Stretch reflex and Golgi Tendon Reflex

Dr. Faten zakareia
Physiology Department , College of Medicine ,
King Saud University
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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 fibres 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)

Stretch reflex

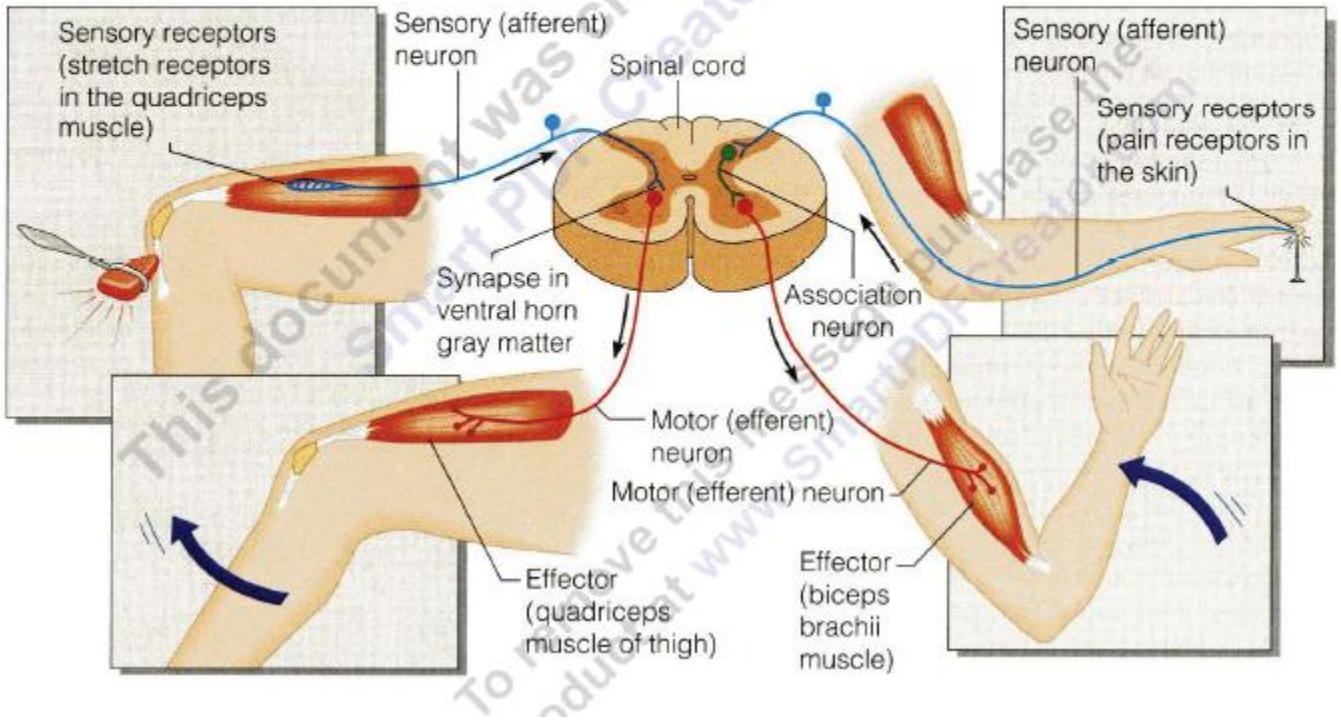
1-Deep-monosynaptic reflex

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 fibers 70% from AHCsto extrafusal muscle fibers) +gamma efferent (from gamma motor neurons 30% to muscle spindle intrafusal fibers)**
- **Effector/muscle**

The knee jerk and biceps jerk are two examples of the stretch reflex



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.

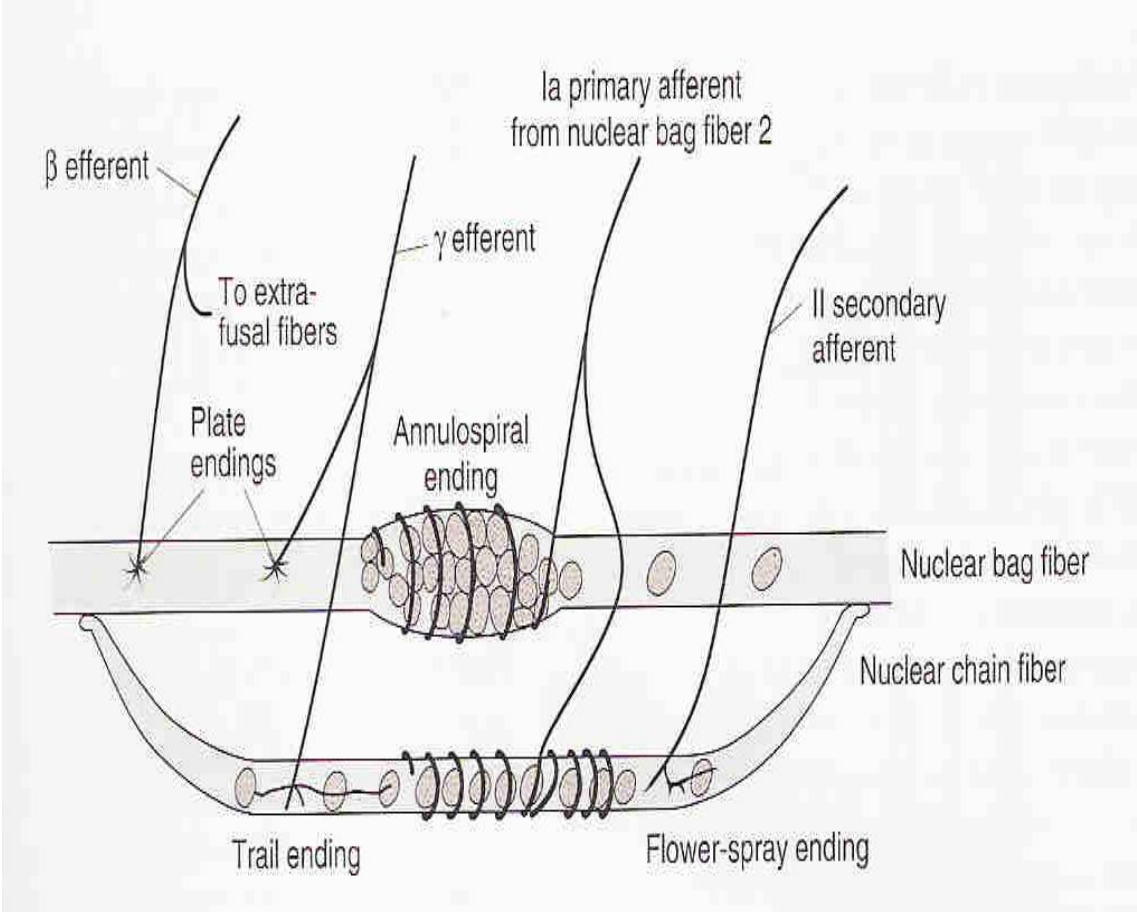
-Each intrafusal fibre has:
-Central non-contractile area (receptor)
-Peripheral contractile area on each side of central zone, it has actin& myosin.

Muscle Spindle(cont)

Has two types of intrafusal fibres:

1-Nuclear bag fibres : (2 / spindle)
- central area is dilated with group of nuclei

2-Nuclear chain fibres: (about 4 /spindle)
Thinner& shorter --
-one line of nuclei in a chain in the receptor zone-
- bind to nuclear bag on each side


Ia primary afferent
from nuclear bag fiber 2
β efferent
γ efferent
To extra-
fusal fibers
II secondary
afferent
Plate
endings
Annulospiral
ending
Nuclear bag fiber
Nuclear chain fiber
Trail ending
Flower-spray ending

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 mainly 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 of nuclear bag fibers (This response is called the Dynamic response (as in tendon jerks)

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

-

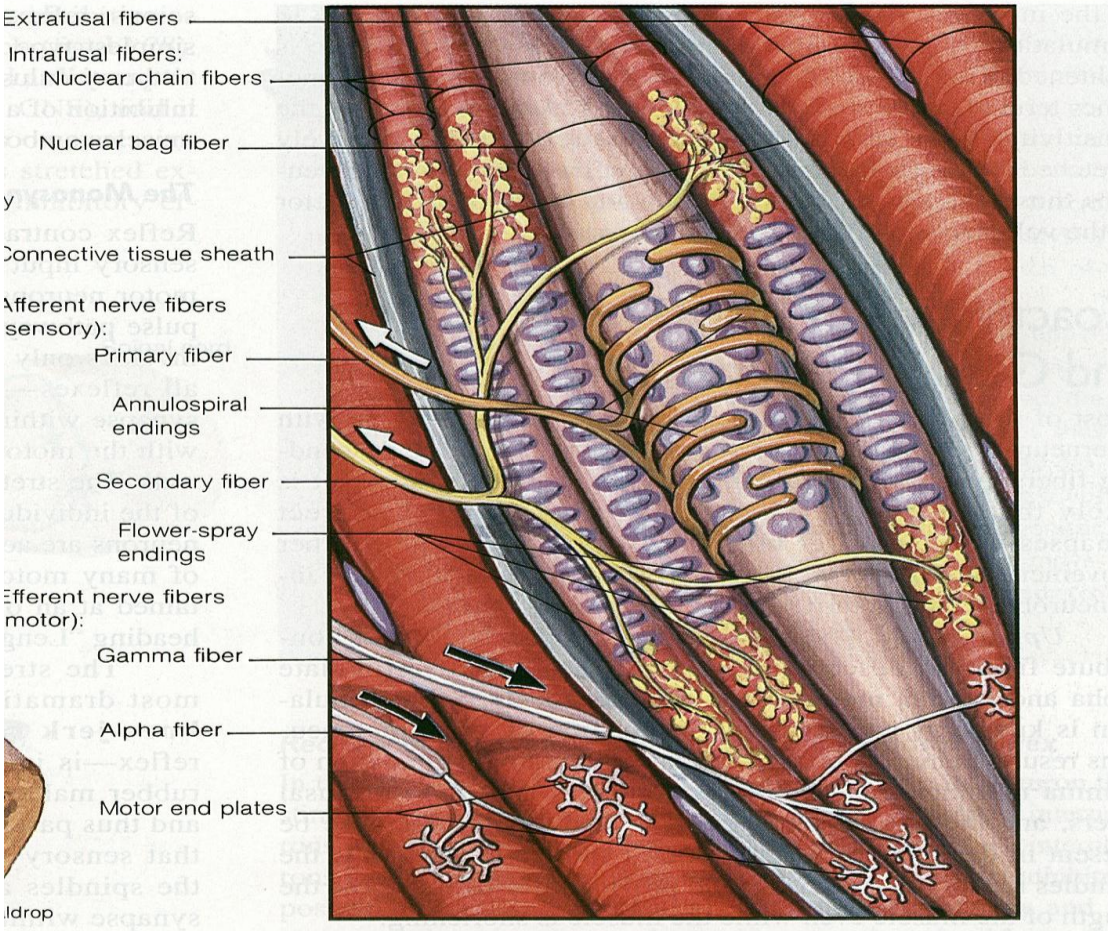
-supplying receptor area of the nuclear chain fibres ONLY.

-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.

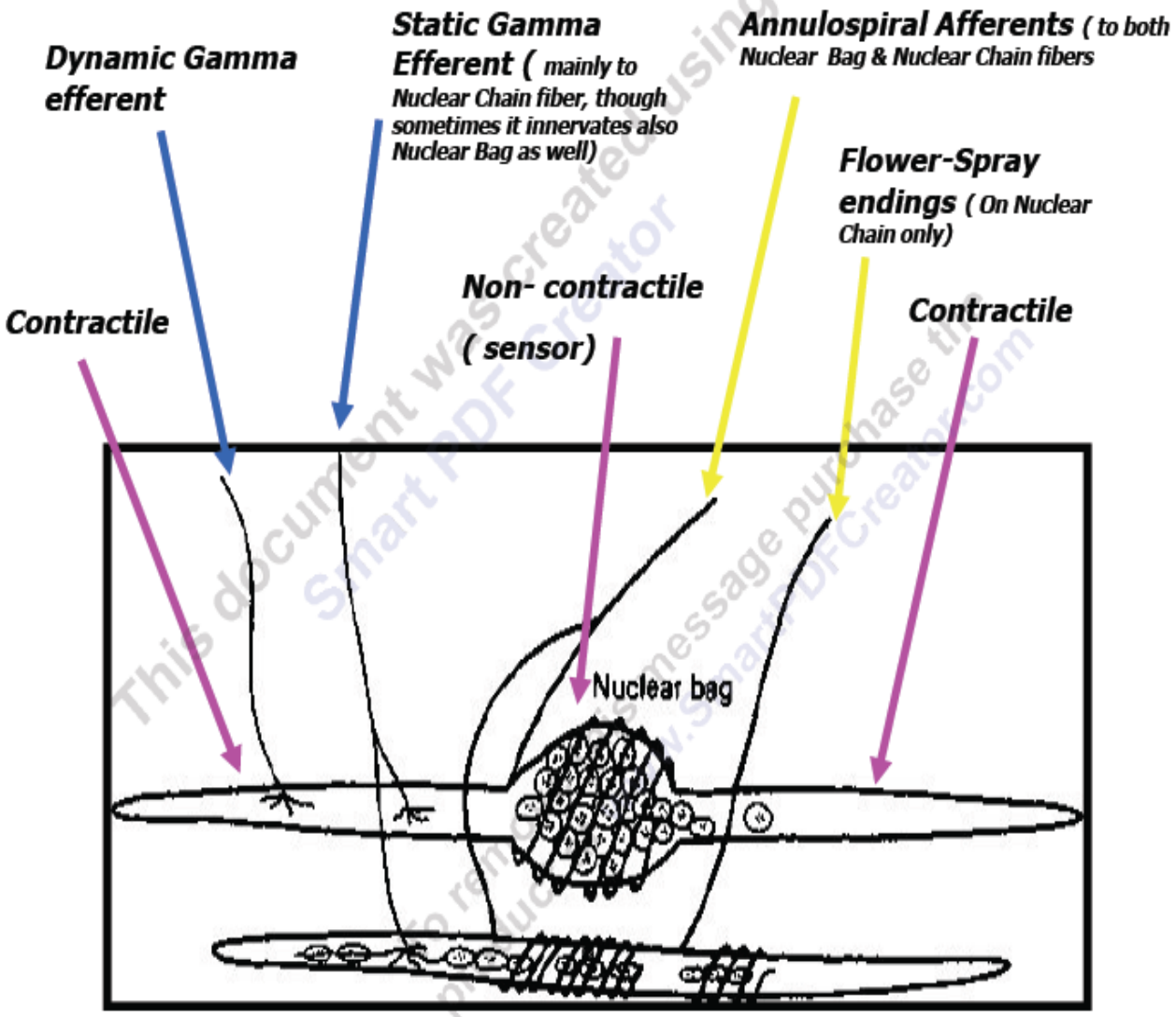

Extrafusal fibers
Intrafusal fibers:
Nuclear chain fibers
Nuclear bag fiber
Connective tissue sheath
Afferent nerve fibers
(sensory):
Primary fiber
Annulospiral
endings
Secondary fiber
Flower-spray
endings
Efferent nerve fibers
(motor):
Gamma fiber
Alpha fiber
Motor end plates

Motor Efferent fibres to muscle 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 (called **Dynamic gamma efferent).**

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


Dynamic Gamma efferent
Static Gamma Efferent (mainly to Nuclear Chain fiber, though sometimes it innervates also Nuclear Bag as well)
Annulospiral Afferents (to both Nuclear Bag & Nuclear Chain fibers
Flower-Spray endings (On Nuclear Chain only)
Contractile
Non- contractile (sensor)
Contractile
Nuclear bag

Stretch reflex

1- Stretching of the muscle>>>>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

Types of responses

Component of stretch reflex

1-Dynamic stretch reflex (dynamic or phasic response)

- Sudden **rapid stretch** of a muscle >> stimulate Nuclear bag fibers which respond to rate or velocity of stretch>>>> discharge **Synchronous** strong impulses from spindles >>>>primary ending (annulospiral)>>>alpha motor neuron >>>motor alpha nerve>>>>causing sudden contraction of muscle extrafusal fibers **synchronously** (**jerk movement**)
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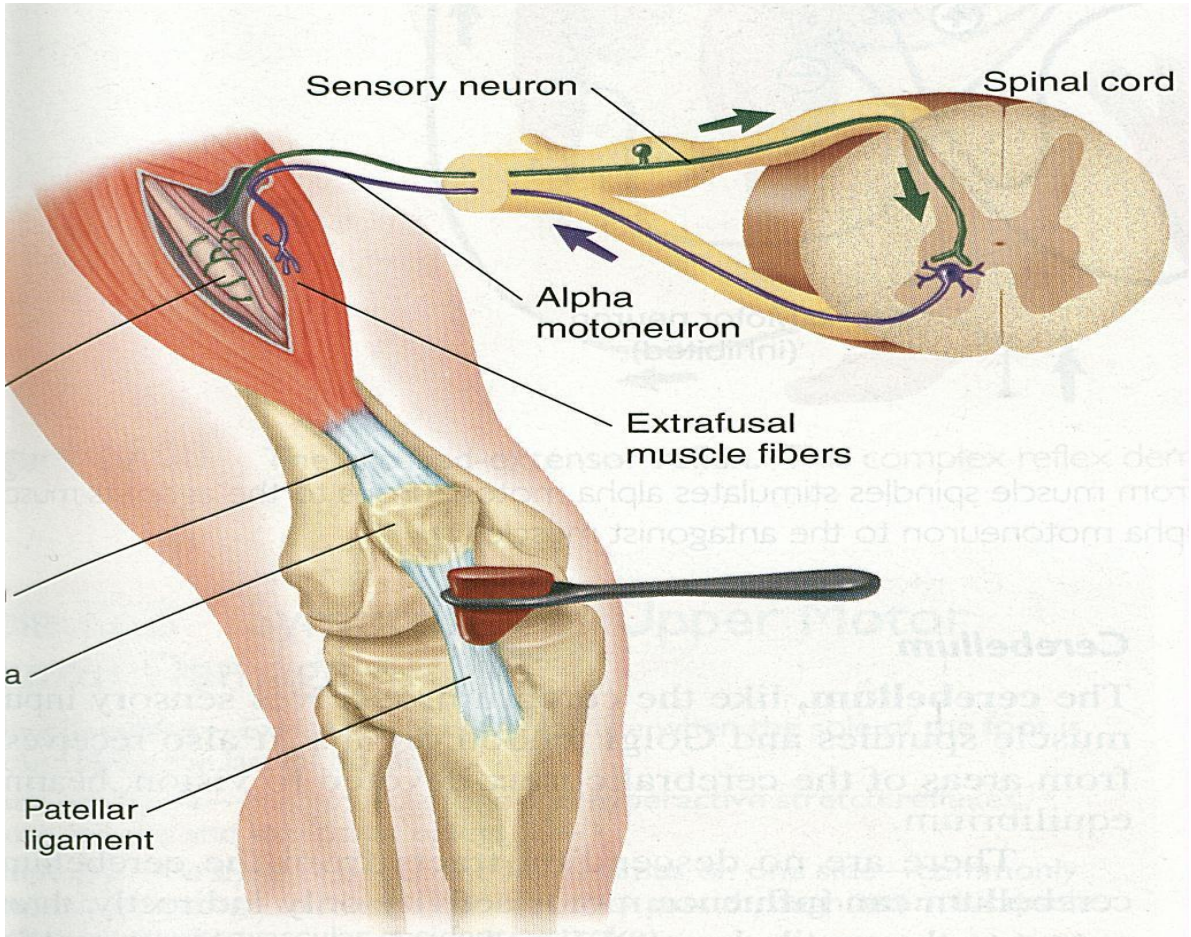
-Basis of tendon jerk (contraction followed by (relaxation) (knee,biceps,triceps)

When muscle contract, it shortens, muscle spindle relax>>> no discharge of 1ry endings, and muscle relax

- -



ure 12.27 **The knee-jerk reflex.** This is an example of a
ynaptic stretch reflex.

2- Static stretch reflex(static response)

- **Maintained** stretch of muscle>>> stimulates **Nuclear chain fibers** to discharge with increased rate >>>Impulses in the **secondary sensory nerve**)(flowerspray)>>>>alpha motor neuron >>> motor nerve>>> contraction of muscle fibers **Asynchronously**(motor units not discharge all together)>>>>>> resulting in **mild sustained** contraction of muscle extrafusal fibers as long as it is stretched

-Basis of **muscle tone**

Effect of gamma efferent discharge:-

1-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

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

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 motor nerve to the 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 to 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 cause >>>>>>>
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 cotract (by glutamate)
2- send collaterals >>>> inhibitory interneurons synapse on the AHCs of the antagonistic muscle & inhibit them (by GABA)

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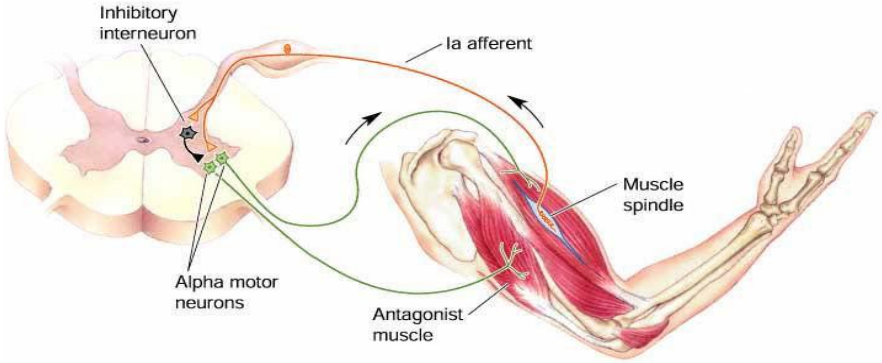


Muscle Tone(Static stretch reflex)

Dif/ resistance of muscle to stretch

-Stimulus for muscle tone /Is 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 flacidity

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

Factors influence stretch reflex

(all act on gamma motor neurons)

Enhances

1-Suprspinal

- -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) >>> cause muscle relaxation

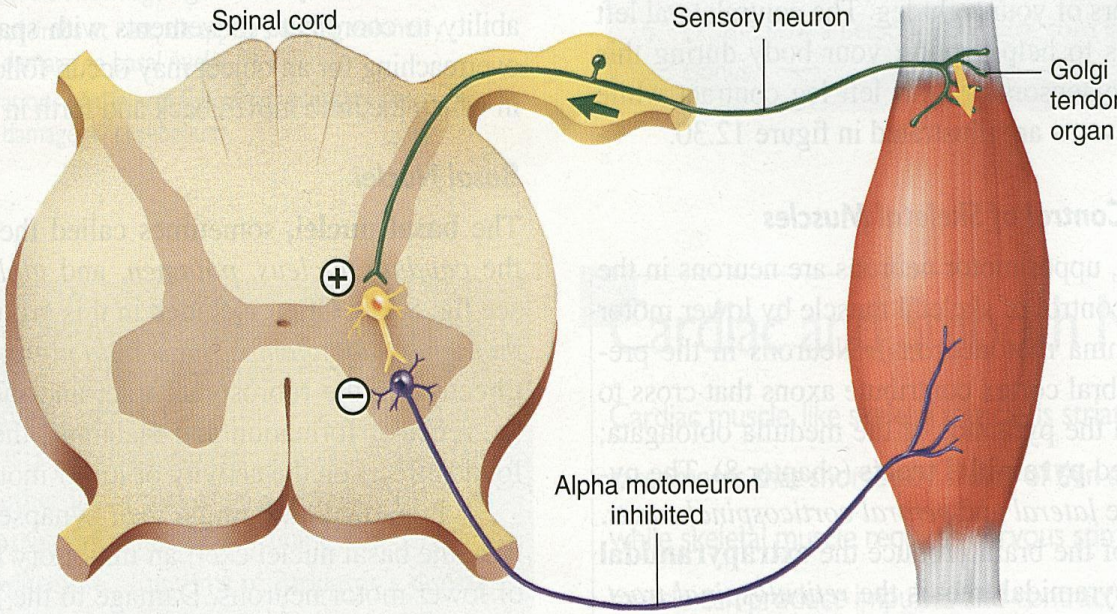
-The receptors are Golgi tendon organs (3-25) present in tendons

-stimulated golgi tendon organ>>> impulses via fast Aα fibers >>>> SC >>> excitation of inhibitory interneuron secrete Glycine >> inhibit alpha motor neuron >>> muscle relaxation

- Also stim excitatory interneuron to antagonist.(reciprocal innervation)

Value/Protect muscle from rupture

The Golgi tendon reflex (inverse stretch reflex)



ure 12.28 **The action of the Golgi tendon organ.** An increase in muscle tension stimulates the activity of sensory nerve endings in the Golgi organ. This sensory input stimulates an interneuron, which in turn inhibits the activity of a motor neuron innervating that muscle. This is therefore a tic reflex.