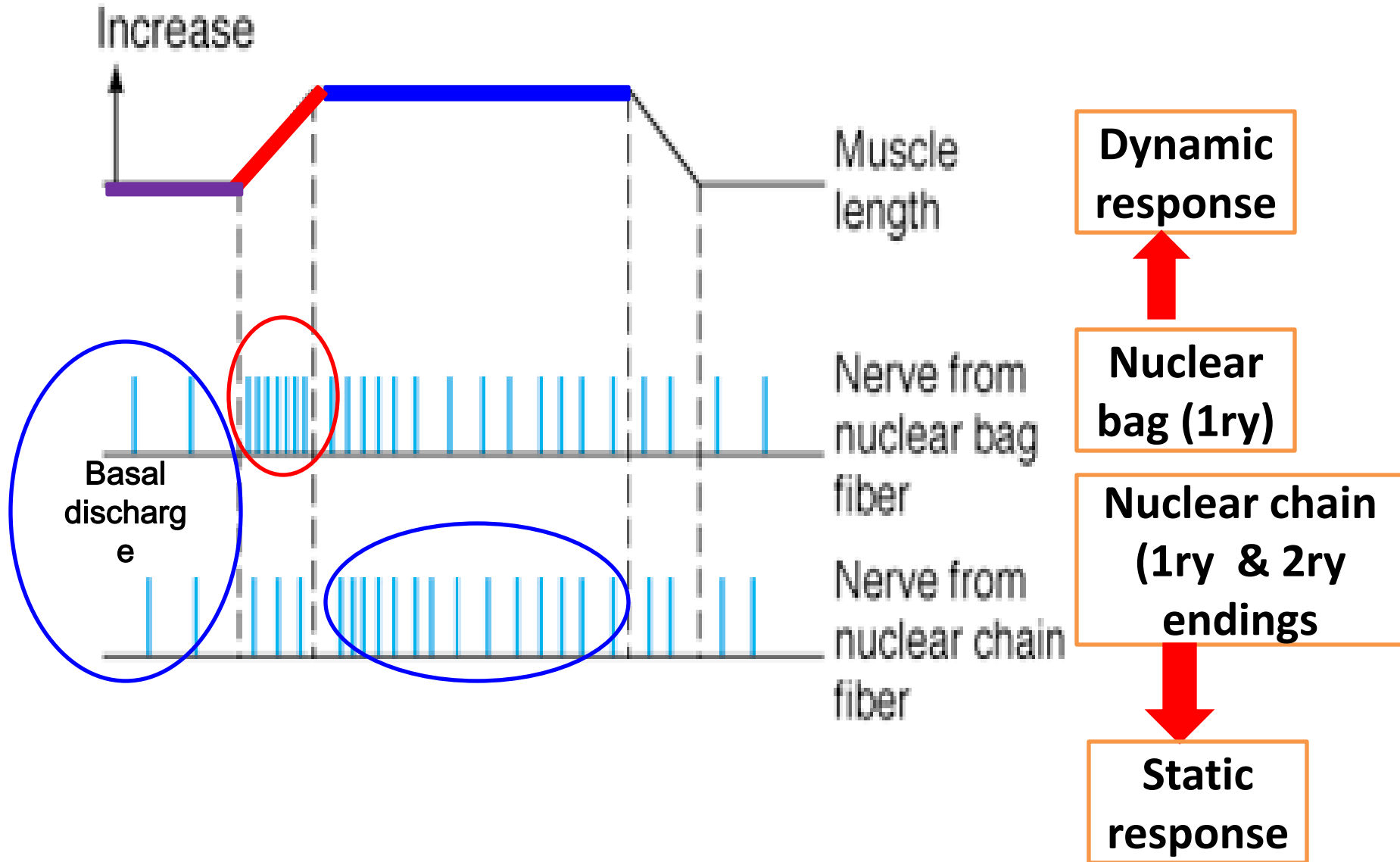
③  $\gamma$ -motor neuron output to the contractile end of spindle fiber

④ Descending pathways co-activate  $\alpha$ - and  $\gamma$ - motor neurons

# Dynamic stretch reflex

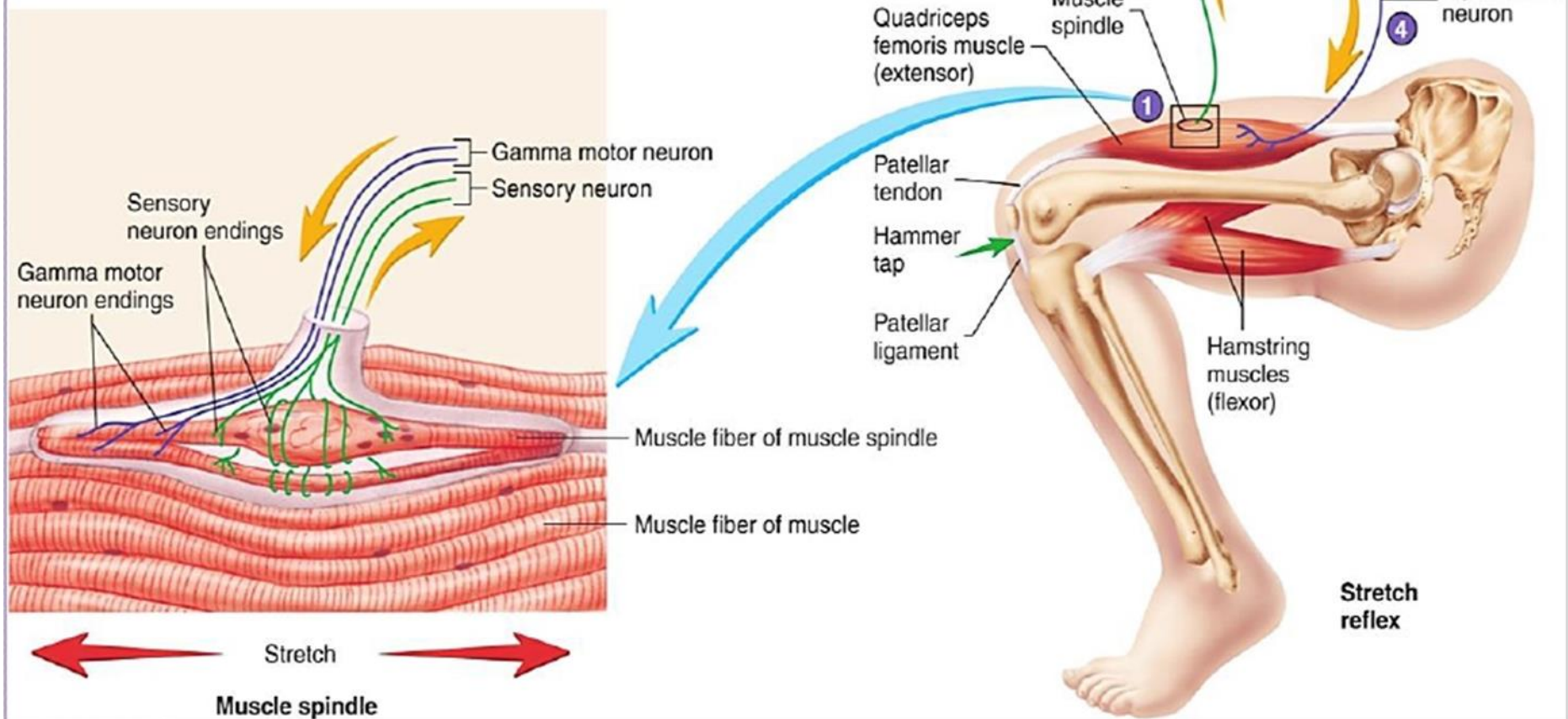
- Sudden (phasic ) rapid stretch of a muscle causes synchronous strong burst of excitatory discharges in annulospiral afferents to the alpha motoneuron
- This causes the latter to send strong motor excitatory impulses to extrafusal fibers →
- Causing sudden , jerky ( brief) muscle contraction ( jerky movement)
- As the muscle shortens → the spindle becomes lax → and ceases to discharge → no more stimulation of alpha motoneuron → no more excitatory impulses from alpha motoneuron to the extrafusal fibers → muscle relaxes
- This is the basis of Tendon Jerks ( dynamic stretch reflexes ) .

# Types of Responses of Ms spindle to Stretch (Types of Stretch Reflex)



Sudden stretch of a muscle results in:

- 1 Muscle spindles detect stretch of the muscle.
  - 2 Sensory neurons conduct action potentials to the spinal cord.
  - 3 Sensory neurons synapse directly with alpha motor neurons.
  - 4 Alpha motor neurons conduct action potentials to the muscle, causing it to contract and resist being stretched.
- Note: The muscle that contracts is the muscle that is stretched.*



# Static stretch reflex

- Maintained ( tonic ) stretch of muscle →
- Impulses from muscle spindle travel through spindle afferents (mainly along secondary ending) to alpha motor neuron , stimulating it to produce →muscle contraction
- Causing sustained ( continuous ) contraction of the muscle as long as it is stretched
- The Static Stretch Reflex is the basis of muscle tone which is defined clinically as resistance to muscle stretch

# Types of Responses of Ms spindle to Stretch (Types of Stretch Reflex)

	Dynamic Response	Static Response
<b>Stimulus</b>	Sudden stretch	Maintained (steady) stretch
<b>Receptors</b>	nuclear bag	nuclear chain
<b>Afferents</b>	1ry endings	primary and secondary endings
<b>Center</b>	Spinal cord	Spinal cord
<b>Response</b>	Rapid contraction followed by rapid relaxation	Maintained subtetanic contraction
<b>Examples</b>	e.g. tendon jerk	e.g. muscle tone

# Muscle Tone

- Is defined as a state of **continuous partial** contraction of skeletal ms during rest.
- It is present in all skeletal ms but specially in the **antigravity msmuscle (extensors of LL, back, neck, flexor of UL, muscle of abdominal wall and elevator of mandible )**

## Functions of Muscle Tone

- A) Postural control
- b) Help in heat production and maintain of body temperature
- c) It helps both the venous return & lymph flow
- d) Keeps viscera in position

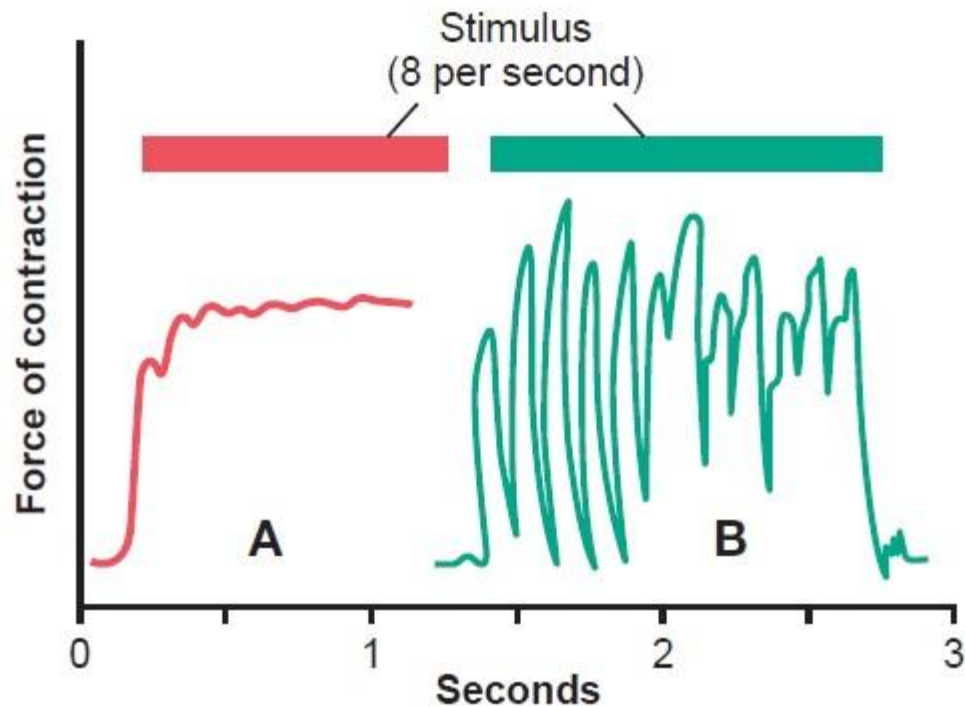


# Functions of stretch Reflex

- They function to oppose sudden changes in muscle length
- They help maintain a normal posture
- Damping or smoothing of muscle contraction
- Generation of muscle tone

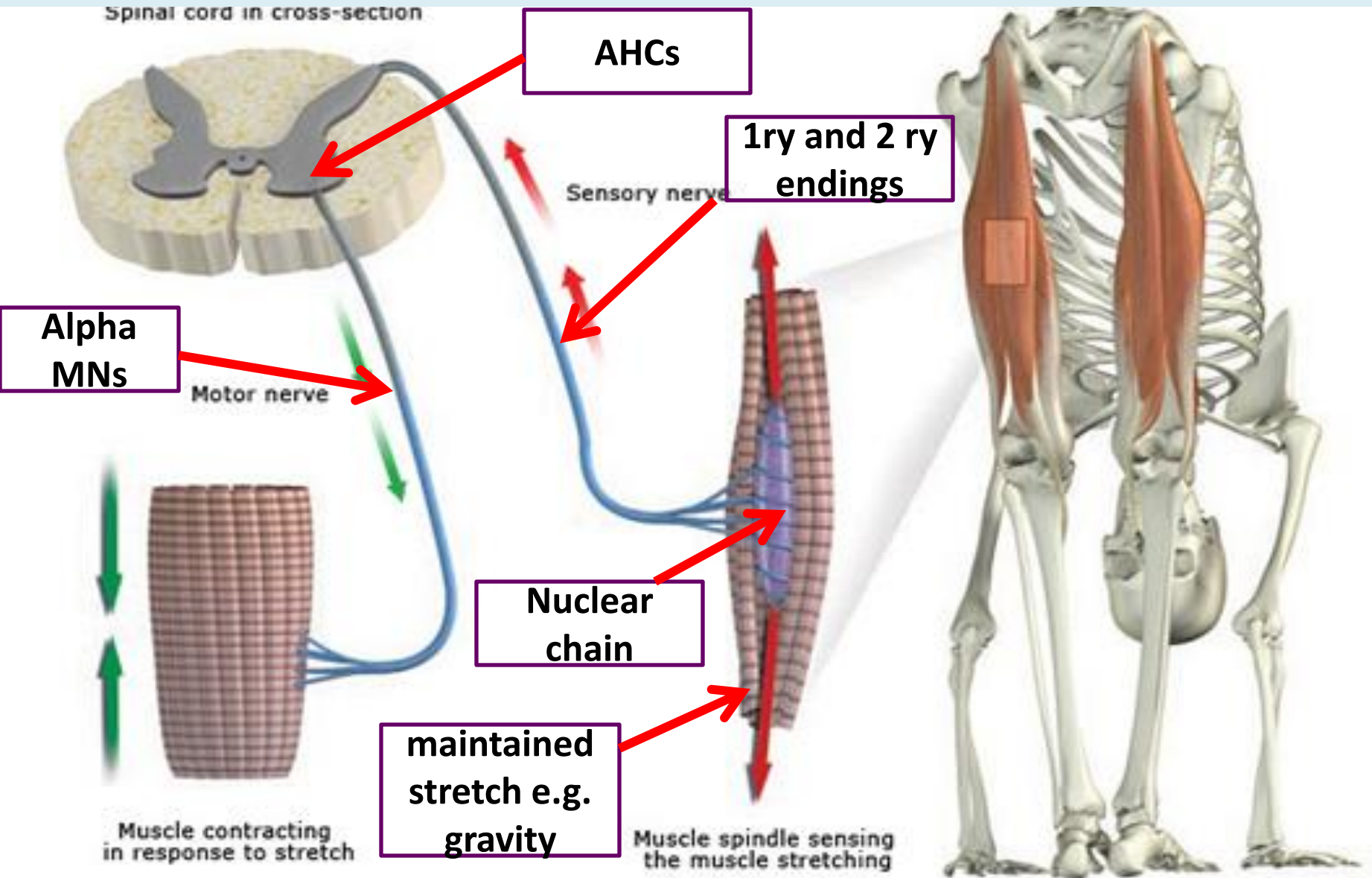
# Damping or Smoothing Function of Stretch Reflex

- **Stretch reflex** prevents **oscillations** or **jerkiness** of body movements
- **Motor signals** from the motor areas are transmitted to the ms in an **unsmooth form** (**↑ for few Sec and ↓ for another Sec**)
- This causes **irregularities** or **oscillations** of movements
- The signals discharged from the **ms spindles** cause **partial activity** of aMNs of the ms
- **So, the motor signals** find aMNs in **state of partial activity**, so they cause continuous activation of them → **cause smooth ms contraction**



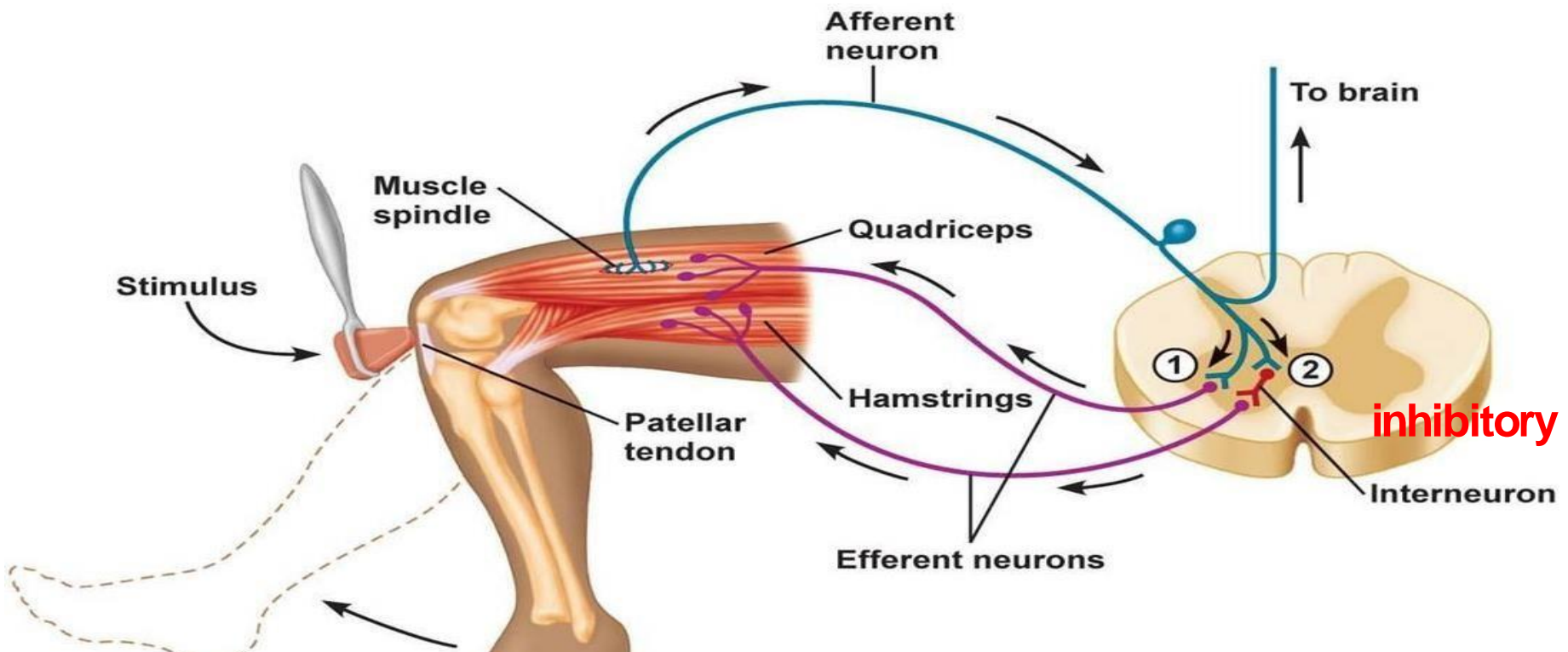
**Figure 55-6.** Muscle contraction caused by a spinal cord signal under two conditions: *curve A*, in a normal muscle, and *curve B*, in a muscle whose muscle spindles were denervated by section of the posterior roots of the cord 82 days previously. Note the smoothing effect of the muscle spindle reflex in *curve A*. (Modified from Creed RS, Denney-Brown D, Eccles JC, et al: *Reflex Activity of the Spinal Cord*. New York: Oxford University Press, 1932.)

# Static stretch reflex

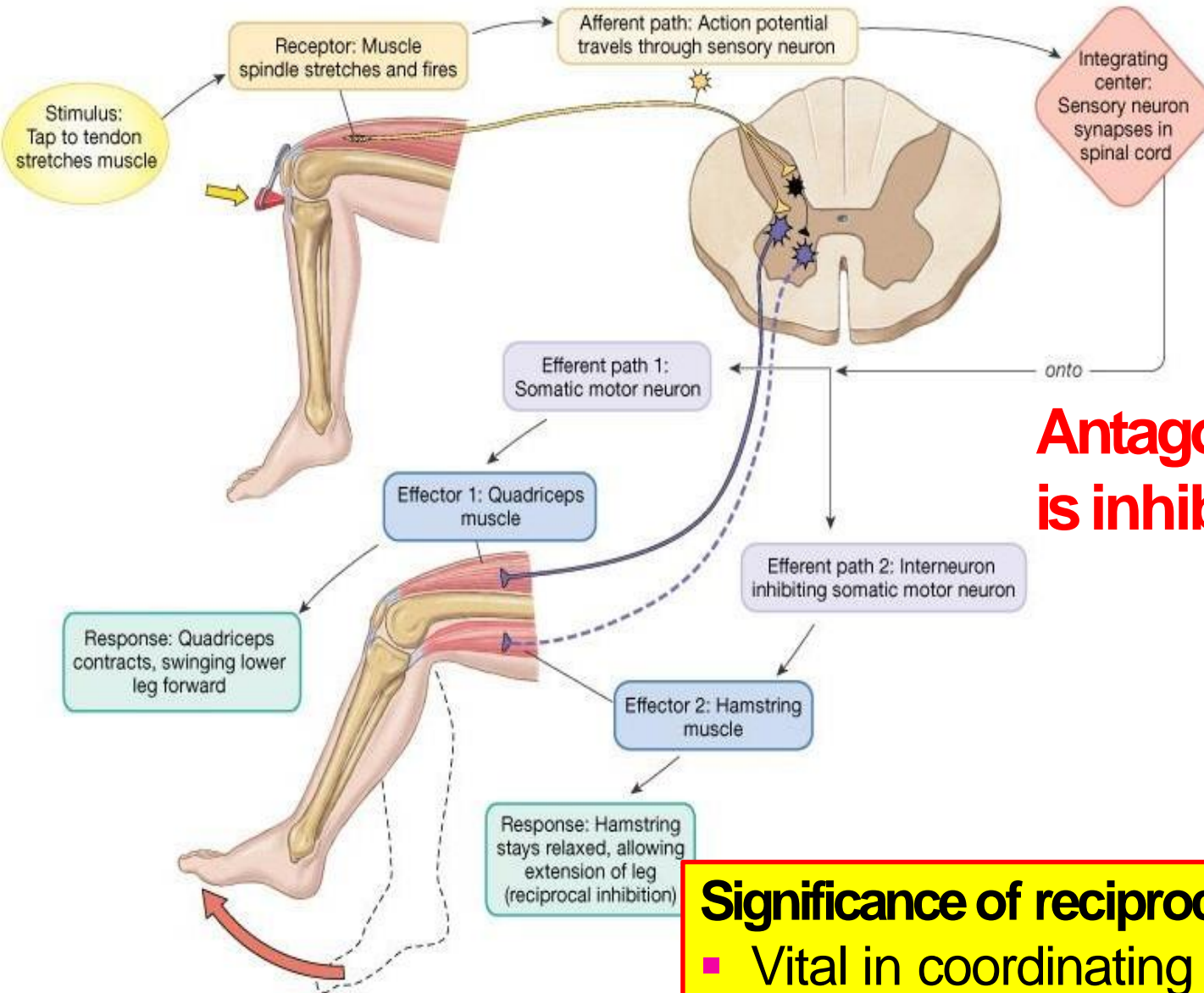


# Clinical application of stretch reflex :Knee Jerk Reflex

- Contraction of the muscle being stretched (quadriceps)
- Reciprocal inhibition of the antagonistic muscle (hamstring) through reciprocal innervation



# Knee Jerk Reflex & Reciprocal Inhibition



**Antagonistic muscle is inhibited**

**Significance of reciprocal Inhibition:**

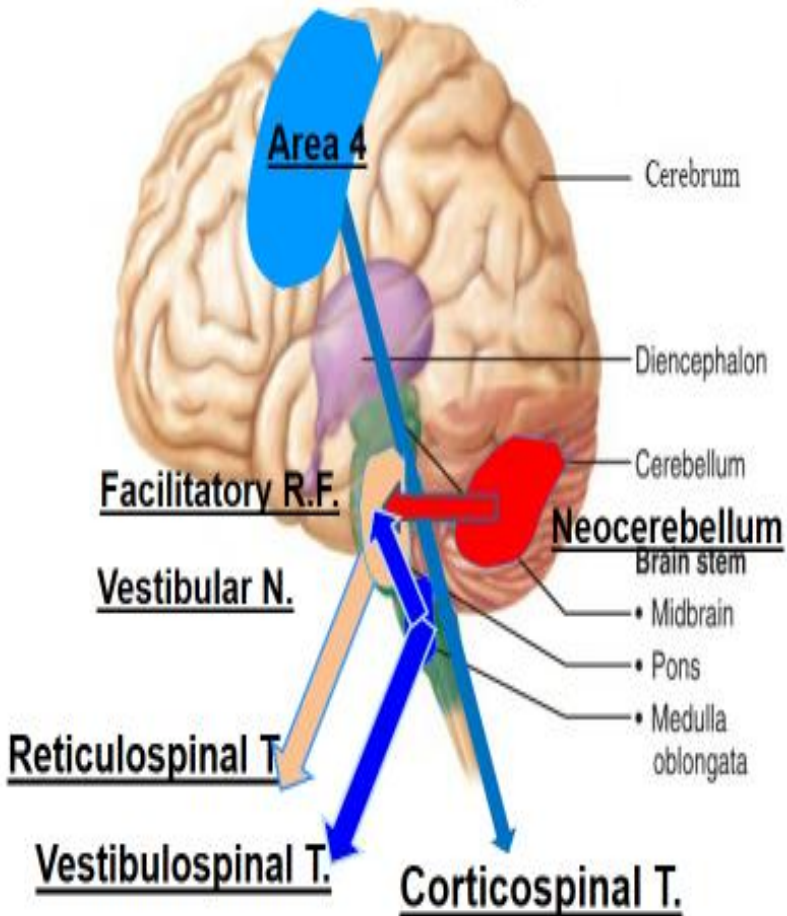
- Vital in coordinating body movements

# What is the Clinical Significance of Tendon Reflexes?

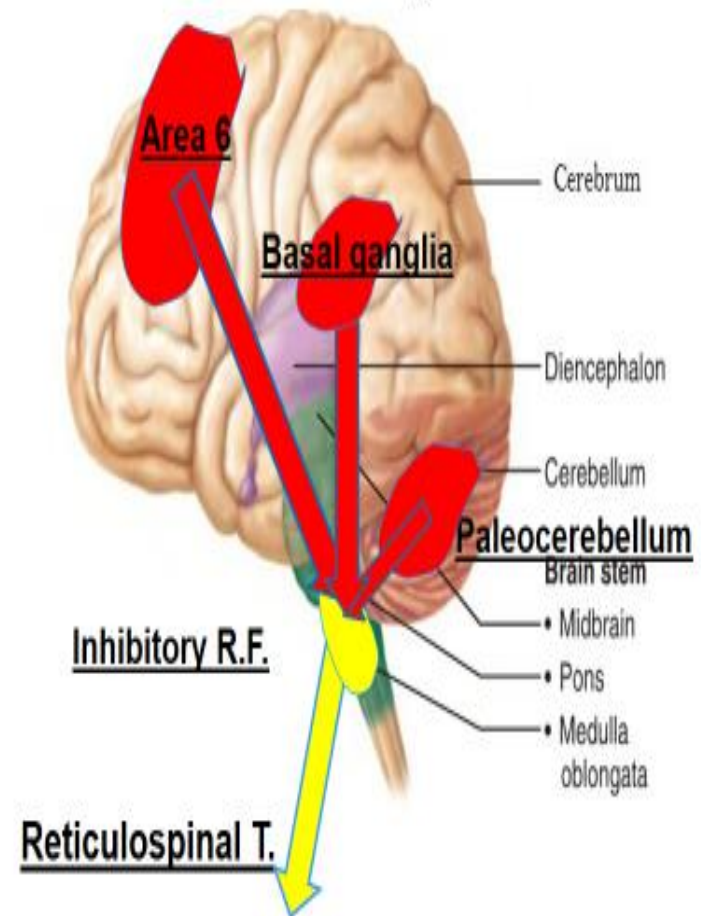
- They are carried out clinically to test the integrity of reflex arc.
- **A-reflexia** or **hypo-reflexia** (hypo-tonia) indicates that the reflex arc is interrupted at one of its components by:
  - Lesions of lower motor neuron *e.g. poliomyelitis*
  - Peripheral nerve lesions *e.g. peripheral neuropathy*
  - Neuromuscular junction disorder *e.g. myasthenia gravis*
  - Primary muscle disorder *e.g. myopathy*
- **Hyper-reflexia** (hyper-tonia): exaggerated deep reflexes.
  - Upper motor neuron lesion.
  - Anxiety

# Supraspinal control of Stretch Reflex-2

## Facilitatory Areas



## Inhibitory Areas



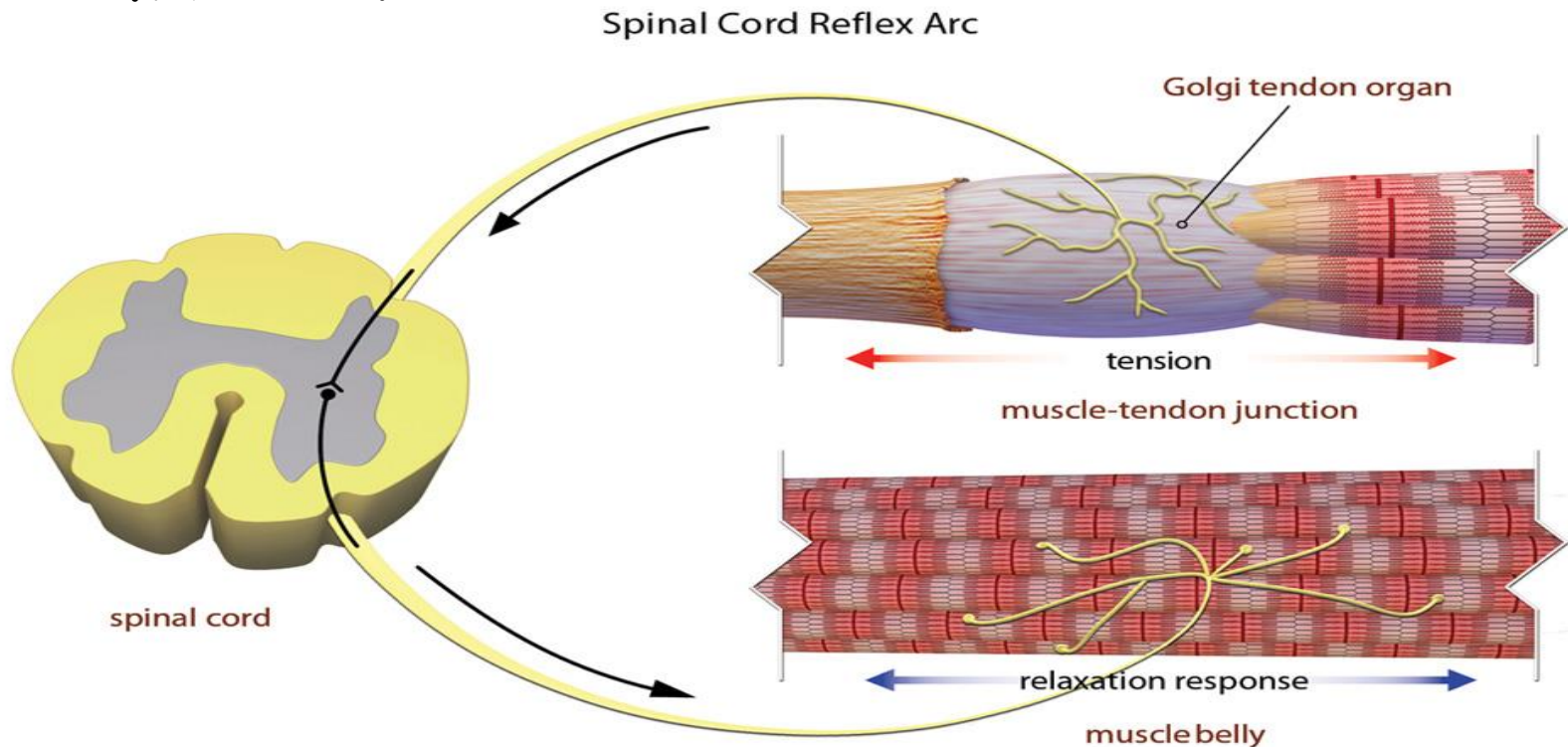


# Factors that Influence Stretch Reflex

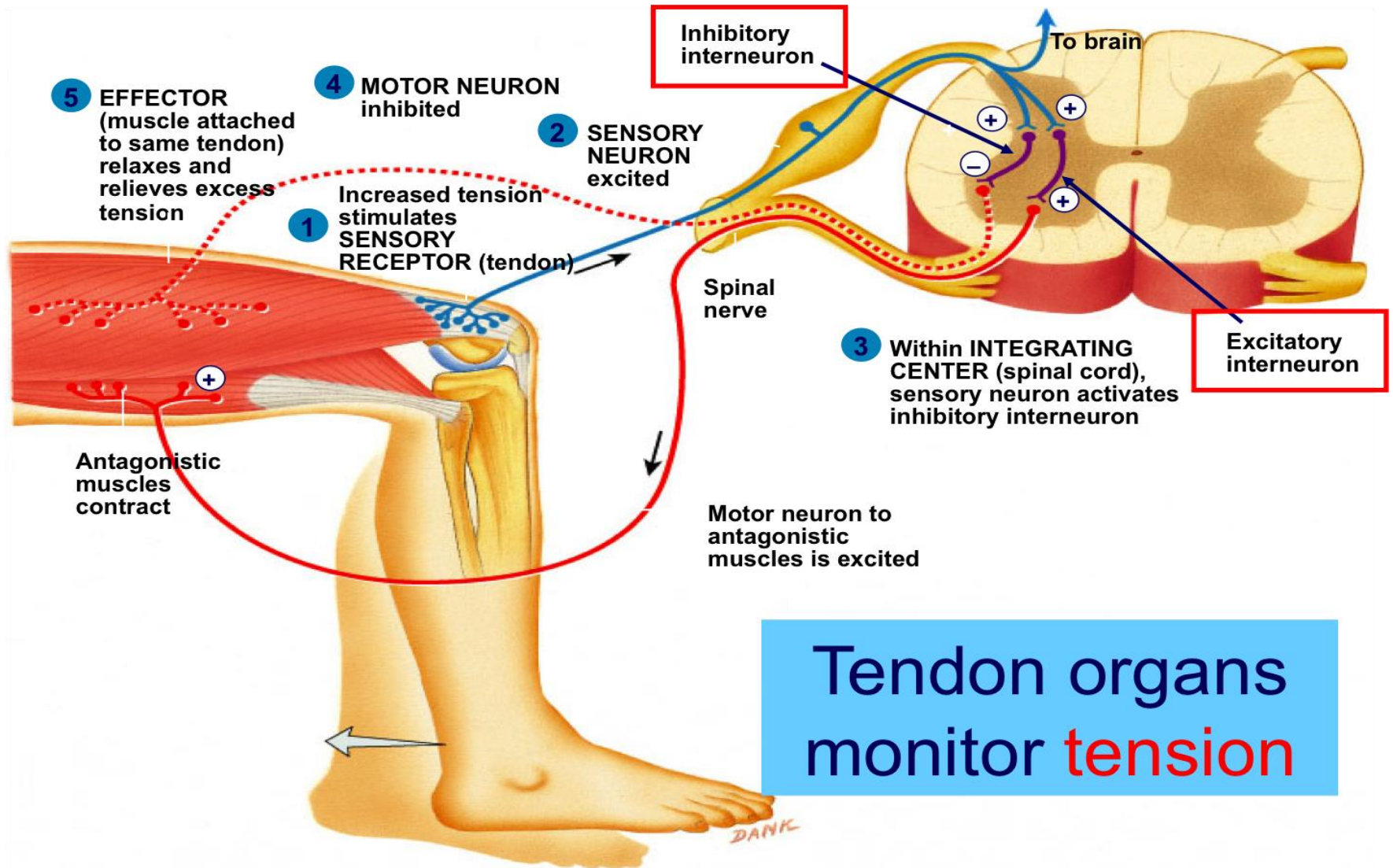
Facilitation	Inhibition
(1) Cortical ( motor area 4)	(1)Cortical ( motor area 6)
(2)Brainstem mechanisms : (i) Vestibular nucleus (ii) Pontine Reticular Formation	(2) Extrapyrarnidal & Brainstem mechanisms : (i)Basal ganglia , (ii) Red Nucleus . (iii) Medullary Reticular formation .
(3) Neocerebellum	(3) Paleocerebellum )
(4)spinal mechanisms : related to noxious ( painful) stimuli . (5) Anxiety (6)Jendrassik-manuver	(4)spinal mechanisms : 1. Excessive muscle stretch ( stimulation of Golgi tendon organ ). 2. Muscle contraction

# Golgi Tendon Reflex (Inverse Stretch Reflex)

- It is a reflex in which there is a **reflex relaxation** (or lengthening) of a muscles in response to **excessive stretch or contraction** of that muscles.



# Inverse Stretch Reflex



# Inverse Stretch Reflex-2

## Neural pathway:

- **Stimulus:** ↑ed muscle tension by;
  - Overstretch or
  - Severe contraction
- **Receptors:** Golgi tendon organs

## 1) Site:

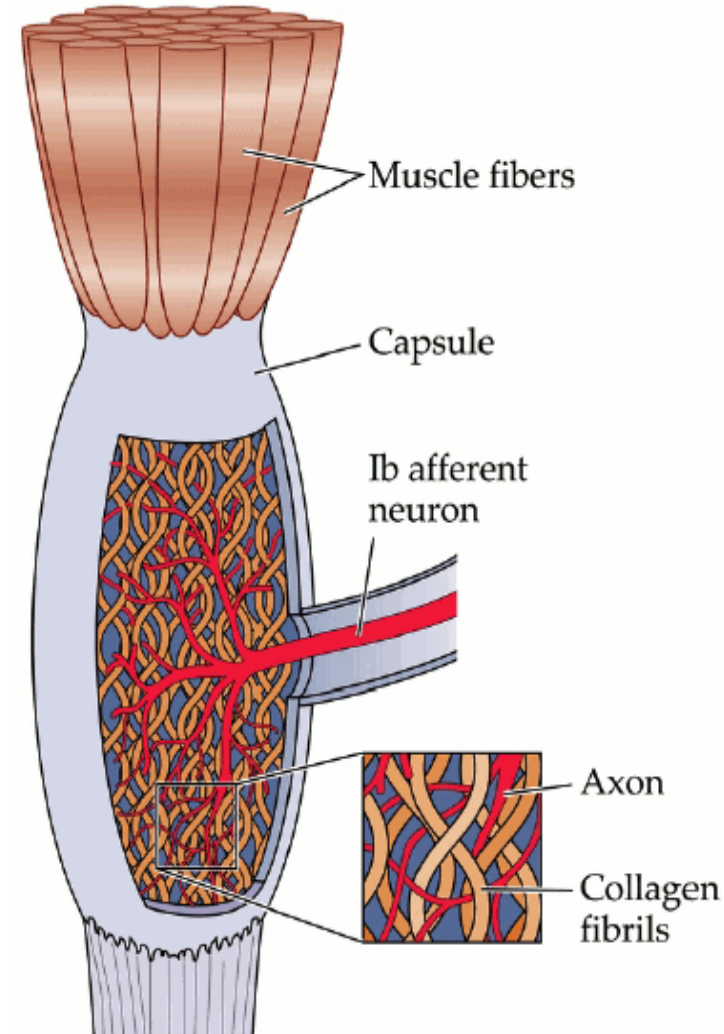
- tendons of skeletal ms in series with ms fibers

## 2) Structure:

- Are encapsulated sensory receptor
- 6-20 elastic fibers

## 3) Innervations:

- Type Ib afferent fibres



# Golgi Tendon Organs (GTOs)

## Receptors: GTOs

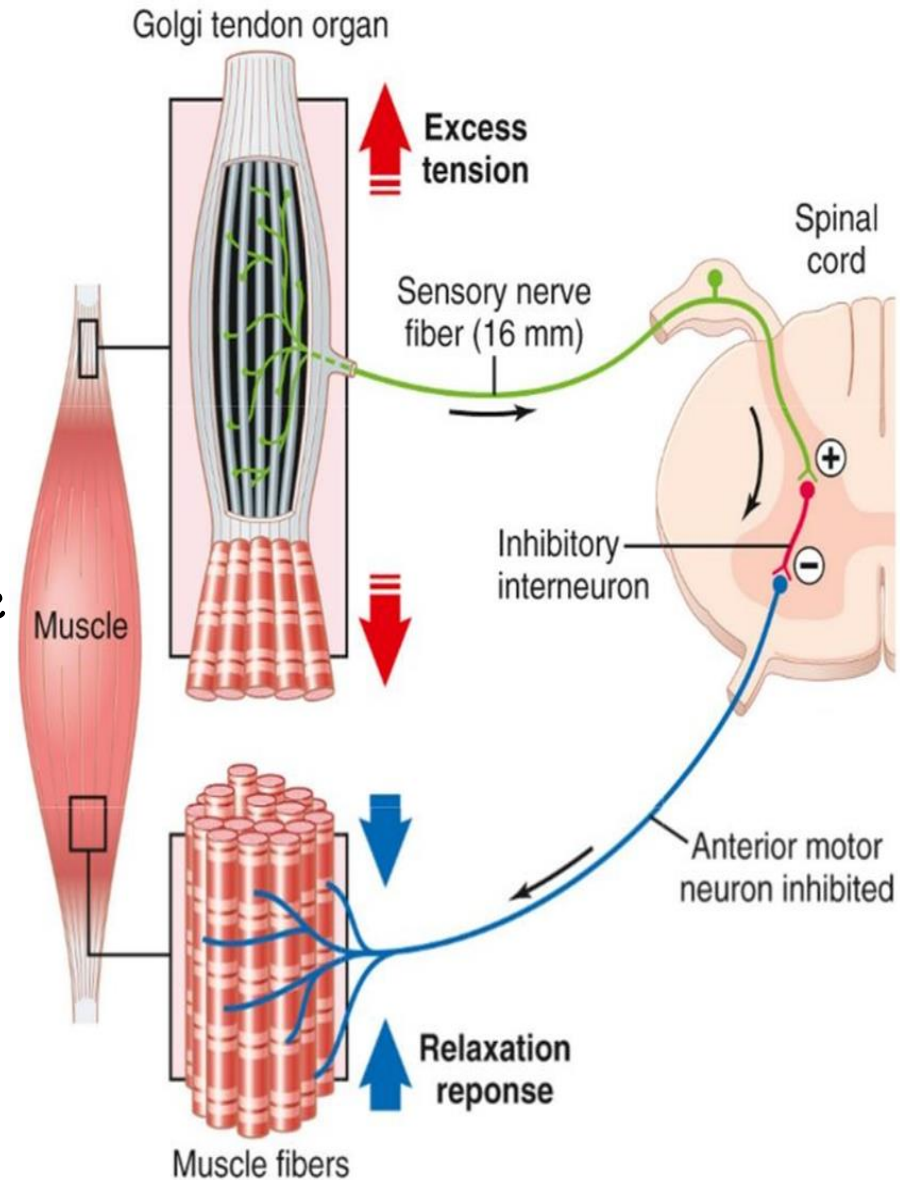
- Stimulated by ↑ed muscle tension caused by **passive overstretch** or **active contraction** of the muscle
- Afferents:
- Ib fibers

## Center (spinal cord) :

- a) inhibitory interneurons → inhibit the α-MNs supplying the same muscle
- b) excitatory interneurons → excite the α-MNs supplying the antagonistic muscle

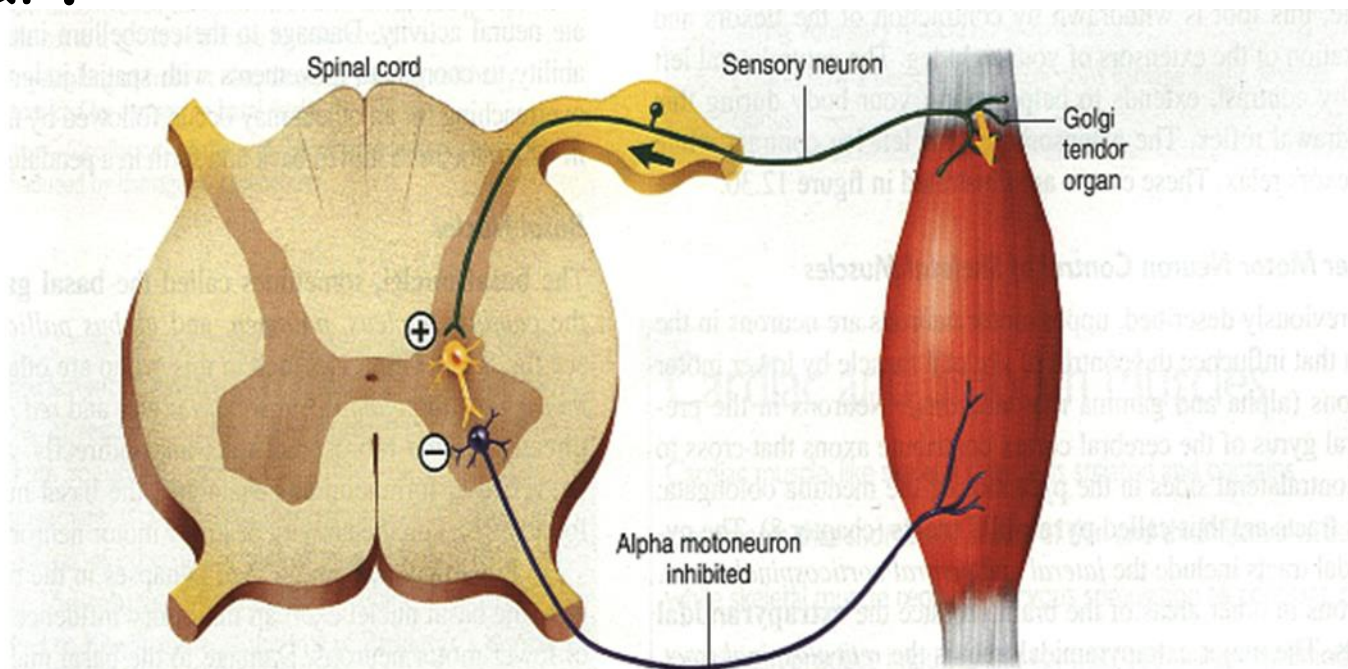
## Response:

- Relaxation of the same muscle
- Contraction of antagonistic group of muscles.



# Significance

- This reflex protects muscle from rupture & tendon from avulsion and tear.



The action of the Golgi tendon organ. An increase in muscle tension stimulates the activity of sensory nerve endings in the Golgi organ. This sensory input stimulates an interneuron, which in turn inhibits the activity of a motor neuron innervating that muscle.

# Comparison Between Stretch & Inverse Reflexes-1

	Stretch reflex	Inverse stretch reflex
STIMULUS	Increased muscle length	Increased muscle tension
RESPONSE	Muscle contraction	Muscle relaxation
RECEPTORS	Muscle spindles	Golgi tendon organs
AFFERENTS	<i>Type Ia &amp; II fibers</i>	Type Ib fibers

# Comparison Between Stretch & Inverse Reflexes-2

	STRETCH REFLEX	INVERSE STRETCH REFLEX
SYNAPSES	Mono-synaptic	polysynaptic
RECEPROCAL INNERVATION	<b><i>Inhibit</i></b> antagonists through inhibitory interneurons	<b><i>Excites</i></b> antagonistic muscles through excitatory interneurons
PHYSIOLOGICAL SIGNIFICANCE	Regulation of muscle <b><u>length</u></b> Genesis of muscle tone	Regulation of muscle <b><u>tension</u></b> Prevent excessive increase in muscle tension )protective role(
CLINICAL ASSESSMENT	Sudden tap of muscle causes brisk contraction muscle jerk	Overstretch of muscle- sudden muscle relaxation (lengthening reaction(



**THANK YOU**

