NeuroPsychiatry Block

جامعة الملك سعود
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Stretch Reflex & Golgi Tendon Reflex

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NeuroPsychiatry Block

Chapter 55

Motor Functions of the Spinal Cord, The cord Reflexes

(Guyton & Hall)

Chapter 3

Neurophysiology

(Linda Costanzo)

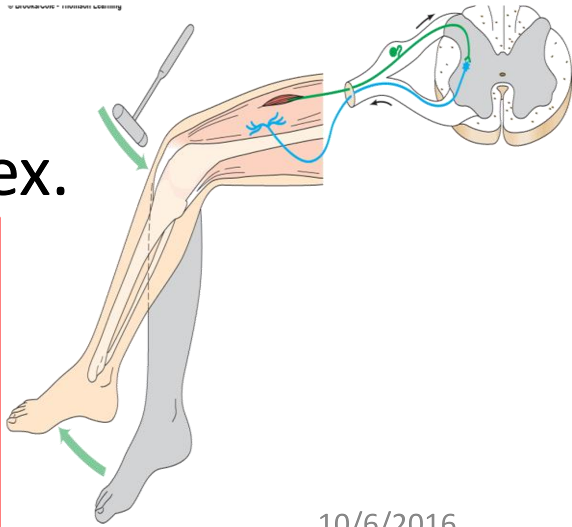
Objectives

By the end of this lecture students are expected to:

- Describe the components of stretch reflex and Golgi tendon reflex
- Differentiate between the functions of muscles spindles and Golgi tendon organ
- Explain the roles of **alpha** and **gamma** motor neurons in the stretch reflex
- Discuss the spinal and supraspinal regulation of the stretch reflex

What is a Stretch Reflex?

- It is a **monosynaptic** reflex (also known as **myotatic** reflex)
- Is a **reflex contraction** of muscle resulting from stimulation of the **muscle spindle (MS)** by **stretching** the whole muscle
- **Muscle spindle** is the sensory receptor that detects change in muscle length
- The classic example of the stretch reflex is the **patellar-tendon** or **knee jerk** reflex.



What is the significance of stretch reflexes?

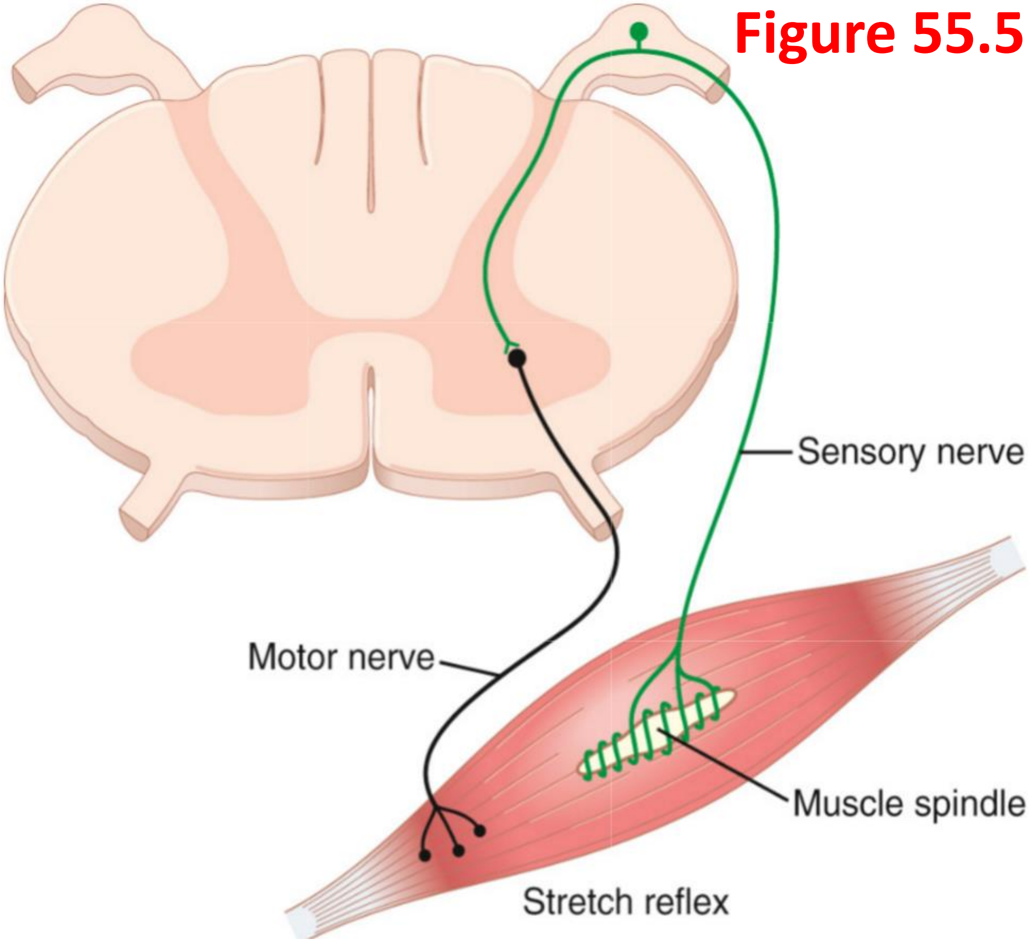
- They help maintain a normal posture
- They function to **oppose sudden changes in muscle length**

Components of the Stretch Reflex Arc

Stretch reflex is a deep monosynaptic reflex and its components are:

1. **Sensory receptor (muscle spindles)**
2. **Sensory neuron (group Ia and group II afferents)**
3. **Integrating center (spinal cord)**
4. **Motor neurons (α- and γ-spinal motor neurons)**
5. **Effector (the same muscle (homonymous) of muscle spindles)**

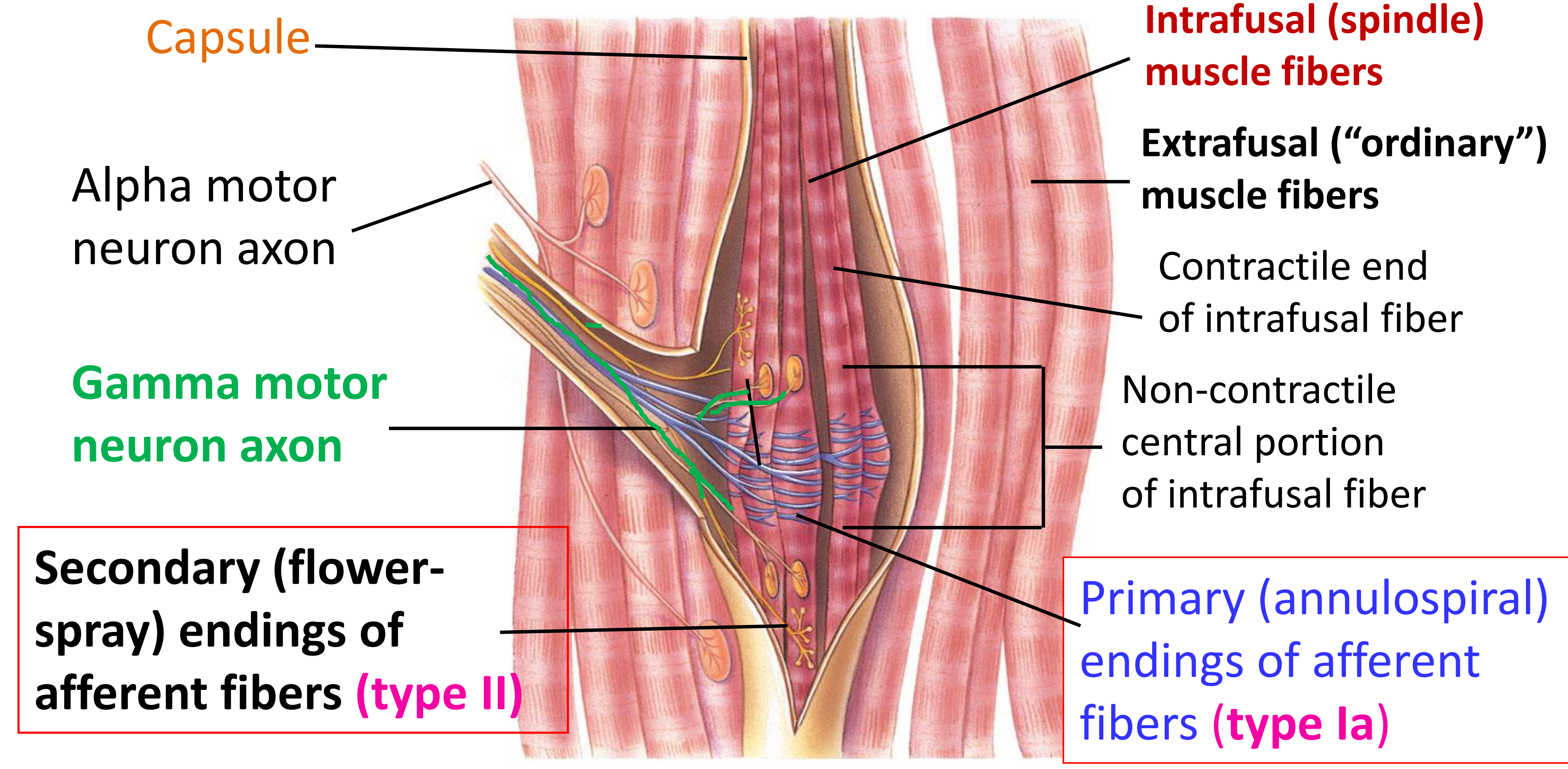
Figure 55.5



This reflex is the simplest; it involves only 2 neurons & one synapse,

Structure of Muscle Spindles-1

- Distributed throughout the belly 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.



Structure of Muscle Spindles-2

Muscle spindle has 2 types of intrafusal fibres:

1-Nuclear bag fibres:(2-3 per spindle); have muscle fiber **nuclei** arranged in the central area (**bag**)

2-Nuclear chain fibres:(3-9 per spindle); thinner/shorter and have **nuclei** aligned in a chain

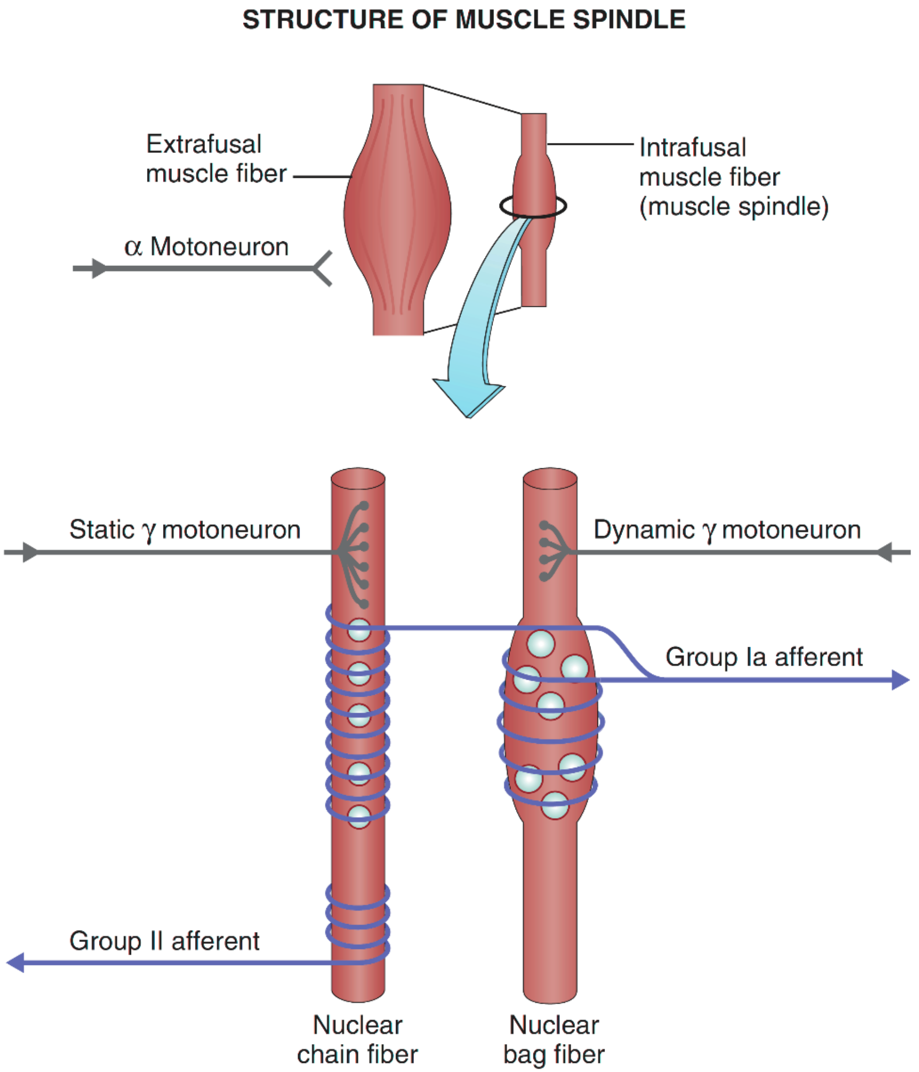


Figure 3–31 (Costanzo)

Innervation of the Muscle Spindle

Muscle spindle has Afferent & Efferent nerve fibers

A. Muscle Spindle Afferents:

- Central receptor area of the intrafusal fibres is supplied by **2 types** of afferent fibres:
  - **Group Ia**
  - **Group II**
- They terminate directly on **α-motor neurons** supplying the extra-fusal fibers of the same (**homonymous**) muscle.

B. Muscle Spindle Efferents:

- **Gamma (γ-) motor neurons**

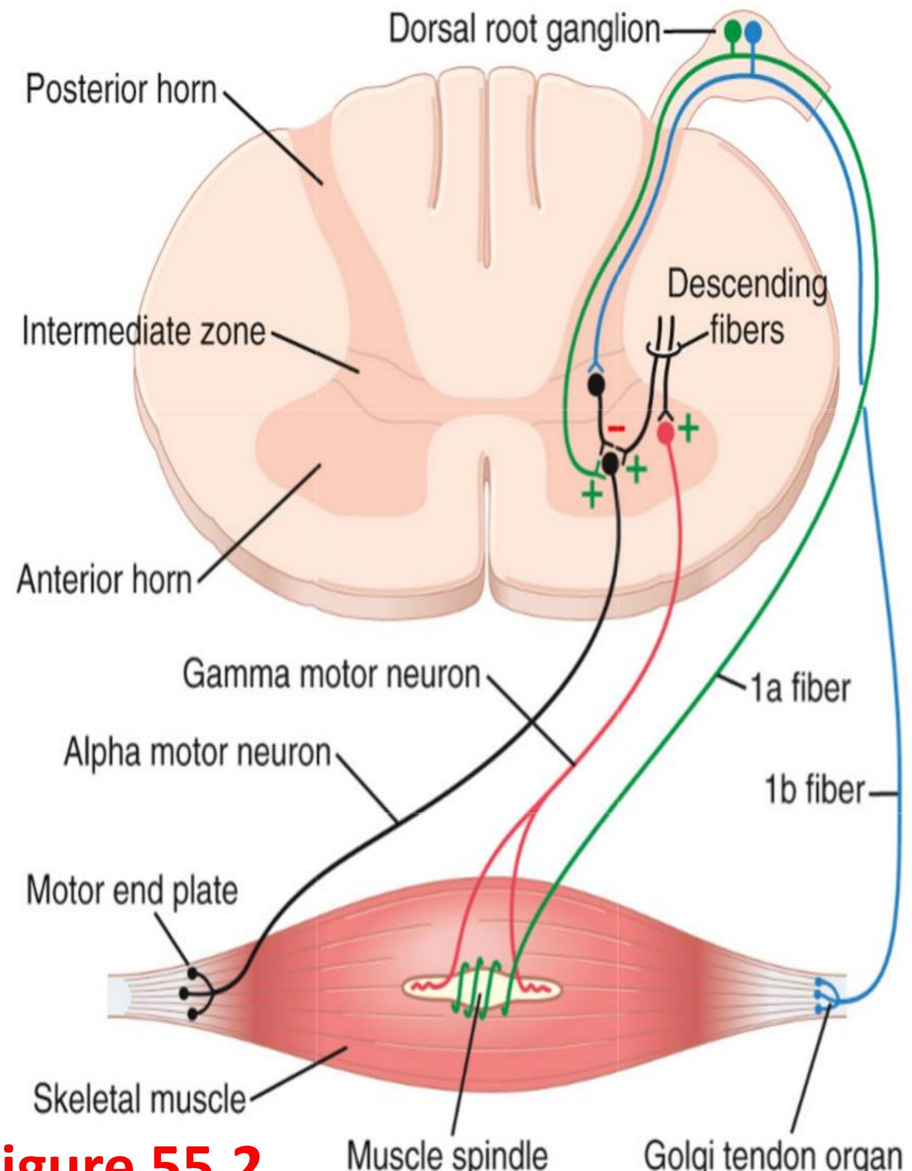


Figure 55.2

1. Afferent Innervation: Group Ia

- Group Ia endings 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
- They signal the rate or velocity of change in muscle length

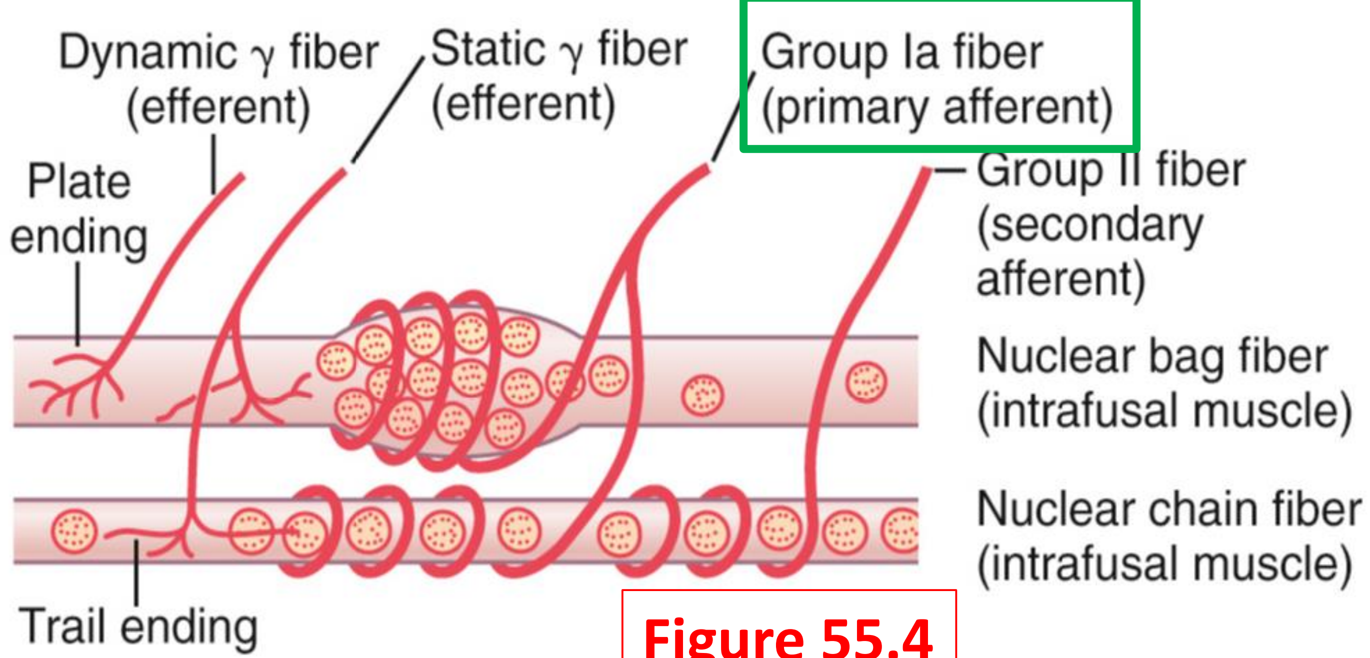


Figure 55.4

2. Afferent Innervation: Group II

- They innervate the central area of the nuclear chain fibres, but not the nuclear bag fibers
- They are thinner and slower than group Ia fibers
- Discharge throughout the period of muscle stretch (static response)

Group II afferents signal mainly muscle length

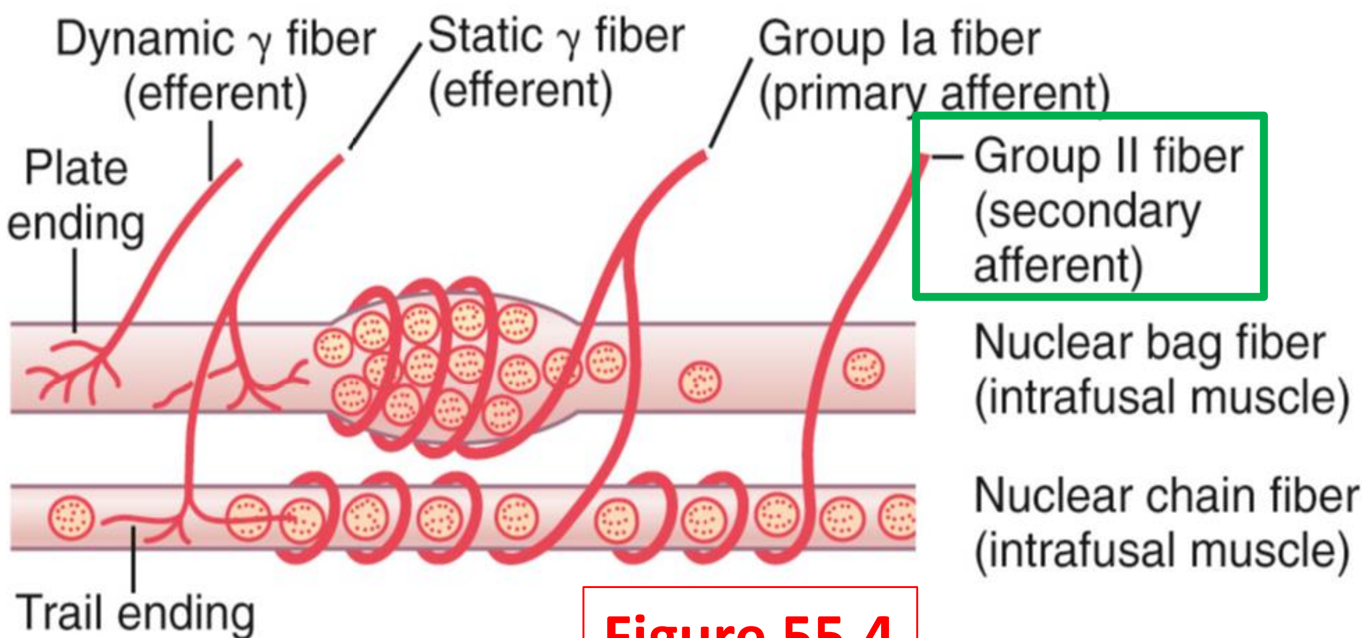


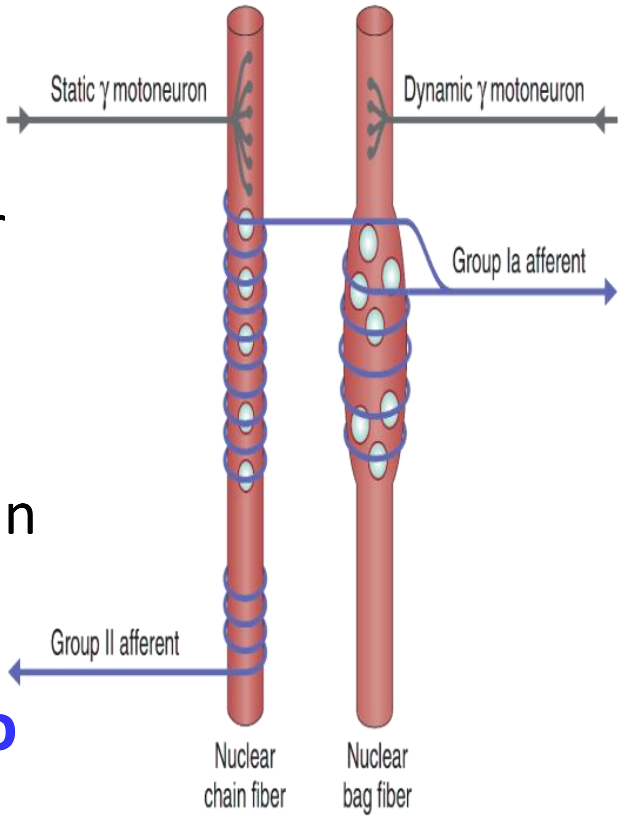
Figure 55.4

Efferent Innervation of Muscle Spindle

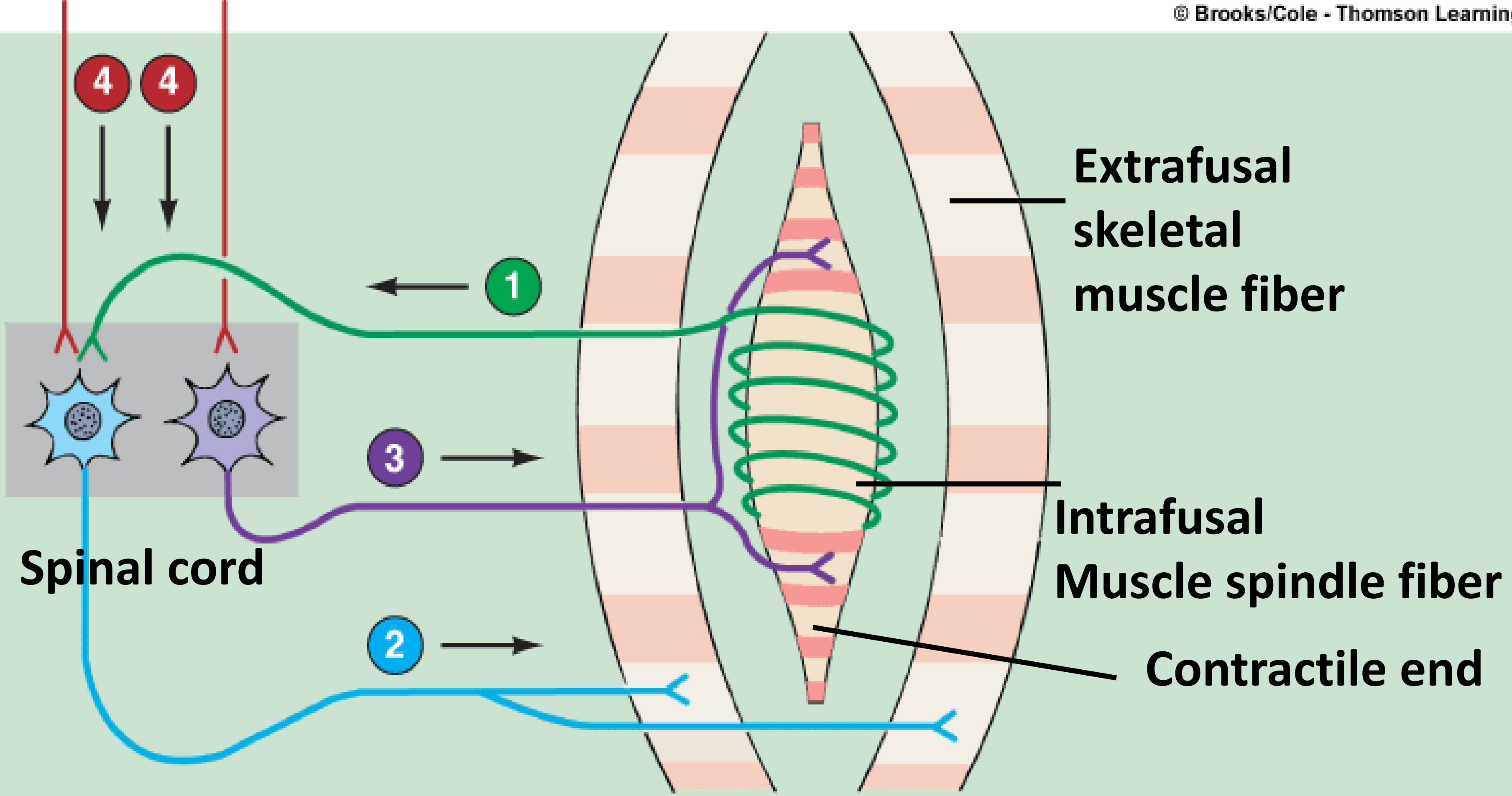
- Gamma (γ) efferent endings terminate on the peripheral contractile parts of the intrafusal muscle fibres as:

  - **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 γ- motor neurons is to regulate the sensitivity of the intrafusal muscle fibers, but HOW?**



(1) Afferent input from sensory endings of muscle spindle fiber

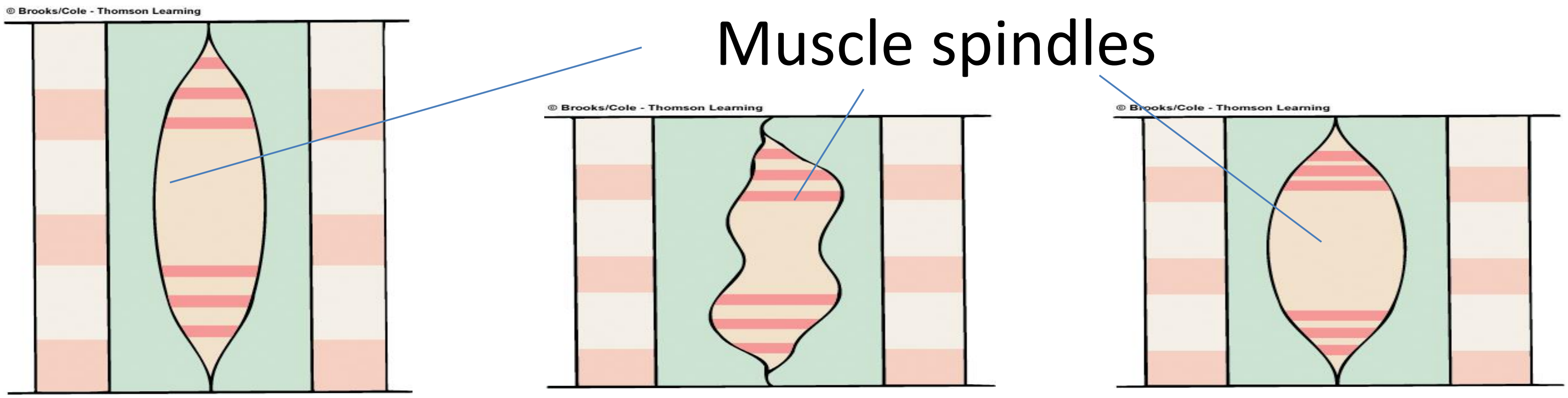
(2) Alpha motor neuron output to regular skeletal-muscle fiber

(1) → (2) Stretch reflex pathway (Arc)

(3) γ-motorneuron output to the contractile end of spindle fiber

(4) Descending pathways co-activate α- and γ- motor neurons ???

Co-activation of α- and γ- Motor Neurons



A. Relaxed muscle: spindle fiber sensitive to stretch of muscle

B. Contracted muscle in hypothetical situation of no spindle coactivation; **slackened** spindle fiber **not sensitive to stretch of muscle**

C. Contracted muscle in normal situation of spindle coactivation; contracted spindle fiber **sensitive to stretch of muscle**

What is the significance of this coactivation?

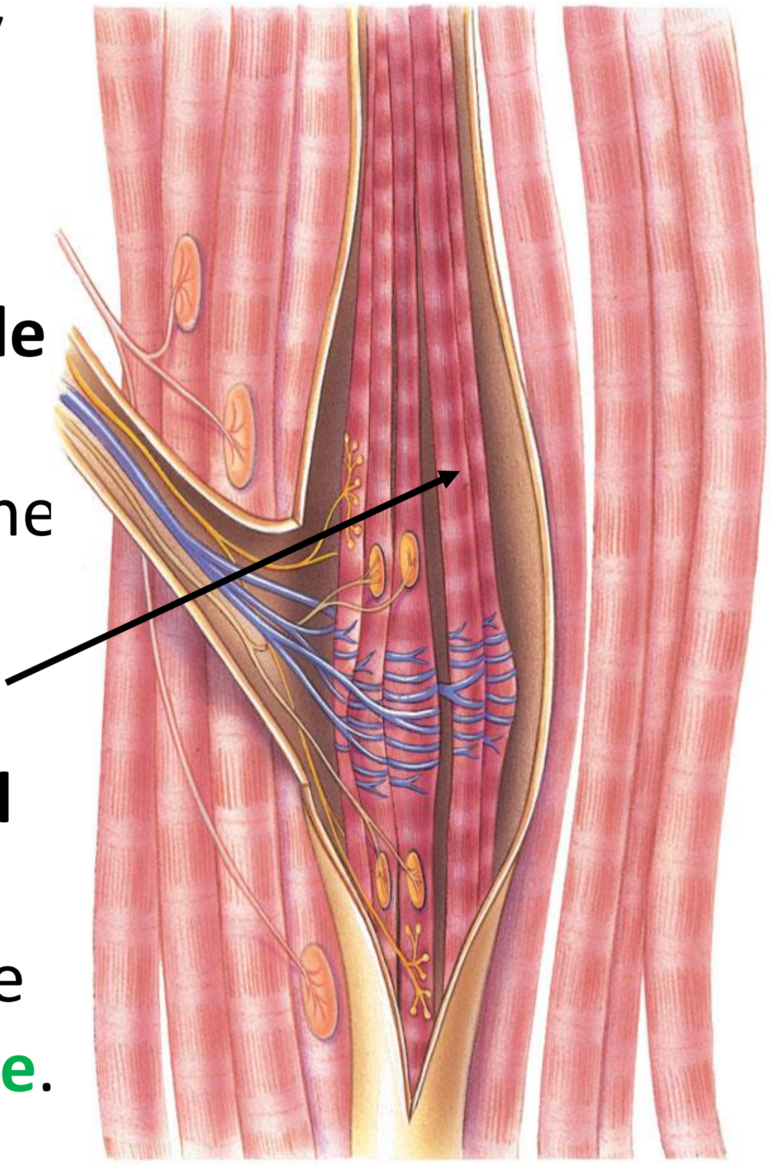
- Regulate the sensitivity of the spindle by keeping its length constant
- Oppose sudden changes in muscle length

How Are Muscle Spindles Activated?

- Muscle spindles are stimulated by **stretching of their mid-portion**.
- They can be excited in two ways:

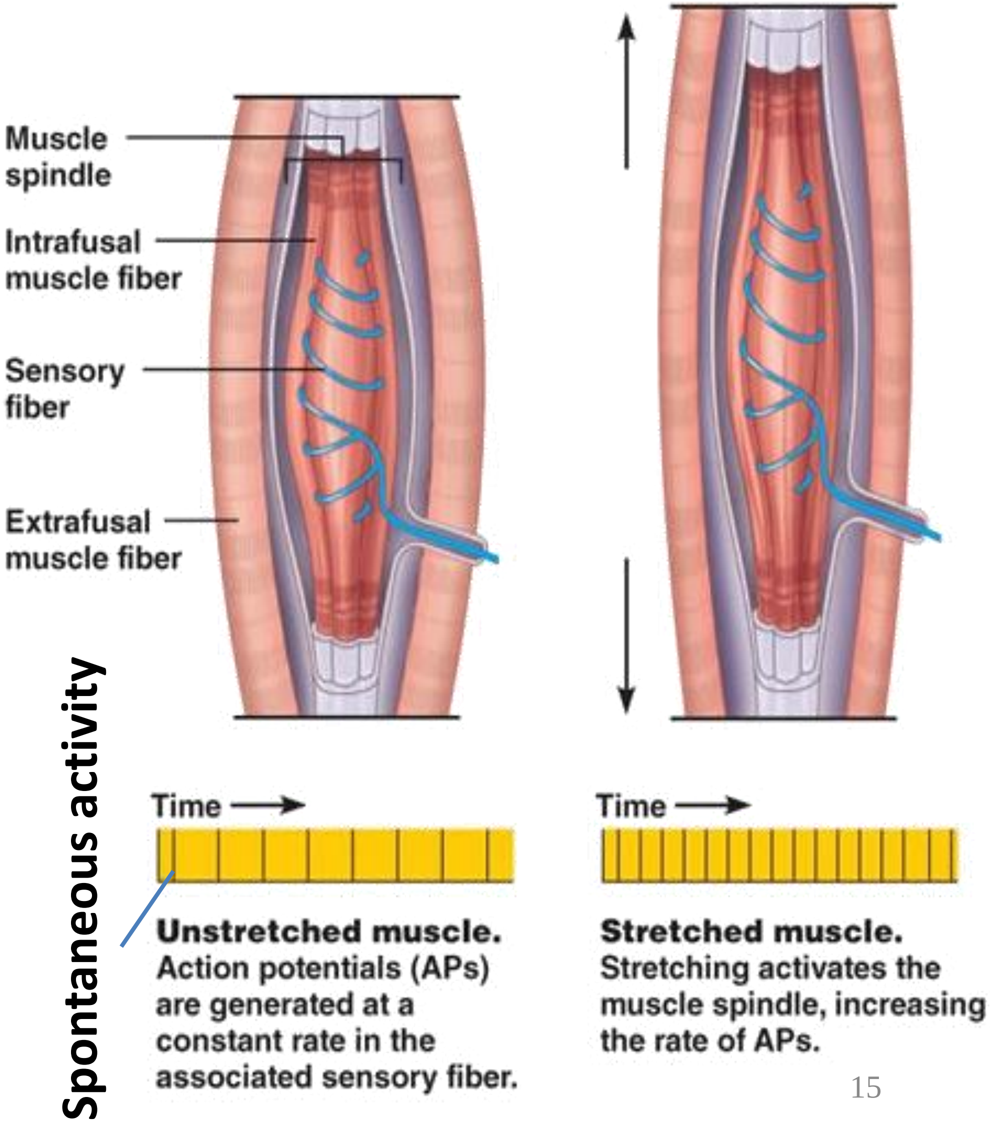
1. **Lengthening of the whole muscle** which stretches the mid-portion of the spindle and, therefore excites the receptor.

2. **Contraction of the contractile portions of the spindle's intra-fusal fibers** which stretches the mid-portions of the spindle & excites the receptor during **γ-efferent discharge**.



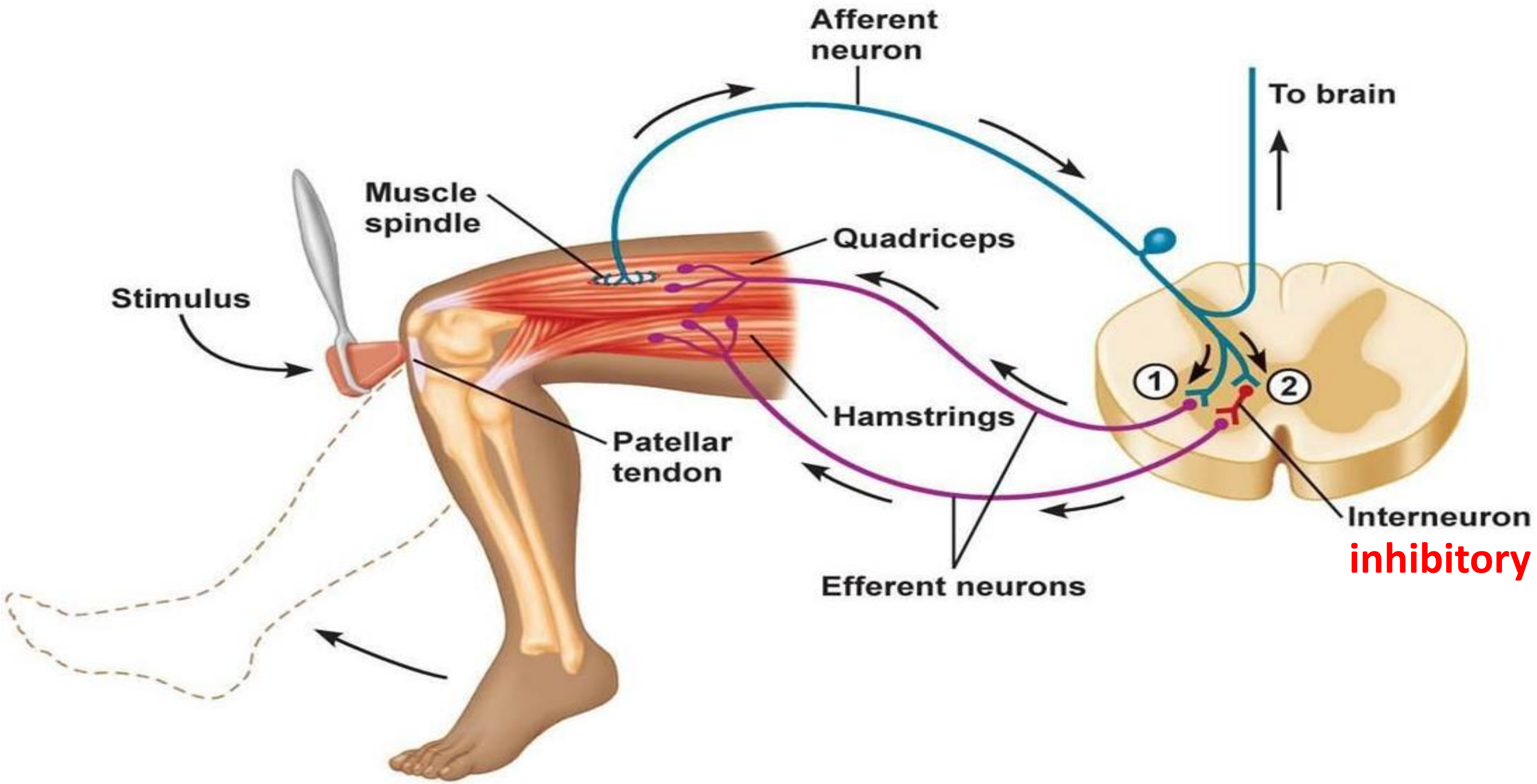
How Muscle Stretch Is detected

- Normally, **MS** discharges continuously (**spontaneous activity**)
- Stretching the MS **increases** the rate of firing (**positive signal to the brain**)
- Shortening the spindle **decreases** the rate of firing (**negative signal**)
- **The number of APs sent are proportional to the stretched length of the muscle (important concept)**

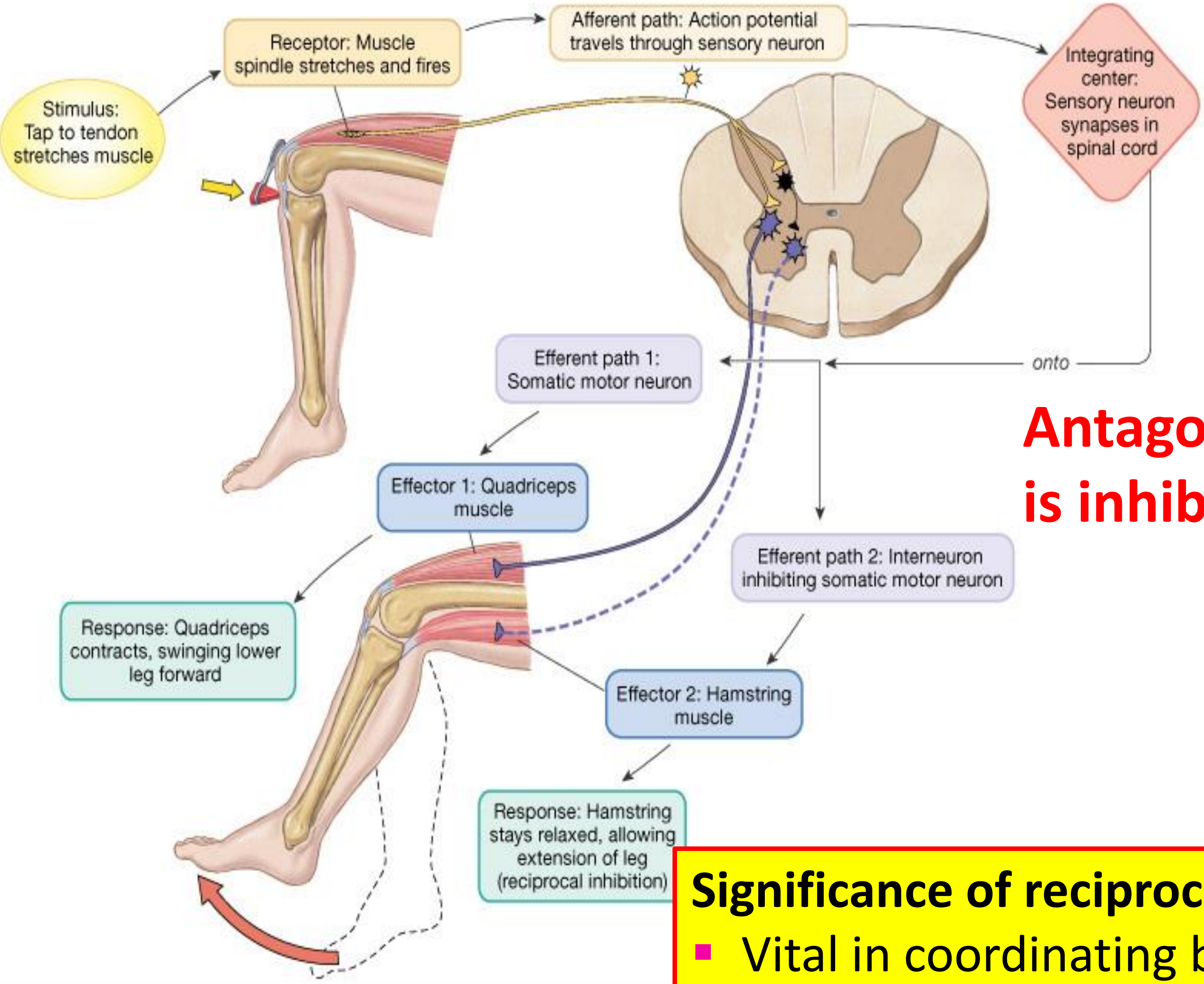


Stretch Reflexes: Knee Jerk Reflex

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



Knee Jerk Reflex & Reciprocal Inhibition

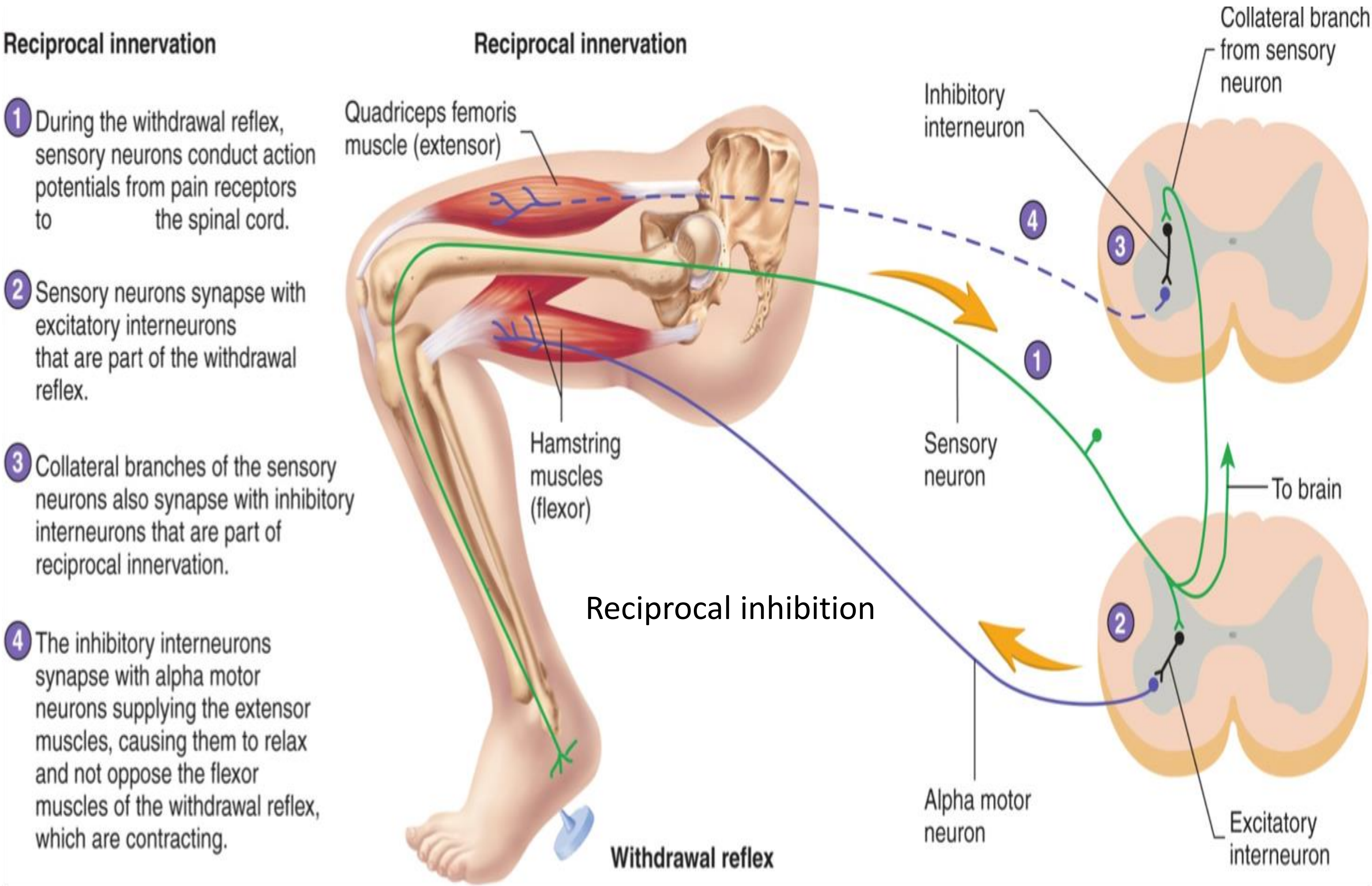


Antagonistic muscle is inhibited

Significance of reciprocal Inhibition:

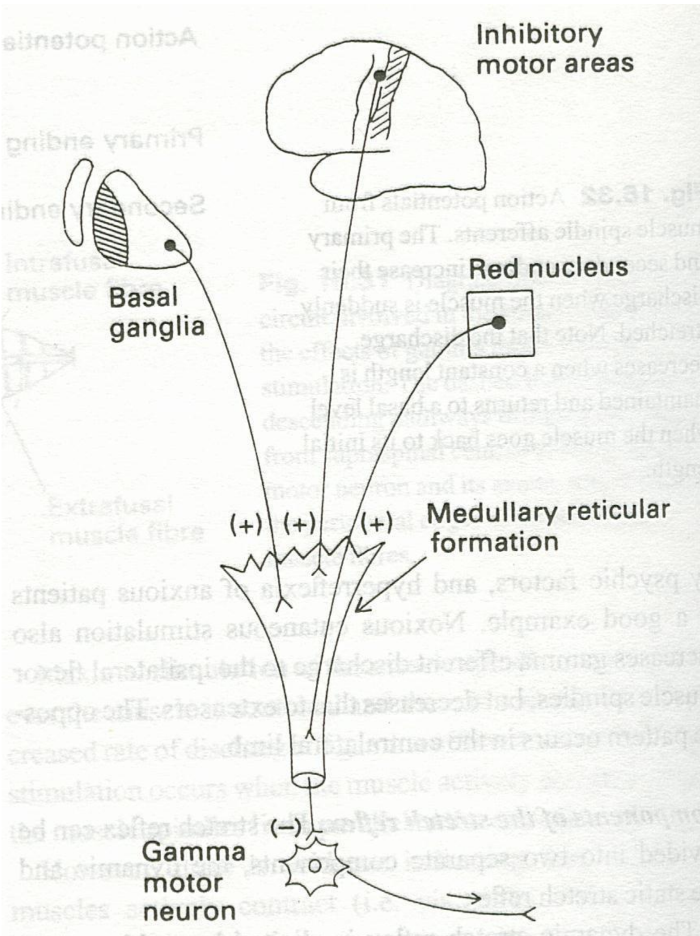
- Vital in coordinating body movements

Reciprocal inhibition

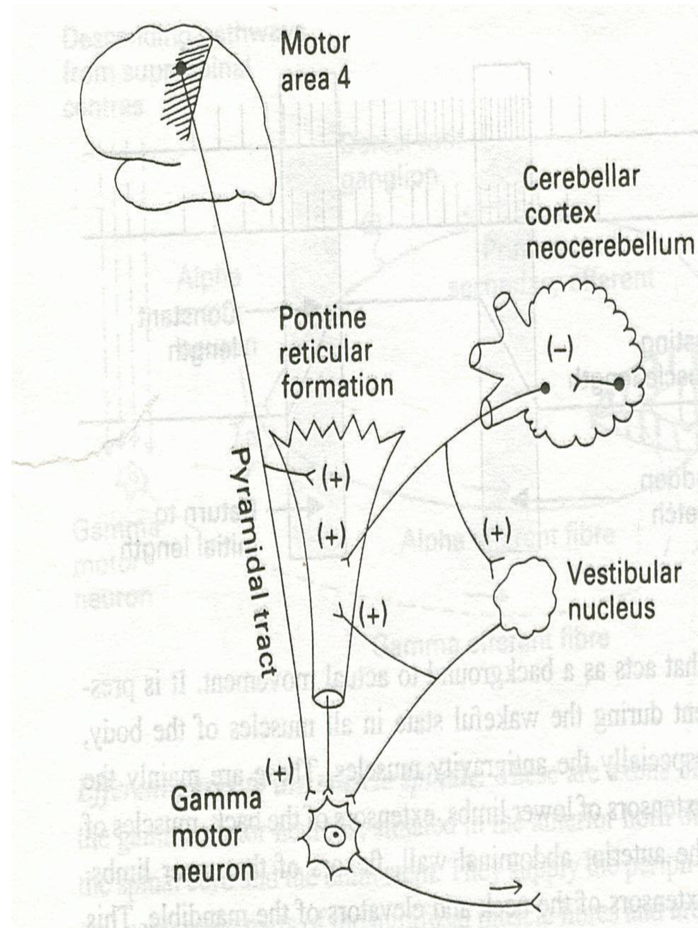


Supraspinal Regulation of the Stretch Reflex

Inhibitory supra-spinal centers to γ-motor neurons



Facilitatory supra-spinal centers to γ-motor neurons



Factors that Influence Stretch Reflex

Stretch reflex can be modulated (enhanced or inhibited) by several factors all of which act on gamma motor neurons

Facilitaion

- Suprspinal
  - Primary motor cortex
  - Vestibular nucleus
  - Pontine RF (bulboreticular)
  - Neocerebellum
- Anxiety
- Noxious painful stimuli
- Jendrassik-manuver

Inhibition

- Supraspinal
  - Inhibitory motor cortical area
  - Basal ganglia
  - Medullary RF
  - Paleocerebellum
- Excessive stretch of muscle (Golgi tendon reflex)

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

Golgi Tendon Reflex (Inverse Stretch Reflex)-1

- Is a **disynaptic reflex** (also called **inverse stretch reflex**).
- The sensory receptor is **Golgi tendon organ,** which is a netlike collections of nerve endings (**group Ib**) in a tendon
- The afferent fibers are entwined within bundles of connective tissue fibers that make up the tendon
- **Transmit information about tendon tension or rate of change of tension.**

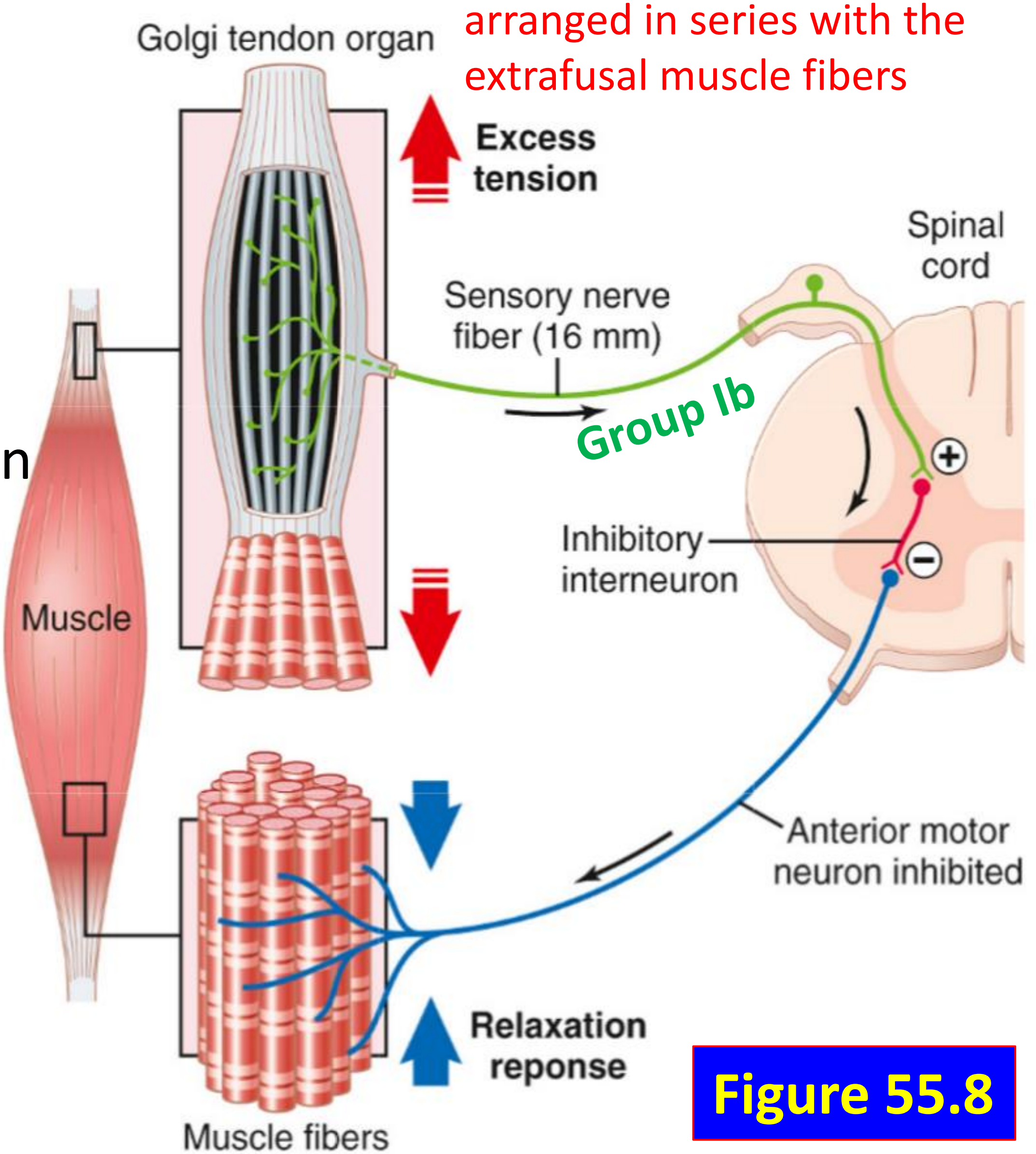
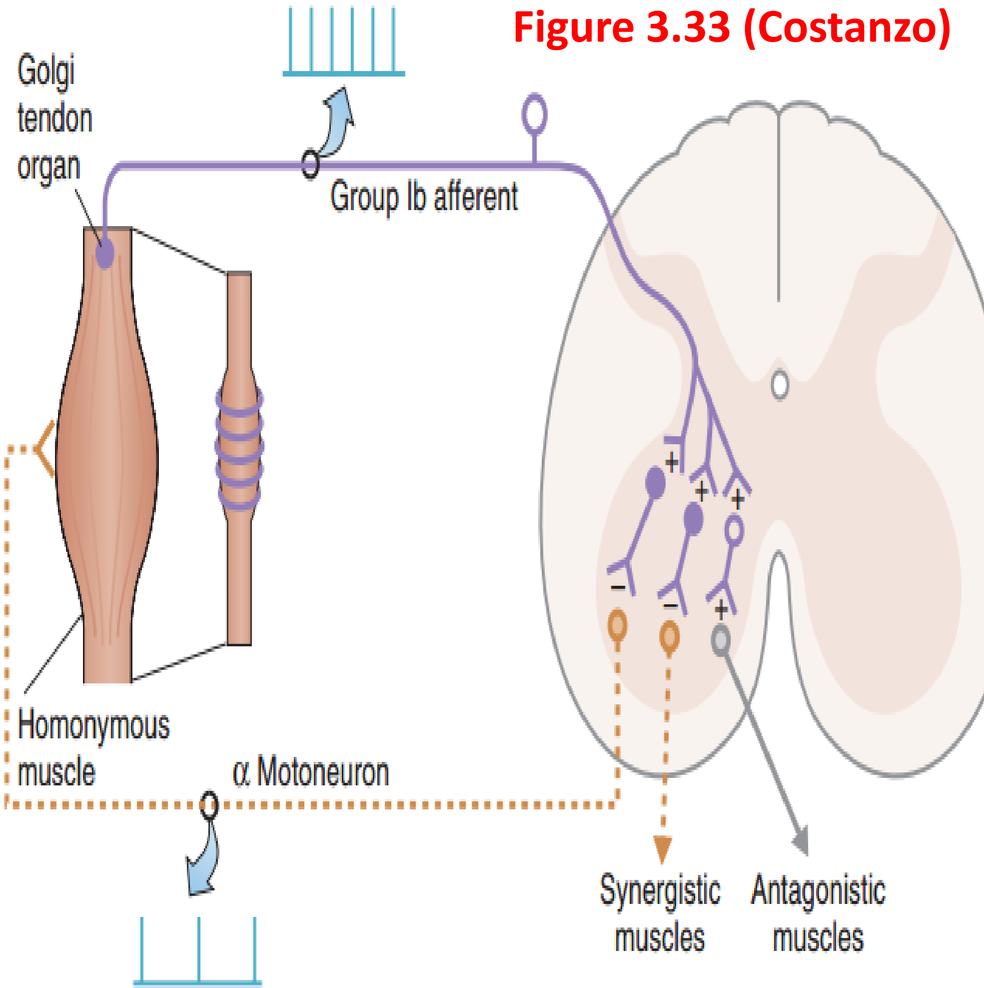


Figure 55.8

Golgi Tendon Reflex (Inverse Stretch Reflex)-2

- It is called **inverse stretch reflex** because it is **the inverse** of stretch reflex
- It is initiated by an increase in **muscle tension**
- This activates **Goup Ib** nerve fibers in Golgi tendon organ
- The sensory input activates an **inhibitory interneuron** in the spinal cord
- This interneuron inhibits the activity of motor neuron innervating the same muscle causing **muscle relaxation**

Figure 3.33 (Costanzo)



✓ **Antagonist muscle is activated via excitatory interneuron**

What is the Significance of the Inverse Stretch Reflex?

- It is a protective spinal reflex that halts further contraction and brings about sudden muscle relaxation when the muscle tension becomes great enough
- It serves to prevent damage to the tendon due to the muscle pulling too hard on it
- The inverse stretch reflex is therefore damping down the effect of the stretch reflex
- **Thus it protects muscle from rupture and tendon from tear**

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	*Type Ia & II fibers*	Type *Ib* fibers

Comparison Between Stretch & Inverse Reflexes-2

	STRETCH REFLEX	INVERSE STRETCH REFLEX
SYNAPSES	Mono-synaptic	Di-synaptic
RECEPROCAL INNERVATION	***Inhibit*** antagonists through inhibitory interneurons	*Excites* antagonistic muscles through excitatory interneurons
PHYSIOLOGICAL SIGNIFICANCE	Regulation of muscle **length** Genesis of muscle tone	Regulation of muscle tension 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
Any Questions
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