CNS- MOTOR SYSTEM

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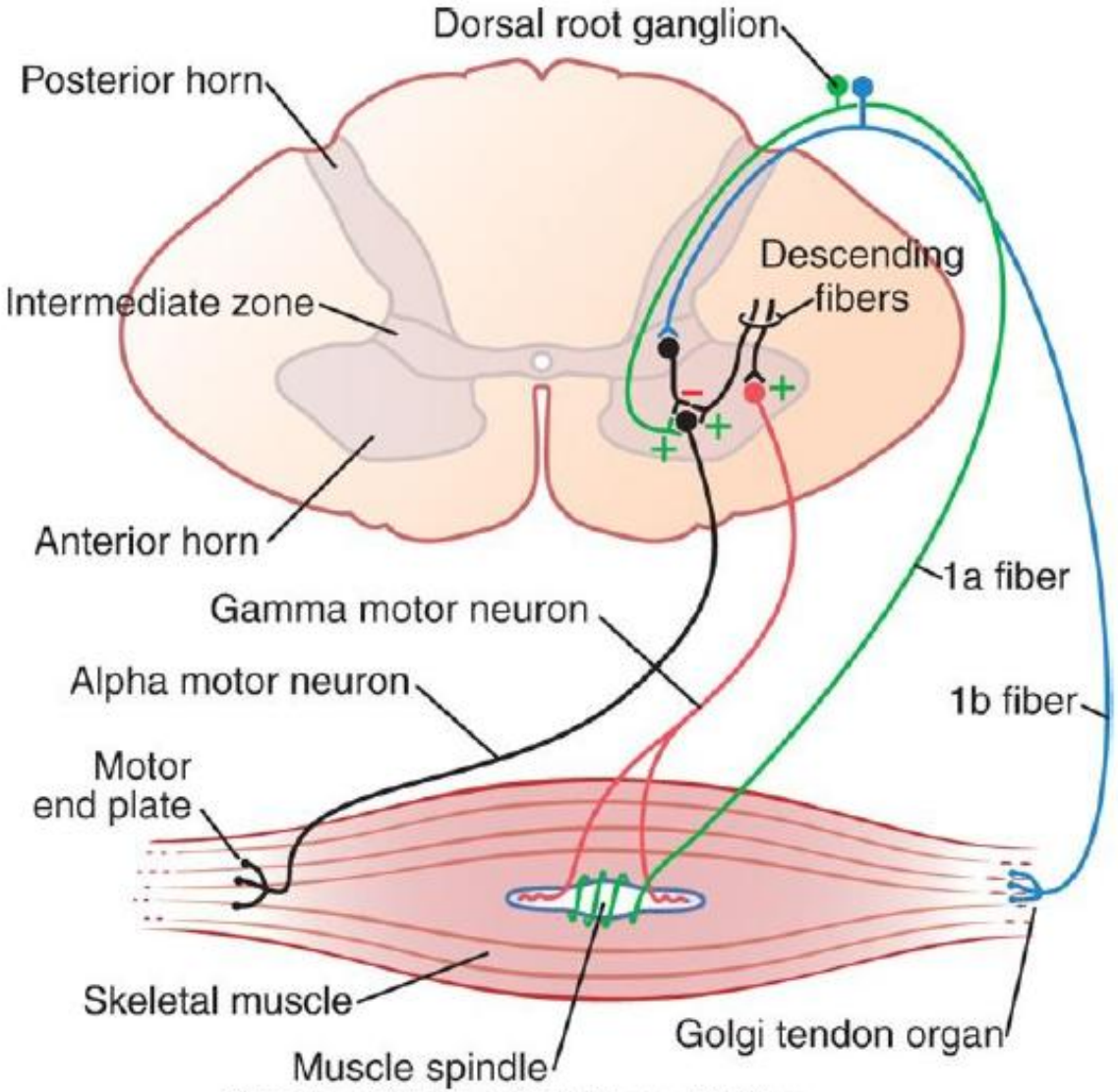
Components of organisation of motor system



Hall: Guyton and Hall Textbook of Medical Physiology, 12th Edition

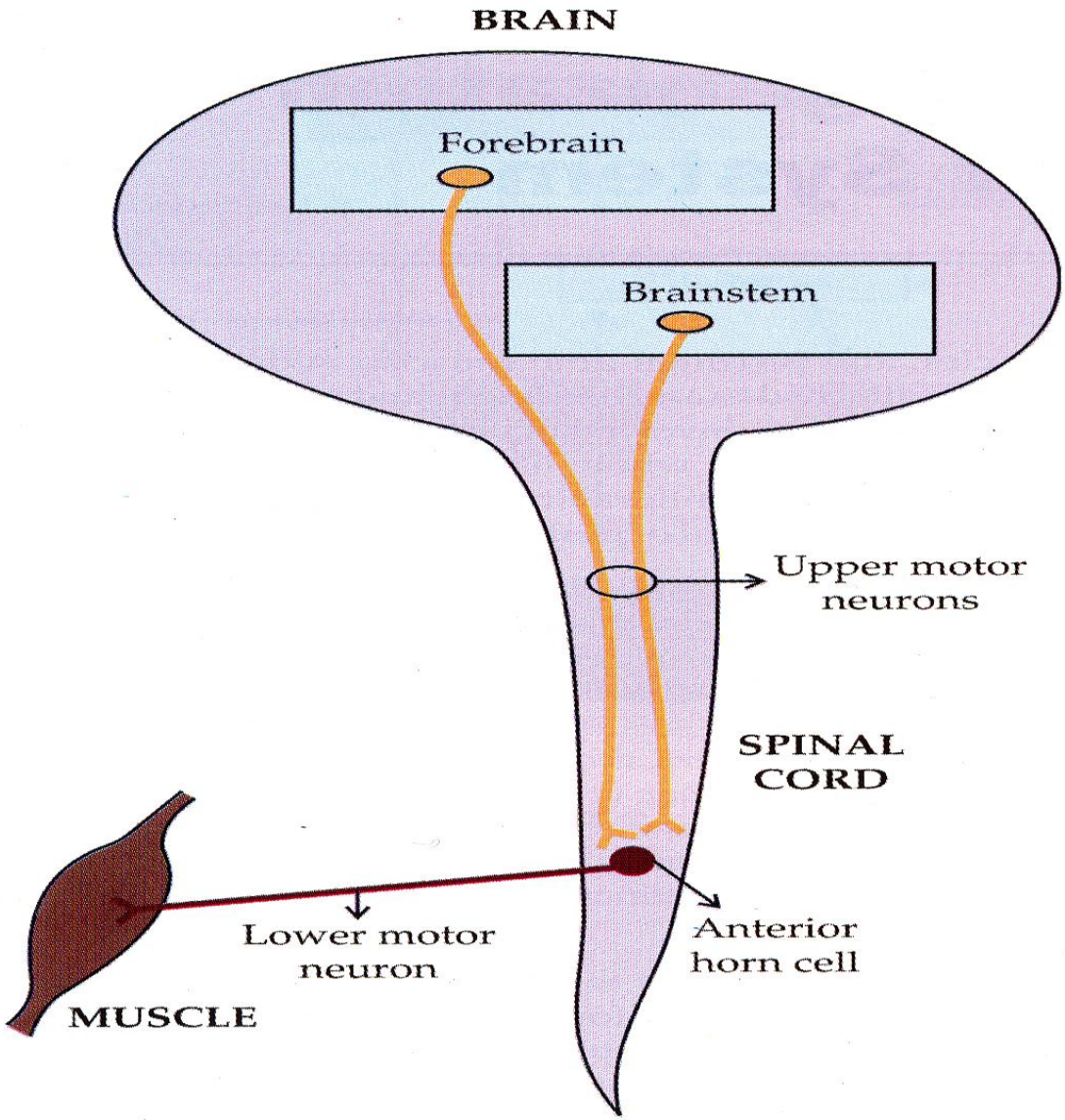
Components of organisation of motor system

- Muscles
- Afferent neuron (Sensory from muscle)
- Interneuron between afferent and motor neuron
- Motor neuron to muscle

Afferent

- Ia (main), Ib, II

Motor neuron



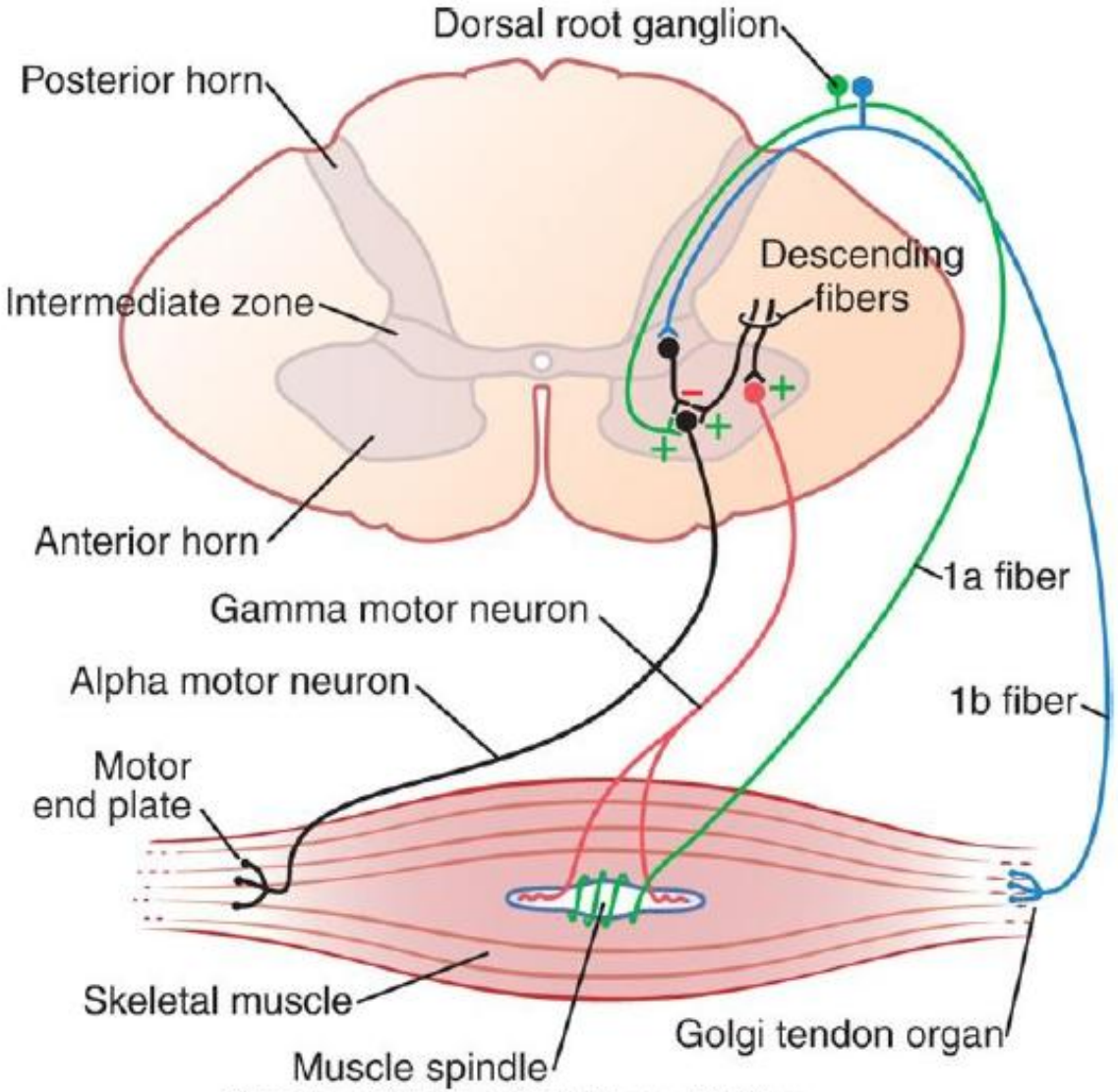
Motor neuron

- Involved in control of motor function
- Two categories
- Upper motor neuron(UMN) and Lower motor neuron(LMN)

UMN

- Motor neuron derived from various motor area of brain
  - motor cortex , brainstem motor nuclei
- Terminate directly or indirectly on lower motor neuron in the spinal cord
- Axons of these neurons form descending pathways
- Example- corticospinal, rubrospinal, vestibulospinal, reticulospinal

LMN- alpha motor neuron



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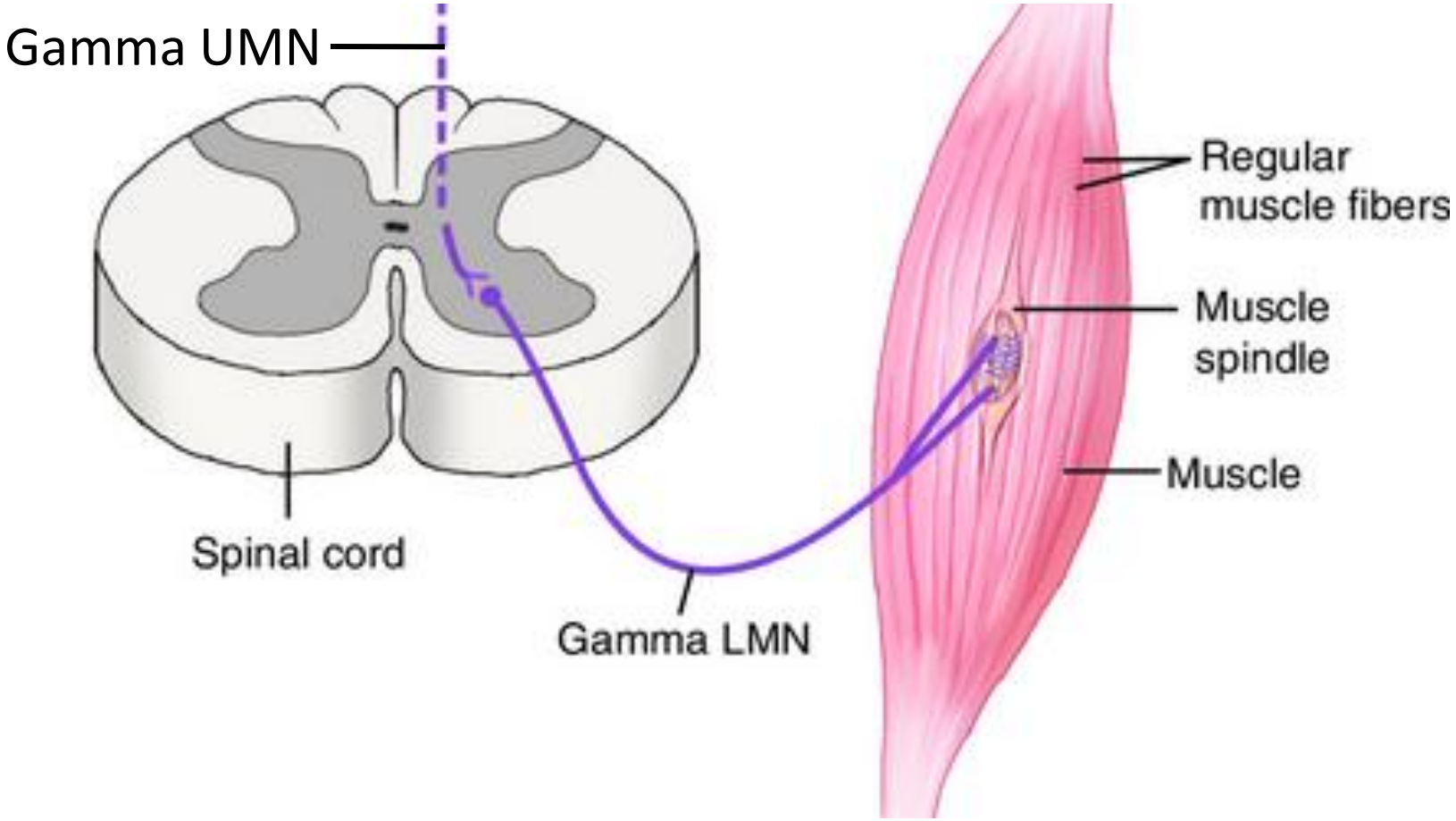
Gamma motor neuron



LMN

- Originates in the anterior horn of spinal cord or in cranial nerve motor nuclei
- Innervates various skeletal muscles
- Two types- α and γ

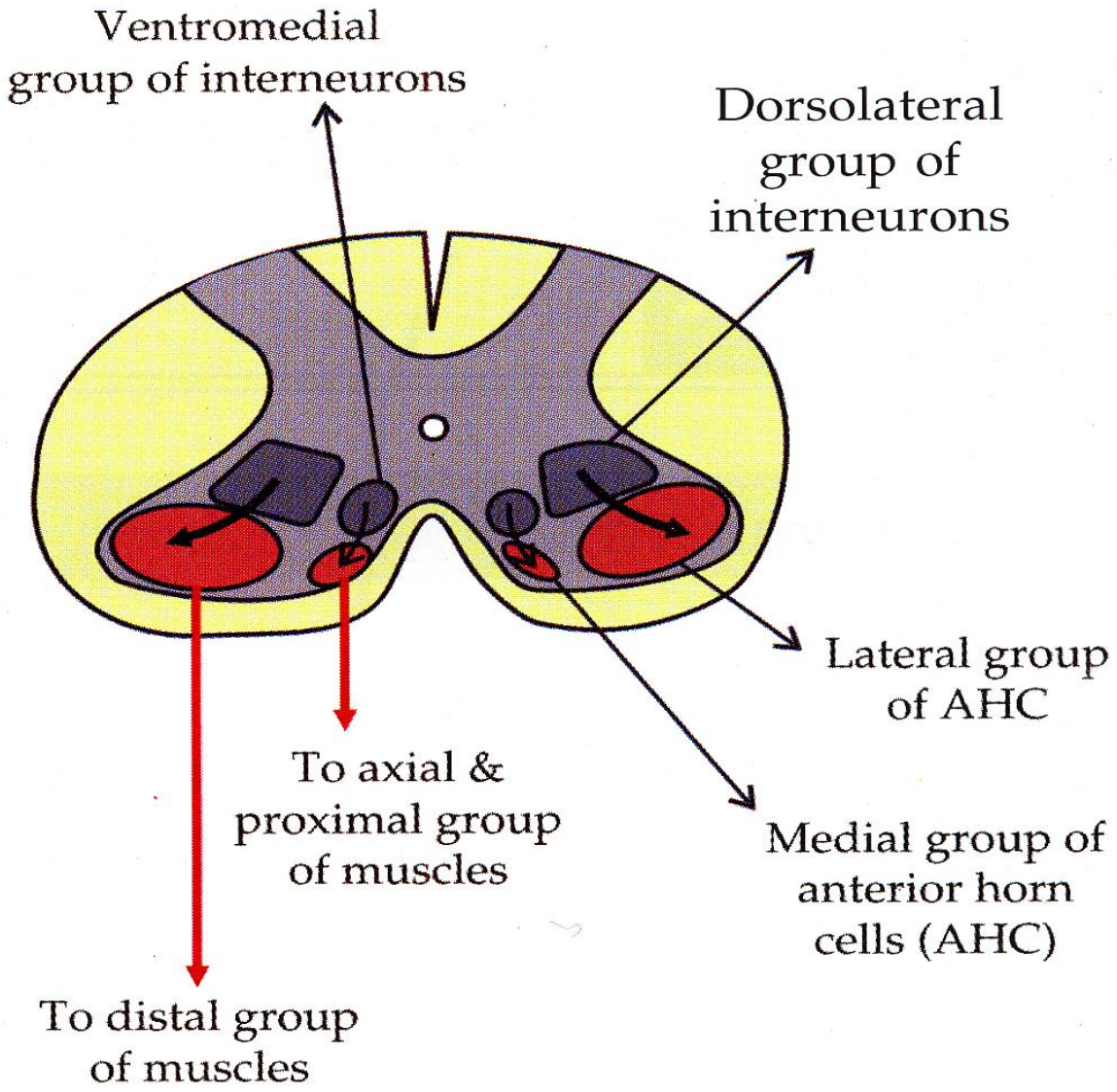
α motor neuron

- Final common path for motor output signal
- Innervates extrafusal muscle fibre
- One alpha motor neuron innervates 10 to 1000 muscles
- 2 types- large, small

γ motor neuron

- Innervates intrafusal muscle fibre
- Regulates muscle length and muscle tone
- Do not receive input from afferents
- Descending pathway influences gamma motor neuron and thus regulates muscle tone
- Gamma motor neurons with intrafusal fibers constitute the **fusimotor system**

Motor neuron and interneuron group



Motor neuron pool

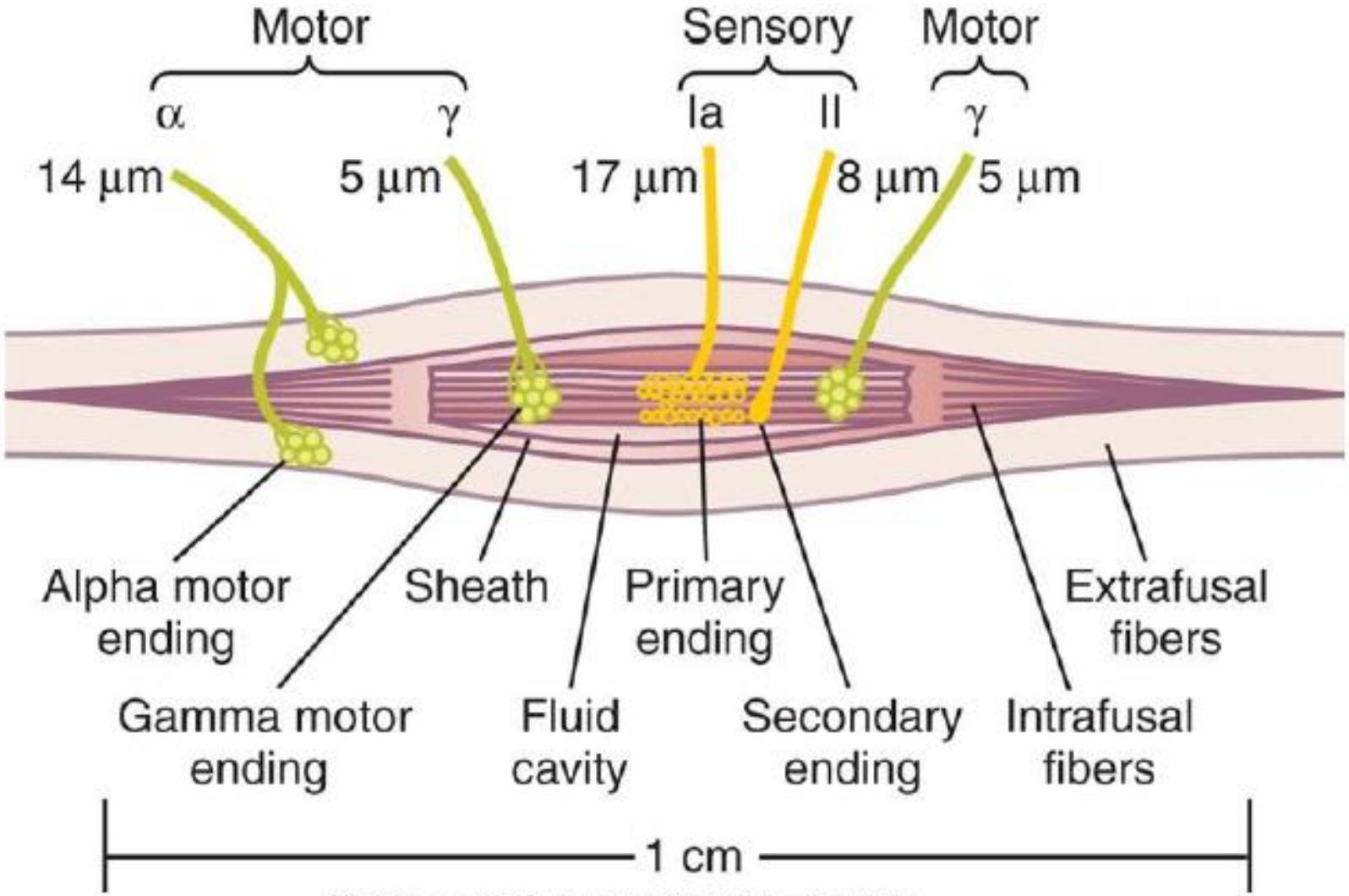
- Two groups
- Medial- control posture
- Lateral- control skilled activities

Spinal interneuron

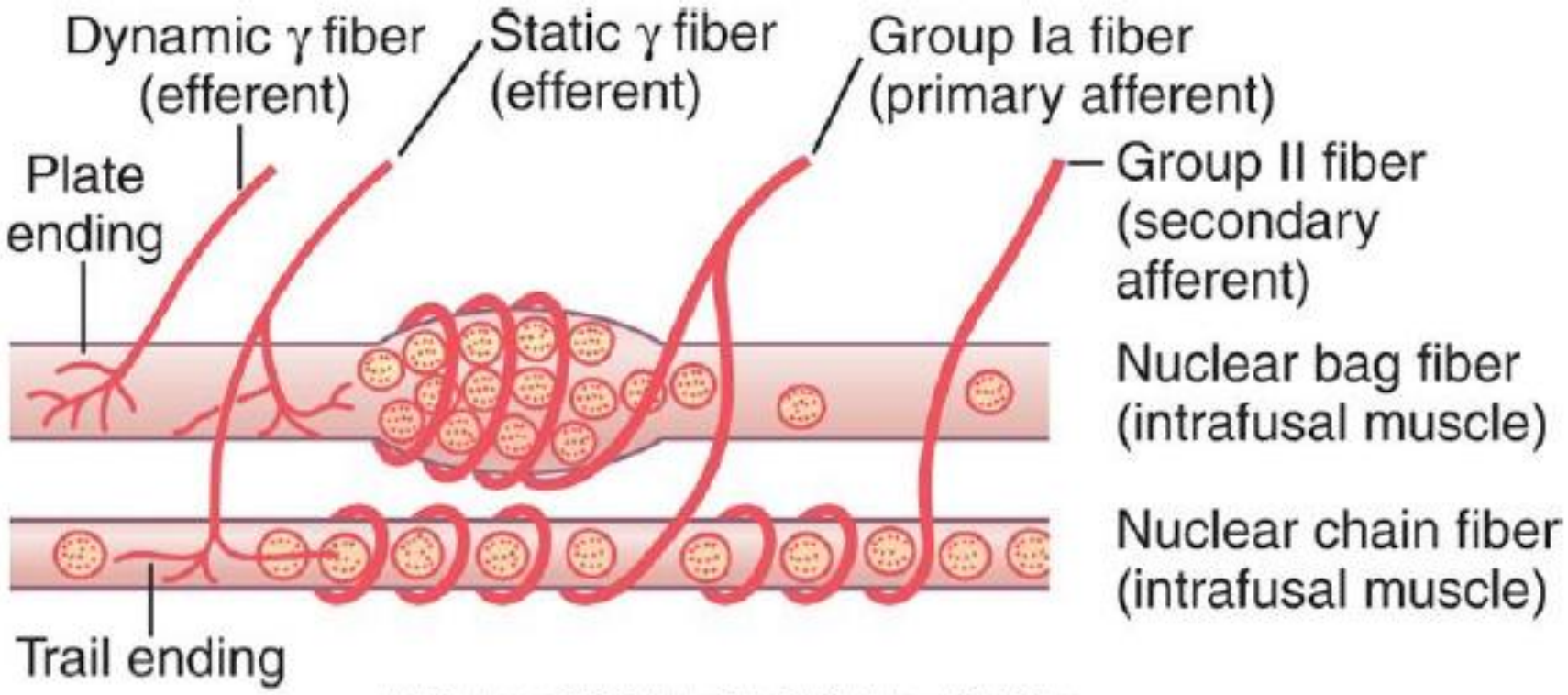
- Descending tracts mainly project to interneuron which project to spinal motor neuron
- Two groups
- Ventromedial interneuron- control posture
- Dorsolateral interneuron- regulates skilled voluntary activities

Muscle spindle

Short essay



Types



Muscle spindle

- Specialized sense organ present in all skeletal muscle
- Receptor that respond to change in muscle length and velocity of lengthening
- Change in muscle length are associated with change in joint angle
- So muscle spindle give information on position (proprioception)
- Fibers are called intrafusal fibers

Structure

- Spindle or fusiform shaped
- 100 µm diameter and 5 to 10 mm length
- Enclosed in a connective tissue capsule
- Regular muscle fibre or the extrafusal fibers are present outside the fusiform capsule of the spindle
- Lies in parallel to the regular muscle fiber
- Distal ends are attached to the tendon of the muscle or to the sides of extrafusal fibers
- Two types
- Nuclear bag and nuclear chain fibers

Nuclear bag fibers

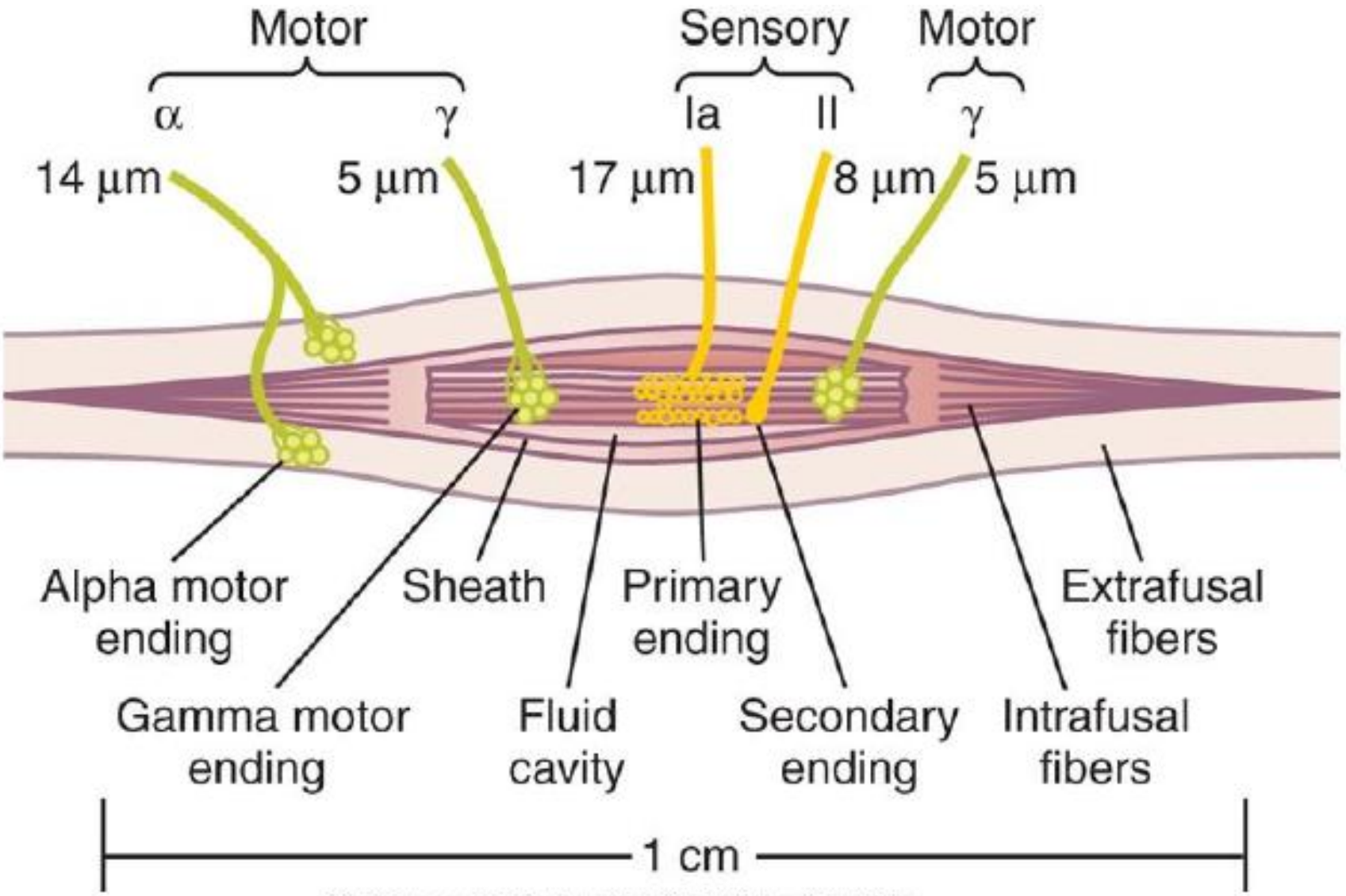
- Longer than nuclear chain
- Dilated at centre to form a bag like structure
- Contains multiple nuclei

Nuclear chain fiber

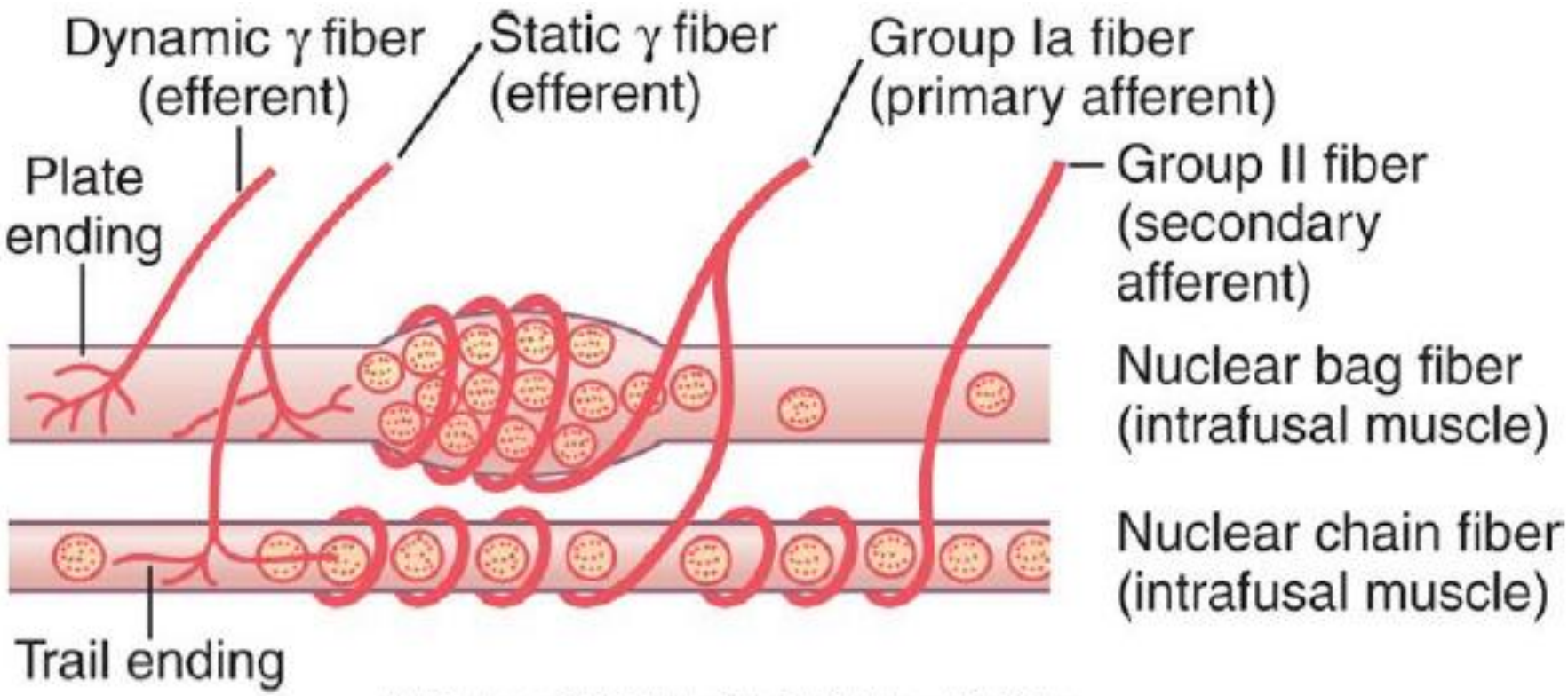
- Thinner and shorter
- Present by the side of nuclear bag
- Do not have definitive bag
- Nuclei are arranged in a row

- Each spindle- 2 to 3 nuclear bag and 5 nuclear chain fibers

Innervation



Draw diagram



Innervation- afferent

- Ia and II
- Ia – larger diameter than II
- Ia- faster than II
- Two types of sensory endings
- Primary and secondary

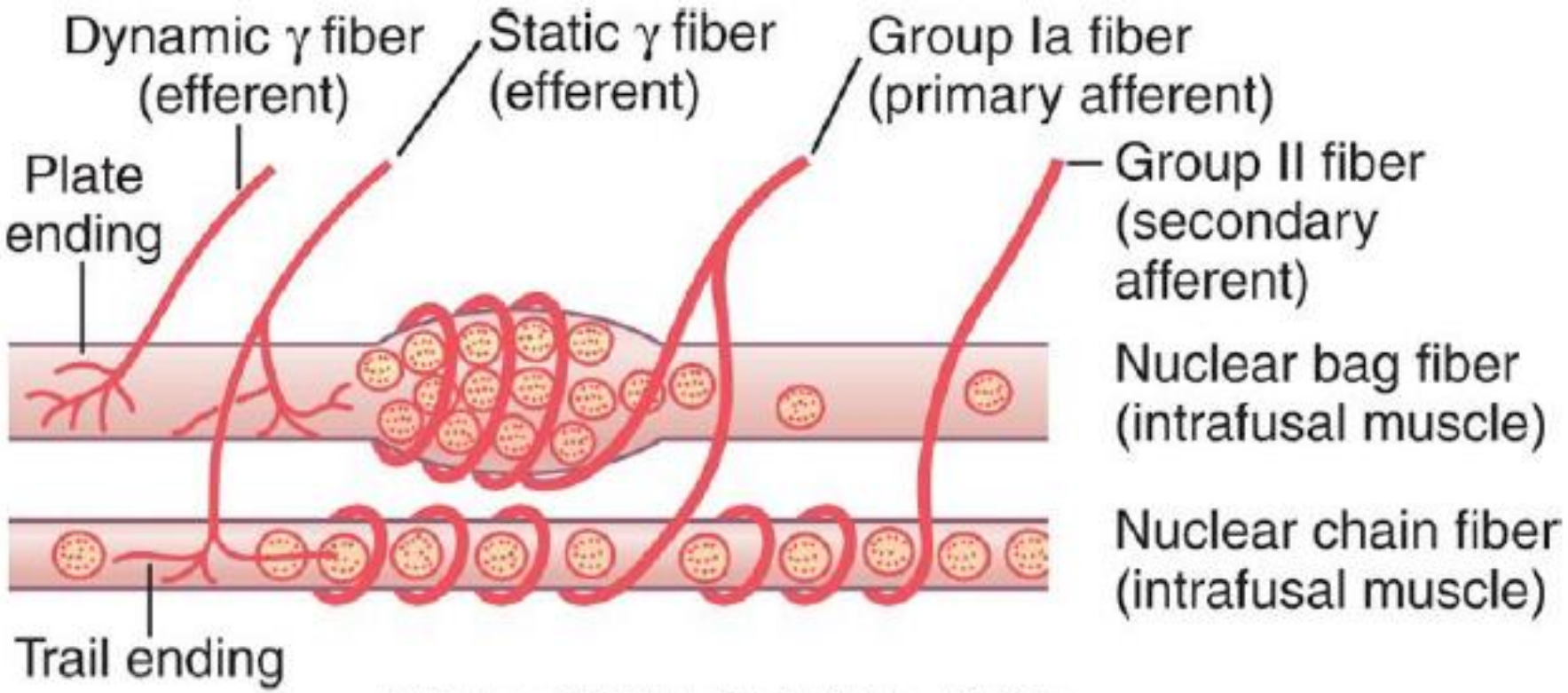
Primary endings

- Terminal of type Ia fiber
- Also called annulospiral ending
- Coiled spirally around the center of the intrafusal fibers
- Present on both nuclear bag and nuclear chain fibers

Secondary endings

- Terminals of type II fibers
- Also called flower spray endings
- Appear like flowers
- Present on nuclear chain fibers
- Located in the paracentral part of spindle

Efferent innervation (motor fiber)
γ motor neuron



Efferent innervation (motor fiber)
γ motor neuron

- Innervates intrafusal muscle fibre
- Also called fusimotor fibers
- Arising from anterior horn cells
- Called as small nerve system
- Do not receive input from afferents
- Descending pathway influences gamma motor neuron and thus regulates muscle tone
- Gamma motor neurons with intrafusal fibers constitute the **fusimotor system**

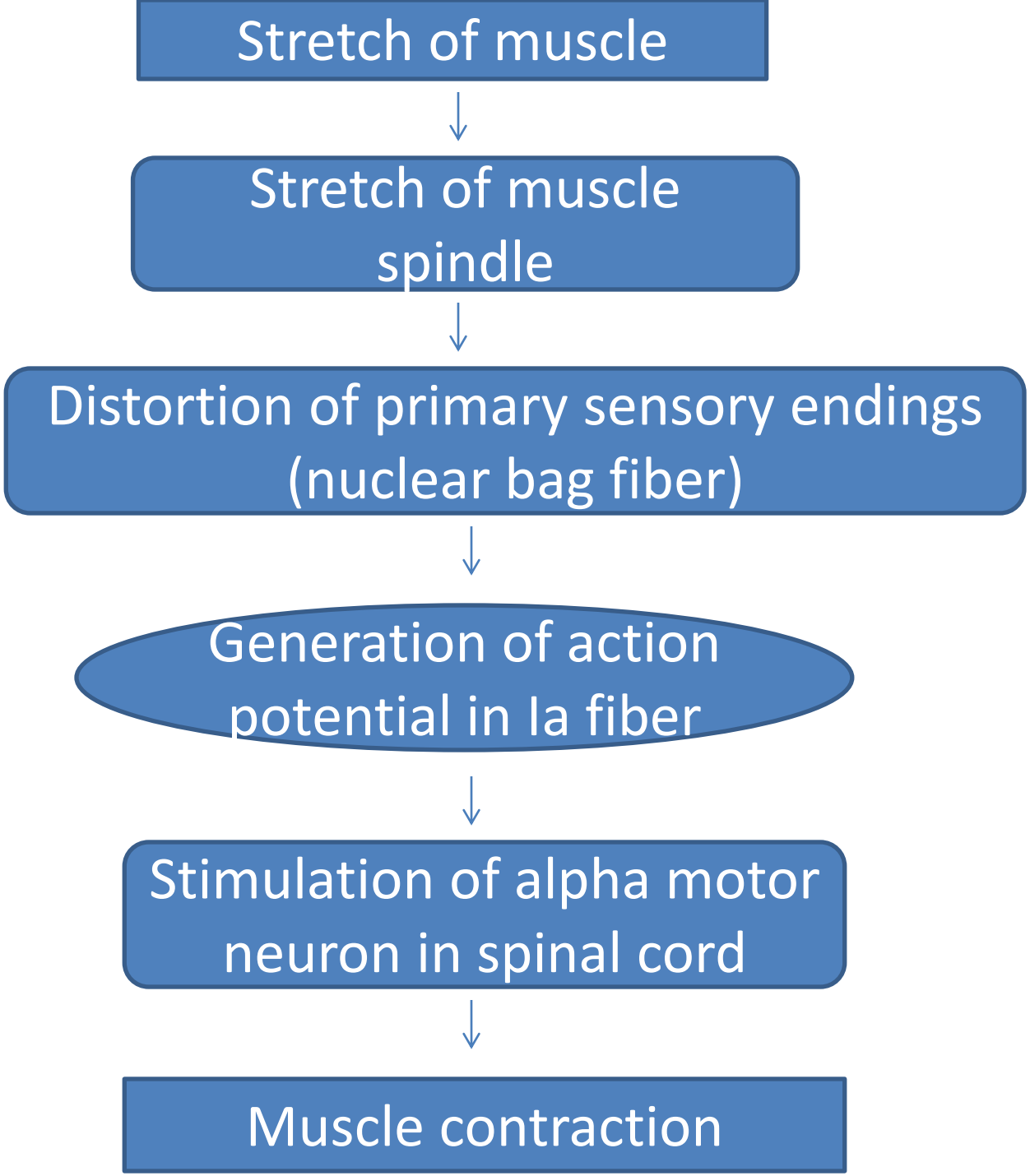
- Regulates muscle length and muscle tone
- Terminal on the nuclear bag fiber- plate ending
- Terminal on the nuclear chain fiber- trail ending

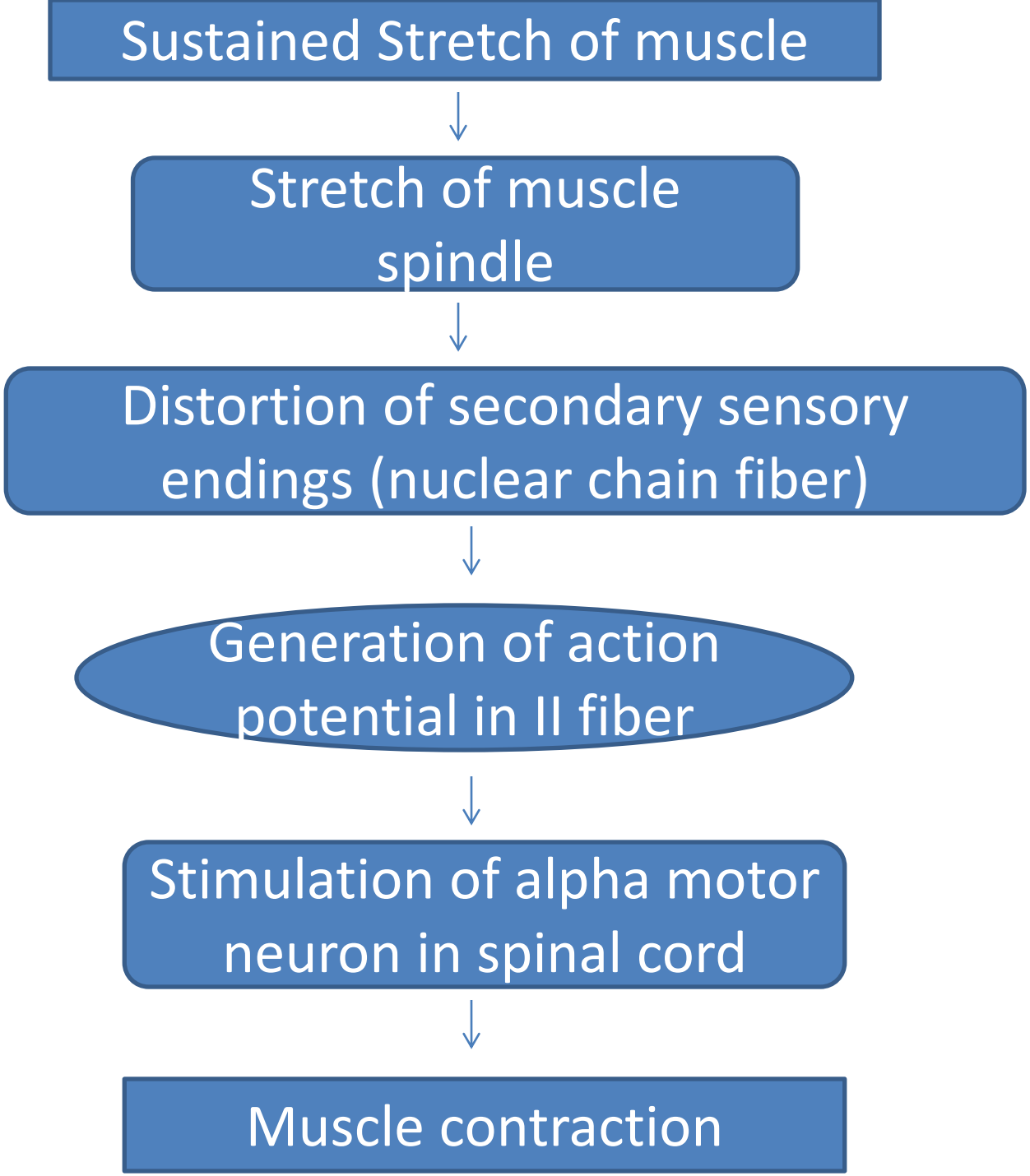
Types of gamma motor neuron

- Dynamic- terminates on nuclear bag fiber
- Static- terminates primarily on nuclear chain fiber (nuclear bag also)
- Stimulation of dynamic gamma motor neuron causes change in muscle length resulting in increased response in type Ia afferent fiber (nuclear bag fiber)
- Stimulation of static gamma motor neuron causes maintained stretch resulting in increased response in type Ia and II afferent fibers (nuclear chain)

- Stimulation of dynamic gamma efferent increases spindle sensitivity to rate of change of stretch(phasic or dynamic component)
- Stimulation of static gamma efferent increases the spindle sensitivity to steady maintained stretch(tonic or static component)

Functions of muscle spindle

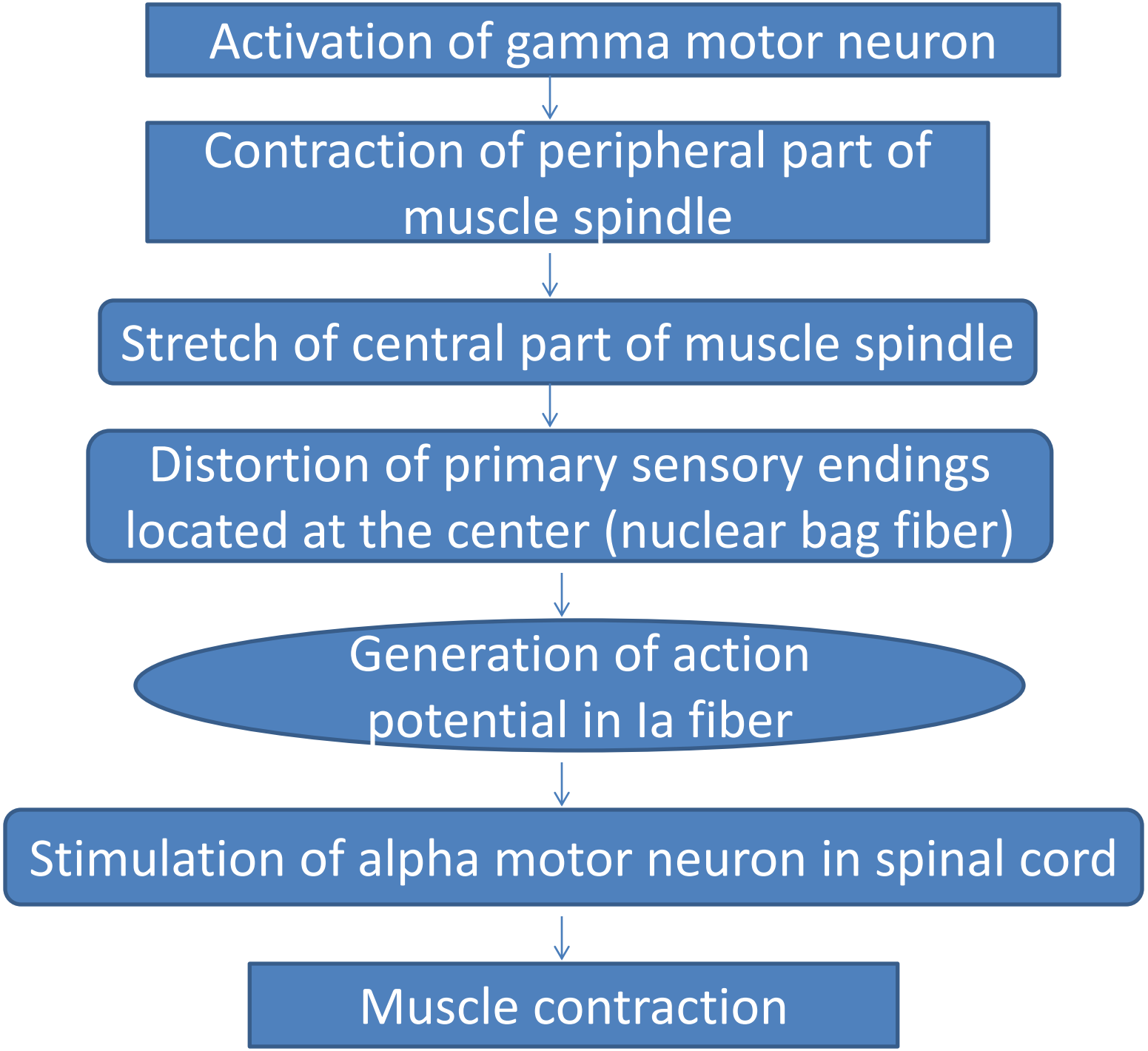

Stretch of muscle
Stretch of muscle spindle
Distortion of primary sensory endings (nuclear bag fiber)
Generation of action potential in Ia fiber
Stimulation of alpha motor neuron in spinal cord
Muscle contraction


Sustained Stretch of muscle
Stretch of muscle spindle
Distortion of secondary sensory endings (nuclear chain fiber)
Generation of action potential in II fiber
Stimulation of alpha motor neuron in spinal cord
Muscle contraction

Functions of muscle spindle

- Receptors sensitive to stretch
- Stretching of muscle spindle generate action potential in the afferent fibers
- Spindle afferent terminates on the cell bodies of alpha motor neurons in the spinal cord
- Results in muscle contraction
- When muscle contracts, spindle activity is less and muscle spindle is no longer stretched resulting in relaxation of muscle

Effect of stimulation of gamma efferent


Activation of gamma motor neuron
Contraction of peripheral part of muscle spindle
Stretch of central part of muscle spindle
Distortion of primary sensory endings located at the center (nuclear bag fiber)
Generation of action potential in Ia fiber
Stimulation of alpha motor neuron in spinal cord
Muscle contraction

Spindle responses

- Dynamic response
- Endings on nuclear bag discharge more rapidly when muscle is stretched and less to sustained stretch (velocity of lengthening of muscle)

- Static response
- Endings on nuclear chain fiber discharge at an increased rate throughout the period of stretch (change in muscle length at a maintained stretch)

Control of gamma efferent discharge

- Gamma neuron do not receive input from primary sensory afferents
- They are primarily influenced by the descending pathways
- Descending pathway increases sensitivity of muscle spindle by adjusting the rate of gamma motor neuron
- Anxiety increases gamma efferent discharge
- Activities originating in sensory pathway influences gamma efferent (noxious stimuli increases gamma discharge in ipsilateral flexor muscle and decreases gamma discharge in ipsilateral extensor muscle)
- Stimulation of reticular formation increases gamma discharge
- Other motor activity increases gamma discharge(eg: Jendrassik's maneuver)

Jendrassik's maneuver

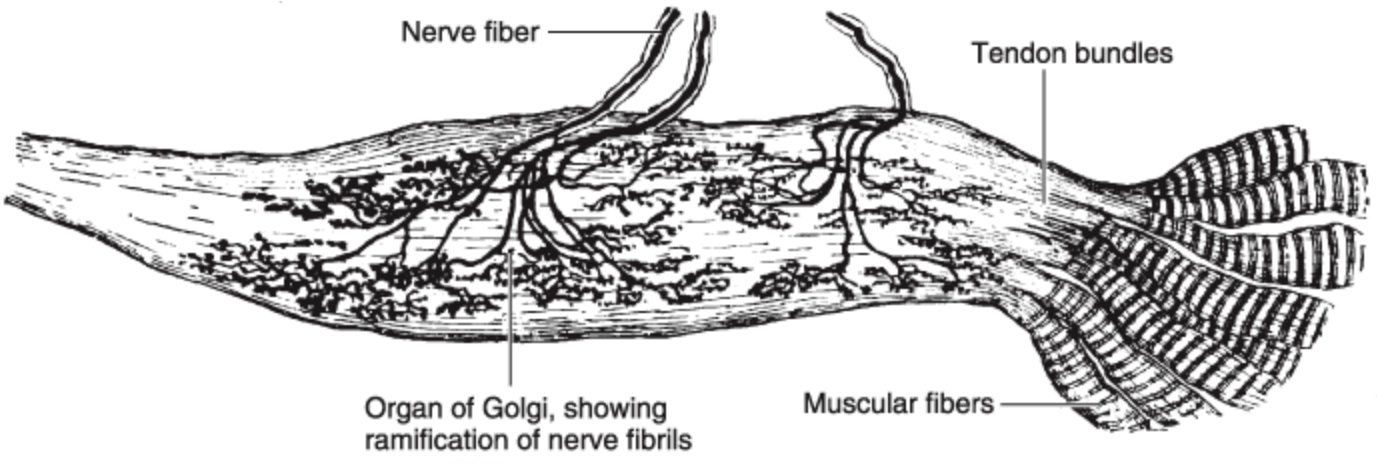
Jendrassik's maneuver (Write briefly)

- Process in which tendon reflex are better elicited by trying to pull the hands apart when the flexed fingers are hooked
- Proprioceptive input from the hand activates the supraspinal centers which increases gamma efferent discharge by stimulating the descending pathways

α-γ colinkage (coactivation)

- Descending pathway that stimulates gamma motor neurons also stimulates alpha motor neurons
- So gamma efferent discharge increases along with the increased discharge of alpha motor neuron called as alpha- gamma colinkage
- Because of this muscle spindle continues to discharge even when muscle is in contracted state
- Muscle spindle adjusts motor neurons discharge throughout the period of muscle contraction
- Helps in continuous contraction of muscle

Golgi tendon organs (Write briefly)



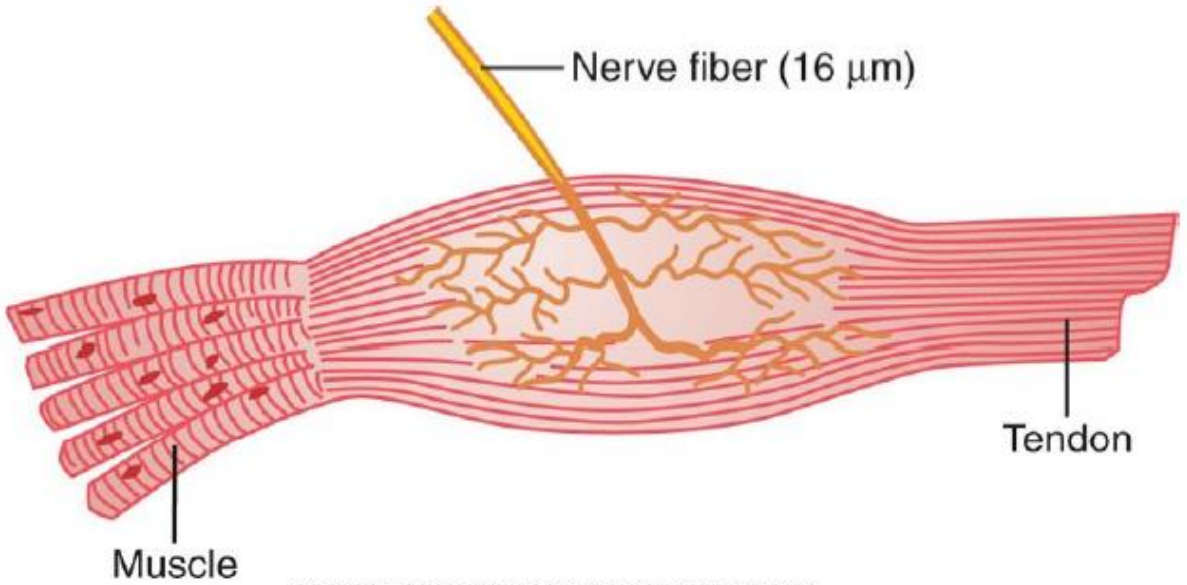
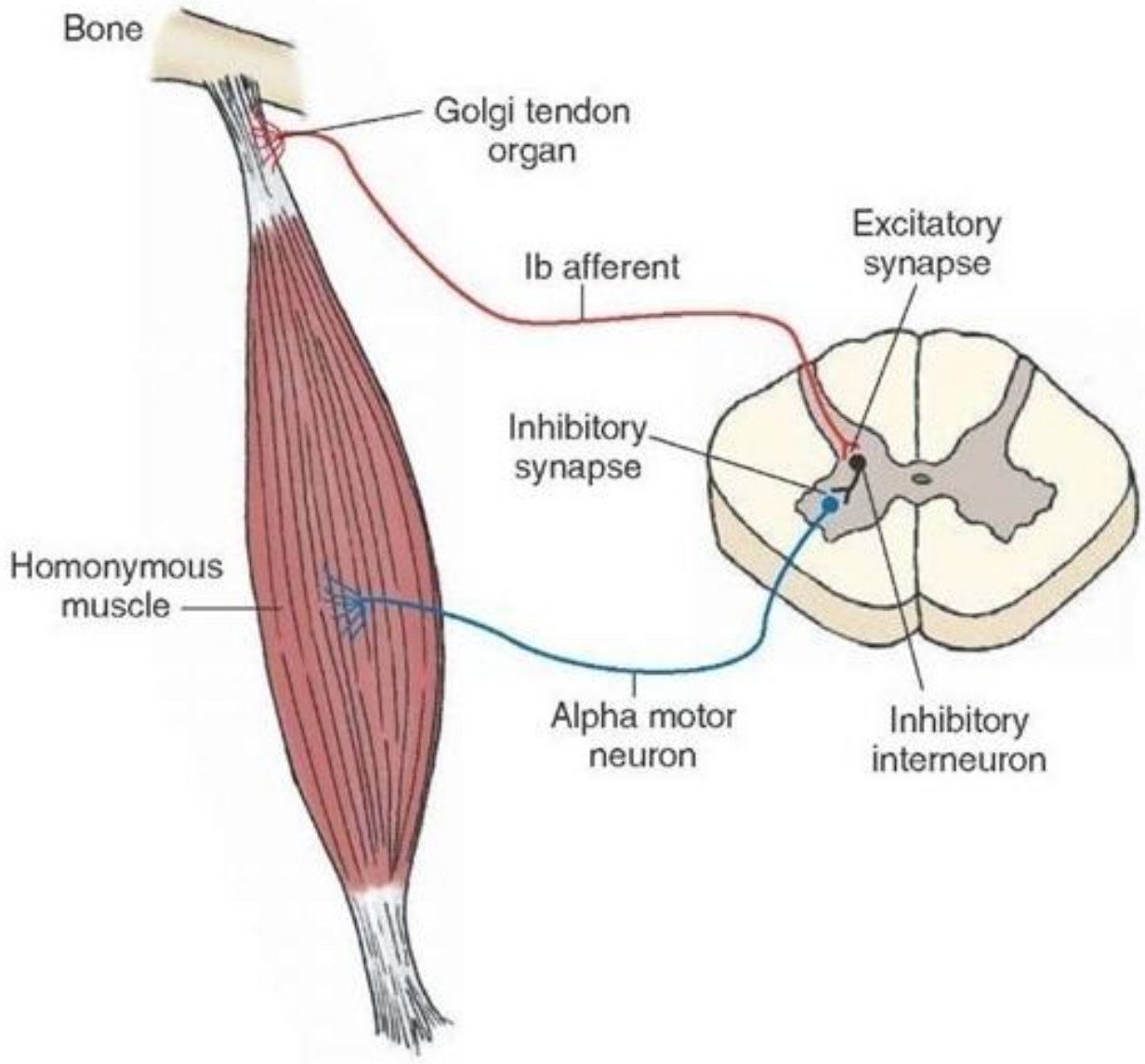


Figure 54-8 Golgi tendon organ.

Function


Bone
Golgi tendon organ
Ib afferent
Excitatory synapse
Inhibitory synapse
Homonymous muscle
Alpha motor neuron
Inhibitory interneuron

Golgi tendon organs (Write briefly)

- Found in the tendon of muscle

➢ Structure

- This organ consists of a net-like collection of knobby nerve endings among the fascicles of a tendon.
- Found by the terminals of Group Ib fibers
- Arranged in series with that of muscle fiber
- Ib fiber terminate indirectly on alpha motor neuron via interneurons
- As interneurons are inhibitory, stimulation of Ib fiber inhibit the motor neuron activity

Functions

- GTO can be activated by muscle stretch or by contraction of muscle
- Stimulus is the force that develops in the tendon
- GTO signals the force of muscle contraction
- Provides the force feedback (Muscle spindle provides length feedback)