

Stretch reflex and Golgi Tendon Reflex

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Objectives: ■

Upon completion of this lecture, students should be able to:

- Describe the definition and components of stretch reflex
- Understand the physiological role of the muscle spindle and its innervation.
- Understand the sensory primary and secondary (flower-spray) afferent fibers to muscle spindle
 - Describe the Dynamic gamma efferent and Trail endings discharge and their functional role
- Describe the Dynamic stretch reflex and Static stretch reflex.
- Describe the muscle tone and its abnormalities
- Explain functional role of facilitatory & Inhibitory supra spinal centers
- Describe properties of Golgi tendon reflex

What is the Stretch Reflex ?

- It is **reflex contraction** of muscle resulting from stimulation of the **muscle spindle by stretch**
- **Muscle spindle** is the receptor that is located inside muscle & detects changes in muscle length)

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Stretch reflex

1-Deep-monosynaptic reflex

2-sudden stretch of a muscle >>>>>reflex contraction of the stretched muscle

-Components:-

● **Receptor : muscle spindle**

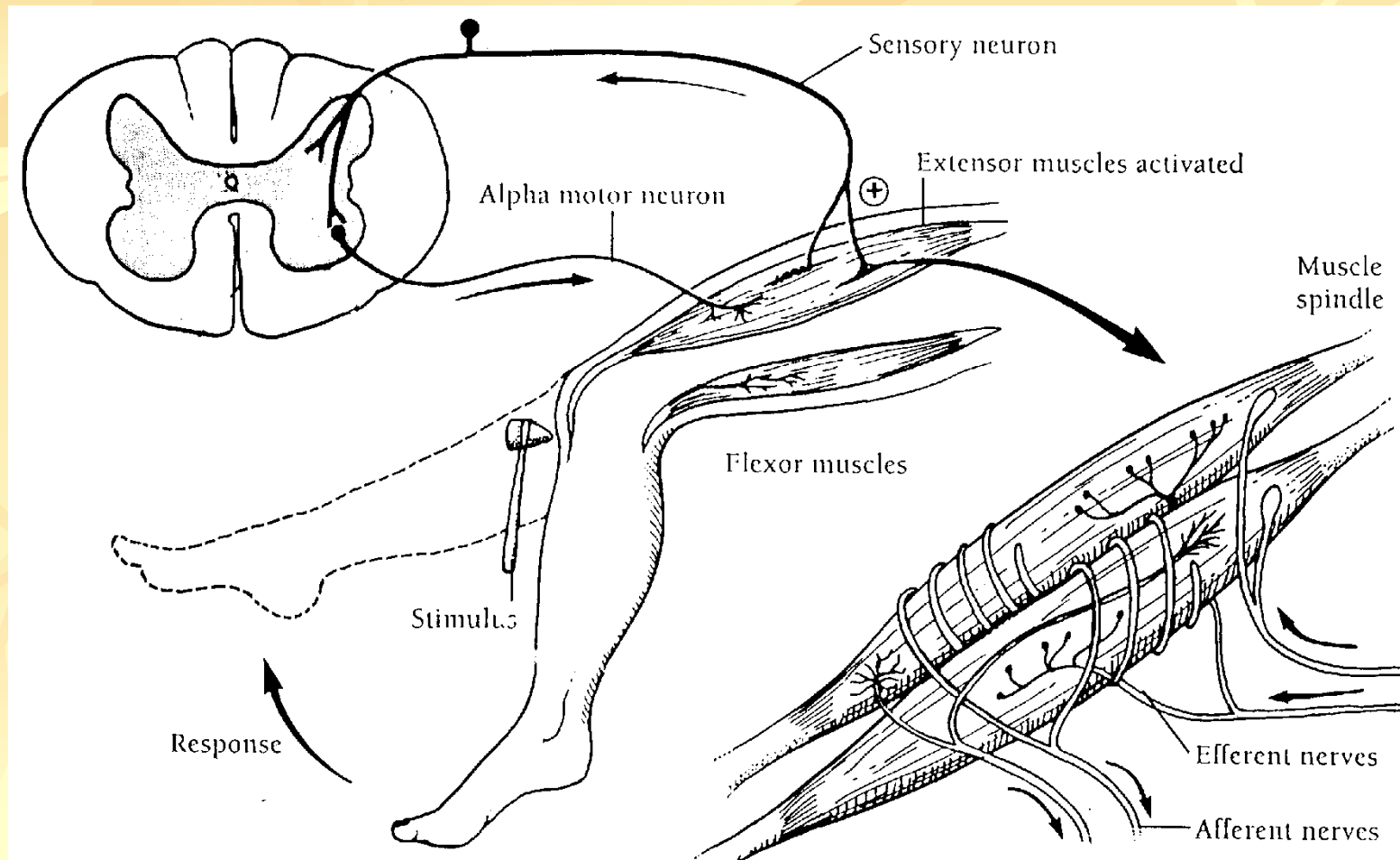
● **Afferent (annulospiral+flower spray)**

● **AHC(center)**

● **Efferent (motor nerve (alpha fibers70%)to extrafusal muscle fibers +gamma efferent 30% to muscle spindle intrafusal fibers)**

● **Effector/muscle**

Stretch Reflex/ example Knee jerk



Stretch reflex receptor (Muscle Spindle)

- Structure of Muscle Spindle:-

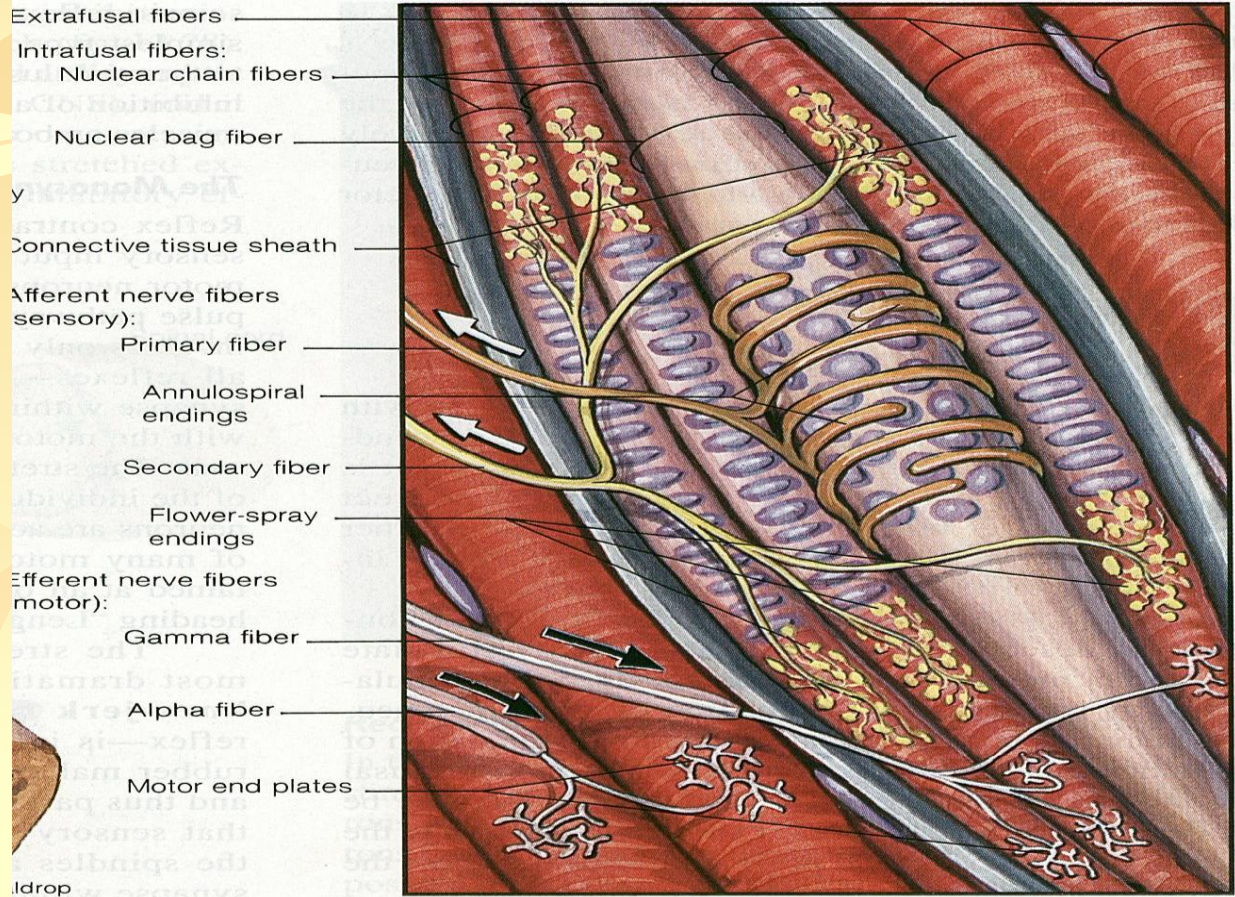
-Muscle spindle consists of 3-12 small muscle fibres (**intrafusal fibres**) within CT capsule.

- parallel to extrafusal fibres & attached to it or to tendons.

-Each intrafusal fibre has:

-**Central** non-contractile area (**receptor**)

-**Peripheral contractile** on sides of central zone has actin & myosin.



Muscle Spindle(cont)

Two types of intrafusal fibres:

1-Nuclear bag fibres : (2 / spindle)

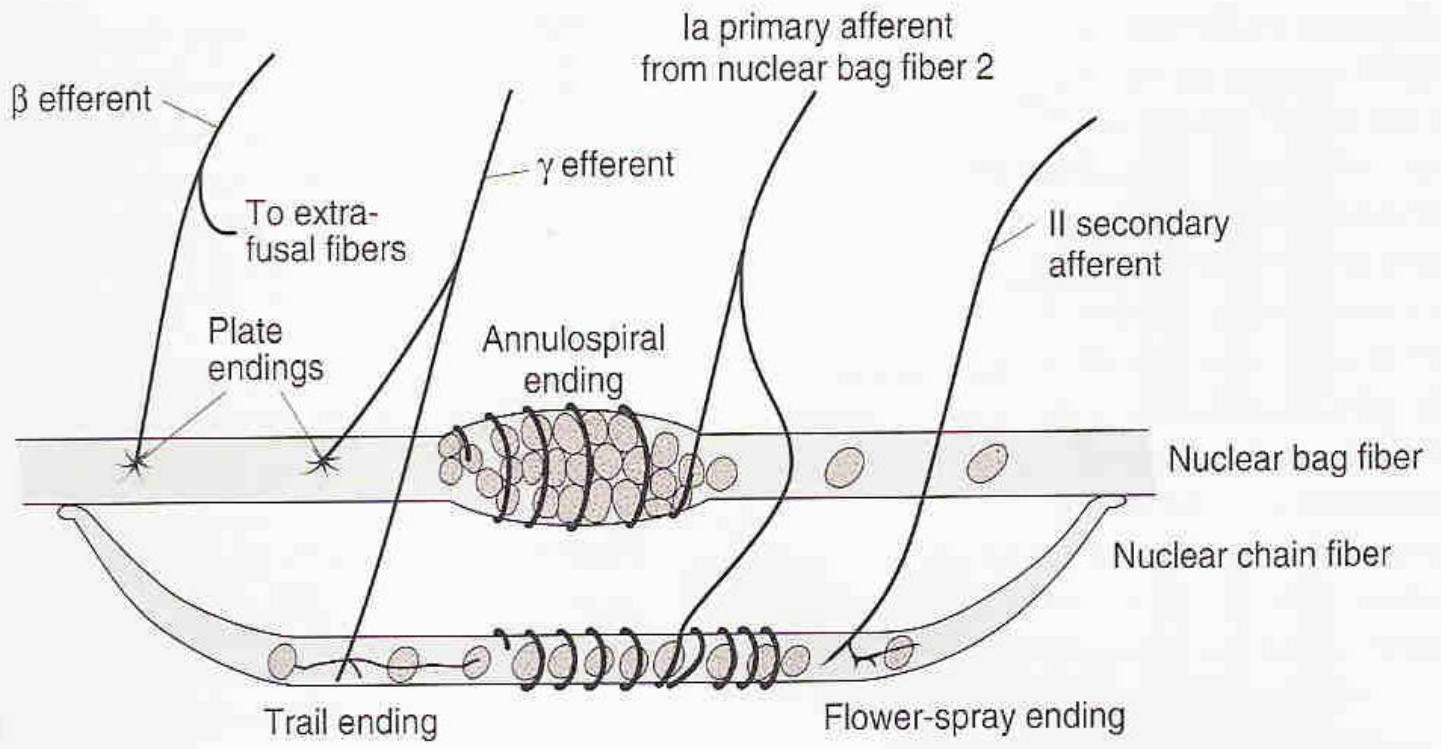
- central area is dilated with group of nuclei

2-Nuclear chain fibres: (4 /spindle)

Thinner& shorter -

-one line of nuclei in a chain in the receptor zone-

- bind to nuclear bag on each side



Muscle Spindle Fibers

Innervation of the muscle spindle

It has afferent & efferent nerve fibers

1-Sensory Afferent fibres:

-Central receptor area of the intrafusal muscle fibres is supplied by **TWO** types of afferent fibres:

1-Primary (annulospiral) endings (Ia fibres): fast, encircle receptor areas of **both** nuclear bag (I&II) and nuclear chain fibres, synapse directly with the motor neurons

-discharge most **rapidly** if the muscle is **suddenly** stretched and less rapidly (or not) during **sustained stretch**

-measure **the rate & or velocity of change in muscle length** from nuclear bag fibers (This response is called the **Dynamic response as in tendon jerks**)

2-Secondary (flower-spray) (Group II) sensory endings:

-

-supplying receptor area of the nuclear chain fibres ONLY.

-Discharge throughout the period of muscle stretch, (sustained stretch)(measure mainly muscle length).

This response is known as the((Static response))

N.B/Nuclear bag fibres are supplied by primary endings only, & responsible for the dynamic response.

Nuclear chain fibres are supplied by both primary and secondary endings & responsible for the static response.

Motor Efferent fibres to spindle

-gamma motor neurons >>>>gamma efferent>>>> to the peripheral contractile parts of the intrafusal muscle fibres, of two types:

1-Plate endings / end mainly on the nuclear bag fibres (Dynamic gamma efferent).

2-Trail endings / end mainly on nuclear chain fibres (Static gamma efferent).

Remember that

Whereas motor innervation of extrafusal fibers is by Alpha Motoneurons, motor supply to the Muscle Spindle is by Gamma Efferents (Motoneurons)

Gamma Efferents cause contraction of the peripheral ends of the intrafusal fiber → leading to stretching & stimulation of the middle, receptor part of the intrafusal fiber

This leads to action potentials in the spindle afferents (annulospiral & flower-spray) → leading to stimulation of Alpha Motoneuron → contraction of the extrafusal fibers.

Effect of gamma efferent discharge:-

- Gamma efferent increase sensitivity of muscle spindle to stretch

a- dynamic gamma efferent (plate endings which end mainly on the nuclear bag fibres , increase sensitivity of muscle spindle to rate of change of stretch as in sudden stretch to the muscle)

B-Static gamma efferent (Trail endings which end mainly on the nuclear chain fibres , increase sensitivity of muscle spindle to steady maintained stretch)

Stretch reflex

-Stretching extrafusal muscle fibers >> Stretching intrafusal peripheral contractile fibers>>>>>> + **stretch receptor zone (central)** in intrafusal fibre >> +**stimulation of sensory** afferent endings encircling receptor area.

-Afferent impulses >> spinal cord >> stimulate:

1-alpha motor neurons, (70%) which send impulses to extrafusal ordinary muscle fibres >>**muscle to contract.**

2-gamma motor neurons (30%) which send impulses to intrafusal peripheral contractile fibers causing **contraction of the peripheral contractile** parts of the intrafusal fibres & **stretch central receptor zone**

Functions of muscle spindle:-

1-keep CNS informed about muscle length & rate or velocity of change in muscle length.

2-muscle spindle act to maintain muscle length against rupture:-

- if muscle is stretched >> muscle spindle discharge >> reflex shortening of muscle by contraction to keep its length

2- Static stretch reflex(static response)

- Maintained stretch of muscle>>> Nuclear chain fibers discharge with increased rate

>>>Impulses in the secondary sensory nerve

>>>>alpha motor neuron >>> motor nerve>>> contraction of muscle fibers

Asynchronously(not all together discharge of motor units)>>>>> resulting in mild

sustained contraction of muscle extrafusal fibers as long as it is stretched

-Basis of muscle tone

Muscle can contract by:-

1- stimulation of alpha motor neurons by muscle stretch:

- Stretching the muscle bulk (extrafusal fibers) stretches the receptor (muscle spindle))
- AP discharges in the spindle afferents (annulospiral or flower-spray)to Alpha Motoneuron , stimulating it, APs discharges from Alpha Motoneurons to Extrafusal muscle fibers cause contraction of muscle bulk

2- stimulation of gamma motor neurons

-By stimulating Gamma Efferents (to the same muscle) . Gamma efferent discharge cause contraction of peripheral ends of intrafusal fiber stretching the receptor zone , thereby stimulating it & afferent discharges in annulospiral or flower-spray fibers stimulate Alpha Motoneuron causing extrafusal muscle fiber contraction .

3-Best contraction by stim of both alpha&gamma neurons

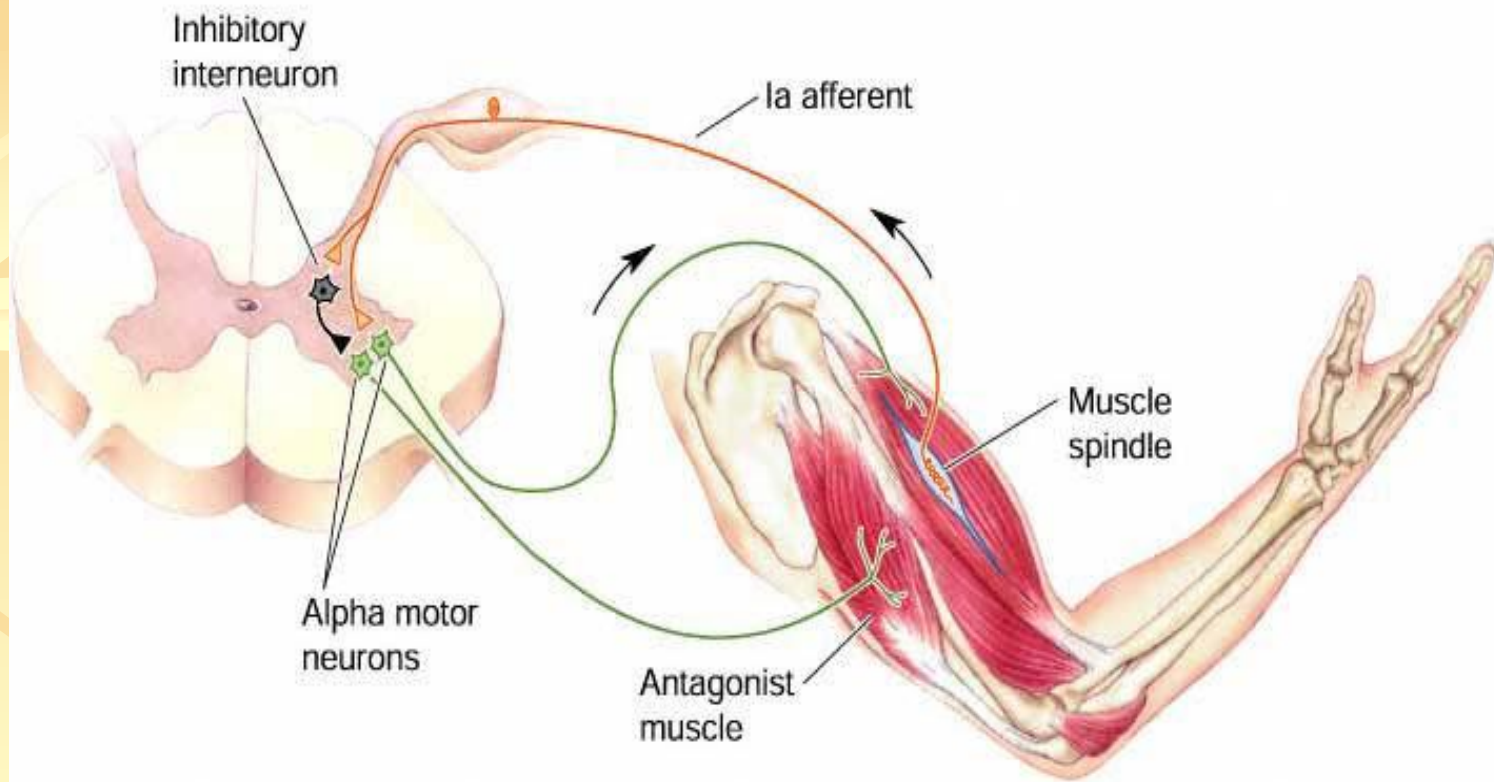
Reciprocal inhibition with stretch

reflex as IN KNEE JERK/

Contraction of EXTENSOR of thigh >>>>>>>

Relaxation of FLEXORS

--Reflex contraction of an agonistic muscle is accompanied by inhibition of the antagonist (contraction of biceps + inhibition of the triceps).



-impulses from stretched muscle>>>> SC to
cause:-

1-stimulate the motor neurons of the stimulated muscle to contract (**by glutamate**)

2- send collaterals >>>> inhibitory interneurons synapse on the AHCs of the antagonistic muscle & inhibit them (by **GABA**)

Muscle Tone(**Static stretch reflex**)

Dif/ resistance of muscle to stretch

-Stimuli for muscle tone / Stretch of skeletal muscle between origin and insertion

-Present in **antigravity muscle** (extensors of LL, back, neck, flexor of UL, muscle of abdominal wall and elevator of mandible)

-if lost by low gamma efferent discharge to muscle
>>>>>**hypotonic or flaccidity**

-if increased by high gamma efferent discharge to muscle >>>>>**hypertonic,spastic** muscle

Factors influence stretch reflex

(all act on gamma motor neurons)

Enhances

1-Supraspinal

- Primary motor area4
- Vestibular N
- Pontine RF
- Neocerebellum

2-Anxiety

3-Noxious 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)

The Golgi tendon reflex (inverse stretch reflex)

- Deep & polysynaptic reflex
- (**opposite response to stretch reflex**).
- Excessive tension** in the muscle (by passive over-stretch of tendon or active muscle contraction) >>> muscle relaxes
- The receptors are **Golgi tendon organs (3-25)** present in **tendons**
- stimulated golgi **tendon organ**>>> impulses via fast **A α** fibers >>>> SC >>> excitation of inhibitory interneuron secrete **Glycine**>> inhibit alpha motor neuron >>> muscle relaxation
- Also stim excitatory interneuron to antagonist.
- Value/Protect muscle from rupture**