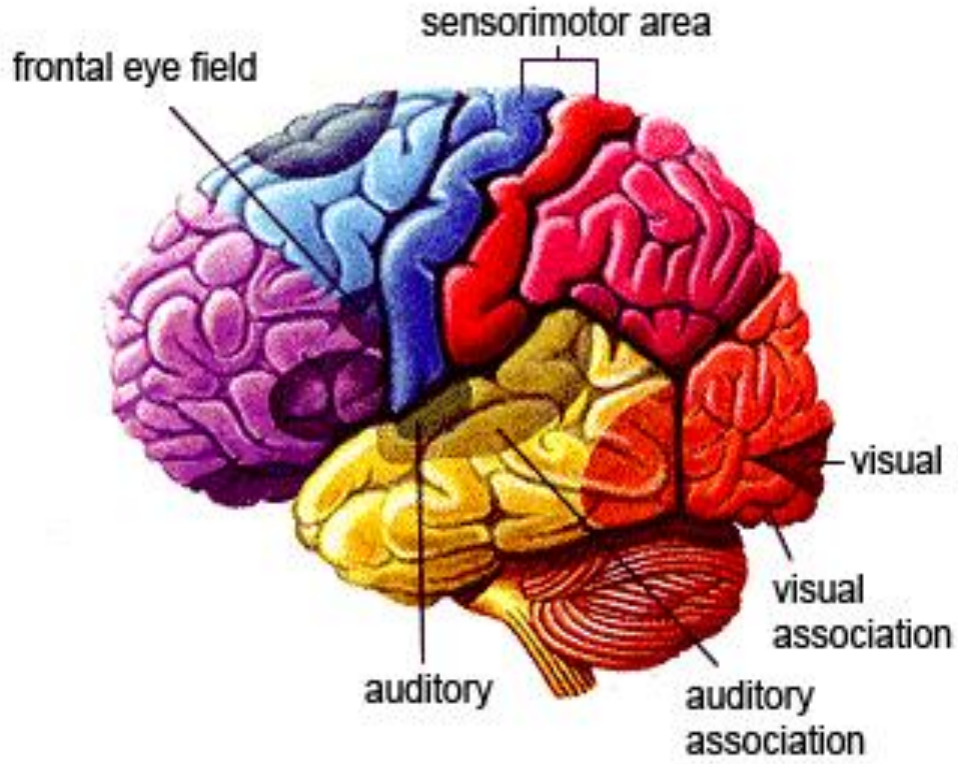
Physiology Team



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(these notes are combination of female and male slides + our notes)

Stretch Reflex & Golgi Tendon Reflex

Stretch Reflex :

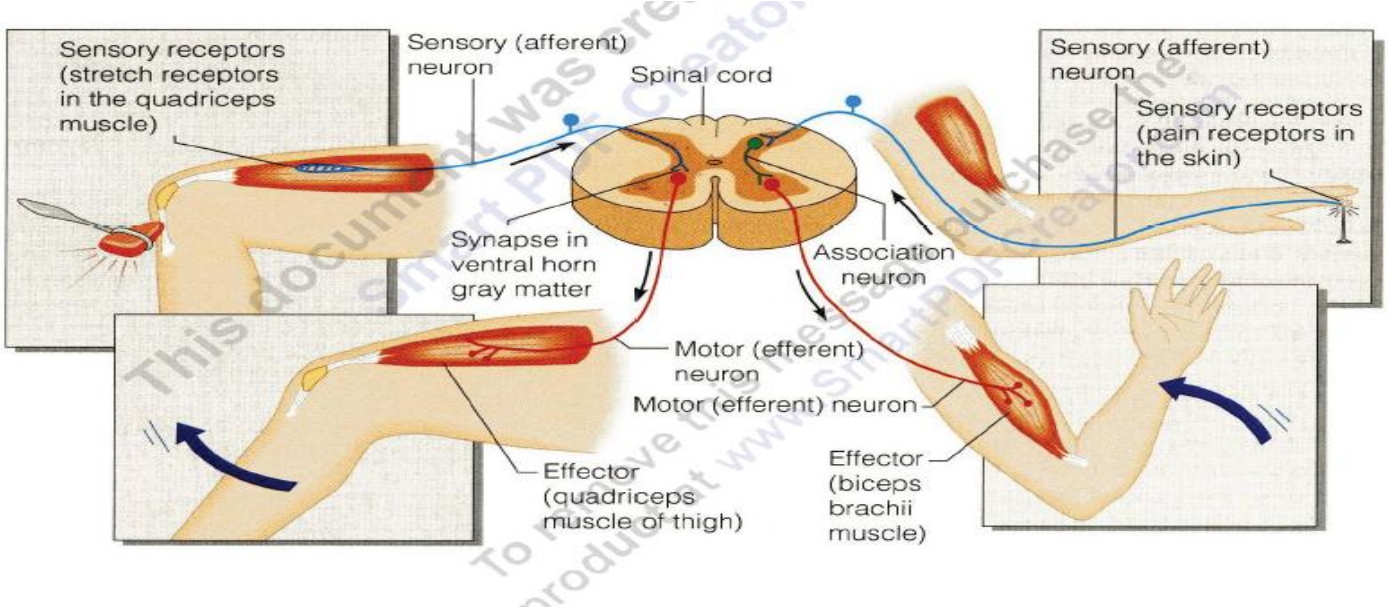
- It is a reflex contraction of muscle resulting from sudden stimulation of the muscle spindle by stretch
- It's a deep monosynaptic reflex

Muscle spindle:

(A receptor that is located inside muscle & detects changes in muscle length)

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 → efferent impulses to the muscle (alpha & gamma)



Function:

Production & modulation { from moment to moment } of muscle tone .

Muscle tone (is the resistance of muscle to stretch)

- It is produced by :
  Co-activation of alpha & gamma motoneurons .

- Its degree is regulated & maintained mainly by:
  the tonic { continuous } discharge of gamma efferents

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

  - if lost → hypotonic or flacidity

  - if increased → hypertonic, spastic muscle

Components of stretch reflex :-

1. muscle spindle (Receptor)
2. Afferent sensory nerve (annulospiral+flower spray)
3. Anterior Horn Cells (center)
4. Efferent motor nerve :
   - Alpha fibers [70%] → to extrafusal muscle fibers
   - Gamma fibers [30%] → to muscle spindle intrafusal fibers
5. Effector/muscle

Muscle Spindle

* Structure of Muscle Spindle:

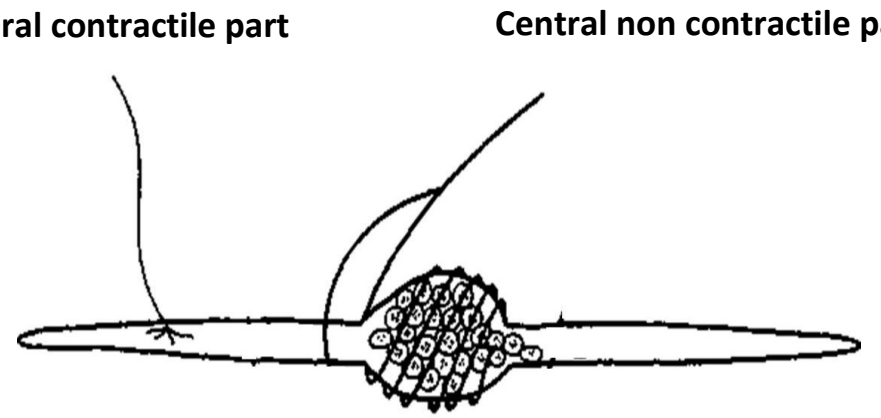
intrafusal fibers + Extrafusal fibers

- 3-12 intrafusal fibres within connective tissue capsule Parallel to extrafusal fibres & attached to it or to tendon

-Each intrafusal fibre has:

1-Central non-contractile area (receptor)

2-Peripheral contractile on sides of central zone (has actin & Myosin)



Two types of intrafusal fibres:

1-Nuclear bag fibres : (2 neuclear bag fiber per spindle)

- Central area is dilated with group of nuclei.

2-Nuclear chain fibres: (4-9 /spindle)

Thinner& shorter than nuclear bag

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

- bind to nuclear bag on each side

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]

Innervations 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 :

- **Primary (annulospiral) endings :**

-It's fast

-It encircle receptor areas of both nuclear bag and nuclear chain fibres

- Are the terminations of rapidly-conducting group Ia fibers

- Measure

1)the rate of change in muscle length

(Information coming from nuclear bag fibers)

This response is called the **Dynamic response** of the receptor

- It occurs mainly when the muscle is **suddenly** stretched

2- the absolute change in muscle length
(Information coming from nuclear chain fibers)
This response is called the **Static Response** .
- It occurs mainly with **maintained** muscle stretch]

- **Secondary (flower-spray) sensory endings:**

1-Supplying receptor area of the nuclear chain fibres **ONLY**.
2-Discharge throughout the period of sustained stretch
(The Static response)

Nuclear bag fibres are supplied by primary endings (annulospiral) only
It's responsible for the **dynamic response.**

Nuclear chain fibres are supplied by both primary and secondary endings (annulospiral&flower-spray)
It's responsible for the **static response**

2-Motor Efferent fibres to spindle

- **Alpha motor neurons**

  To the extrafusal muscle fibers

- **Gamma motor neurons :**

  To the peripheral contractile parts of the intrafusal muscle fibres **which are two types**

1-Plate endings :

End mainly on the nuclear bag fibres **(<u>Dynamic gamma efferent)</u>**

- increase sensitivity of muscle spindle to rate of change of stretch

2-Trail endings :

End mainly on nuclear chain fibres **(<u>Static gamma efferent)</u>**

- increase sensitivity of muscle spindle to steady maintained stretch

<u>Effect of gamma efferent discharge:</u>

Gamma Efferents cause <u>contraction</u> of the *peripheral* ends of the intrafusal fiber

↓

stretching & stimulation of the middle receptor part of the intrafusal fiber

↓

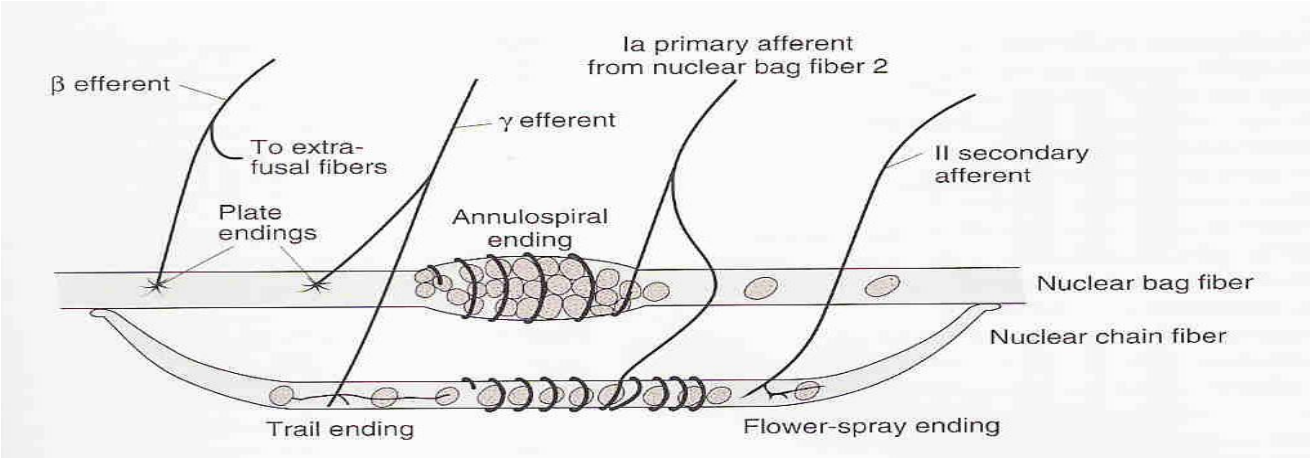
action potentials in the spindle afferents (annulospiral & flower-spray)

↓

stimulation of Alpha Motoneuron

↓

contraction of the extrafusal fibers



There are 2 mechanisms to stimulate the receptor:

- **(I) First mechanism:**

  By stretching the whole muscle.

Stretching the muscle bulk (extrafusal fibers)

↓

Stretches the receptor, muscle spindle.

[Because the muscle spindle intrafusal fibers lie in parallel with the extrafusal fibers of the muscle bulk]

↓

AP discharges in the spindle afferents (annulospiral or flower-spray)

↓

monosynapse on Alpha Motoneuron and stimulate it

↓

Action Potentials motor discharges from Alpha Motoneurons to Extrafusal muscle fibers

↓

contraction of muscle bulk

- **(II) Second mechanism:**

By stimulating Gamma Efferents without need to Stretch the muscle extrafusal fibers.(at the same muscle length)

Gamma efferent discharge

↓

cause contraction of peripheral ends of intrafusal fiber

↓

stretching the receptor , thereby stimulating it

↓

afferent discharges in annulospiral or flower-spray fibers

↓

stimulation of Alpha Motoneuron

↓

extrafusalmuscle fiber (whole muscle) contraction

Types of stretch reflex

1-Dynamic stretch reflex (dynamic or phasic response)

- Sudden rapid stretch of a muscle → Nuclear bag fibers respond to rate or velocity of stretch →discharge Synchronous strong impulses from spindles→primary ending (annulospiral) →alpha motor neuron →motor nerve → causing sudden contraction of muscle extrafusal fibers synchronously (jerk movement)

  Ex: Basis of tendon jerk (contraction followed by relaxation) (knee,biceps,triceps)

Then When muscle contract, it shortens, muscle spindle relax→no discharge of anmulospiral endings→ muscle relax

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)→ resulting in mild sustained contraction of muscle extrafusal fibers as long as it is stretched

Ex:-Basis of muscle tone

Muscle can contract by:-

1- stimulation of alpha motor neurons by muscle stretch:

2- stimulation of gamma motor neurons

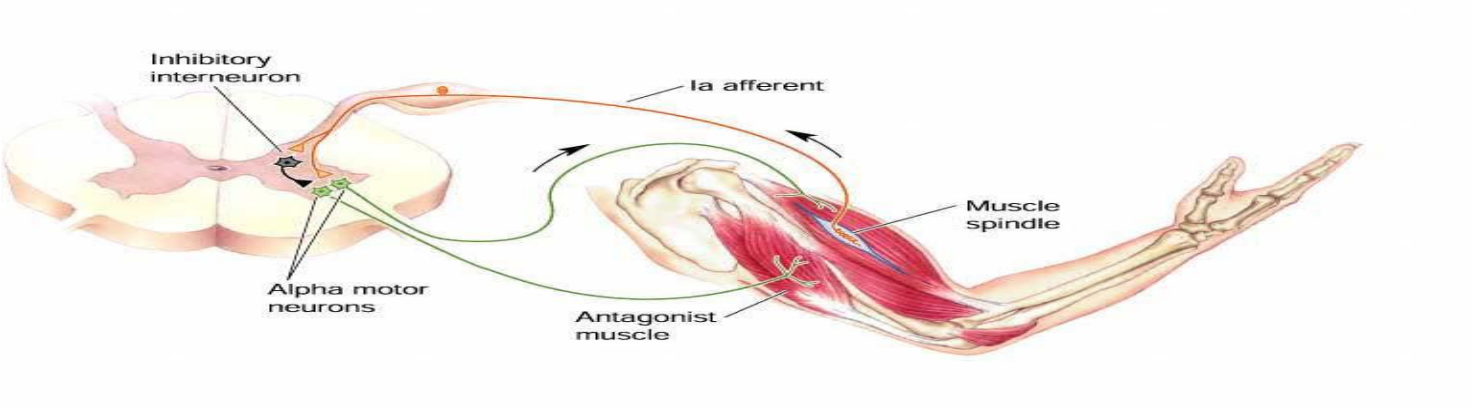
3-Best contraction by stim of both alpha&gamma neurons

Reciprocal inhibition with stretch reflex:

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

Ex:in knee jerk

Contraction of extensor of thigh **>>>**relaxation of flexors



Mechanism of reciprocal inhibition:
impulses from stretched muscle → spinal cord → cause:-
1-stimulate the motor neurons of the stimulated muscle (by ?)
glutamate ((a neurotransmitter))

2- send collaterals inhibitory interneurons synapse on the AHCs of the antagonistic muscle and inhibit them (by?)
GABA ((a neurotransmitter))

Summary of Factors Influencing/Modulating Gamma Efferent Activity (& hence the Stretch Reflex)

Enhances

A/ Supraspinal influences :

(1) Cortical (motor area 4) :
(voluntary , conscious + limbic → fear/apprehension , and anxiety , pain)

(2) Brainstem mechanisms :
(i) Vestibular nucleus
(ii) Pontine Reticular Formation

(3) Neocerebellum

B/ Largely spinal mechanisms :
related to noxious (painful) stimuli .

Inhibits

A/Supraspinal :

(1) Cortical (motor area 6)
(voluntary , conscious , mostly) .

(2) Extrapyramidal & Brainstem mechanisms :
(i)Basal ganglia ,
(ii) Red Nucleus .
(iii) Medullary Reticular formation

(3) Paleocerebellum)

B/ Largely spinal mechanisms :
1. Excessive muscle stretch
(stimulation of Golgi tendon organ).
2. Muscle contraction

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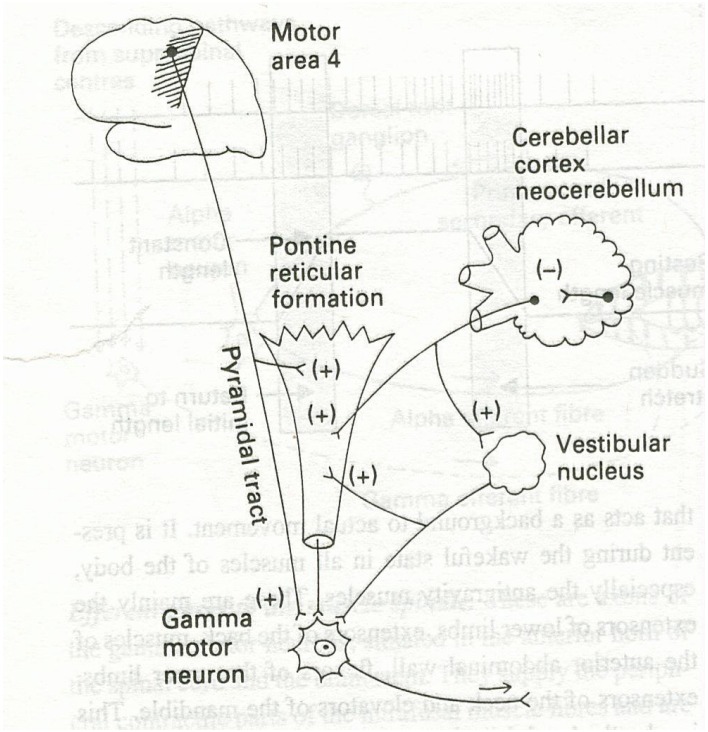
The cerebellum.

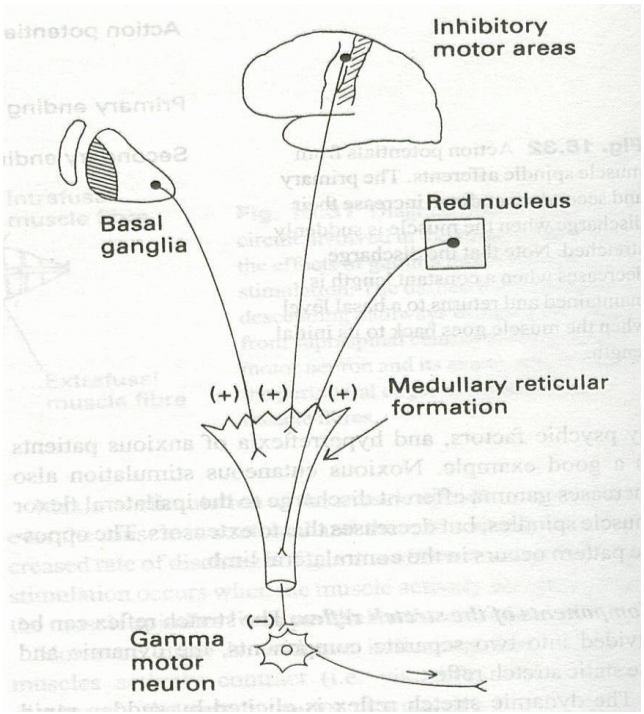
- Cerebellar cortex exerts an inhibitory influence on the stretch reflex.
- Deep cerebellar nuclei (DCN) are excitatory via lateral vestibular nuclei.

However , <u>cerebellar lesions</u> in humans are characterized by <u>hypotonia</u>, due to deep cerebellar nuclei involvement

Facilitatory supra spinal centers



Inhibitory supra spinal centres



The Golgi tendon reflex (inverse stretch reflex)

When muscle is excessively stretched

↓

it contracts strongly and pulls on the tendon

↓

excessive tension is conveyed/transferred to the tendon

↓

this stimulates Golgi Organ in the tendon

↓

sends afferent impulses via the fast A alpha fibers

↓

excitation of inhibitory interneuron in spinal cord

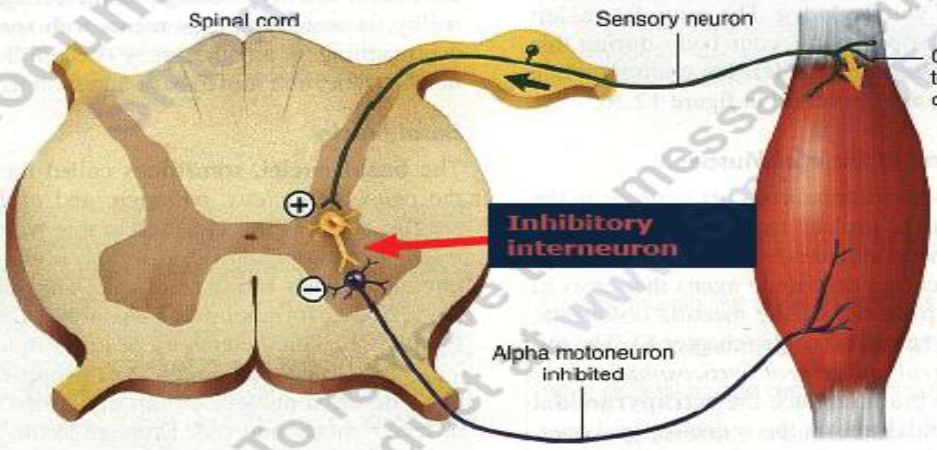
↓

inhibition of alpha motor neuron

↓

muscle relaxation

This reflex protects muscle from rupture by excessive stretch & tension.



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.