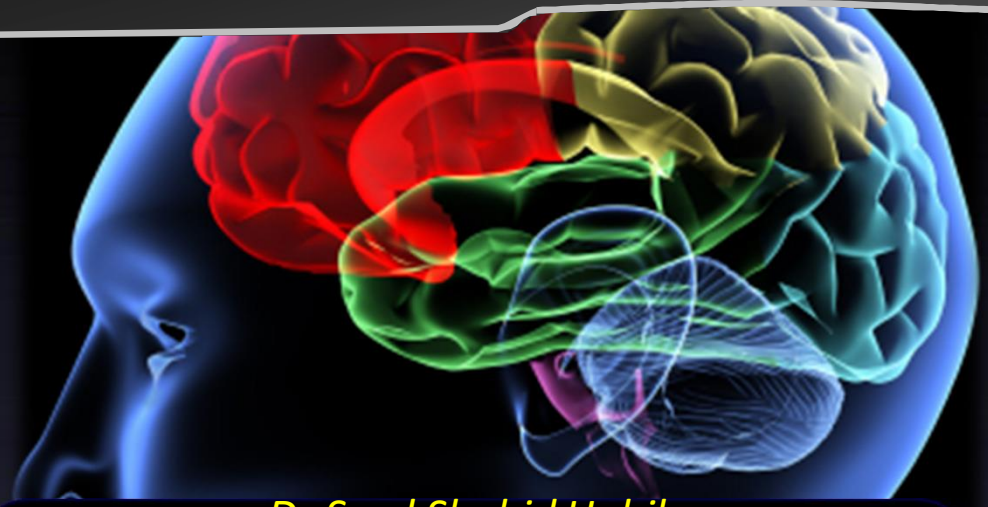
Stretch reflex and tendon jerks



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OBJECTIVES

At the end of this lecture the student should be able to :

(1)be able to describe a stretch reflex .

(2) be able to explain what is muscle tone

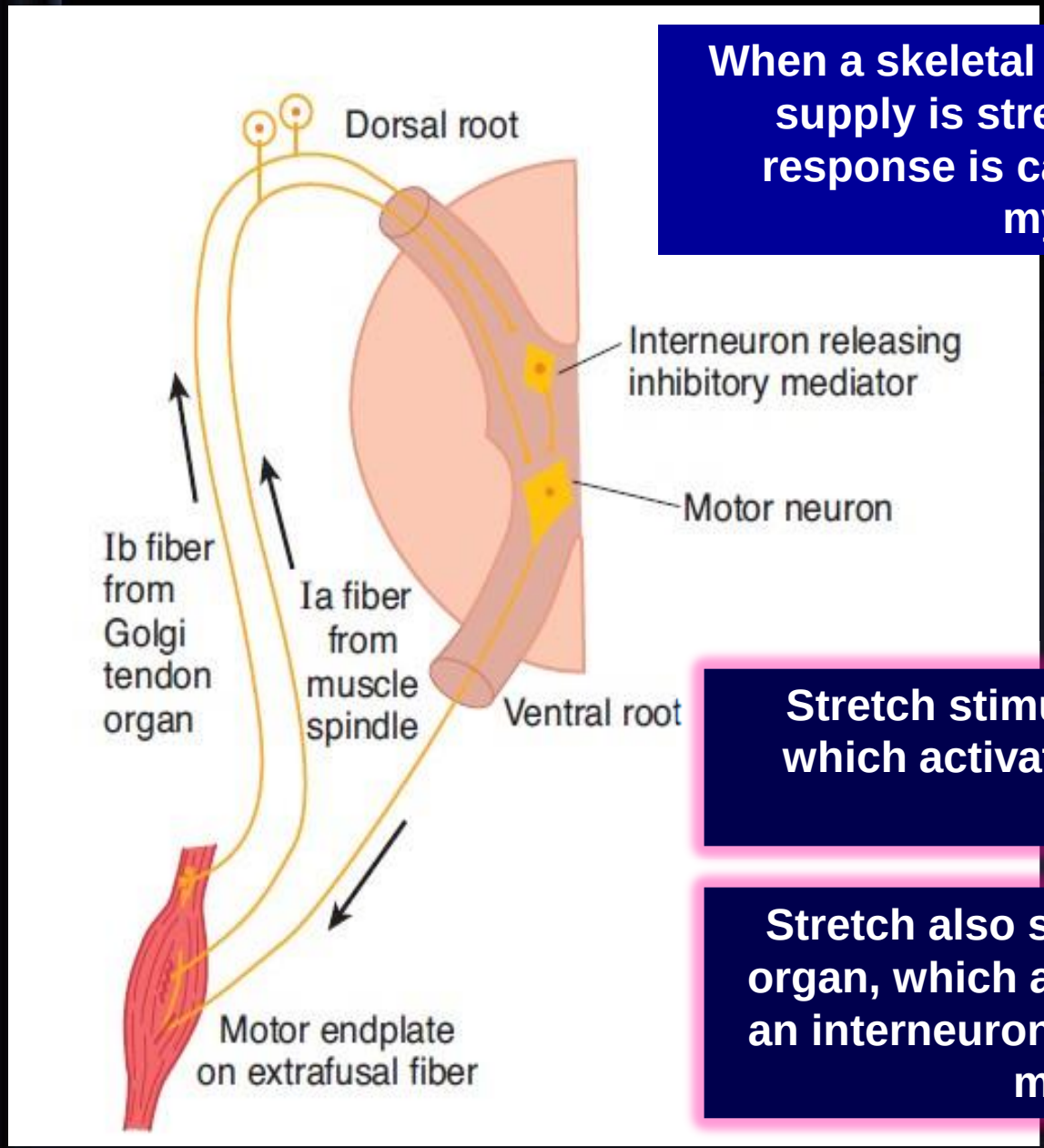
(3)describe the structure , innervations and function of the muscle spindle .

(4) explain what is meant by static and dynamic stretch reflex .

(5)describe the spinal and supraspinal regulation of the stretch reflex .

(6) describe the inverse stretch reflex and its function

WHAT IS STRETCH REFLEX?



When a skeletal muscle with an intact nerve supply is stretched, it contracts. This response is called the stretch reflex or myotatic reflex.

Stretch stimulates the muscle spindle, which activates Ia fibers that excite the motor

Stretch also stimulates the Golgi tendon organ, which activates Ib fibers that excite an interneuron that releases the inhibitory mediator glycine

MUSCLE SENSORY RECEPTORS

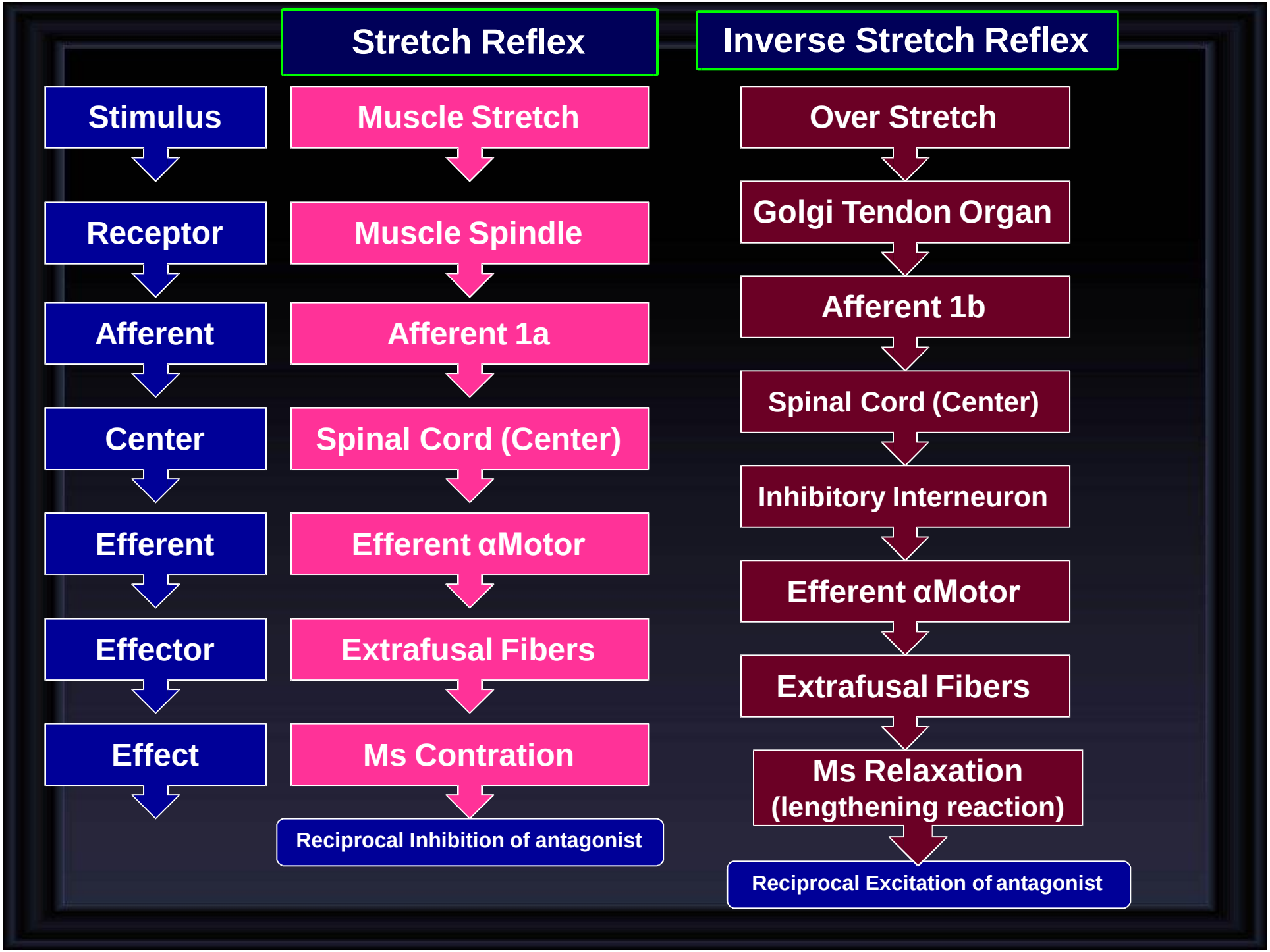
MUSCLE SPINDLES AND GOLGI TENDON ORGANS

Proper control of muscle function requires not only excitation of the muscle by spinal cord anterior motor neurons but also continuous feedback of sensory information from each muscle to the spinal cord, indicating the functional status of each muscle at each instant

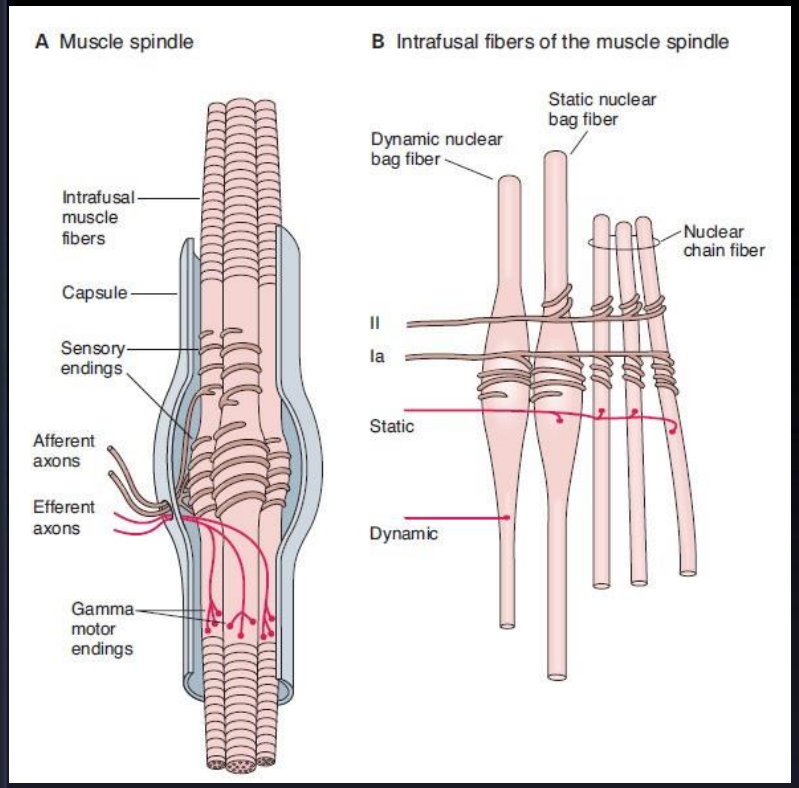
1. **what is the length of the muscle?**
2. **what is its instantaneous tension?**
3. **how rapidly is its length or tension changing?**

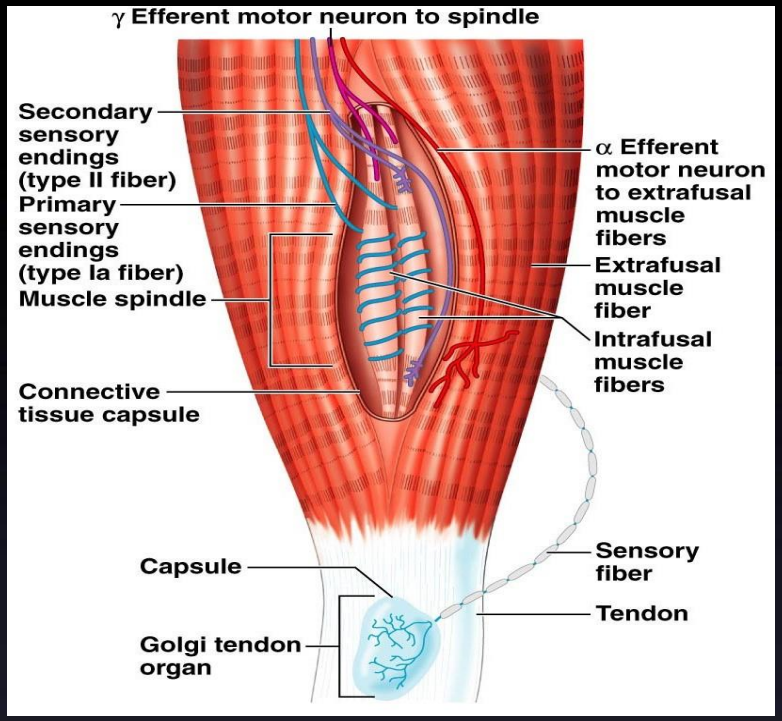
Entirely for the purpose of intrinsic muscle control and operate almost completely at a subconscious level

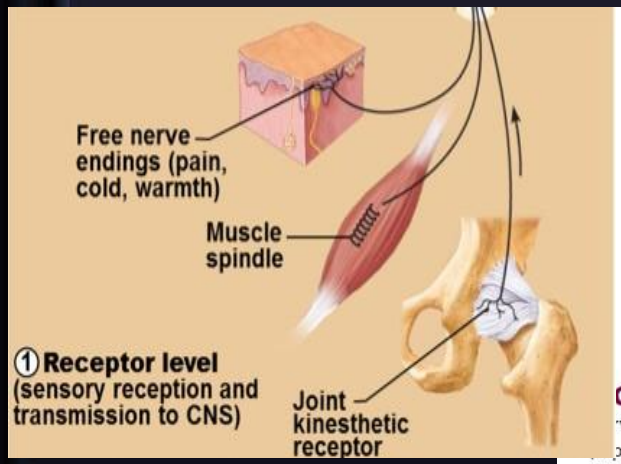
Continuous Discharge of the Muscle Spindles Under Normal Conditions to maintain tone

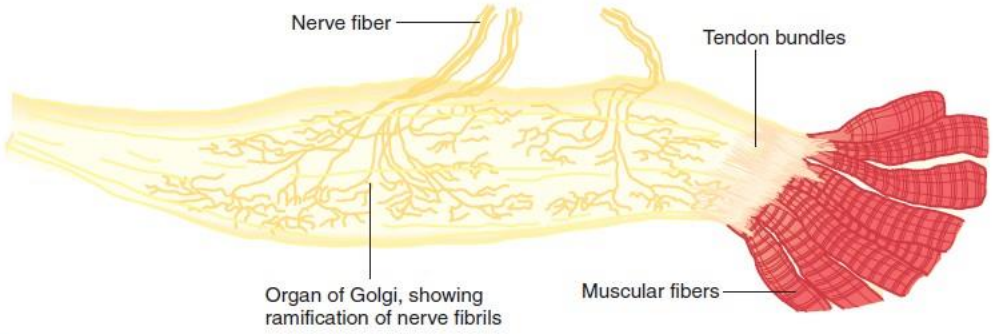

Stretch Reflex
Inverse Stretch Reflex
Stimulus
Muscle Stretch
Over Stretch
Receptor
Muscle Spindle
Golgi Tendon Organ
Afferent
Afferent 1a
Afferent 1b
Center
Spinal Cord (Center)
Spinal Cord (Center)
Efferent
Efferent αMotor
Inhibitory Interneuron
Effector
Extrafusal Fibers
Efferent αMotor
Effect
Ms Contration
Extrafusal Fibers
Ms Relaxation
(lengthening reaction)
Reciprocal Inhibition of antagonist
Reciprocal Excitation of antagonist

Structure of Proprioceptors









GURE 12–5 **Golgi tendon organ.** This organ is the receptor for the inverse stretch reflex and consists of a netlike collection of knobby ve endings among the fascicles of a tendon. The innervation is the Ib group of myelinated, rapidly conducting sensory nerve fibers.
oduced with permission from Gray H [editor]: *Gray's Anatomy of the Human Body,* 29th ed. Lea & Febiger, 1973.)

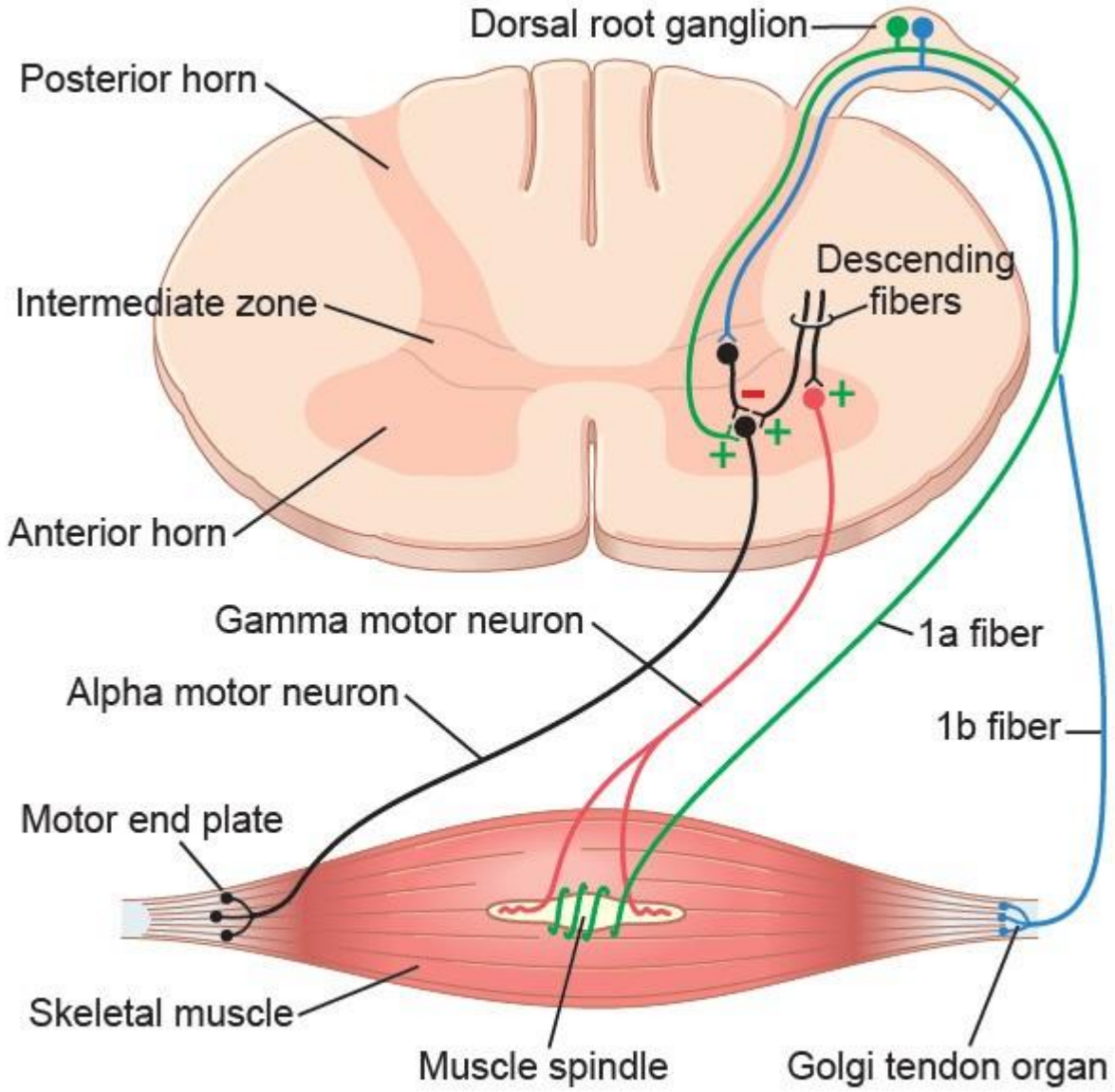
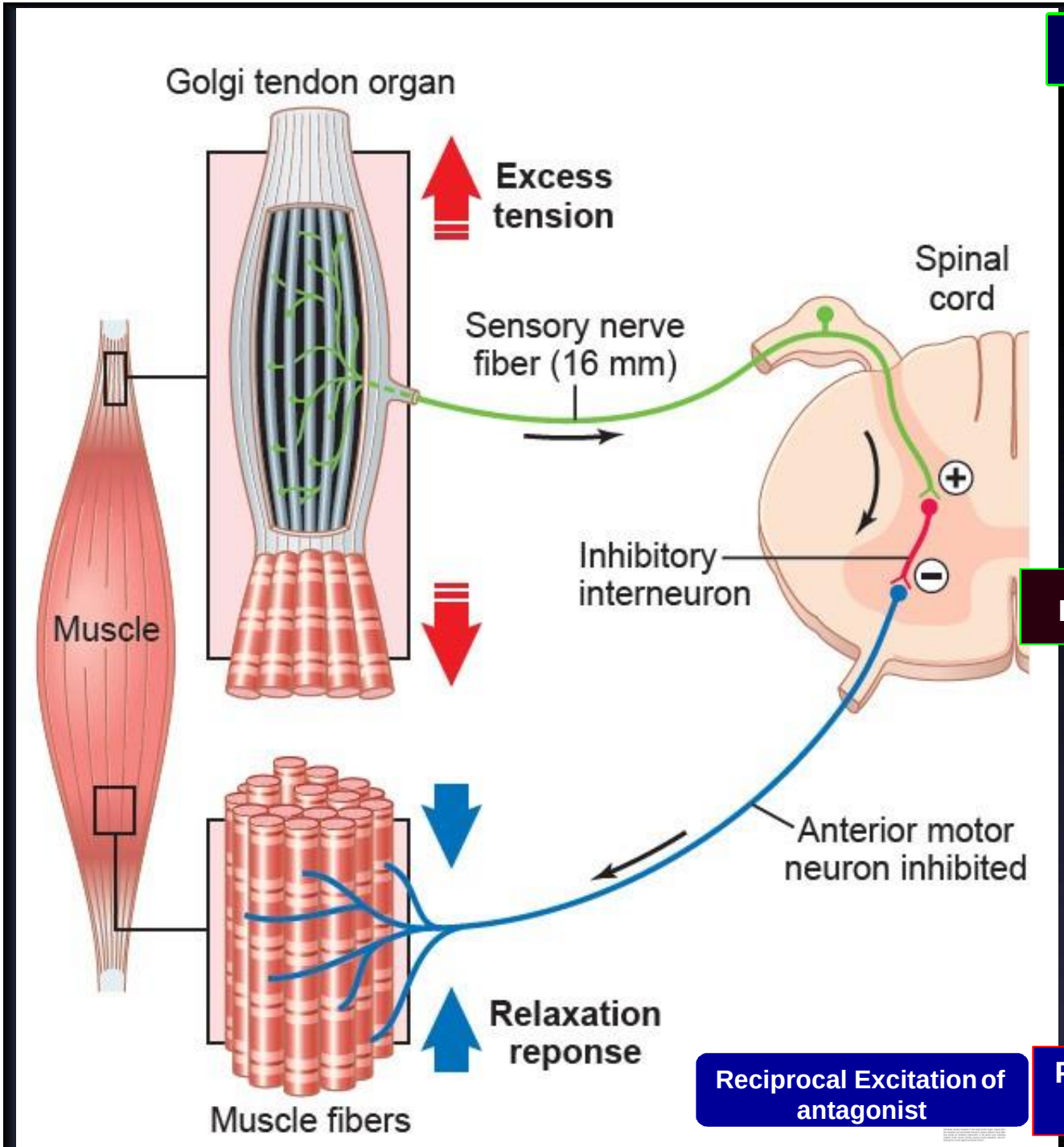


Figure 55-2. Peripheral sensory fibers and anterior motor neurons innervating skeletal muscle.

Stretch reflex

- Muscle Stretch
- Muscle Spindle
- Afferent 1a
- Spinal Cord (Glutamate)
- Efferent αMotor
- Extrafusal Fibers
- Ms Contration

Reciprocal Inhibition of antagonist



inverse stretch reflex

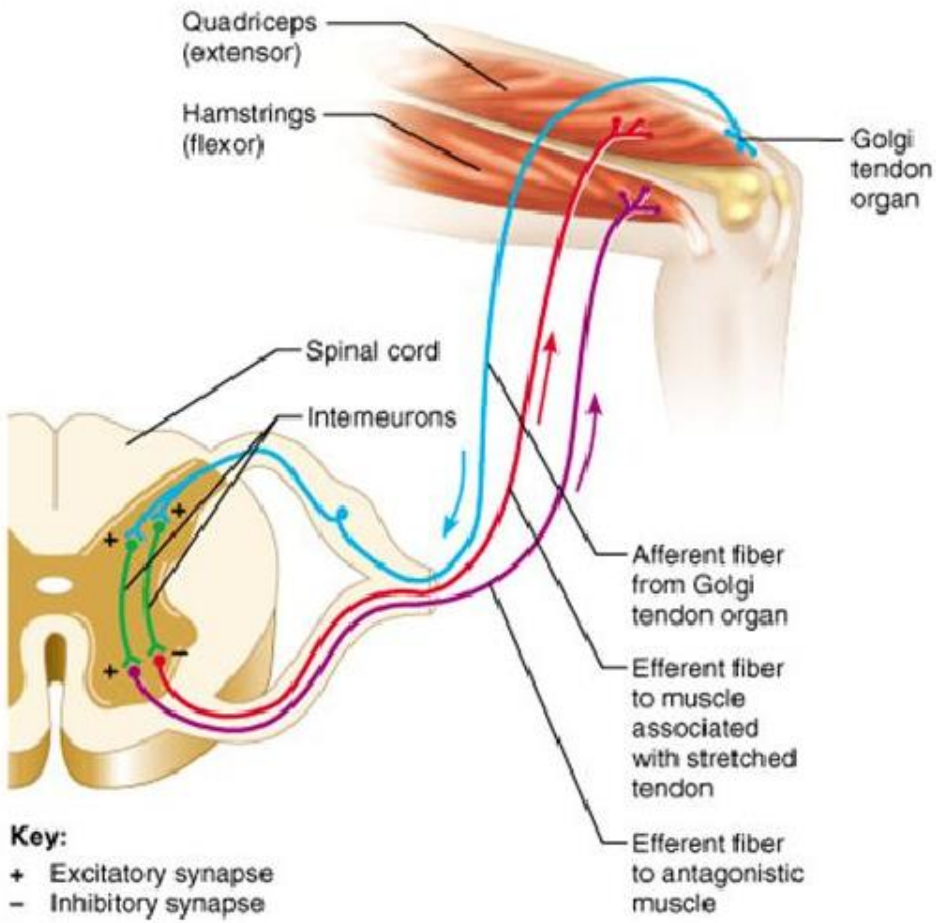
- Over Stretch
- Golgi Tendon Organ
- Afferent 1b
- Spinal Cord (Center)
- Inhibitory Interneuron (Glycine)
- Efferent αMotor
- Extrafusal Fibers
- Ms Relaxation (lengthening reaction)
- Prevent tearing of the muscle or avulsion of the tendon

Reciprocal Excitation of antagonist

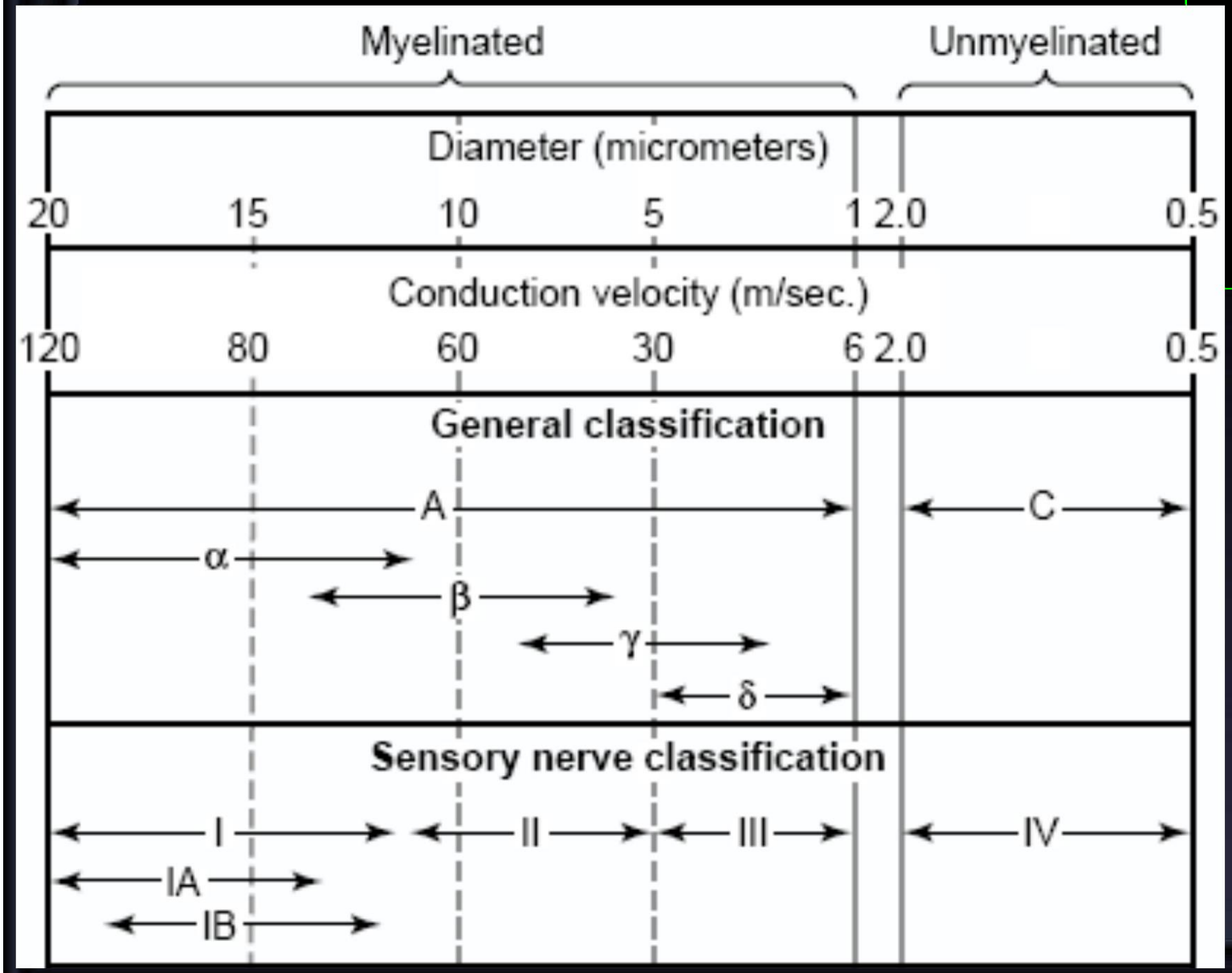
Golgi (Deep) Tendon Reflex

Inverse stretch reflex

- Receptor: Golgi tendon organ
  - Mechanoreceptor that responds to muscle tension (via the tendon)
  - Stimulus: increased tension (increased nerve impulses to spinal cord)
  - Response: muscle relaxes (decreased nerve impulses to spinal cord)
    - **Inhibits the agonist**
    - **Reciprocal path: activates the antagonist**
- Polysynaptic, ipsilateral, and segmental



NERVE FIBERS CLASSIFICATION



- **Type A**
  - **Alpha**
  - **Beta**
  - **Gamma**
  - **Delta**
- **Type C**

TABLE 4–1 Types of mammalian nerve fibers.

Fiber Type	Function	Fiber Diameter (μm)	Conduction Velocity (m/s)	Spike Duration (ms)	Absolute Refractory Period (ms)
Aα	Proprioception; somatic motor	12–20	70–120		
Aβ	Touch, pressure	5–12	30–70	0.4–0.5	0.4–1
Aγ	Motor to muscle spindles	3–6	15–30		
Aδ	Pain, temperature	2–5	12–30		
B	Preganglionic autonomic	<3	3–15	1.2	1.2
C, Dorsal root	Pain, temperature	0.4–1.2	0.5–2	2	2
C, Sympathetic	Postganglionic sympathetic	0.3–1.3	0.7–2.3	2	2

PROPRIOCEPTION

Perception about the relative positions of different body parts and strength of effort being employed in movements.

Three Types of Proprioceptors

- **Muscle spindles – measure the changing length of a muscle**
  - **Imbedded in the perimysium between muscle fascicles**
- **Golgi tendon organs – located near the muscle-tendon junction**
  - **Monitor tension within tendons**
- **Joint kinesthetic receptors**
  - **Sensory nerve endings within the joint capsules**

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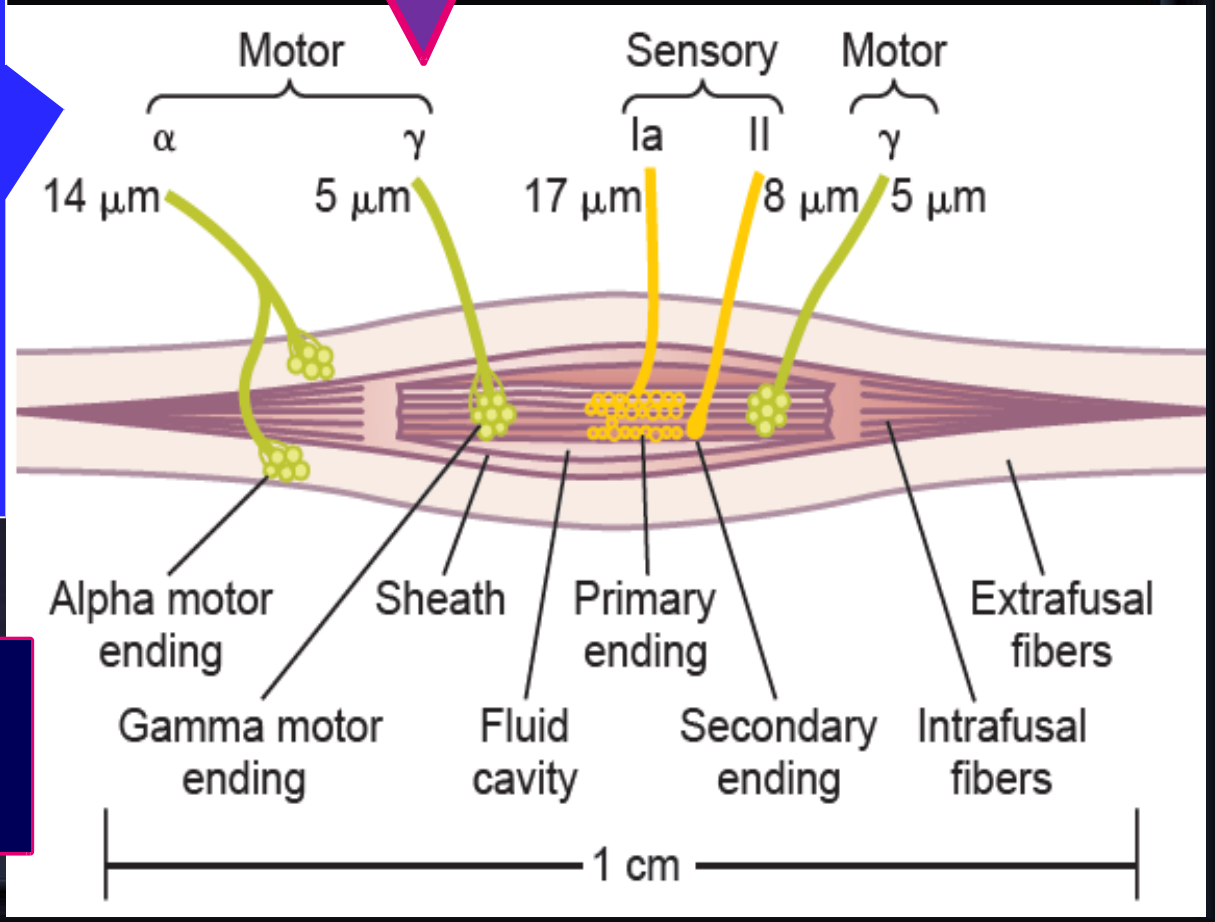
Alpha motor neurons innervate the large skeletal muscle fibers. (Extrafusal Fibers)

Gamma motor neurons supply intrafusal fibers in middle of the muscle spindle, which helps control basic muscle “tone”

- 3 to 10 mm
- 3 to 12 tiny intrafusal fibers pointed at their ends and attached to the glycocalyx of the surrounding large extrafusal skeletal muscle fibers.



Intrafusal fibers
Receptors for stretch reflex
Central non-contractile area
Peripheral contractile area

INTRAFUSAL FIBERS
Nuclear Bag and Nuclear Chain Fibers

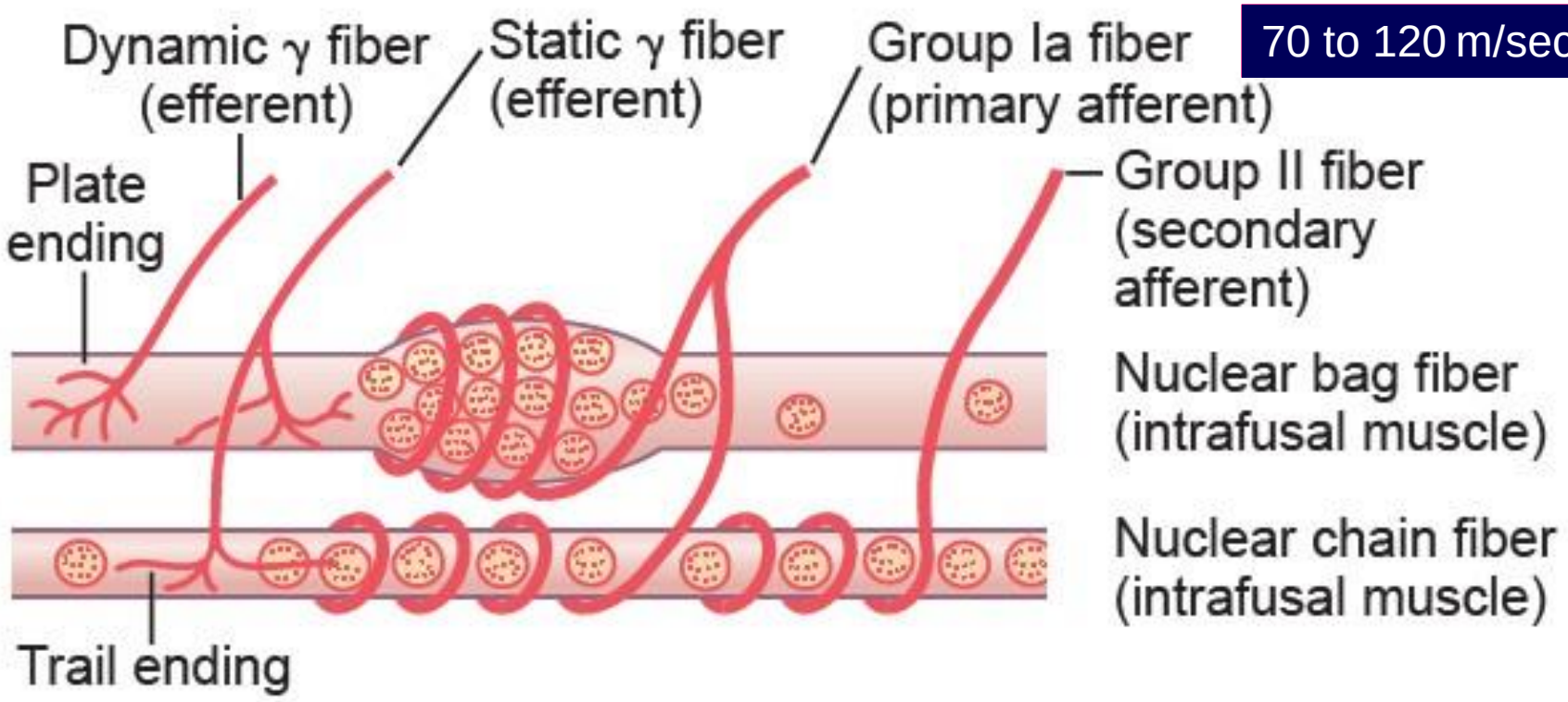


Figure 55-4. Details of nerve connections from the nuclear bag and nuclear chain muscle spindle fibers. (Modified from Stein RB: Peripher

The secondary afferent is usually excited only by nuclear chain fibers

Response of Both the Primary and the Secondary Endings to the Length of the Receptor

"Static" Response.

steady-state length of the muscle

When the receptor portion of the muscle spindle is stretched slowly, both the primary and the secondary endings are stimulated and transmit impulses for several minutes

Response of the Primary Ending (but Not the Secondary Ending) to Rate of Change of Receptor Length

"Dynamic" Response.

When spindle is stretched suddenly, the primary ending (but not the secondary ending) is stimulated powerfully called the dynamic response

EFFECTS OF αMOTOR NEURON DISCHARGE

Stimulation of α-motor neurons results in detectable contraction of the muscles directly

EFFECTS OF γMOTOR NEURON DISCHARGE

Stimulation of γ-motor neurons does not lead directly to detectable contraction of the muscles because the intrafusal fibers are not strong enough or plentiful enough to cause shortening.
Initiating impulses in the Ia Fibers can lead to reflex contraction of the muscle indirectly.

γ-Static Efferent (trail ending)	γ-Dynamic Efferent (plate ending)
⓪ Nuclear Chain intrafusal fibers	⓪ Nuclear Bag intrafusal fibers

DESCENDING EXCITATORY INPUT TO SPINAL MOTOR CIRCUITS CAUSE COACTIVATION

intrafusal and extrafusal fibers shorten together, and spindle afferent activity can occur throughout the period of muscle contraction.

Factors influencing stretch reflex

(all act on gamma motor neurons)

Enhances

1Suprspinal

- -Primary motor area4
- -Vestibular N
- -Pontine RF(bulboreticular)
- -Neocerebellum

2 Anxiety

3Noxious painful stimuli

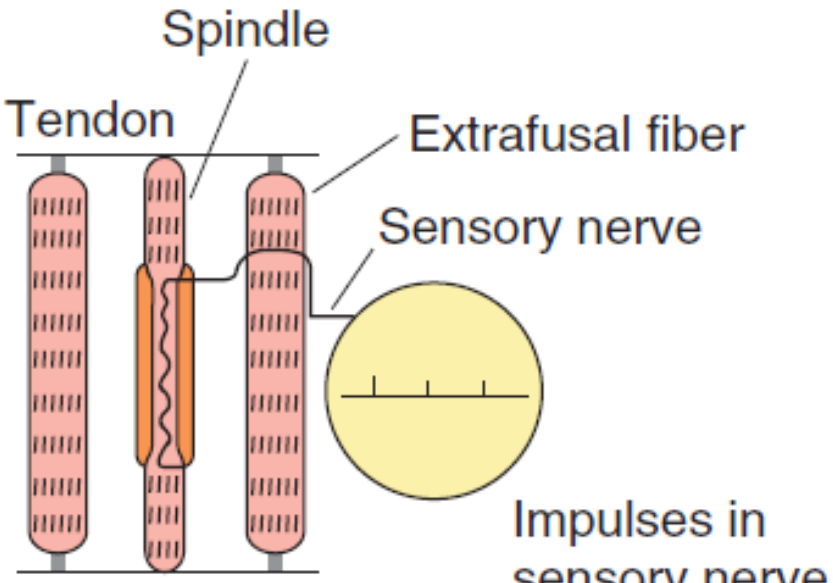
4-Jendrassik-manuver

Inhibits

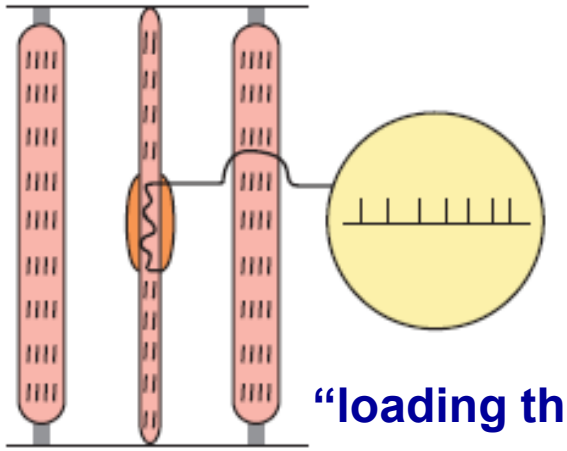
1 Supraspinal

- -Cortical (suppressor area4&Area 6)
- -Basal ganglia
- -Medullary RF
- -Red nucleus
- -paleocerebellum

2 Excessive stretch of muscle(golgi tendon reflex)

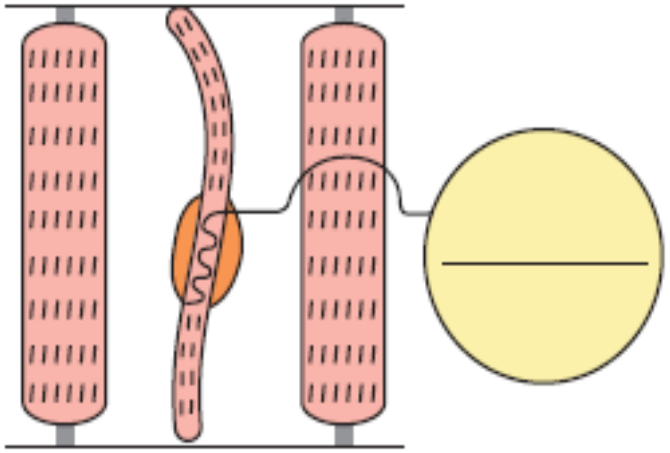


Muscle at rest



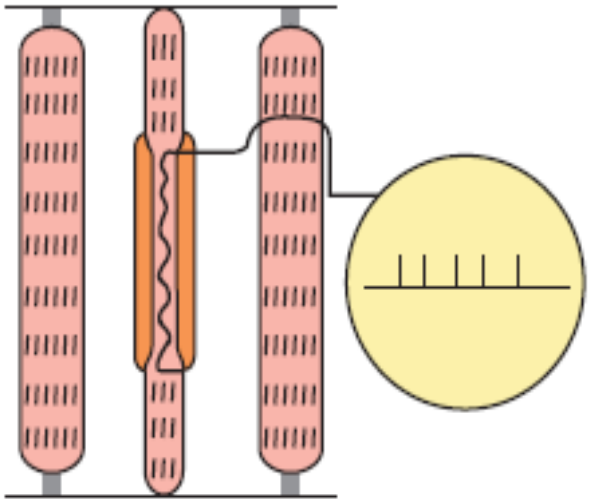
Muscle stretched

“loading the spindle”



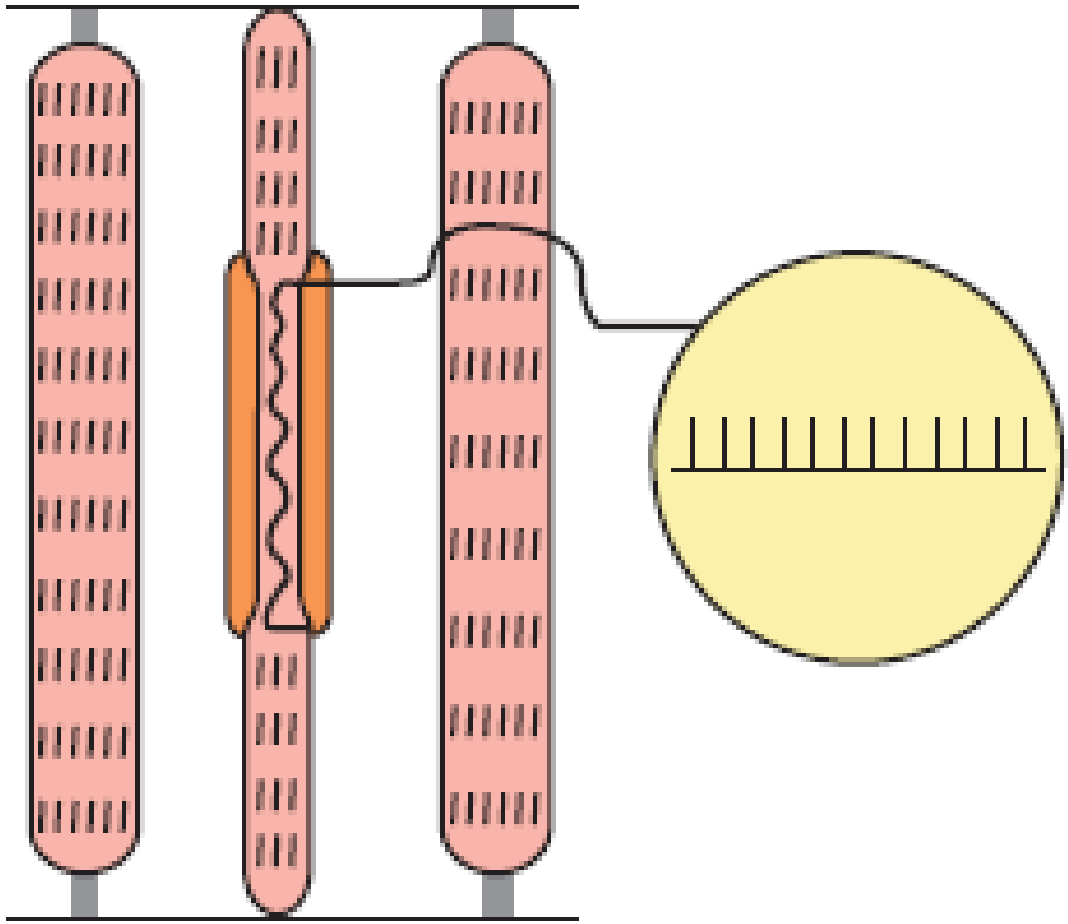
Muscle contracted

“unloading the spindle”



γ-motor discharge

If the whole muscle is stretched during stimulation of the γ-motor neurons, the rate of discharge in sensory fibers is further increased.



Increased γ efferent discharge—muscle stretched

ROLE OF THE MUSCLE SPINDLE IN VOLUNTARY MOTOR ACTIVITY

With alpha motor neurons, in most instances the gamma motor neurons (31%) are stimulated simultaneously, an effect called

COACTIVATION

- **It keeps the length of the receptor portion of the muscle spindle constant. Therefore, coactivation keeps the muscle spindle reflex from opposing the muscle contraction.**
- **Second, it maintains the proper damping function of the muscle spindle, regardless of any change in muscle length.**

Otherwise receptor portion of the spindle would sometimes be flail and sometimes be overstretched, causing unsmooth muscle contractions

Signal averaging function of the muscle spindle reflex.

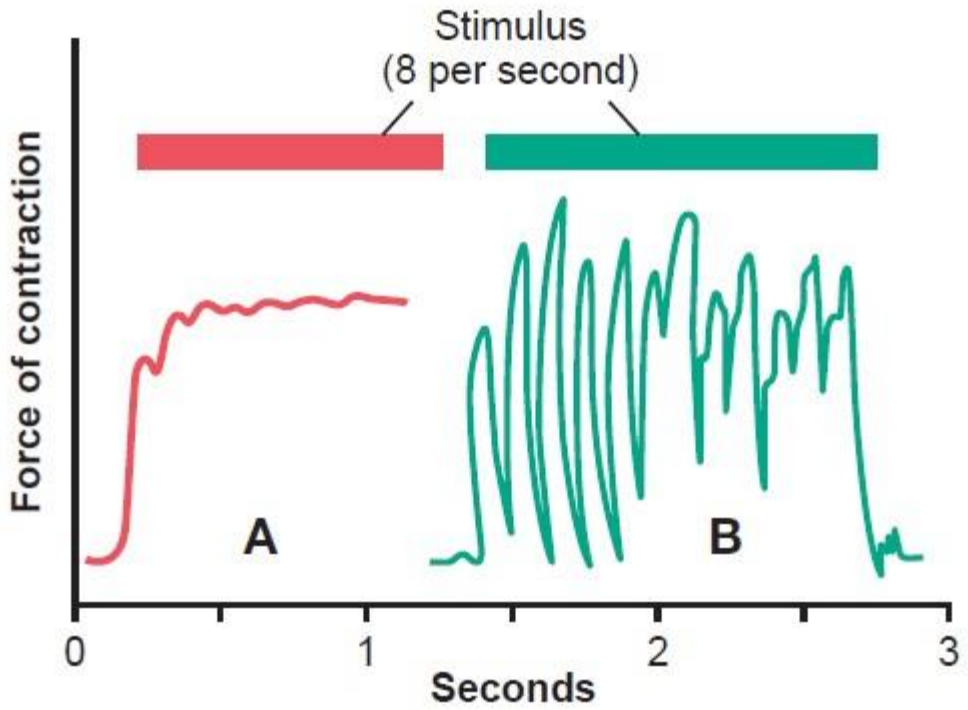


Figure 55-6. Muscle contraction caused by a spinal cord signal under two conditions: *curve A,* in a normal muscle, and *curve B,* in a muscle whose muscle spindles were denervated by section of the posterior roots of the cord 82 days previously. Note the smoothing effect of the muscle spindle reflex 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.)*