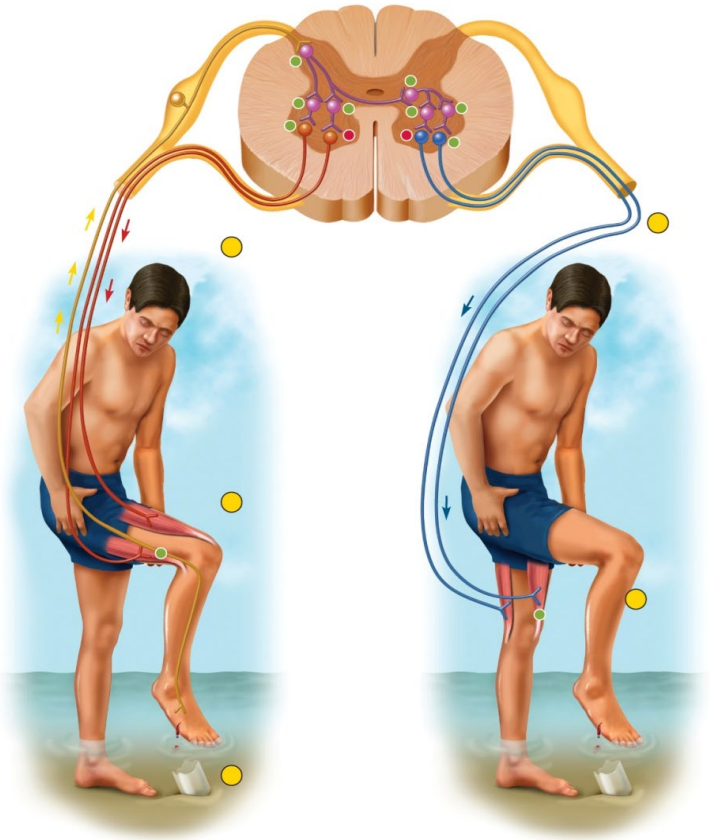
Chapter 13.3

Somatic Reflexes, Muscle Spindles, and Posture



Nature of Reflexes

A reflex is an involuntary responses initiated by a sensory input (stimulus)

A reflex causes a change to the effecter tissue (e.g. a gland or muscle tissue)

Occurs without our intent (not voluntary)

Many reflexes occurs without our awareness

Examples: smell food and your salivary glands start to secrete saliva // you touch a hot item, and you pull your hand away

Four important properties of a reflex arc

– a reflex is not a spontaneous action

–*a reflex require a stimulus* // a response to sensory input

The three properties of a reflex:

–reflexes are *quick* // involve few if any inter-neurons // minimum synaptic delay

–reflexes are *involuntary* // occur without intent and difficult to suppress // automatic response

–reflexes are *stereotypic* // occur essentially the same way every time

Pathways for a Skeletal Muscle Reflex Arc

Stimulus originates in one of three locations

somatic receptors (e.g. pain receptor in skin)

muscle spindles (proprioceptors located inside muscle organ)

Golgi tendon organs (proprioceptor located within muscle tendons)

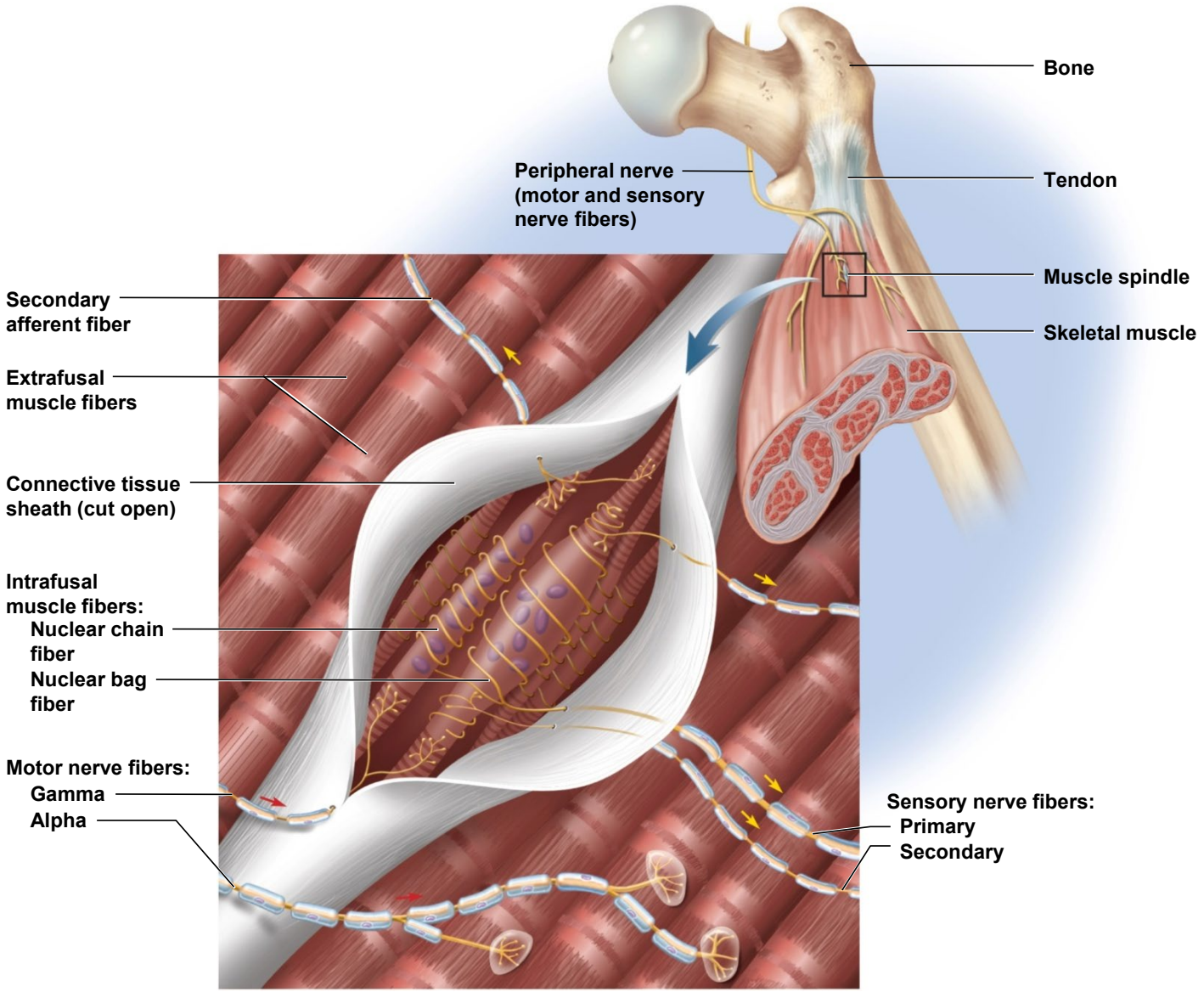
What is a Proprioceptor

What is proprioception?

A sensation mediated by a type of sensor called a muscle spindles. They are located in skeletal muscle organs to informs us about rate of muscle contractions, adjust muscle organ tension, maintain posture, and the stretch reflex.

(See Video) Proprioreception is called the "hidden sensation"

What is a Muscle Spindle?
(It's a Proprioreceptor)



The Muscle Spindle

Muscle spindles are embedded in skeletal muscles and have several functions

–Number of muscle spindles in a muscle organ may vary

–Higher concentration in muscles with fine control // hands may have 100 muscle spindles per gram // gastrocnemius only 10 per gram.

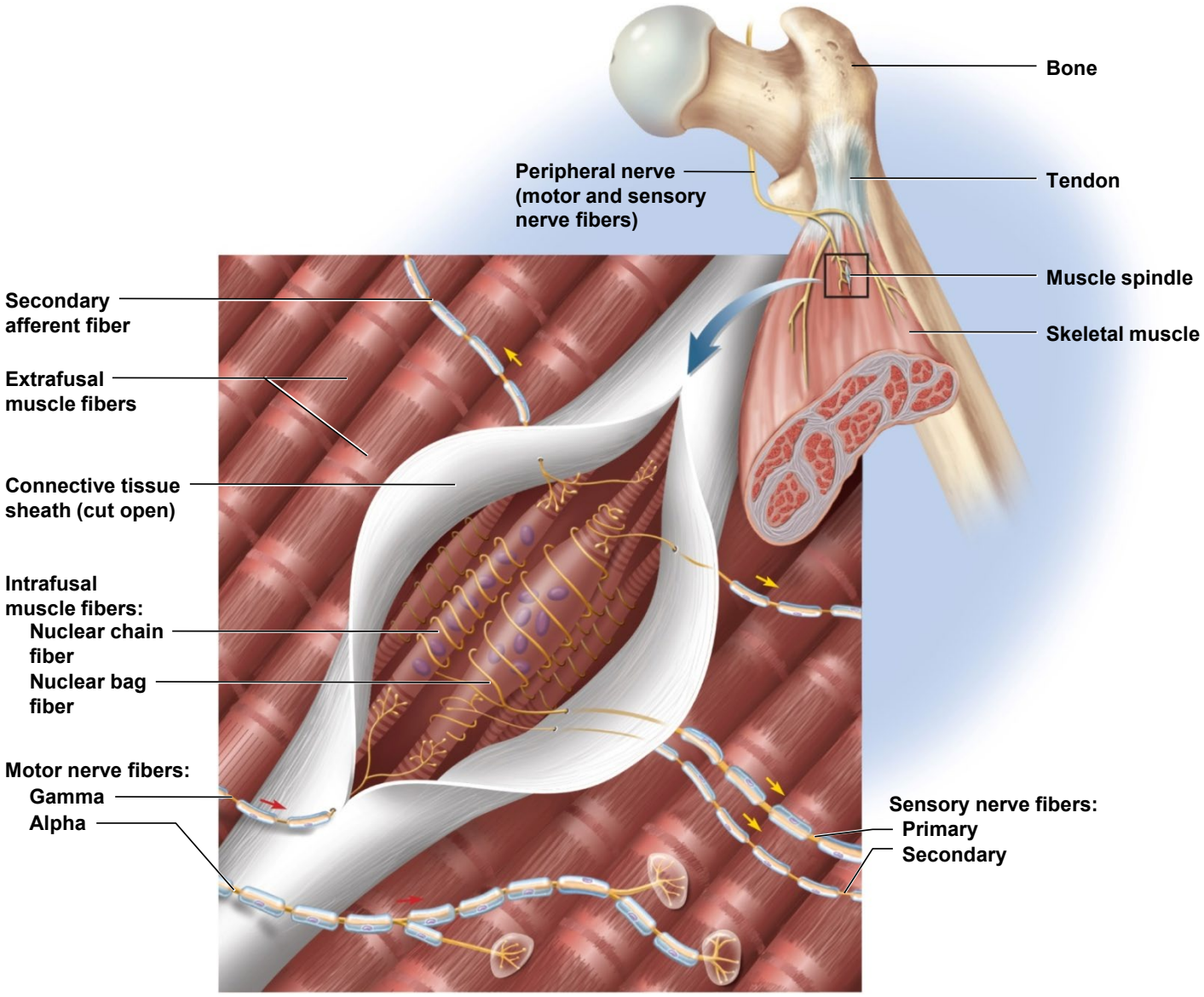
Muscle spindles inform the brain of muscle length, rate of contraction, may adjust muscle spindle's tension as muscle contracts, inform brain about body movement/location, and create mechanism for the brain to adjust the tone of our muscles (posture & stretch reflex subconsciously)

Enables brain to send motor commands back to the muscles that control coordinated movement // adjust the intent!

Important role in corrective reflexes, muscle tone, and posture

One component of the muscle spindle will "immediately" activate some muscle fibers (alpha) which causes muscle to contract even if spinal cord is severed from brain // spinal cord reflex

Muscle Spindle



The Muscle Spindle

(not test information)

•Intra-fusal fibers – are special muscle fibers inside the muscle spindle / adjust tone of spindle as muscle length changes

•Muscle spindle have two type of sensory fibers ///

–Primary afferent – large / fast/ very sensitive to small changes in muscle length and sudden body movement /// called nuclear chain fibers

–Secondary afferent fibers – intermediate sized fibers / slower conduction speed / less responsive to the rate of muscle /// shorteningnuclear bag fibers

–As muscle shortens then the muscle spindle will adjust tension within muscle spindle so the muscle spindle will continue to function

•Extra-fusal fibers – muscle fibers outside spindle / responsible for the contraction of the organ // these generate the "force or tension" of the muscle

–Signal sent to cerebellum (spinal cerebellar tract = subconscious)

–Cerebellum send signal to cerebrum and motor strip send signals to groups of muscles to adjust posture.

–Muscle spindles plays role in both reflex and brain assisted muscle control

The Muscle Spindle

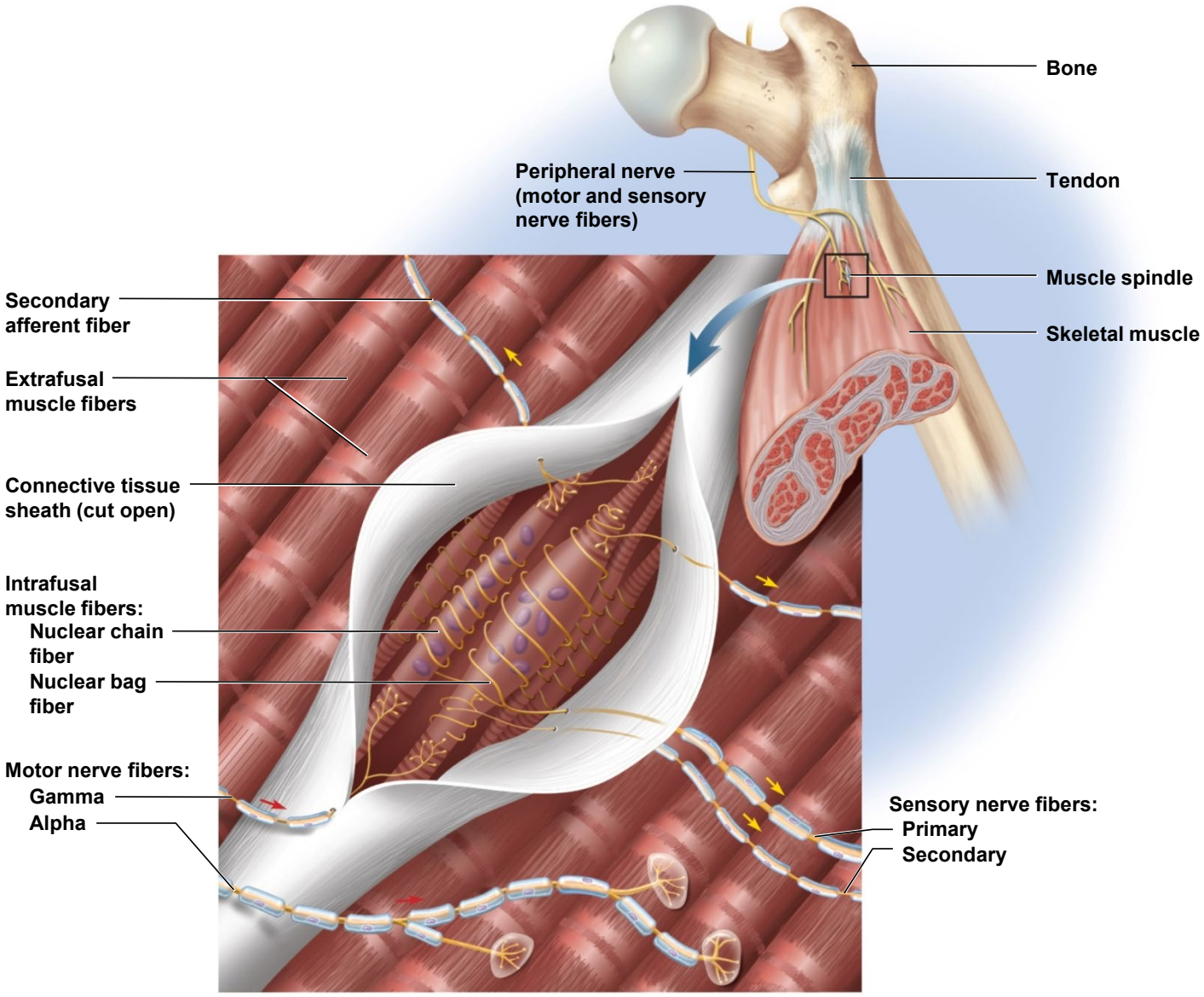
Motor Neurons carry action potentials to skeletal muscle fibers

Two different types of efferent fibers originate in anterior horn

Gamma motor neurons – from anterior horn to the intrafusal fibers / slow fibers / adjust the length of the intrafusal fibers as the extrafusal fibers change length

Alpha motor neurons – from anterior horn to extrafusal fibers / respond to signals from brain or spinal refexes

Muscle Spindle



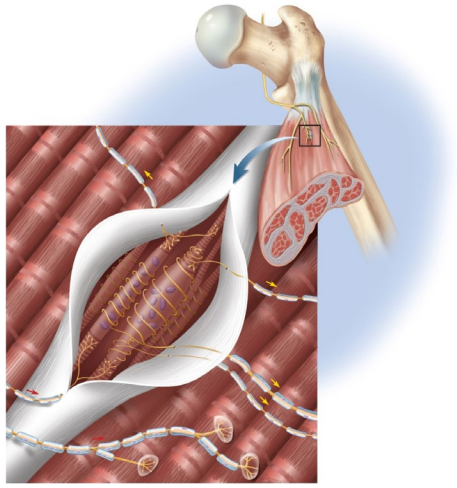
The Muscle Spindle = A Proprioreceptor

Fundamentally, a muscle spindle does this:

When a muscle is at rest and relaxed the muscle spindle is itself slightly stretched. Both types of sensory nerve fibers transmit a steady stream of signals to the brain informing brain of the length of the muscle. This is called a steady-state or tonic response.

As a muscle contracts, the spindles shorten along with the muscle. The secondary fiber fires at lower frequency and the primary fiber completely ceases firing: this is called a dynamic or phasic response.

When the muscle is fully contracted and stable. the primary fiber resumes firing, but at a slow rate, Both fiber types inform the brain of the length of the muscle, but the primary fiber also informs it of how fast muscle length is changing.



These responses quickly inform the brain of the speed of body movements and allow it to initiate quick corrective reflexes – for example when your body tilts a little bit to one side then you adjust muscle tension on other side of body to keep your balance. // Taken from Saldin / 4th Edition

Review of Muscle Function
(Flexors VS Extensors)

This information is required to understand reflexes in arms and legs

- At the elbow joint
  - –Flexors = brachialis and brachii biceps
  - –Extensor = brachii triceps
- At the knee joint
  - –Flexor = hamstring group // bicep femoris, semitendinosus, semimembrnosus
  - –Extensor = quadriceps femoris group // rectus femoris, vastus lateralis, vastus medialis, vastus intermedium (e.g. kick ball)

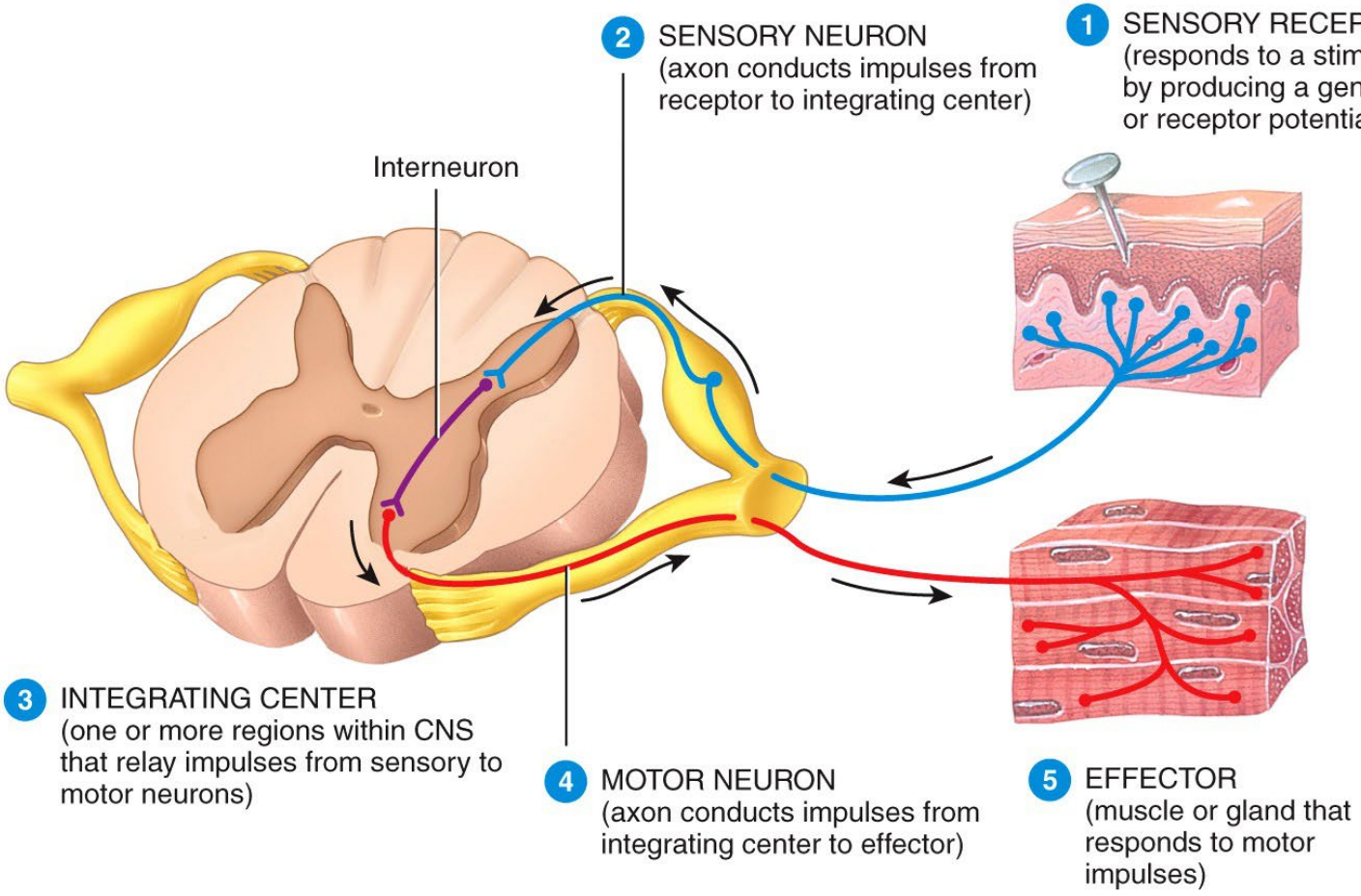
You Need to Know These Reflexes!

Use the Web Site's Videos to Learn These Reflexes

- Somatic Flexor Reflex (e.g. The withdrawal reflex that occurs at elbow and knee)
- Flexor Crossed Extensor Reflex
- Tendon Reflex (e.g. Patellar Reflex)
- Stretch Reflex (Posture)
- Golgi Tendon Organ Reflex (Protects Skeletal Muscle)

The Somatic Flexor Reflex (Withdrawal Reflex / Spinal Cord Reflex)

Stimulate nociceptor (pain) receptor in skin // initiates reflex arc // afferent fiber synapse with local neural circuit in anterior gray horn // result in stimulation of flexor muscles (e.g. biceps brachii or biceps femoris)



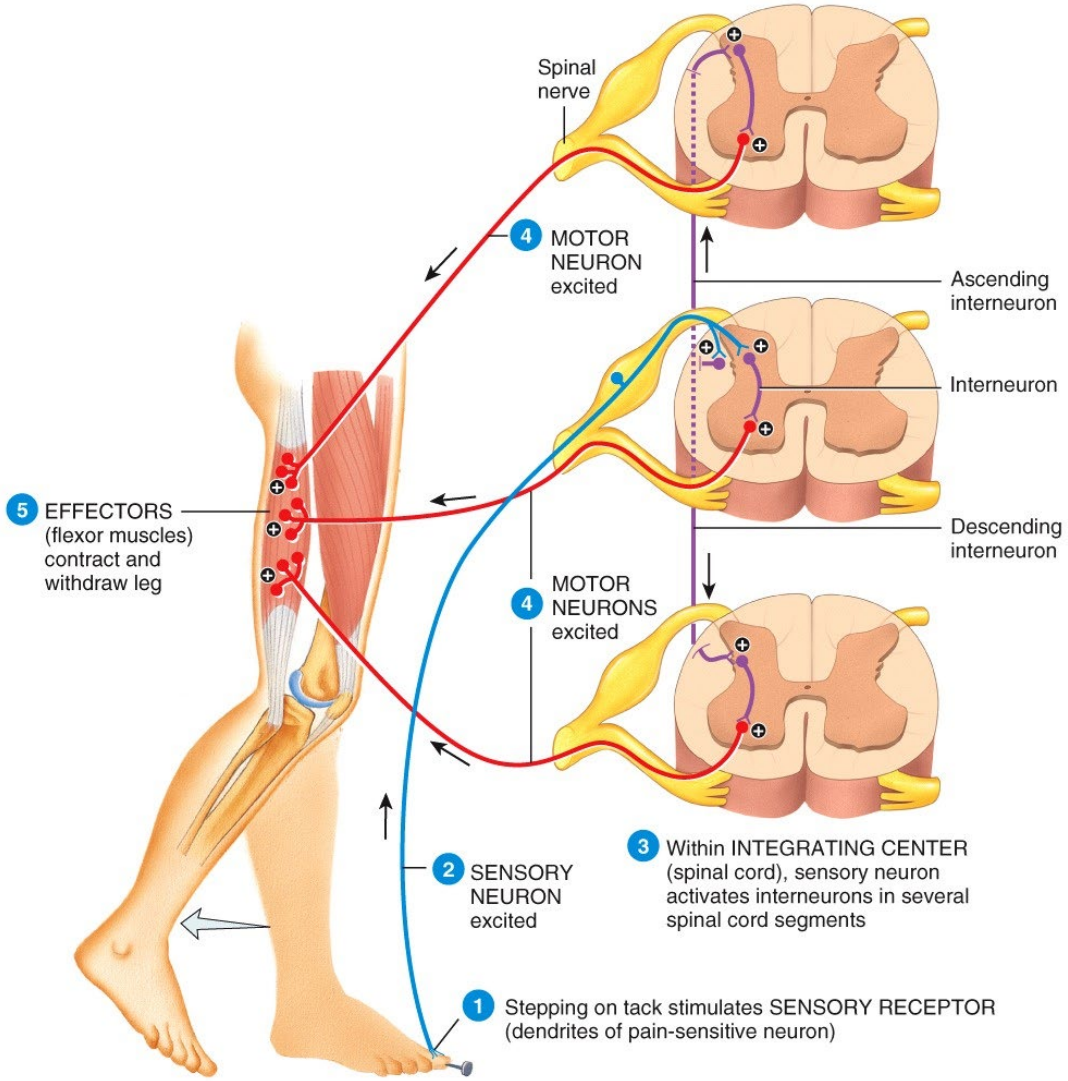
Skeletal Muscle Reflex Arc Pathway

- afferent nerve fibers // carry information from receptors in skeletal muscle to posterior horn of spinal cord or the brainstem
- Interneuron // a neuron located between the sensory and motor neuron within the gray matter of the spinal cord // determines whether the efferent neurons will issue a signal to the skeletal muscle
- efferent nerve fibers // carry motor impulses to skeletal muscle
- The skeletal muscles = the somatic effectors that carry out the response

Note: we are conscious of the muscle contraction caused by the spinal cord reflex arc // How?

The interneuron bi-forcates to carry signal via spinalcortical pathway // this pathway goes to the somatosensory gyrus and arrives slightly after the muscle contration // Why? T

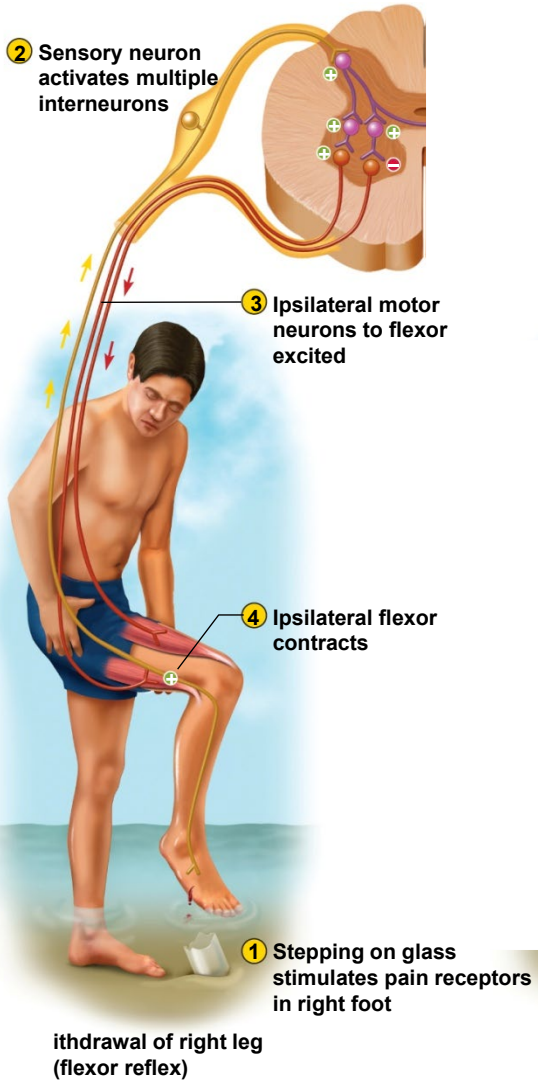
The Somatic Withdrawal Flexor Reflex (2nd Example)



Note: several different efferent fibers radiate throughout the muscle to form "motor units"

Force created "diffused" throughout muscle

The Somatic Flexor Reflex with Reciprocal Inhibition



–the quick contraction of flexor muscles resulting in the withdrawal of a limb from an injurious stimulus

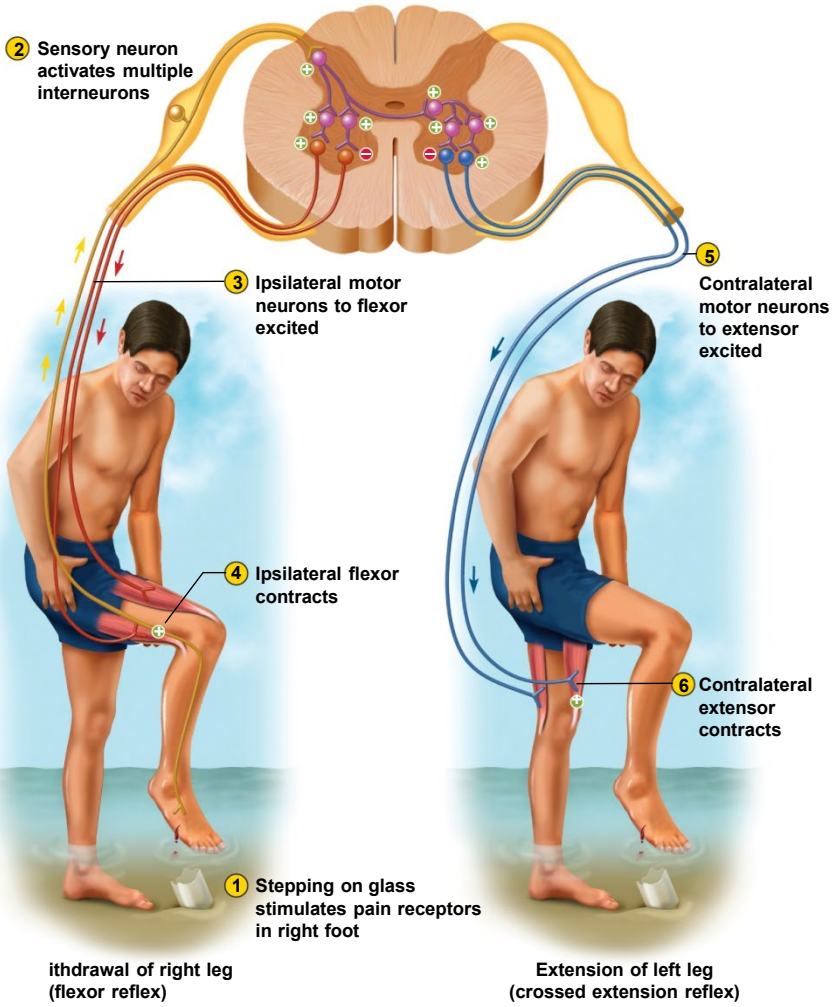
–Note – now a reciprocal inhibition pathway has been added to this event

•reflex phenomenon that prevents an antagonistic muscle from working against prime mover by inhibiting the antagonistic muscles

•Afferent fiber may synapse on several "inter-neurons" which then synapse on efferent fibers going to primary movers, synergist, and/or antagonistic muscles.

The Flexor Crossed Extensor Reflex

This occurs when you step on a piece of glass. One leg is withdrawn (i.e. flexed) while the other leg is extended!



•polysynaptic reflex arc - pathway in which signals travel over many synapses on their way back to the muscle

•Cross extensor reflex

–the contraction of extensor muscles in the limb opposite of the one that is withdrawn

•maintains balance by extending other leg

–ipsilateral reflex arc – one in which the sensory input and the motor output are on the same sides of the spinal cord

•flexor reflex

–contralateral reflex arc – one in which the input and output are on opposite sides

•crossed extension reflex

–intersegmental reflex – one in which the input and output occur at different levels (segments) of the spinal cord

•View Video – Crossed Extensor Reflex

More About Flexor Crossed Extensor Reflex Arc

–This is two separate reflexes which occur at the same time but on opposite sides of the body

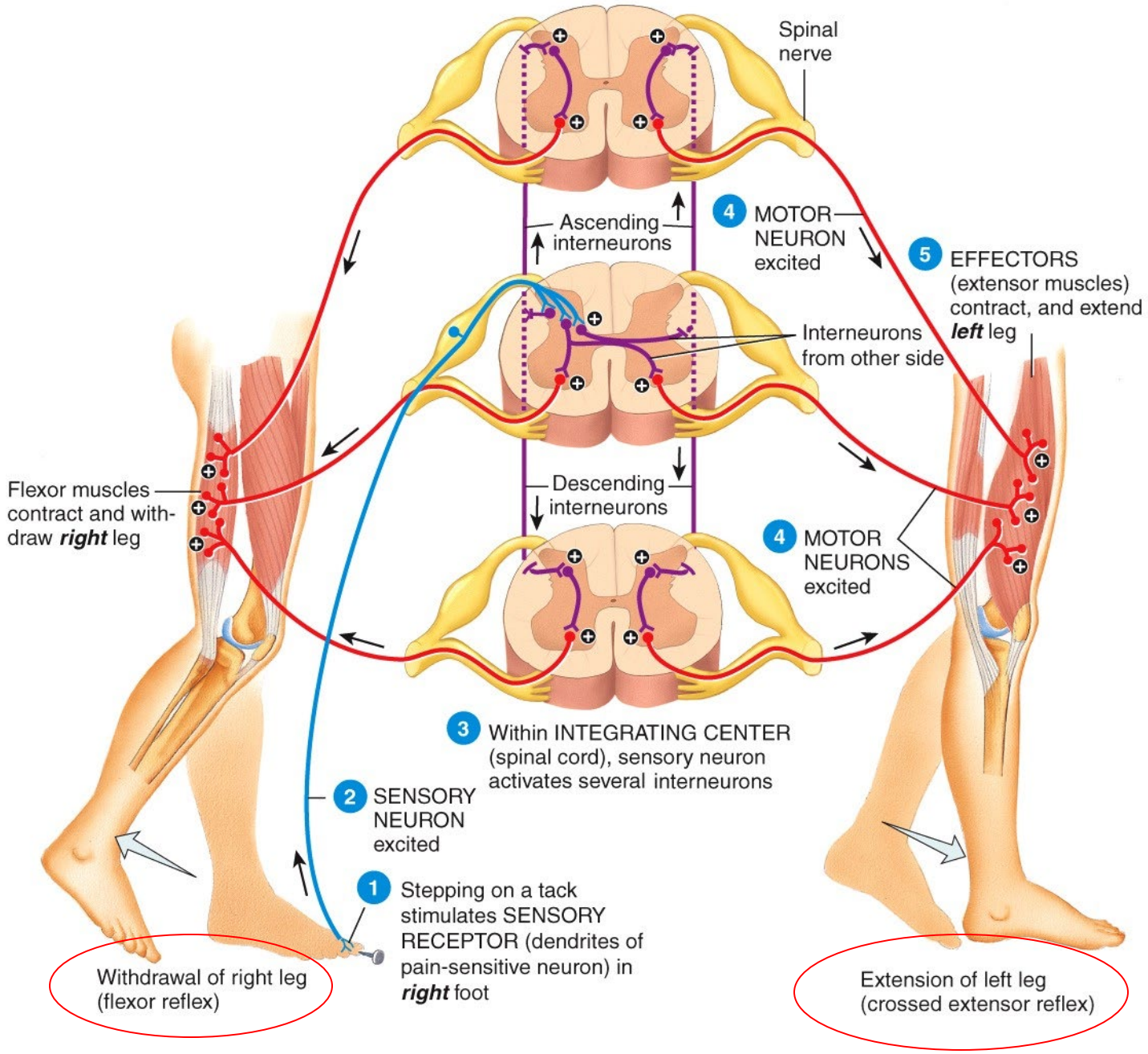
–A flexor reflex arc occurs on the ipsilateral side to the stimulus (e.g. step on a piece of glass)

–An extensor reflex arc occurs on the contralateral side to the stimulus // Afferent fiber synapse in posterior grey horn with commissual fibers which send motor signal to contralateral nerve pathway

–Contract extensors contralateral to muscle(s) which were flexed.

- step on glass results in contraction of biceps femoris (the flexor withdrawal reflex arc)

- at same time but on opposite side of body the quadriceps femoris contracts (extensors)


Spinal nerve
Ascending interneurons
4 MOTOR NEURON excited
5 EFFECTORS (extensor muscles) contract, and extend *left* leg
Interneurons from other side
Flexor muscles contract and withdraw *right* leg
Descending interneurons
4 MOTOR NEURONS excited
3 Within INTEGRATING CENTER (spinal cord), sensory neuron activates several interneurons
2 SENSORY NEURON excited
1 Stepping on a tack stimulates SENSORY RECEPTOR (dendrites of pain-sensitive neuron) in *right* foot
Withdrawal of right leg (flexor reflex)
Extension of left leg (crossed extensor reflex)

Patellar Tendon Reflex (A Monosynaptic Arc)

Pathway between stimuli in muscle to spinal cord to effector muscle

–Note: this causes extensor muscles to contract in contrast to the withdrawal reflex which contracts the flexor muscles

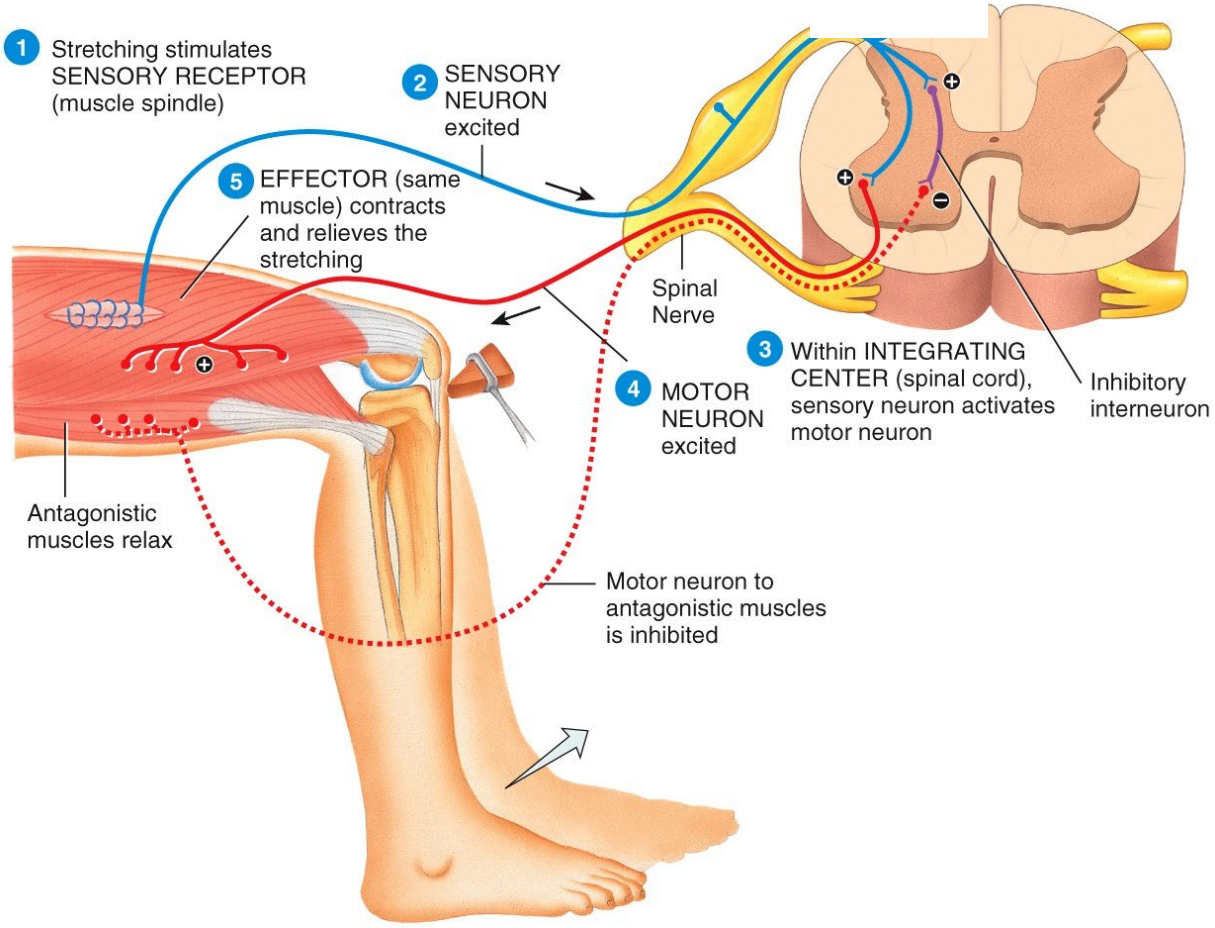
–This is monosynaptic // e.g. patella tendon reflex arc or called the knee-jerk reflex

–This reflex does not involve the brain // occurs even if spinal cord is severed to the brain

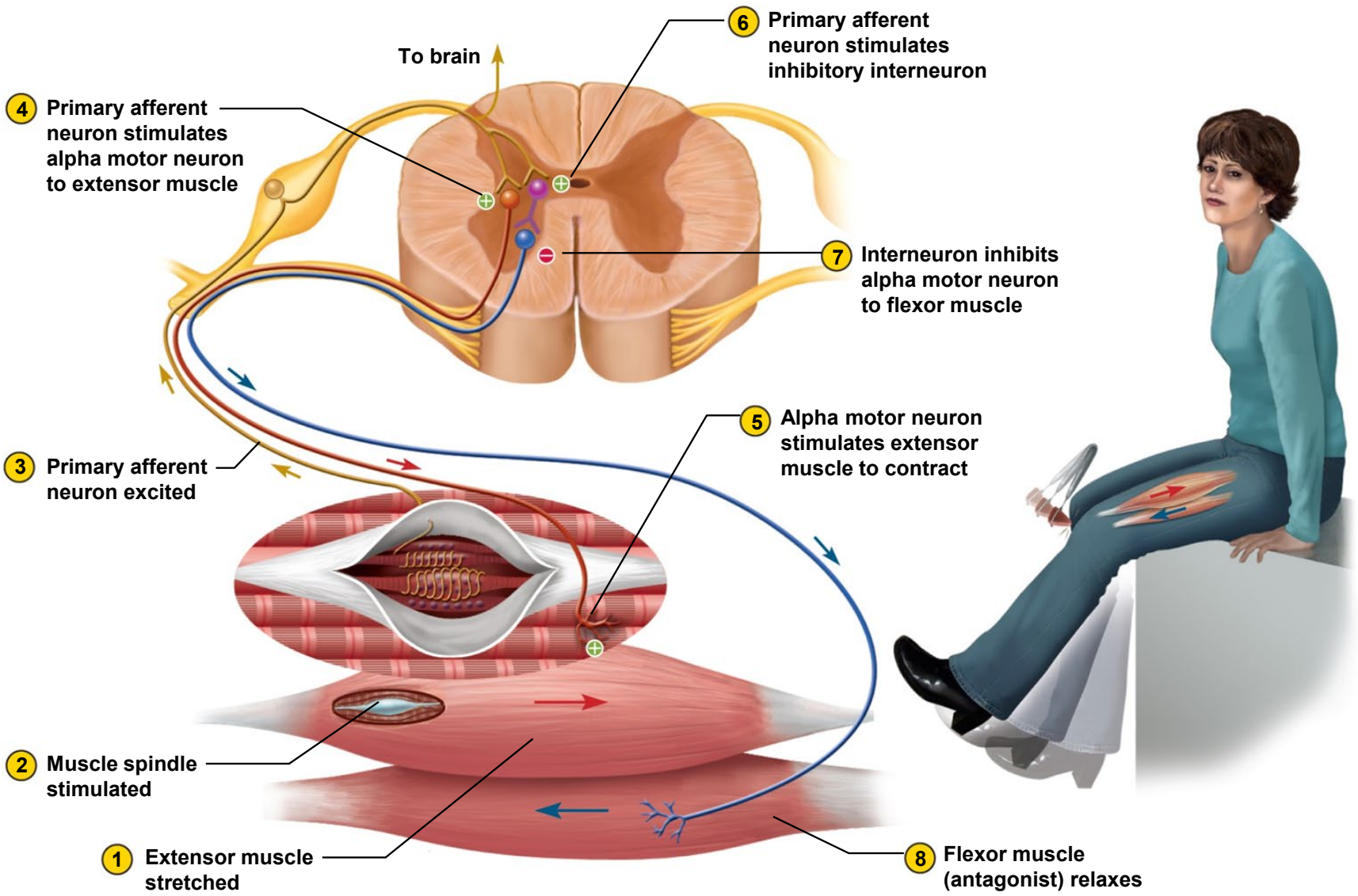
–Tapping on tendon activates proprioreceptors (muscle spindle that generates the afferent pathway)

Patellar Tendon Reflex (Spinal Cord Reflex)

Tapping on Tendon Activates Muscle Spindle in Quadricept Muscles. This stimulates extensor (e.g. quadricep femoris) muscle and at same time second efferent fiber causes flexor (bicep femoris)muscle to relax



Patellar Tendon Reflex
(Spinal Cord Reflex/ Monosynaptic)



The Stretch Reflex
(Think About Your Posture)

If you are awake but not “moving” then your skeletal muscles may seem like they are at rest, but they are not.

Some of the muscle fibers are contracted while you are sitting in your chair. This is what we call muscle tone. This is what maintains our posture. These are monosynaptic reflexes.

As a muscle is stretched the muscle will resist the stretch by slightly increasing the muscle “tone”

As muscle is stretched the muscle ‘fights back’ to increase more muscle tone and counter the stretching force. /// The muscle becomes stiffer than the un-stretched muscle

Muscle ability to resist a stretching force helps maintain *equilibrium and posture* /// stabilize joints by balancing tension in extensors and flexors smoothing muscle actions

This stretch reflex is a monosynaptic reflex (a spinal cord reflex). It is regulated by muscle spindles' alpha and gamma intrafusal fibers.

The Stretch Reflex

–If you extend a supinated arm then you put a heavy book on your palm, the muscles in your arm will start to be stretched

–Muscles in the arm will resist this stretching by generating tension // the muscle "fights back" // there is an increase muscle tone as muscle is stretched

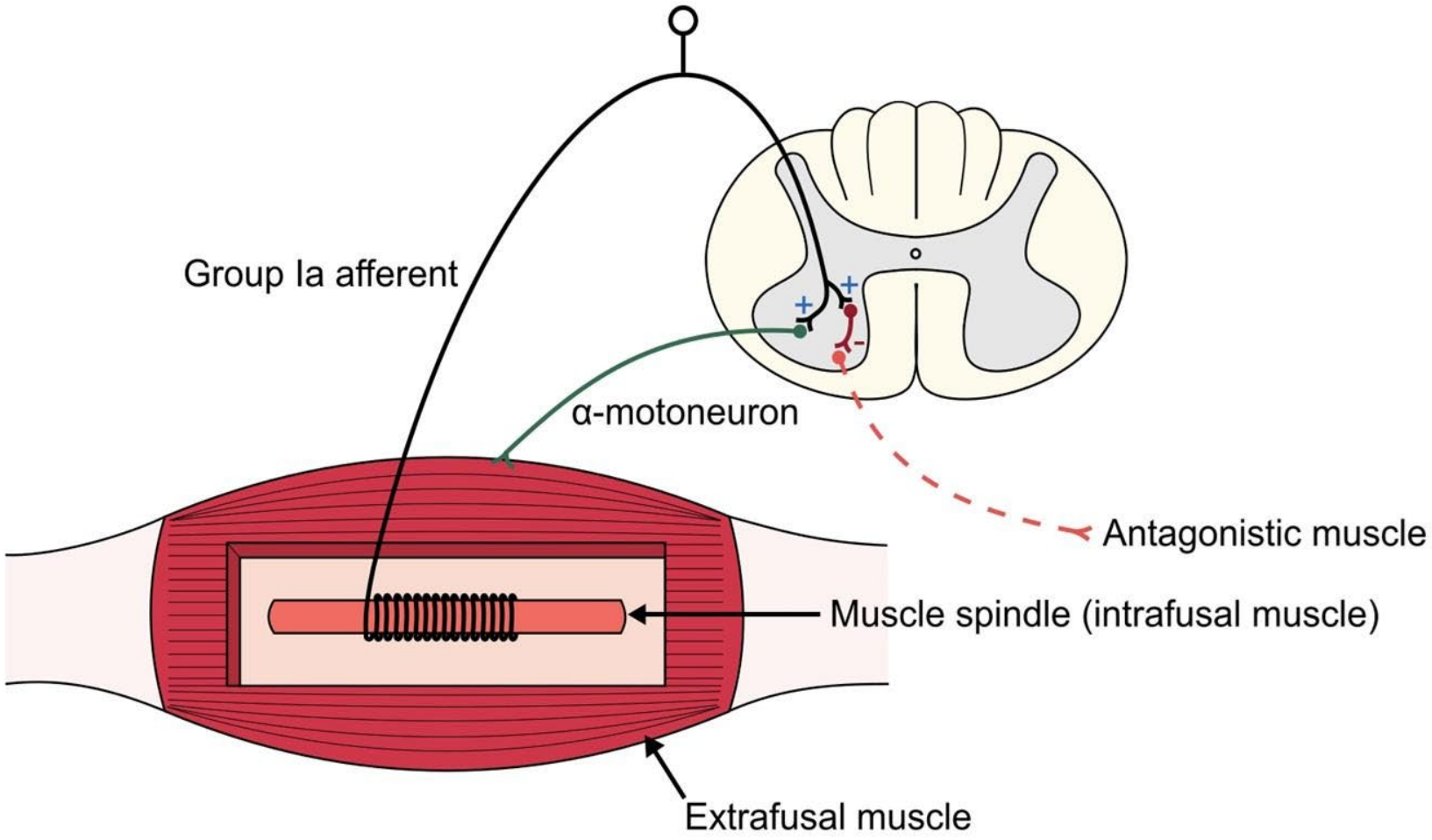
–This type of reflex is associated with posture // involves "groups of muscles" // muscle spindles play an import role in this reflex to control groups of muslces // much more than a spinal cord relex

–This action requires the function of thousands of muscle spindles / type of proprioreceptor

–Muscle spindles adjust "internal tension of individual muscle spindles as muscle tension changes

–This is how we maintains muscle tone and posture

Stretch Reflex



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Moises Dominguez

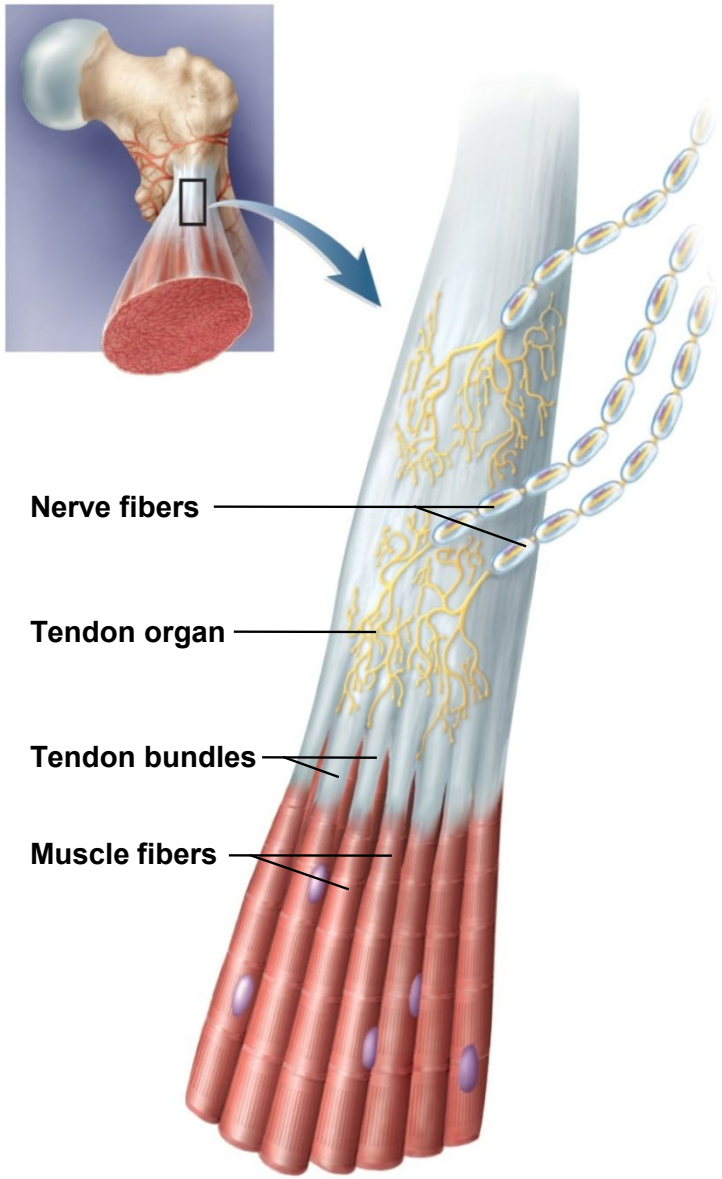
The Golgi Tendon Organ Reflex

•tendon organs (Golgi Tendon Organ)

–proprioceptors in a tendon near its junction with a muscle

–1mm long, nerve fibers entwined in collagen fibers of the tendon

–Sends to the spinal cord that provide the CNS with feedback on the degree of muscle tension at the joint



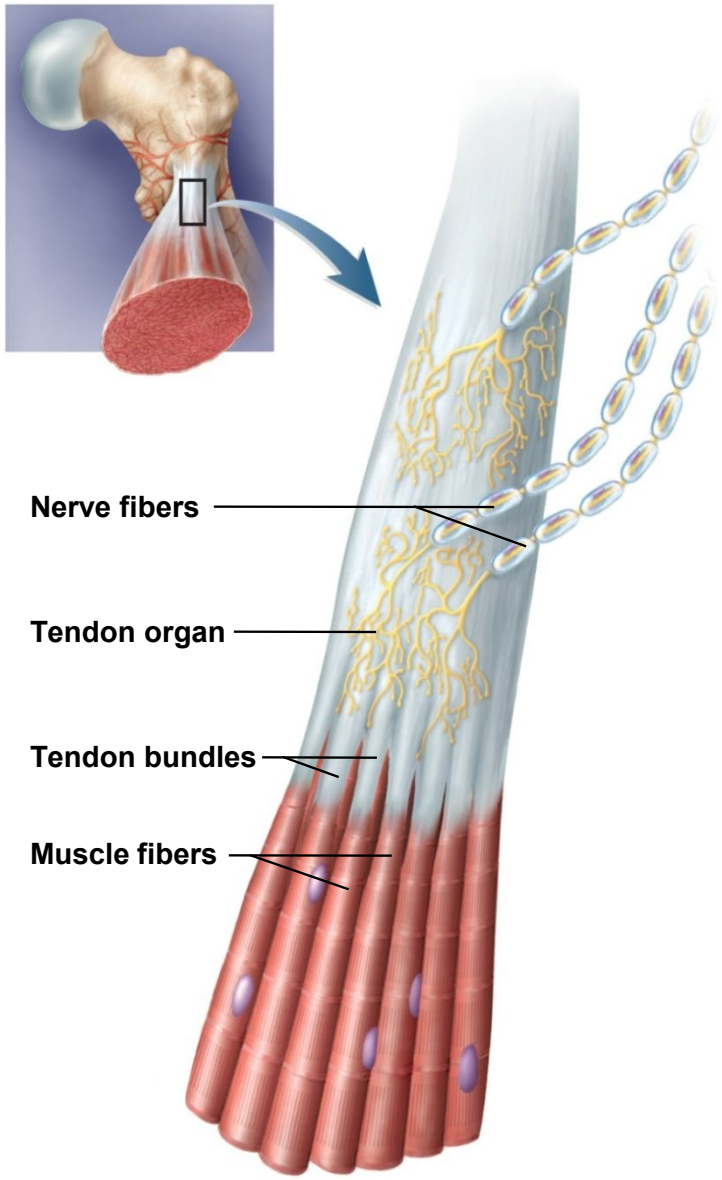
The Golgi Tendon Organ Reflex

•tendon reflex // in response to excessive tension on the tendon

–inhibits muscle from contracting too strongly

–moderates muscle contraction before it tears a tendon or pulls it loose from the muscle or bone

–Balance contraction force between different fascicles



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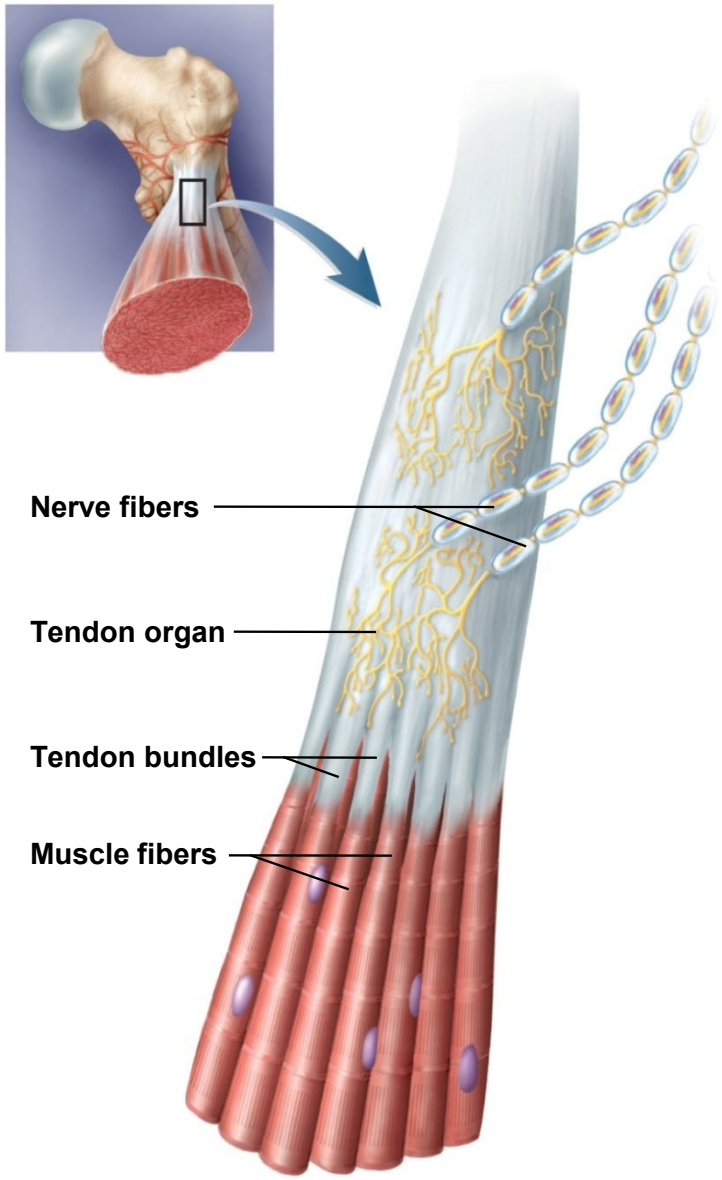
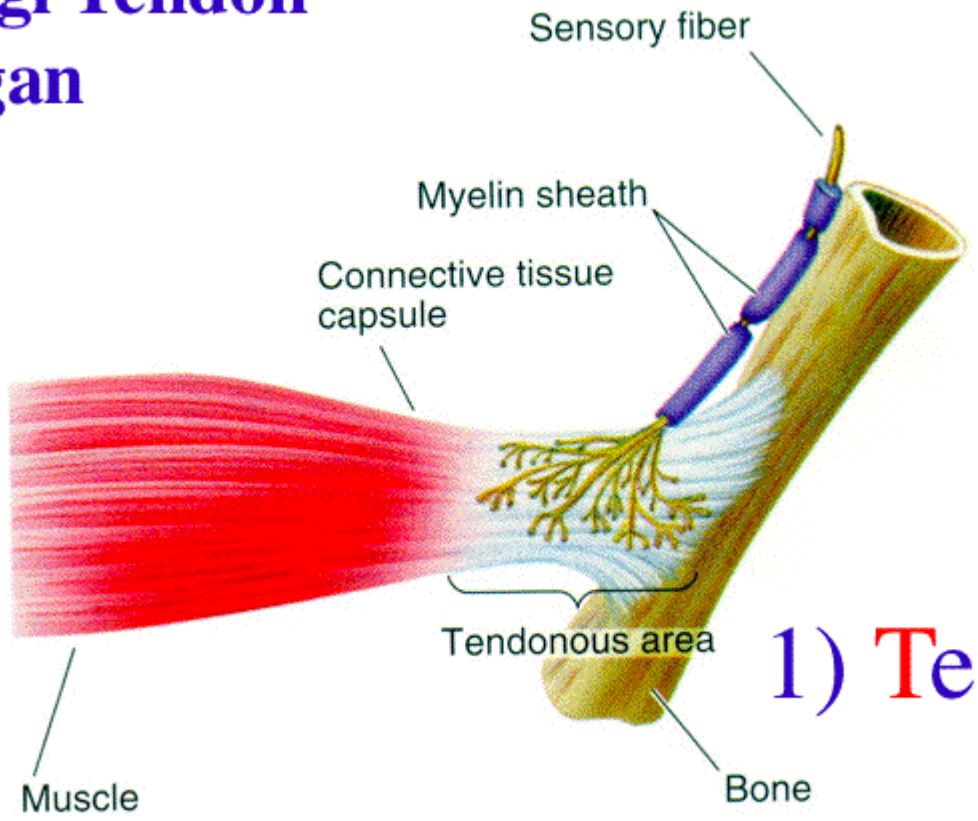
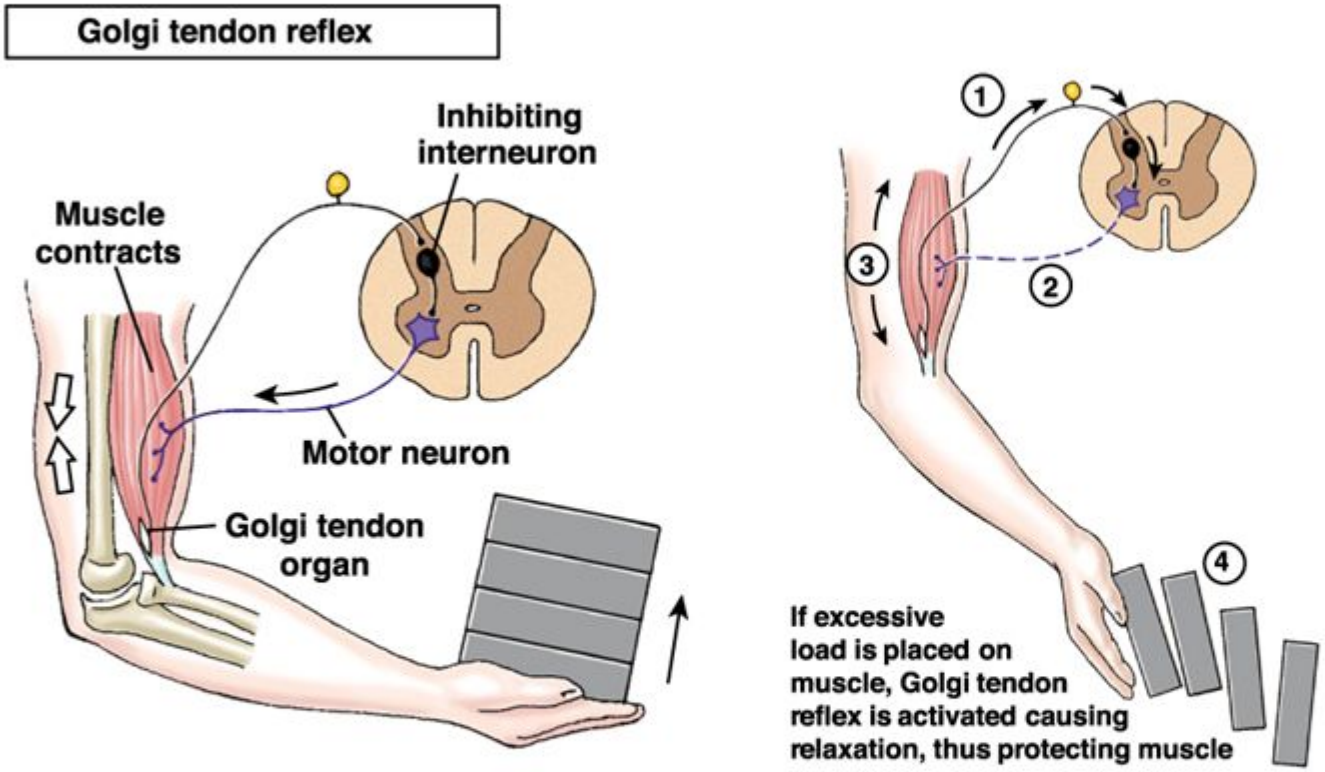


Golgi Tendon Organ



1) Tension

Golgi Tendon Reflex



Examples of the Nerves Associated with Stretch Reflexes

Jaw jerk reflex (CN5)

Biceps reflex (C5 and C7)

Brachioradialis reflex (C6)

Extensor digitorum reflex (C6 and C7)

Triceps reflex (C6 and C7)

Patellar reflex (L2 through L4 and C7)

Ankle jerk reflex (S1 and S2)

Conditioned Reflexes
(These Are Learned Responses)

You may condition your pet to their feeding routine

•If you keep the dog food in a kitchen cabinet your dog knows this.

•When you go to the cabinet to get dog food and the feeding bowl.....

•The dog will start to salivate as you go to the cabinet

•The dog's salivation is a “visceral reflex” associated with the ANS and this ANS “reflex has been conditioned”

Visceral Reflexes

- These are reflex arcs which involve the visceral motor fibers (ANS)

  – Parasympathetic nerve fibers

  – Sympathetic nerve fibers

  – These are reflex arcs that regulate essential "homeostatic reflexes" like temperature regulation and blood pressure.

  – We will exam these reflexes in Chapter 15