

431

CNS System
central Nervous

Block

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Stretch reflex and Golgi Tendon Reflex

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Stretch Reflex and Golgi Tendon Reflex

- The spinal cord is responsible for integration of many basic reflexes .
- The spinal cord gray matter is the integrative area for the cord reflexes.

Keep in mind :

- Proper control of muscle functions requires:

1) Excitation of the muscle (by spinal cord anterior motor neurons).

Anterior motor neurons are located in each segment of the anterior horn of the cord gray matter . They have two types :

- Alpha motor neurons: They branch into type A alpha motor nerve fibers . Each alpha motor nerve fiber excites a motor unit (several muscle fibers) and **innervates the extrafusal muscle fibers**.

- Gamma motor neurons: They transmit impulses through smaller type A gamma nerve fibers . They **supply the intrafusal** fibers (small special skeletal muscle fibers that are located in the middle of the muscle spindle and they help in controlling the muscle tone).

2) Continuous feedback of sensory information of the muscles' functional status from each muscle to the spinal cord.

To provide this information the muscle and their tendons are supplied by two special types of sensory receptors :

**** Golgi tendon organs:**

Site: Located in the muscle tendons

Function: transmit information about tendon's tension or the rate of change of tension.

**** Muscle spindles:**

Site: Distributed throughout the belly of the muscle. parallel to extrafusal fibers (which constitute the muscle bulk) & attached to it or to tendons.

Function: send information about the muscle's length or the rate of change in the muscle's length
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.

Structure: Each spindle consists of 3-12 Intrafusal muscle fibers that are pointed at their ends.

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)

Any muscle stretch must contract for protection (prevent torn by over stretching).

Stretch reflex

1-Deep-monosynaptic reflex

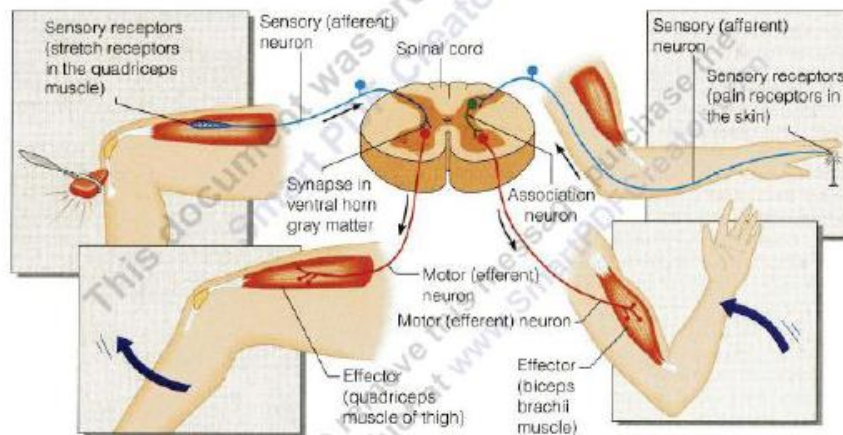
2-sudden stretch of a muscle >>>>>reflex contraction of the stretched muscle

Components:-

- **Receptor : muscle spindle**
- **Afferent (annulospiral + flower spray)**
- **AHC(center)**
- **Efferent (motor nerve (alpha fibers 70% from AHCsto extrafusul muscle fibers) +gamma efferent (from gamma motor neurons 30% to muscle spindle intrafusul fibers)**
- **Effector/muscle**

1. Deep→ inside the muscle (not superficial like skin), monosynaptic= no interneuron.
2. Annulospiral= fast, flower spray= slow ___ more details will be mentioned at the end of this lecture.

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



Knee jerk: tapping on the muscle tendon leads to stretching of muscle → stimulation of the muscle receptor (muscle spindle) → spindle afferents excite the alpha motor neuron → muscle contraction.

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.

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Each intrafusal fiber consists of :

1) **Central non-contractile area** .It has few or no actin or myosin filaments, therefore it does not contract. It acts as the **receptor area**.

(sensory)

2) **Peripheral contractile parts** on either side of the central receptor area (motor).

Muscle Spindle(cont)

Has two types of intrafusal fibres:

1-Nuclear bag fibres : (2 / spindle)

- central area is dilated with group of nuclei

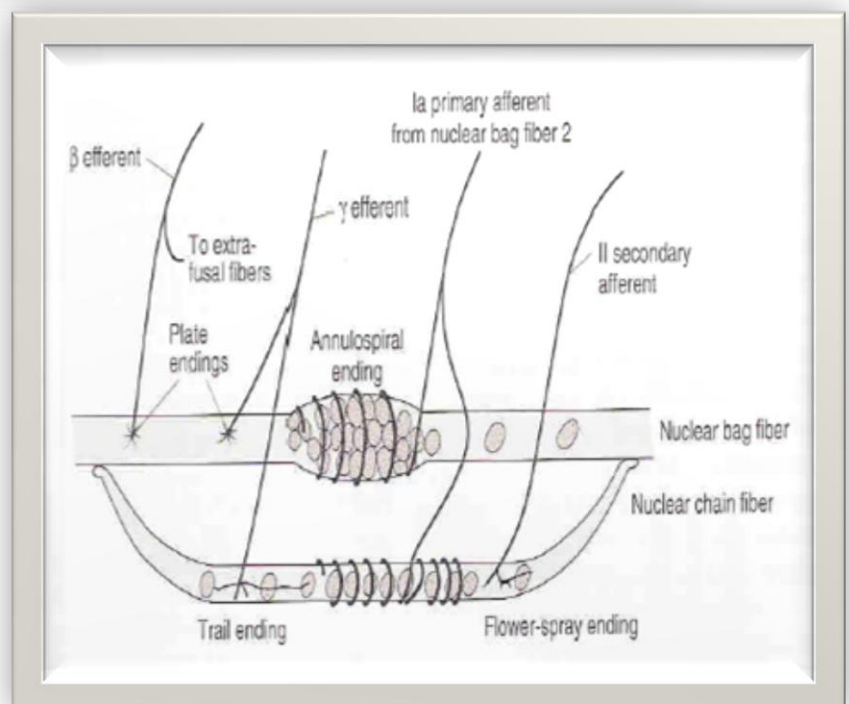
2-Nuclear chain fibres: (about 4 /spindle)

Thinner & shorter --

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

- bind to nuclear bag on each side

- Nuclear bag fibres are supplied by primary endings, **Only** responsible for the **dynamic response** (Like knee-jerk)
- Nuclear chain fibres are supplied by **both** primary and secondary endings responsible mainly for the **static response** (and to a much lesser extent , dynamic response).



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))

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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.

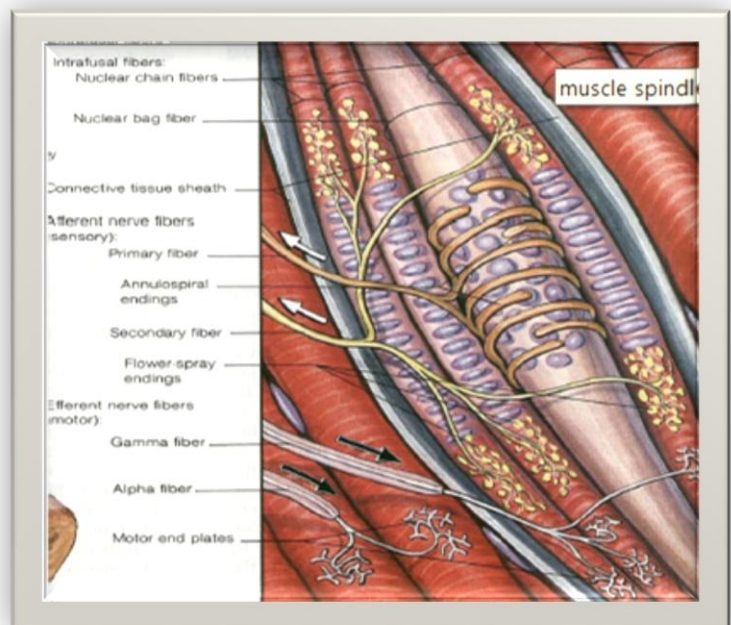
Nuclear chain fibres are supplied by both primary and secondary endings & responsible for the static response.

Sensory Afferent :

Remember that :

The Dynamic Response occurs mainly when the muscle is suddenly stretched.

The Static Response occurs mainly with maintained muscle stretch .



Motor Efferent fibres to muscle spindle

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

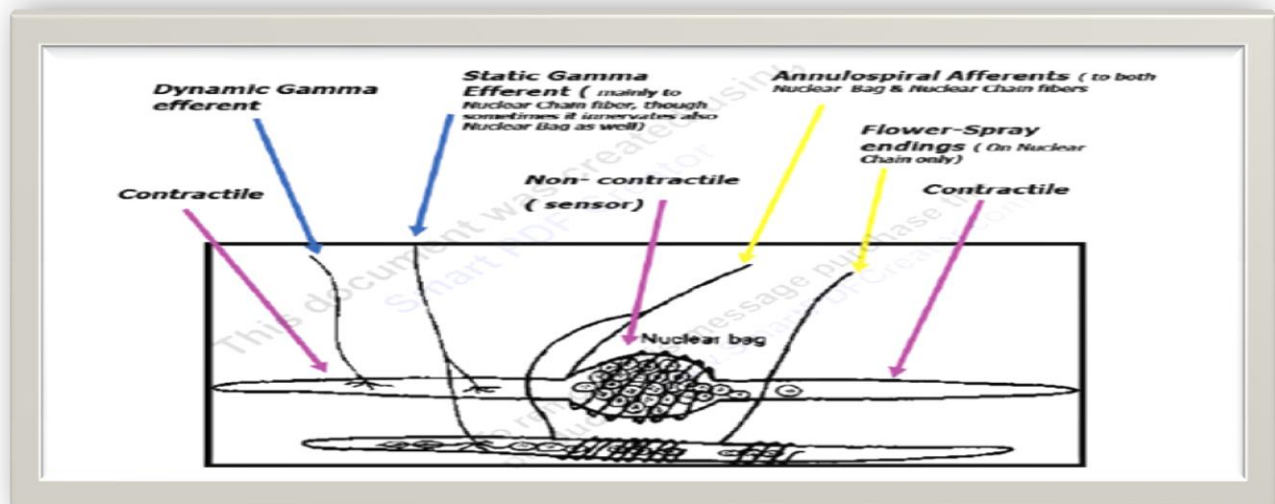
1-Plate endings / end mainly on the nuclear bag fibres (called **Dynamic gamma efferent**).

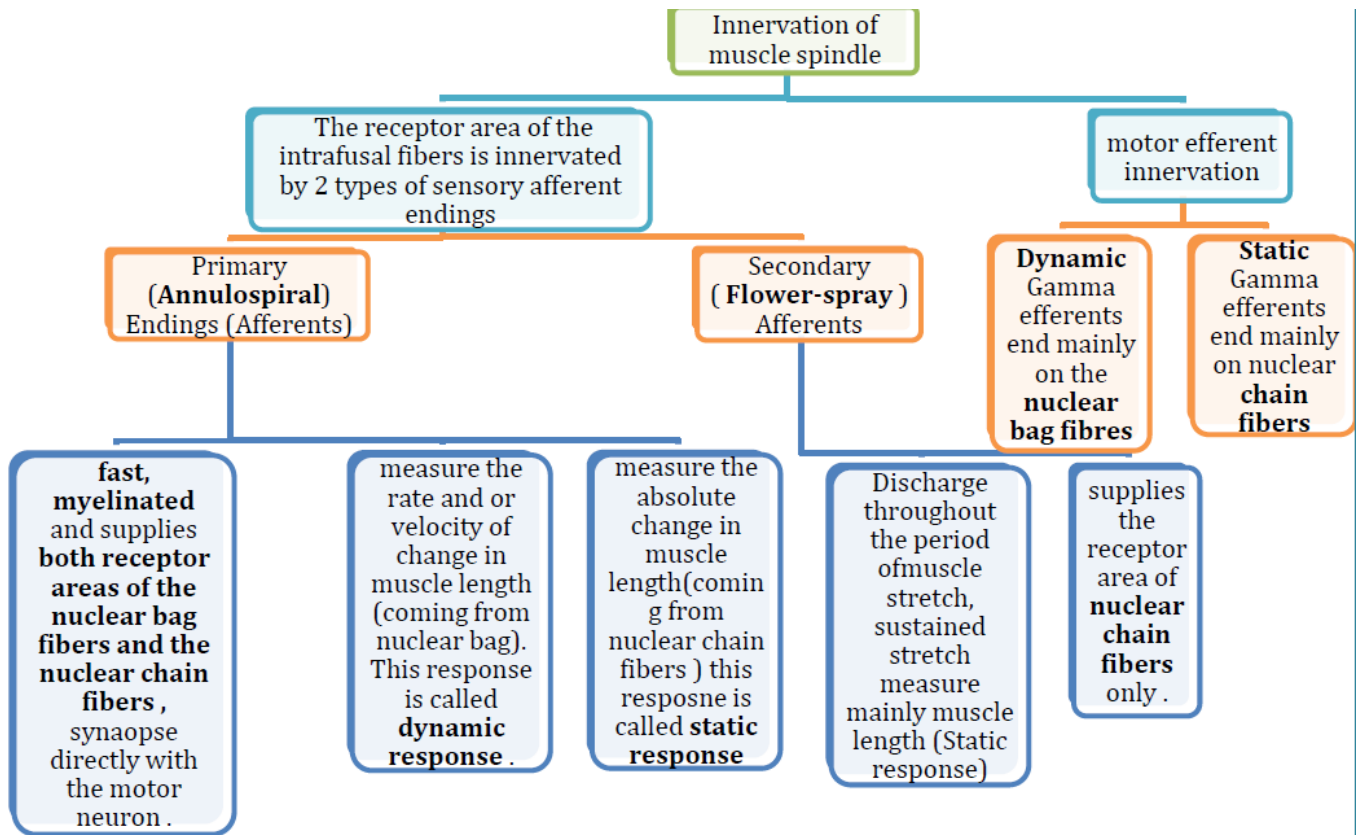
2-Trail endings / end mainly on nuclear chain fibres (called **Static gamma efferent**)

Motor efferents :

Motor supply to the Muscle Spindle is by Gamma Efferents (Motoneurons)
Function :

- 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 Motor neuron contraction of the extrafusal fibers.





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)**

- **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

Stretching extrafusal muscle fibers will lead to Stretching of the intrafusal peripheral contractile fibers so it will stimulate the stretch receptor zone (central) in intrafusal fibers (muscle spindle) and this will cause stimulation of sensory afferent endings encircling receptor area.

-Afferent impulses →spinal cord will stimulate:

- 1- Alpha motor neurons (70%) which send impulses to extrafusal ordinary muscle fibers, which will lead to muscle contraction.
- 2- Gamma motor neurons (30%) which send impulses to intrafusal peripheral contractile fibers causing contraction of the peripheral contractile parts of the intrafusal fibers & stretch central receptor zone.

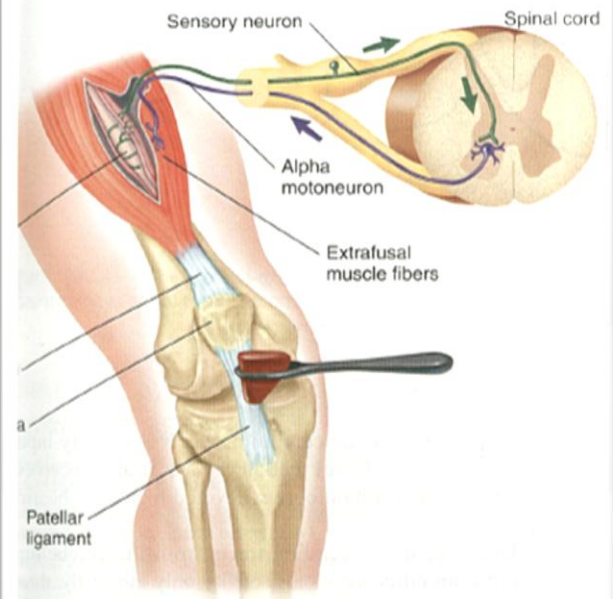


Figure 12.27 The knee-jerk reflex. This is an example of a synaptic stretch reflex.

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

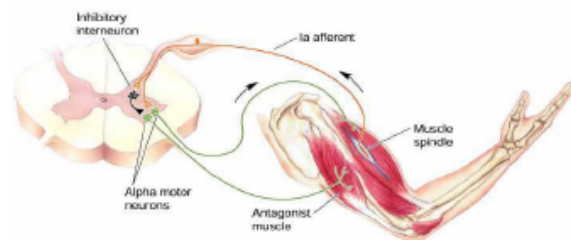
Reciprocal inhibition with stretch reflex as IN KNEE JERK/
Contraction of EXTENSOR of thigh cause >>>>>>>
Relaxation of FLEXORS

--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 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

-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 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)

jendrassik- maneuver:

If the examiner/ physician is applying the instrument (hammer) on the patient's knee to test his reflex while the patient is observing the instrument (hammer) the reflex will not be achieved (no involuntary , rapid movement to the receptor stimulus).Therefore , a technique was invented " Jendrassik Maneuver " by jendrassik person which can distract the patient by stressing on both of his hands and teeth .

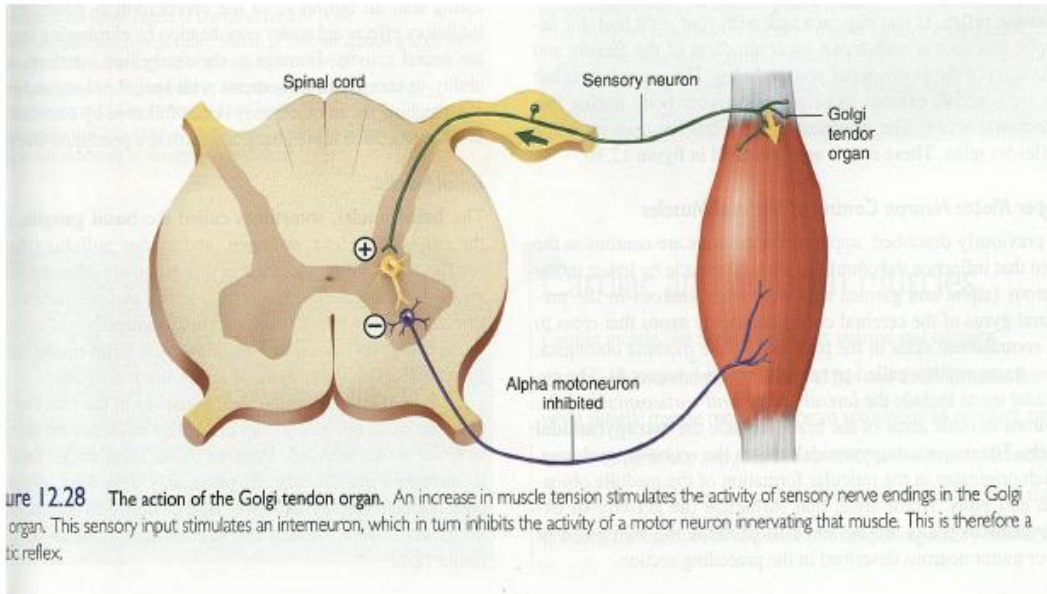
The Golgi tendon reflex

(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 **A α** 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

When muscle is excessively stretched ,it contracts strongly and pulls on the tendon, excessive tension iscovered/transfered to the tendon ,this stimulates Golgi Organ in the tendon →it sends afferent impulses via the fast A alpha fibers →excitation of inhibitory interneuron in spinal cord (secretes glycine – inhibitory neurotransmitter)
→ inhibition of alpha motor neuron → muscle relaxation.

The Golgi tendon reflex (inverse stretch reflex)



تم الاستعانة بعمل تيم ٤٣٠ في هذه المحاضرة

جزاهم الله خيرا