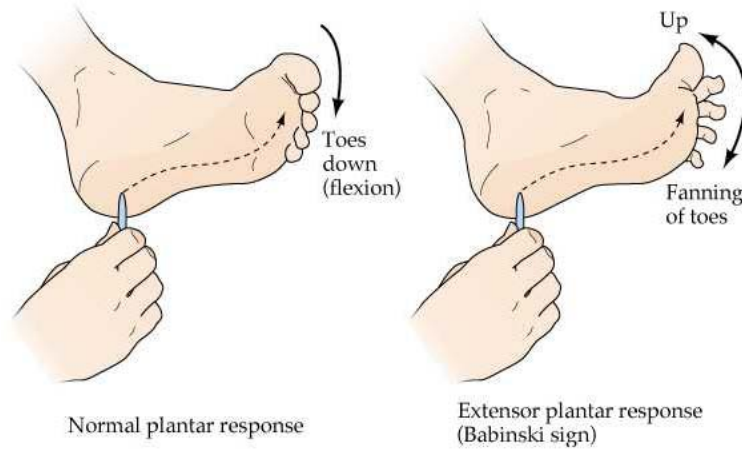
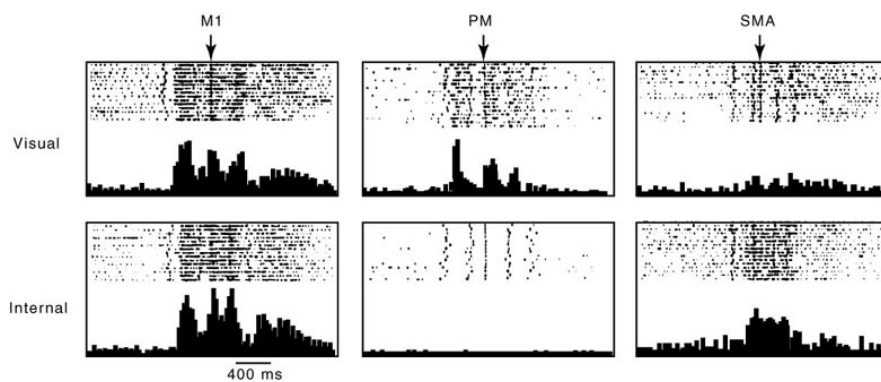


Babinski reflex and corticospinal tract lesion



Planning activity in supplementary motor cortex



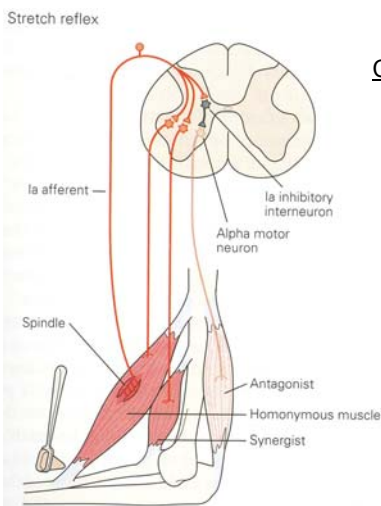
Activity of three neurons in M1, PM and SM as the monkey pressed three buttons in sequence

Spinal Reflexes

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Simple reflexes such as stretch reflex require coordinated contraction and relaxation of different muscle groups



Categories of Muscle Based on Direction of Motion

Flexors → reduce the angle of joints

Extensors → increase the angle of joints

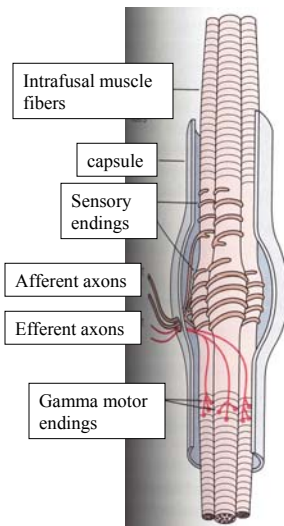
Categories of Muscle Based on Movement

Agonist → muscle that serves to move the joint in the same direction as the studied muscle

Antagonist → muscle that moves the joint in the opposite direction

2

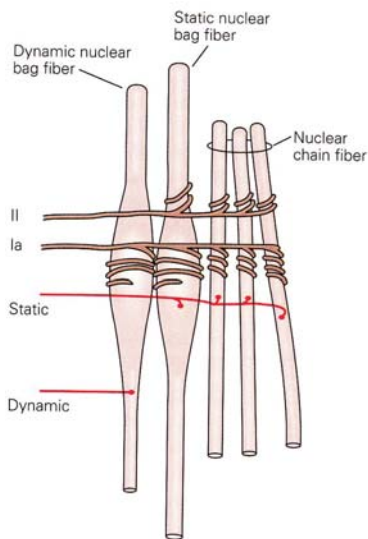
Muscle Spindles



- Small encapsulated sensory receptors that have a spindle-like shape and are located within the fleshy part of the muscle
- In parallel with the muscle fibers
- Does not contribute to the overall contractile force
- Mechanoreceptors are activated by stretch of the central region
 - Due to stretch of the whole muscle (including intrafusal f.)
 - Due to contraction of the polar regions of the intrafusal fibers

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Muscle Spindles



Organization

2 kinds of intrafusal muscle fibers

- Nuclear bag fibers (2-3)
 - Dynamic
 - Static
- Nuclear chain fibers (~5)
 - Static

2 types of sensory fibers

- Ia (primary) - central region of all intrafusal fibers
- II (secondary) - adjacent to the central region of static nuclear bag fibers and nuclear chain fibers

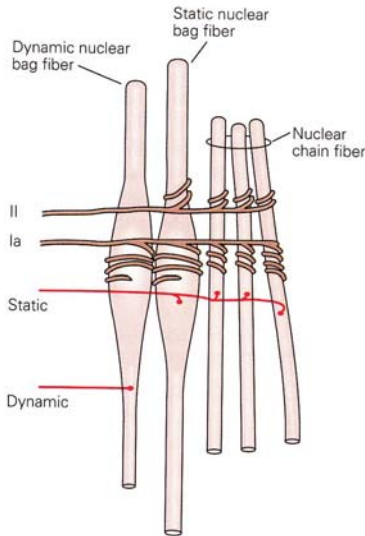
Intrafusal fibers stretched (loading the spindle) → Sensory ending stretched, increase firing

Muscle fibers lengthens (stretched) → Sensory ending stretched, increase firing

Muscle fiber shortens → Spindle unloaded, decrease firing

4

Muscle Spindles



Organization

Gamma motor neurons innervate the intrafusal muscle fibers.

Activation of gamma neurons → Shortening of the polar regions of the intrafusal fibers

Stretches the noncontractile center regions → Increase firing of the sensory endings

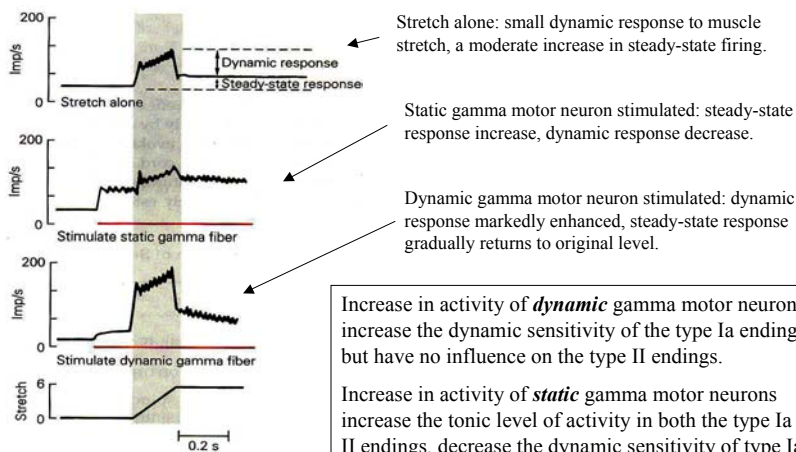
Therefore, the gamma motor neurons provide a mechanism for adjusting the sensitivity of the muscle spindles.

2 types of motor fibers

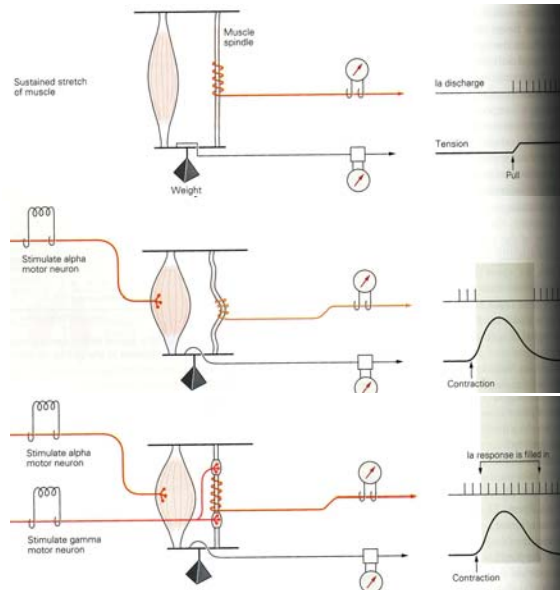
- Static gamma motor neuron – innervate both static bag and chain fibers
- Dynamic gamma motor neuron – innervate only dynamic bag fibers

Gamma motor neurons: Static and Dynamic Responses

Ia sensory fiber response



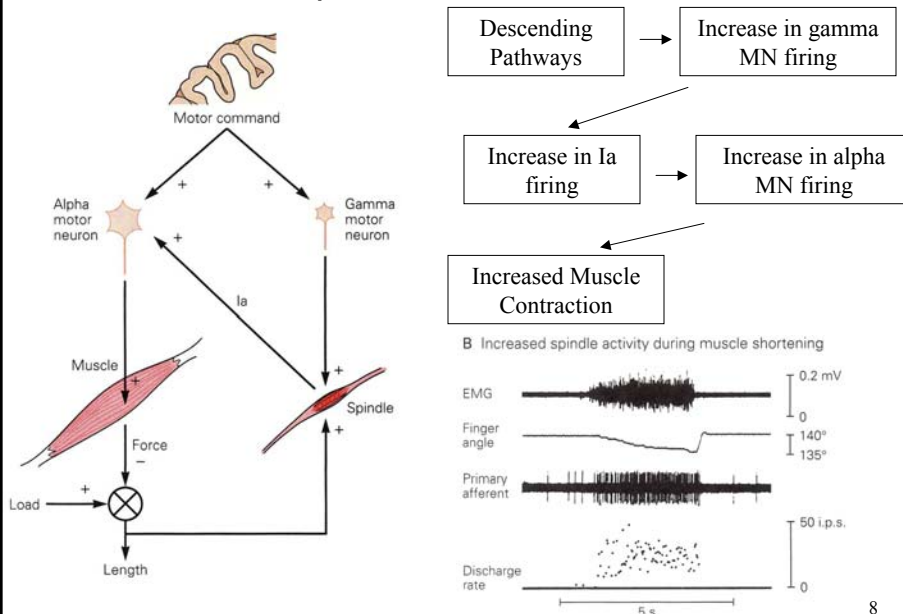
Activation of gamma MN during active muscle contraction enables the muscle spindles to continue sensing changes in muscle length



- Activation of the gamma motor neurons leads to contraction of the ends of the fibers, which stretch of the central regions.
- This allows the spindle to respond to changes in muscle length over a wide variety of lengths. I.e. **adjusts the spindle sensitivity**
- The activation of alpha and gamma motor neurons together enable the muscle spindle to respond during long contractions.
- Alpha and gamma MN are activated together during voluntary movements. (**alpha-gamma coactivation**)

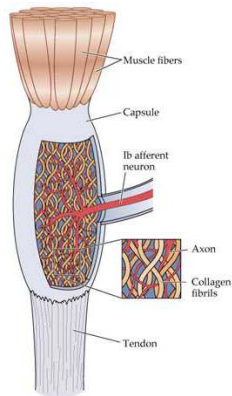
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The Alpha-Gamma Co-activation



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Golgi Tendon Organ



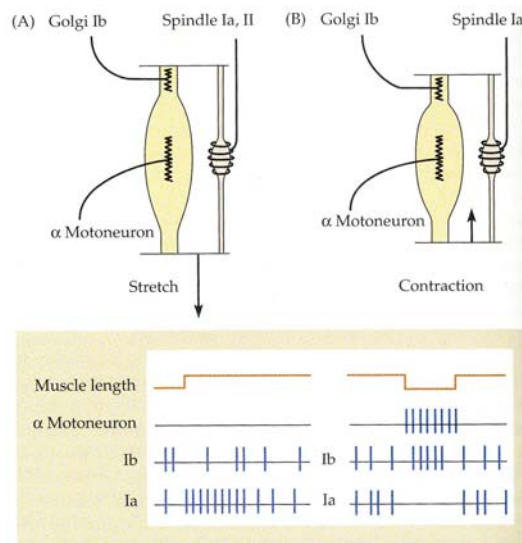
- Located at the junction between muscle fibers and tendon
- Connected **in series** with the skeletal muscle fibers
- Tendon Organs are most sensitive to muscle tension
- Innervated by a single Ib axon, which demyelinates when entering the capsule. There are branches into many small endings which intertwine with the collagen fibers.
- Stretching of the tendon organ (when the muscle contracts) straightens the collagen fibers, compressing the Ib branches and causing the cell to fire
- The average level of activity in a population of tendon organs in a muscle gives a good idea of the force done by the muscle

Muscle spindles: sensitive to changes in muscle length.

Golgi tendon organs: sensitive to changes in muscle tension.

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Muscle Spindle vs Golgi Tendon Organ



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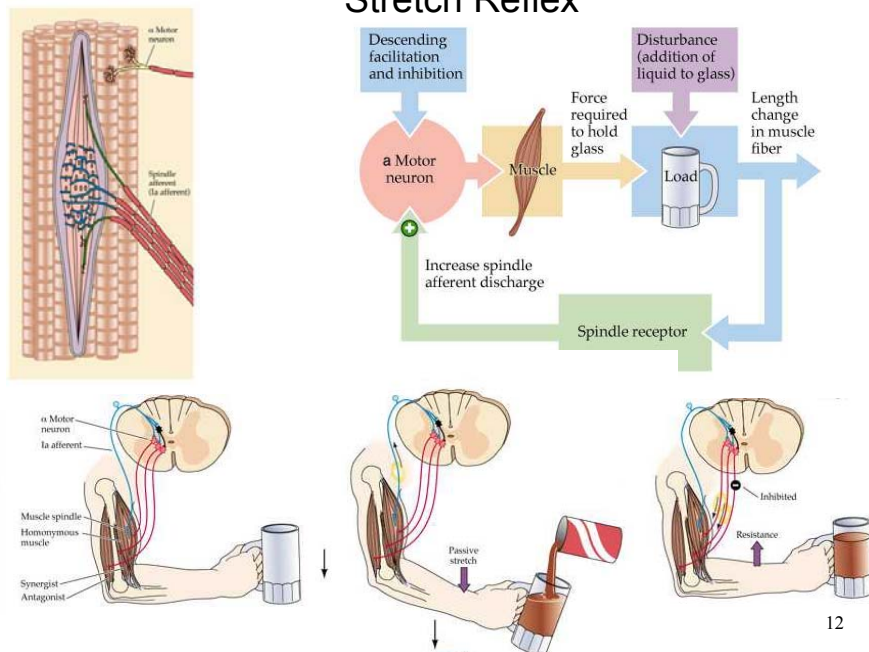
Summary of Sensory Fibers

- Ia**
 - Goes from the chain and bag nuclear fibers (static and dynamic) of the muscle spindle to the spinal cord.
 - Sensitive to muscle length and rate of change of length
- II**
 - Goes from the chain and bag nuclear fibers (static) of the muscle spindle to the spinal cord.
 - Sensitive to muscle length
- Ib**
 - Goes from the Golgi Tendon Organs to the spinal cord.
 - Sensitive to muscle tension

And others that respond to painful stimuli, temperature, etc

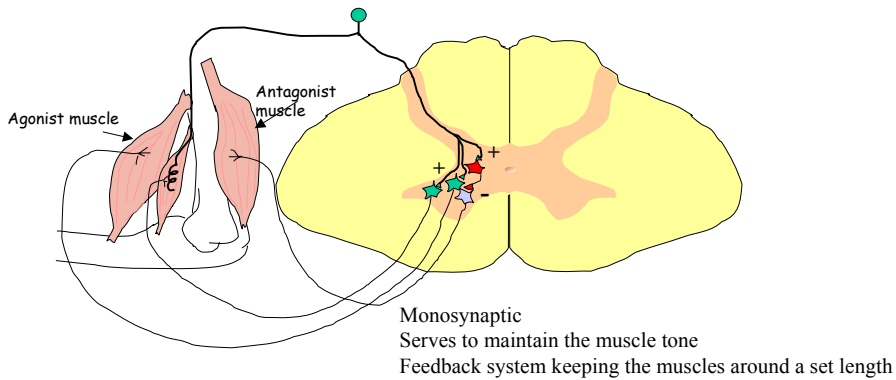
11

Stretch Reflex



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Stretch Reflex



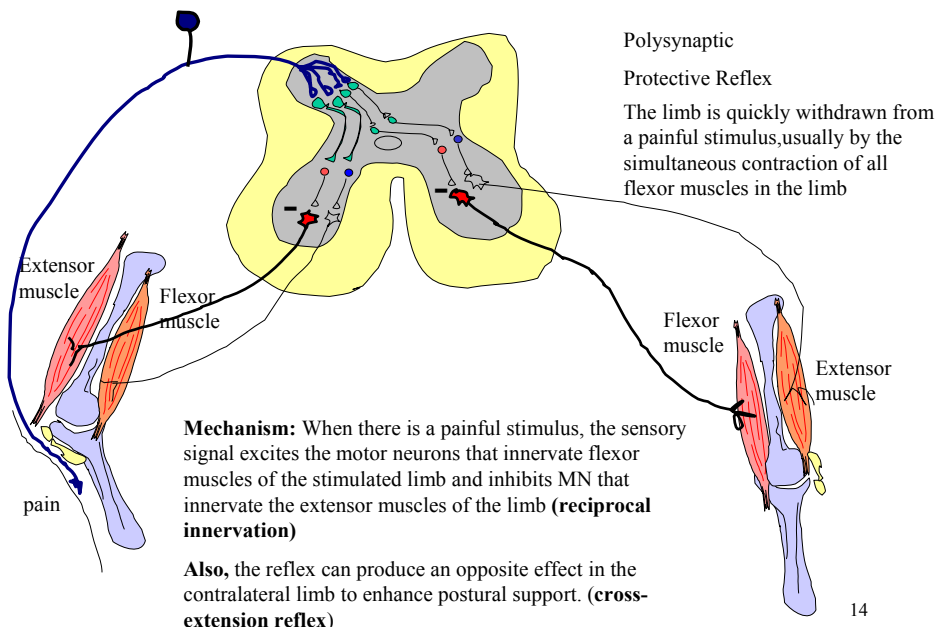
It involves a contraction that takes place when the muscle gets stretched.

Mechanism: When the muscle is stretched, this results in the stretching of the intrafusal muscle fibers in the muscle spindle. As a result, the Ia endings are stretched and increase their firing rate. They make excitatory connections onto the alpha MN innervating the same muscle and also onto those innervating synergistic muscles. Thus, the muscle contracts and its length is reduced.

Ia fibers can also synapse onto inhibitory interneurons and cause the relaxation of the antagonist muscles. (polysynaptic component)

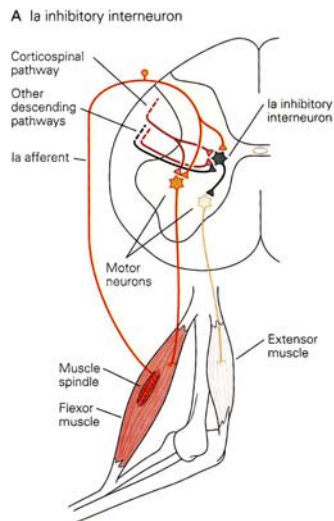
13

Flexion Withdrawal Reflex



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Functions of the Ia inhibitory interneurons

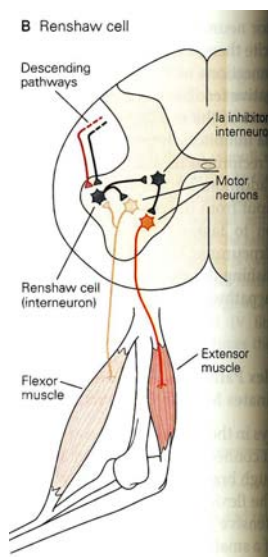


The Ia interneuron allows higher centers to coordinate opposing muscles at a joint through a single command.

- 1) Mediates reciprocal innervation in stretch reflex circuits.
- 2) Receives input from cortical descending pathway. A single descending signal that activates one set of muscles automatically leads to relaxation of the antagonists.
- 3) Other descending pathway provides excitatory or inhibitory connections to Ia neurons (I.e. greater inhibition allowing contraction of opposing muscles to occur).

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Functions of the Renshaw Cells



- inhibitory interneuron
- Inputs: Excited by collaterals of the axons of motor neurons (leads to presynaptic inhibition); descending pathways
- Effects:
 - Inhibition of large transient movements
 - Dis-inhibition of the antagonist muscle
- Central modulation regulates the sensitivity of MN to afferent input

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