NeuroPsychiatry Block

Stretch reflex and Golgi Tendon Reflex

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Objectives:•

Upon completion of this lecture, students are expected to :

Describe the stretch reflex and its components -

- Describe the structure and function of the muscle spindle

- Differentiate between primary and secondary afferent fibres of muscle spindle

- Differentiate between the Dynamic gamma efferent and Trail endings discharge and their functional role

- Differentiate between static and dynamic stretch reflex

- Describe muscle tone and its abnormalities

- Discuss spinal and supraspinal regulation of the stretch reflex

-Describe the components of the inverse stretch reflex (golgi - tendon reflex)and its function

-Reference book/Gyton & halls –chapter 55 & Ganong review of medical physiology

What is the Stretch Reflex or myotatic Reflex?

• **When a skeletal muscle is stretched, it contracts. This response is called the stretch reflex or myotatic reflex.** ;It results from stimulation of the **muscle spindle** by stretching the whole muscle

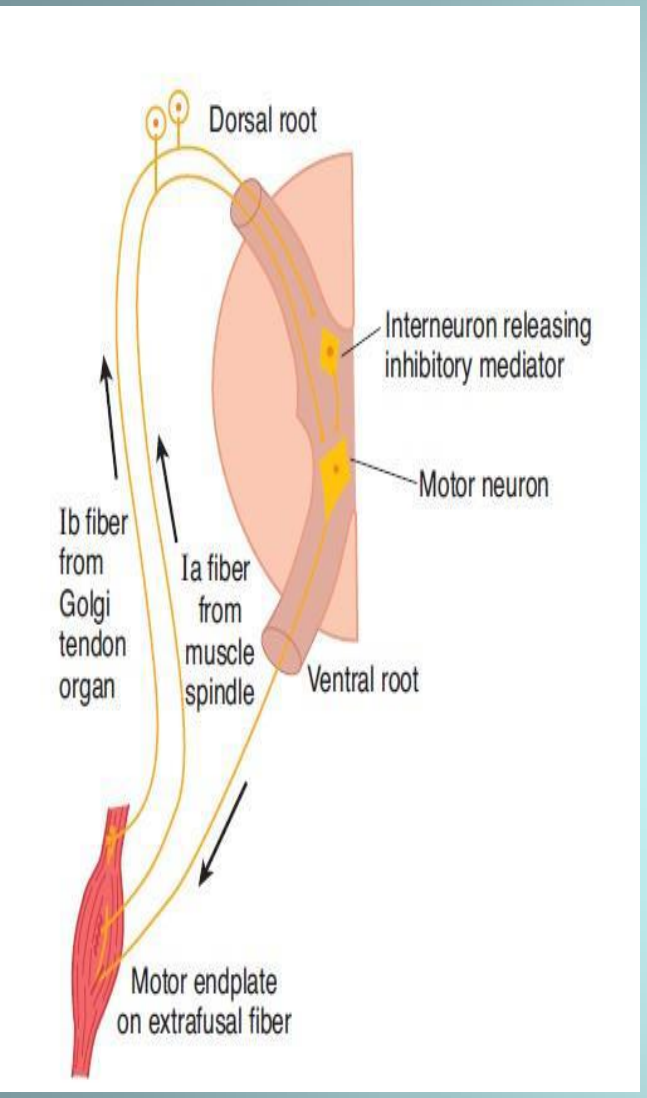
-It is a **Monosynaptic Deep reflex**(one sensory neuron synapse with one motor neuron)

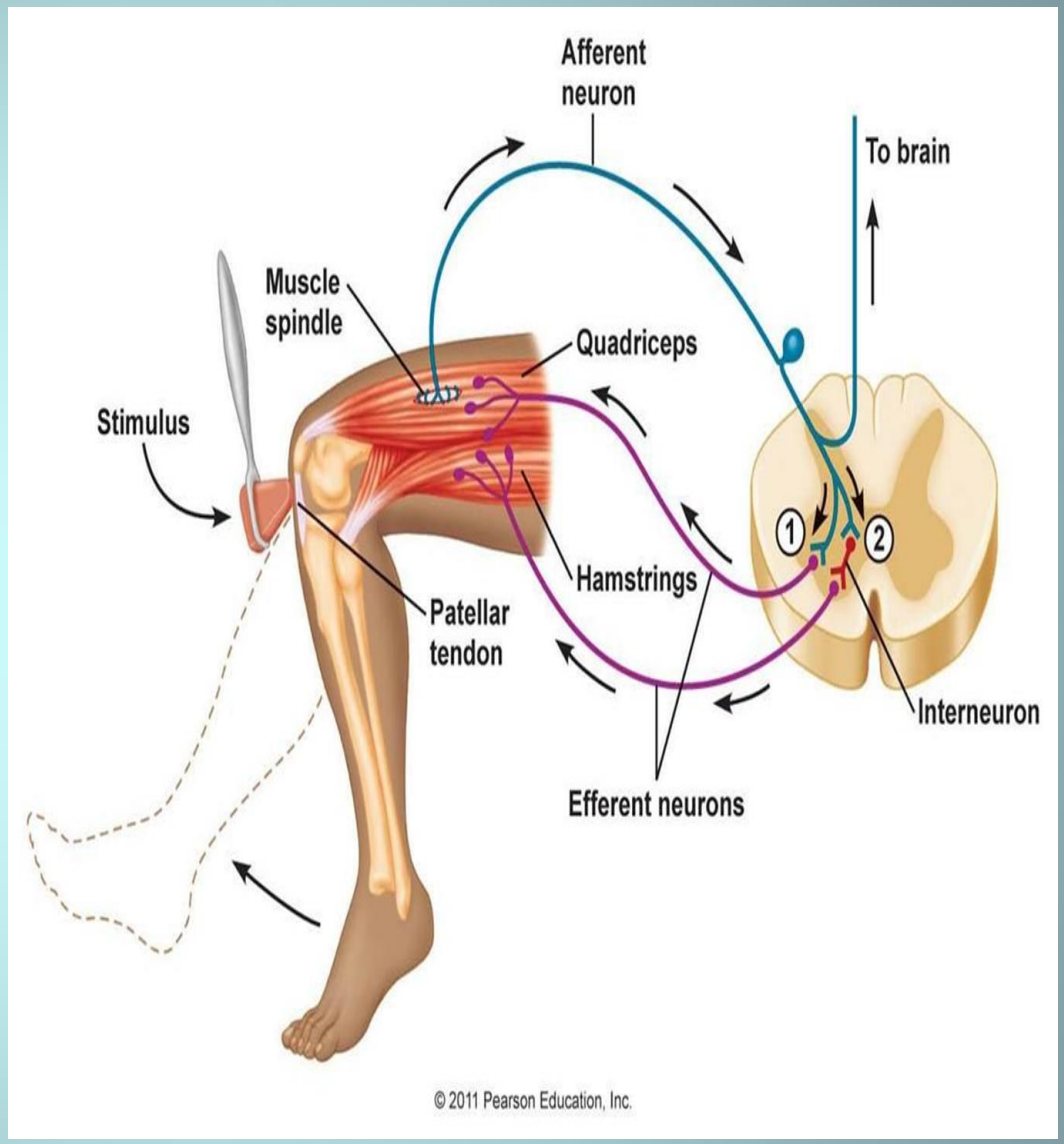
-It has two components:

A-dynamic stretch reflex (Example/tendon jerks as patellar-or knee jerk

B**-static** stretch (muscle tone)

Value/aids in maintaining posture, avoid muscle rupture


Dorsal root
Interneuron releasing inhibitory mediator
Motor neuron
Ib fiber from Golgi tendon organ
Ia fiber from muscle spindle
Ventral root
Motor endplate on extrafusal fiber


Afferent neuron
To brain
Muscle spindle
Quadriceps
Stimulus
Hamstrings
Patellar tendon
Interneuron
Efferent neurons
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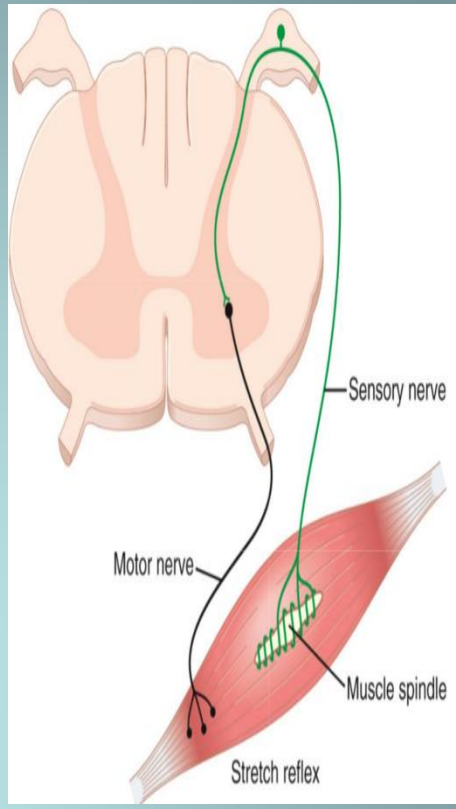
Components of the Stretch Reflex Arc

- **Sensory Receptor : muscle spindle**
- **Afferent (group Ia and group II afferents)**
- **Integrating center (spinal cord) AHC**
- **-Alpha motor neurons synapse with the afferent sensory neurones in the spinal cord (secrete glutamate)**
- **Efferent include/**
- **1- alpha motor efferent arise from alpha motor neurons to supply extrafusal muscle fibers**
- **2- gamma efferent (from gamma motor neurons to supply intra-fusal muscle fibers inside muscle spindle.**
- **Effector / Skeletal muscle**

-Effect_/Muscle contration & Reciprocal Inhibition of antagonist



MUSCLE SENSORY RECEPTORS

Proprioceptors/ muscle spindles and golgi tendon organs

Proper *control of muscle function requires:-*

***1- excitation of the muscle by spinal cord anterior motor* neurons**

2-continuous feedback of sensory information from muscle to the spinal cord, indicating :-

1.what is the length of the muscle

2.what is its tension?

Structure of the Muscle spindles

--Muscle spindle is the receptor located inside muscle & detects changes in muscle length

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

-Each intrafusal fibre has:

-Central non-contractile area (receptor)

-Peripheral contractile area on each side of central zone, it has actin & myosin

-Has two types of intrafusal fibres:

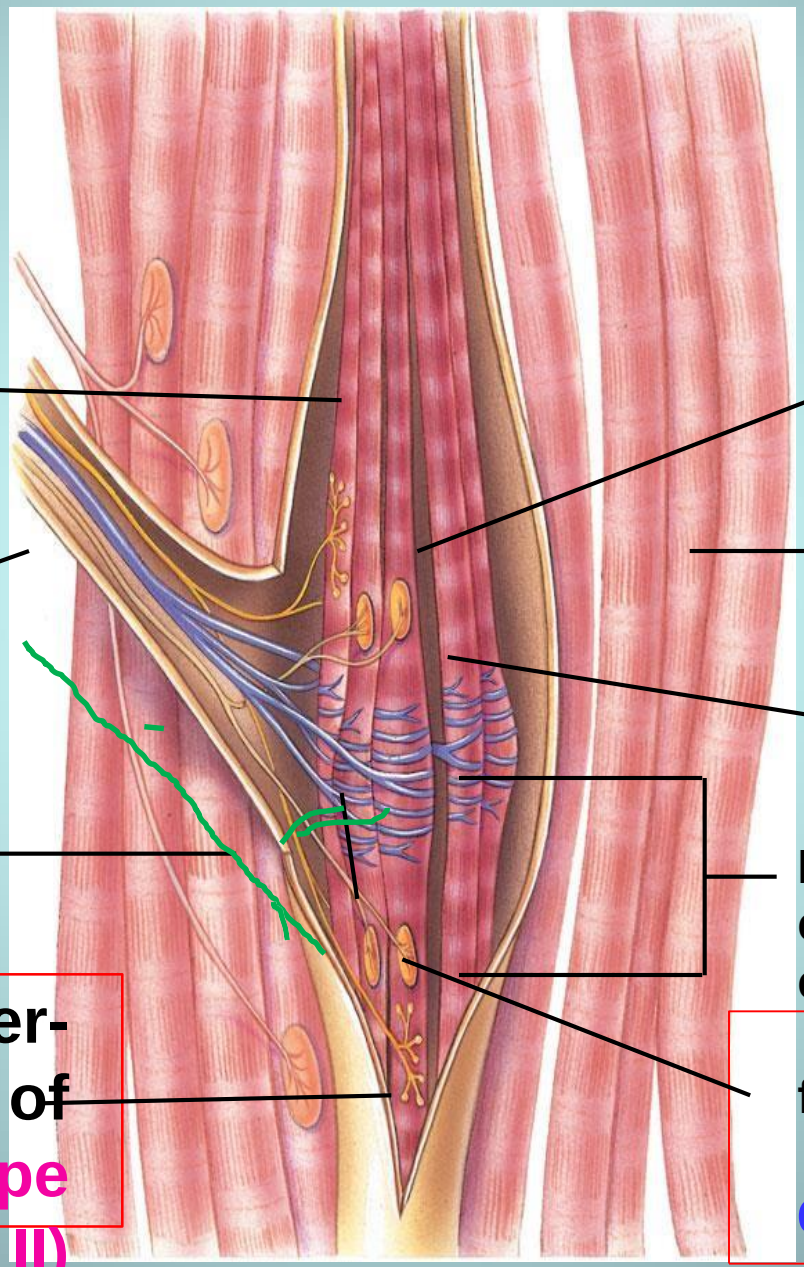
1-Nuclear bag fibres : (2 / spindle)

- Central area is dilated with group of (bag) nuclei

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

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

Muscle Spindles-1



Capsule

Alpha motor neuron axon

Gamma motor neuron axon

Secondary (flower-spray) endings of afferent fibers (type II)

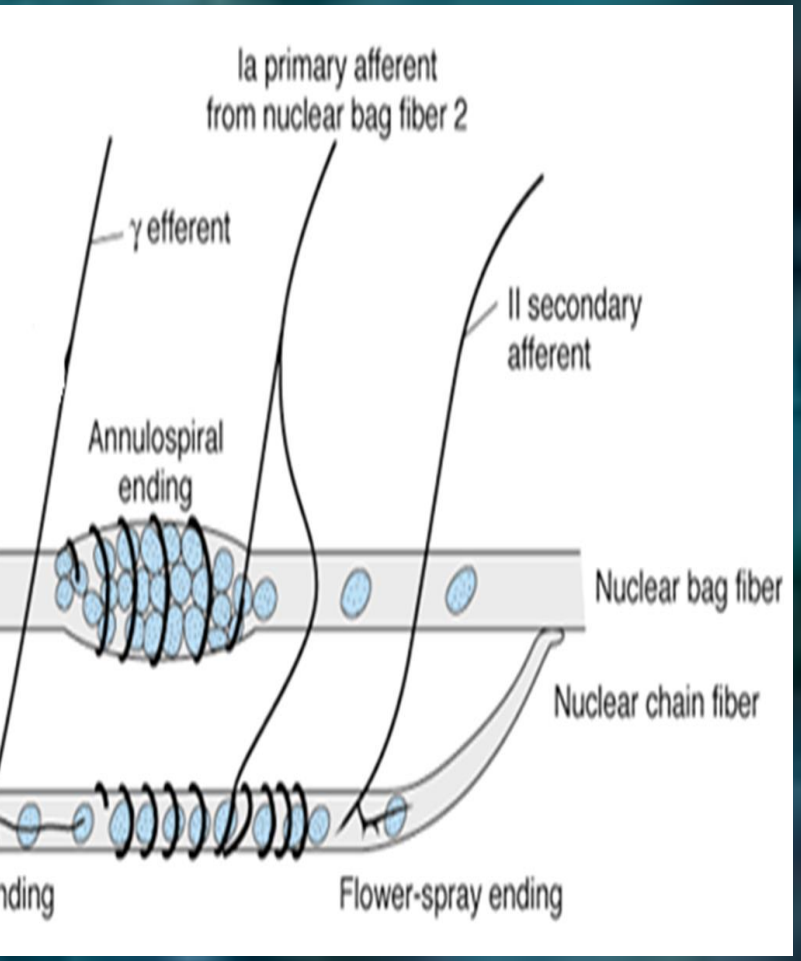
muscle fibers

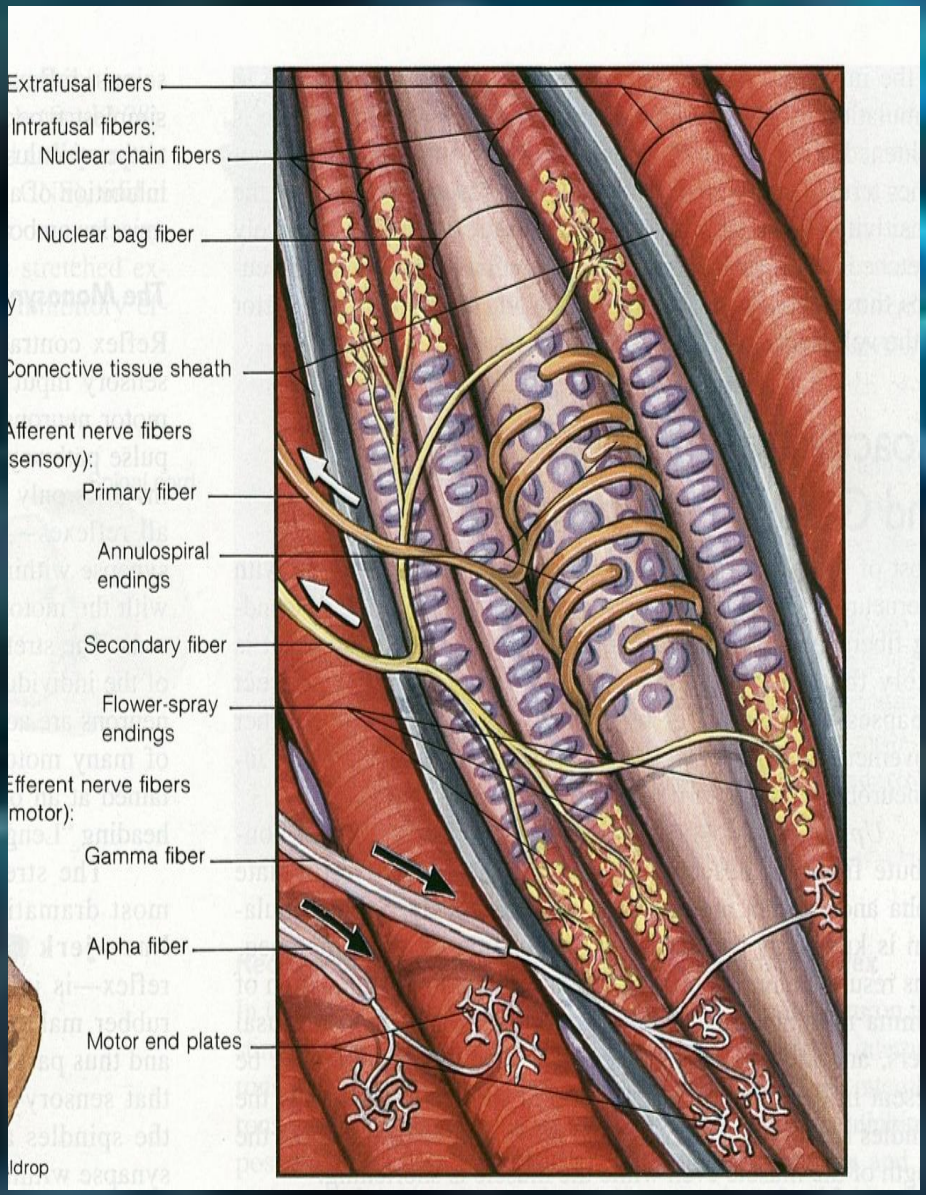
Extrafusal ("ordinary") muscle fibers

Contractile end of intrafusal fiber

Non-contractile central portion of intrafusal fiber

Primary (annulospiral) endings of afferent


Ia primary afferent
from nuclear bag fiber 2
γ efferent
II secondary
afferent
Annulospiral
ending
Nuclear bag fiber
Nuclear chain fiber
nding
Flower-spray ending


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

Innervation of the muscle spindle

-It has afferent & efferent nerve fibers

1-Sensory Afferent fibres:

1-Primary (annulospiral) endings (Ia fibres):

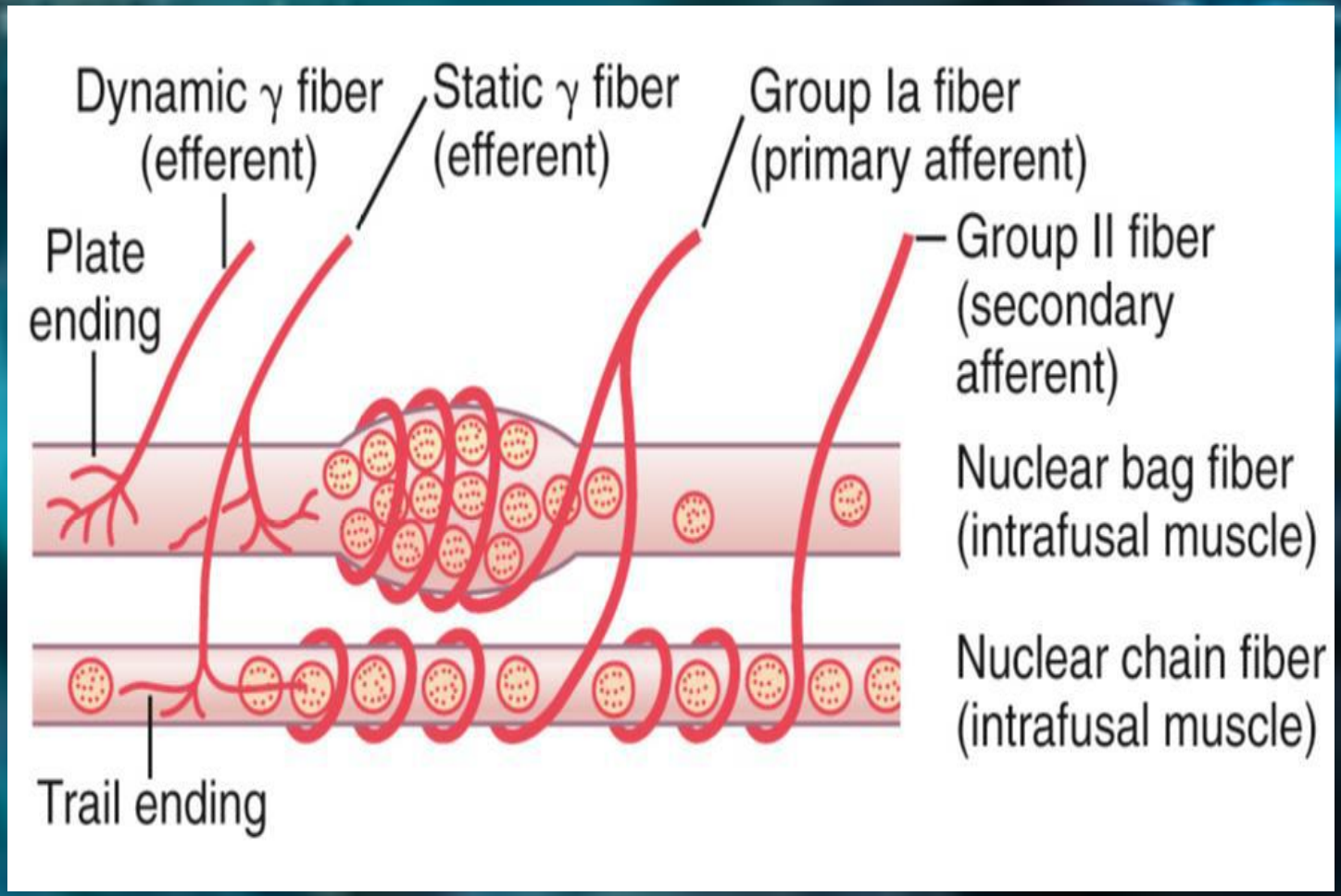
-

-Fast, encircle receptor areas of **both** nuclear bag and nuclear chain fibres ,synapse directly with the motor neurons(AHC)

-Discharge most **rapidly** if the muscle is **suddenly** stretched (dynamic response) & less rapidly (or not) during **sustained stretch (static response)**

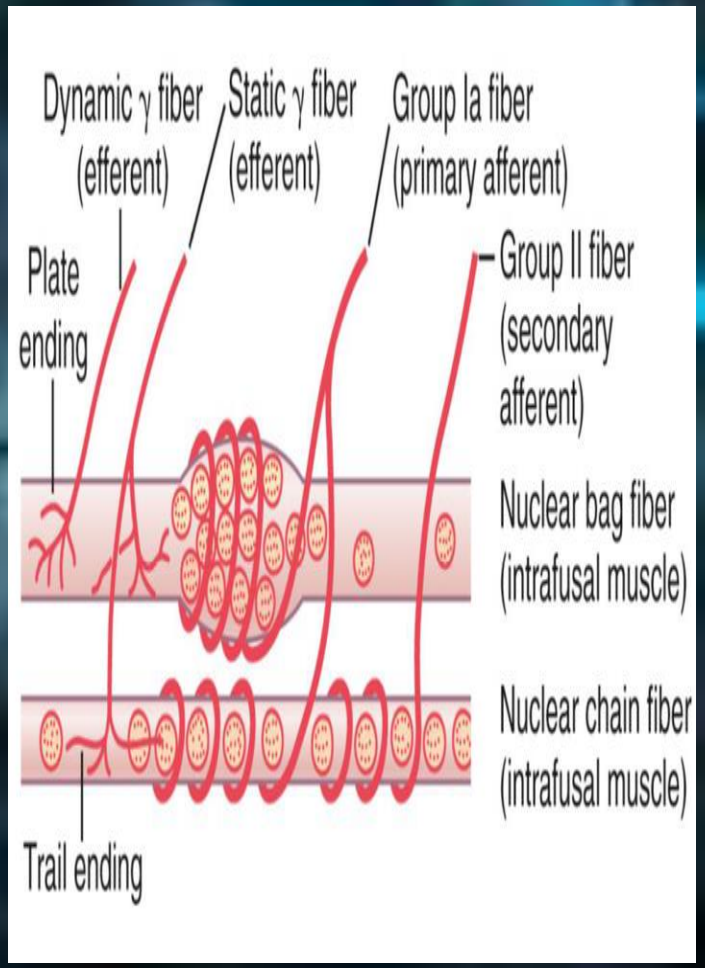
-17 micrometers diameter - transmits sensory signals to the spinal cord at a velocity of 70 to 120 m/sec

-Measure **the rate & or velocity of change in muscle length** of nuclear bag fibres


Dynamic γ fiber
(efferent)
Static γ fiber
(efferent)
Group Ia fiber
(primary afferent)
Group II fiber
(secondary
afferent)
Plate
ending
Nuclear bag fiber
(intrafusal muscle)
Nuclear chain fiber
(intrafusal muscle)
Trail ending

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

-8 micrometers in diameter -
- innervate the receptor area of the **nuclear chain fibres ONLY.**
-Discharge throughout the period of muscle stretch, **(sustained stretch) (measure mainly muscle length) (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**

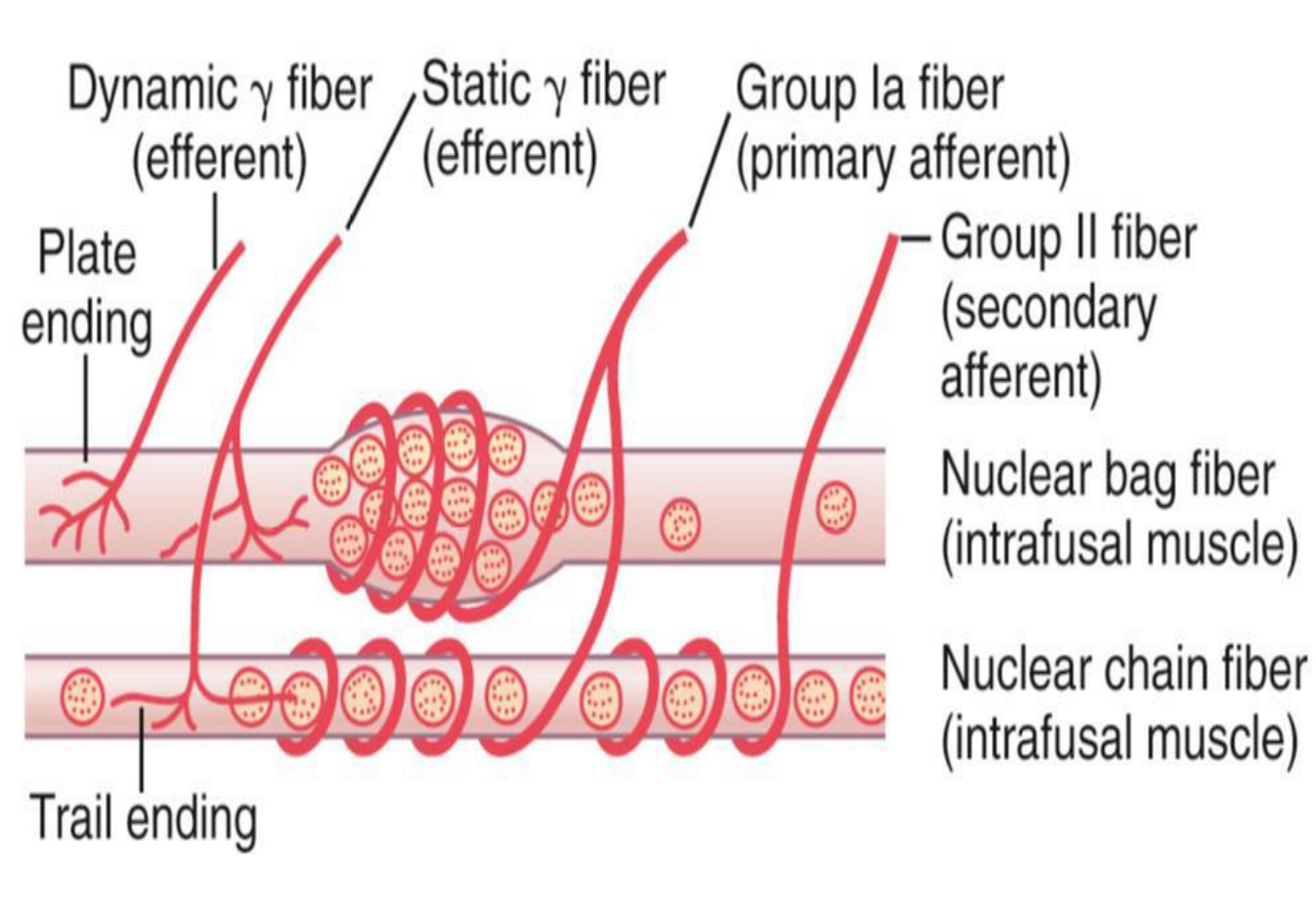
(Motor Efferent fibres to muscle spindle)

-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)

-The function of the γ motoneurons (either static or dynamic) is to regulate the sensitivity of the intrafusal muscle fibres


Dynamic γ fiber
(efferent)
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Group Ia fiber
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Plate
ending
Nuclear bag fiber
(intrafusal muscle)
Nuclear chain fiber
(intrafusal muscle)
Trail ending

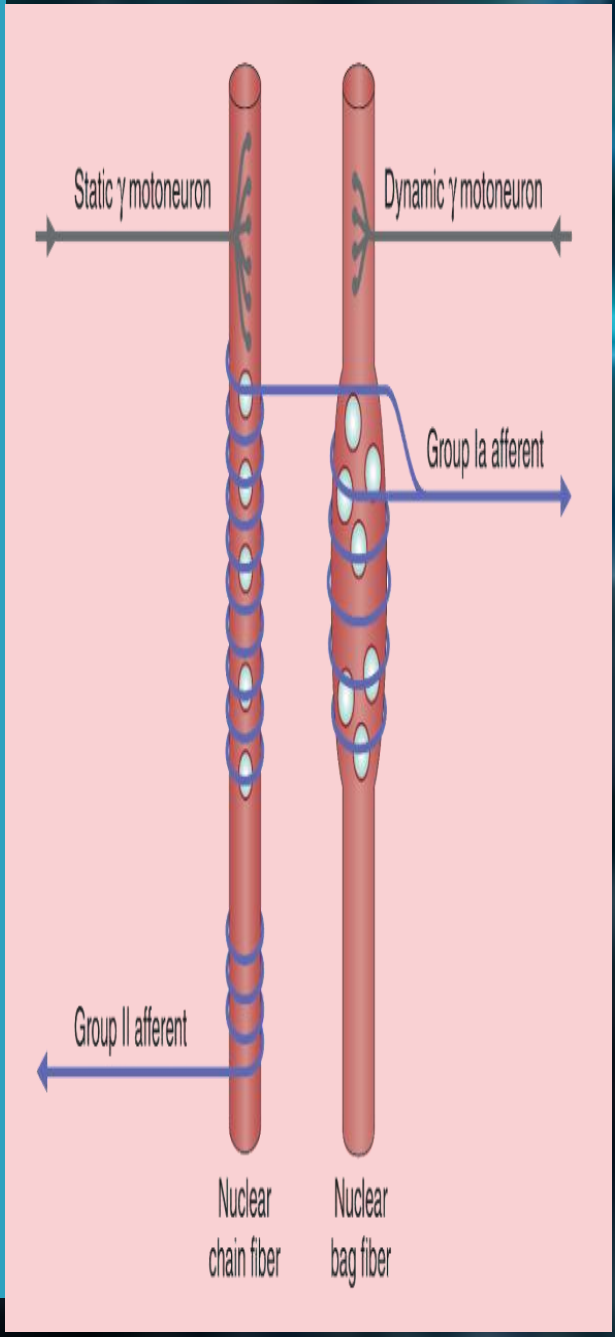
Gamma motor neurons function:-.

-When Gamma motor neurons are activated, can make peripheral parts of the muscle spindles to contract

- They increase muscle spindle sensitivity to stretch

-When the gamma-d fibers excite the nuclear bag fibers, the dynamic response of the muscle spindle becomes enhanced

-Conversely, stimulation of the gamma-s fibers, which excite the nuclear chain fibers, enhances the static response



1-Dynamic stretch reflex (dynamic or phasic response)

-Sudden rapid stretch of a muscle >> stimulate Nuclear bag fibers which respond to velocity of change of Receptor Length >>>> discharge Synchronous strong impulses >>>> to the fast primary ending (annulospiral) mainly to send rapid signals>>> alpha motor neuron >>>motor alpha nerve>>>>causing sudden contraction of muscle extrafusal fibers synchronously (jerk movement) followed by relaxation)

muscle shortens → the spindle becomes lax
→ and ceases to discharge → no stimulation of alpha motorneuron → no excitatory impulses from alpha motorneuron to the extrafusal fibers → muscle relaxes

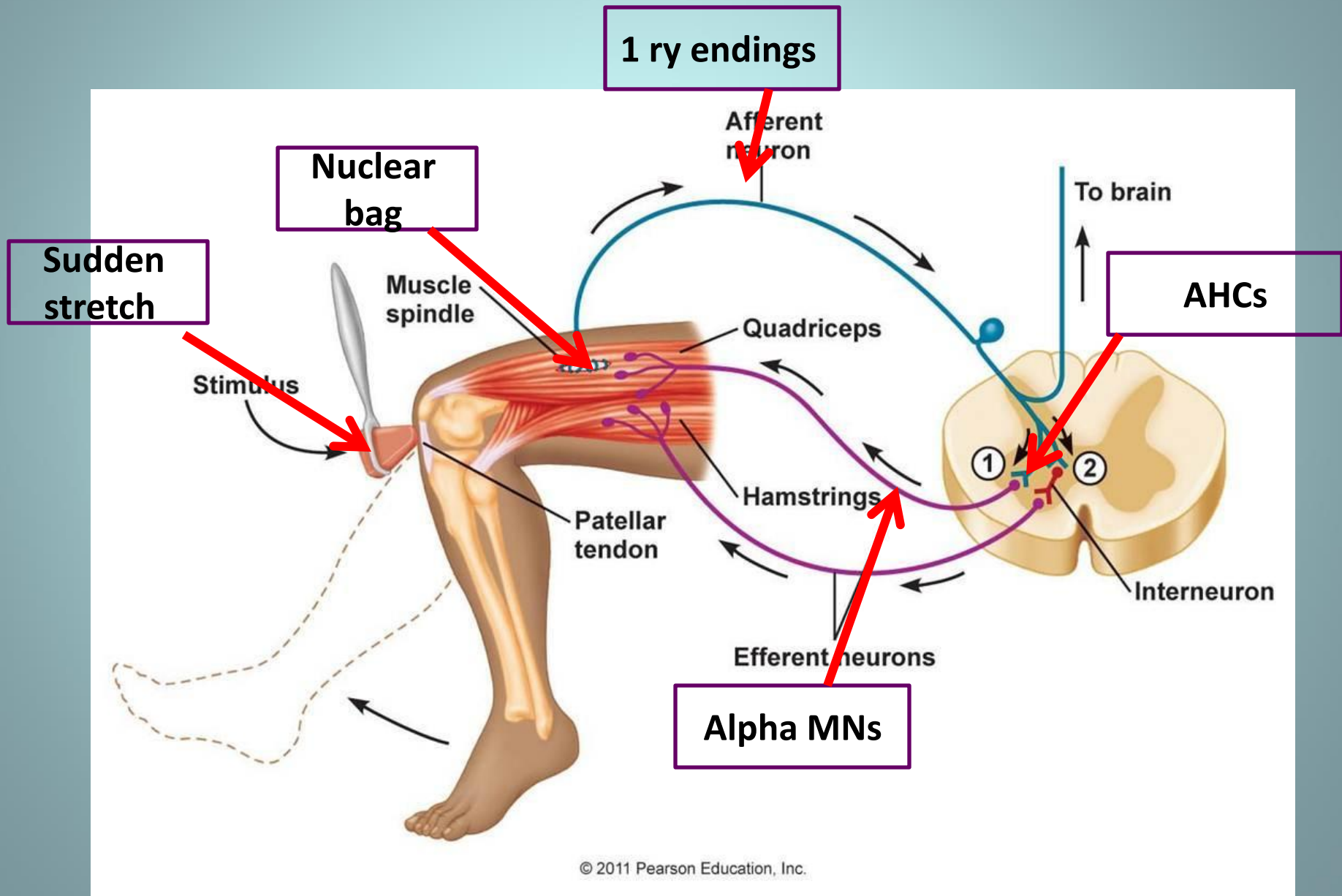
-Dynamic stretch reflex-cont

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

-Role of Dynamic gamma efferent (plate endings)
- Tapping the tendon, stretch the muscle ,so it contracts & shorten, nuclear bag fibres relax during muscle contraction ,its sensitivity to stretch decreases.

- Plate gamma endings which end mainly on the nuclear bag fibres periphery , stretching it to increase sensitivity of muscle spindle to new sudden stretch & enhances the dynamic response

Dynamic stretch Reflex



2- Static stretch reflex(static response)

-Maintained stretch of muscle>>> stimulates the receptor portion of the Nuclear chain fibers discharge slowly, both the primary and the secondary endings are stimulated

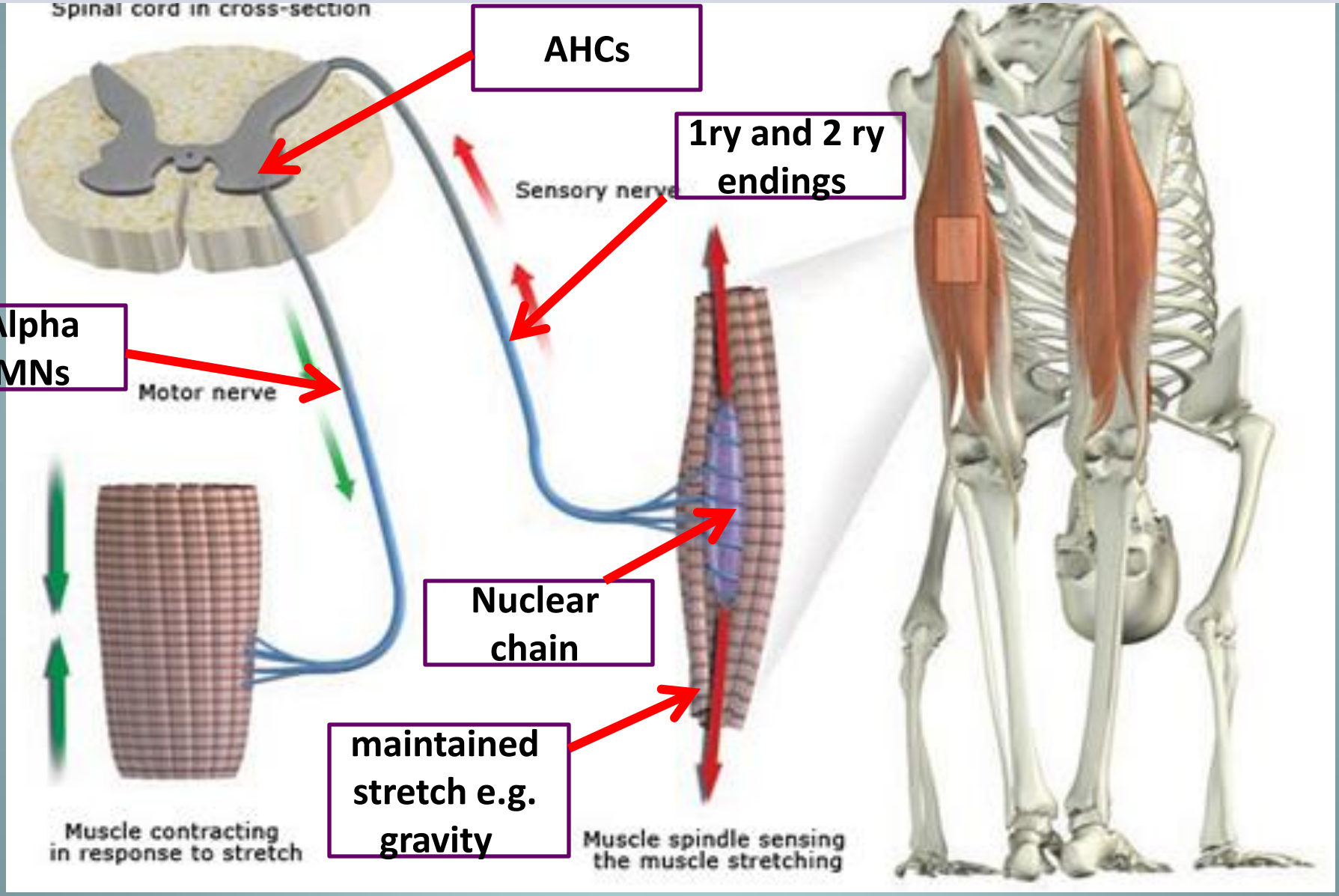
>>>Impulses to >>>>alpha motor neuron >>> motor nerve>>> contraction of muscle fibers Asynchronously (motor units not discharge all together)>>>>>> resulting in mild sustained contraction of muscle extrafusal fibers as long as it is stretched

-Basis of muscle tone

-Static gamma efferent (Trail endings)

(Trail endings which end mainly on the nuclear chain fibres periphery , stretching it to increase sensitivity of muscle spindle to steady maintained stretch & enhances the static response

Static stretch reflex



Stretch reflex

REFLEX	STRETCH (MYOTACTIC) REFLEX
CLINICAL TEST | STIMULUS	RAPID STRETCH OF MUSCLE (TAP ON MUSCLE TENDON)
RESPONSE	STRETCHED MUSCLE CONTRACT RAPIDLY (I.E. KNEE JERK)
SENSORY RECEPTOR	MUSCLE SPINDLE PRIMARY
SYNAPSES INVOLVED	MONOSYNAPTIC
EFFECTS ON MUSCLE	CONTRACTS (+) SAME MUSCLE
OTHER EFFECTS	RELAXES (-) ANTAGONISTIC MUSCLE
FUNCTION	AIDS IN MAINTAINING POSTURE, AVOID MUSCLE RUPTURE,COUNTERS SUDDEN LOADS

Muscle Tone(Static stretch reflex)

Dif/ resistance of muscle to stretch

-Stimulus for muscle tone /Is sustained 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

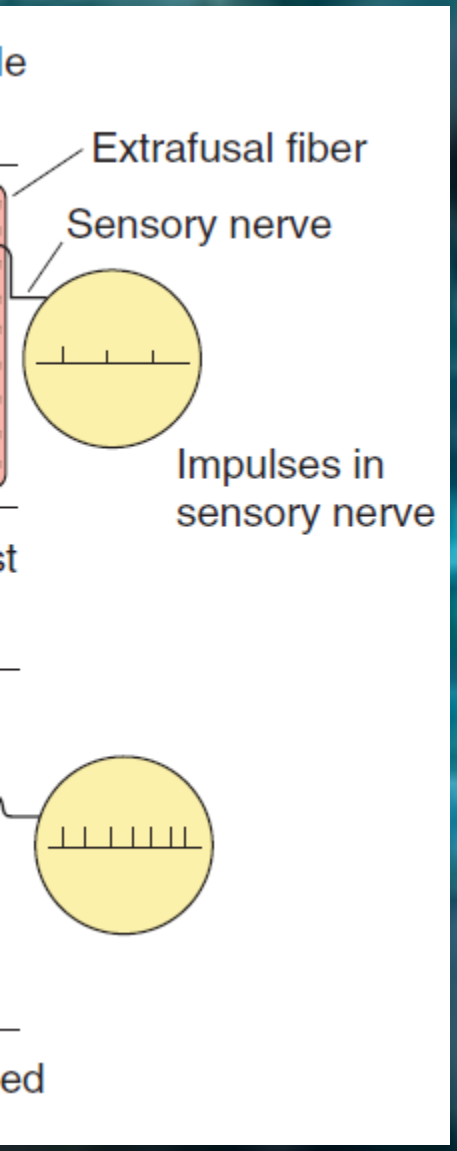
-if lost by low gamma efferent discharge to muscle >>>>>hypotonic muscle or flacidity

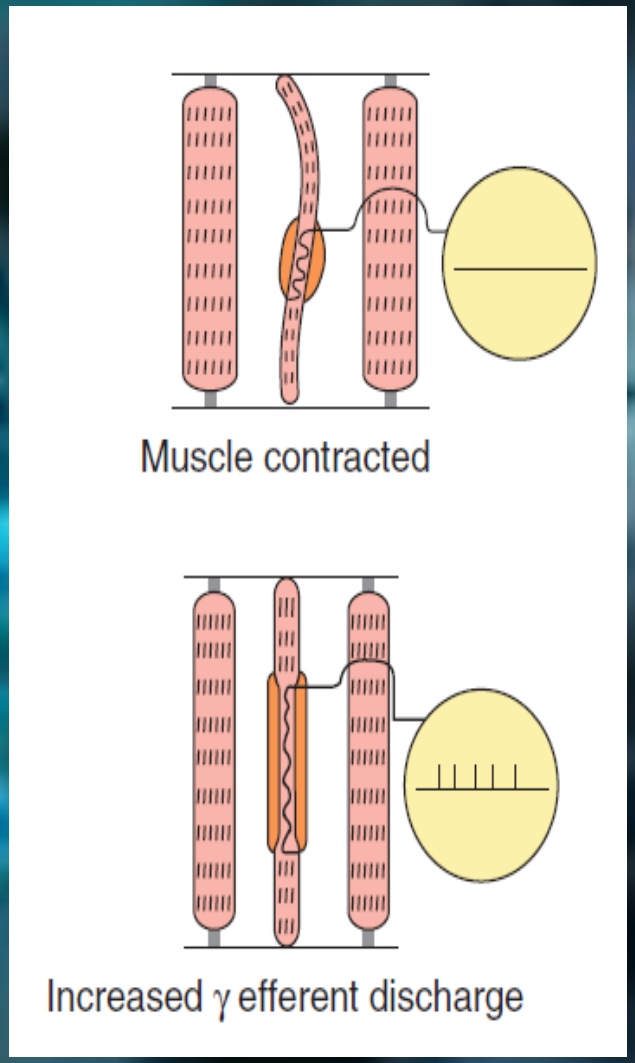
-if increased by high gamma efferent discharge to muscle >>>>>>hypertonic muscle , spastic muscle

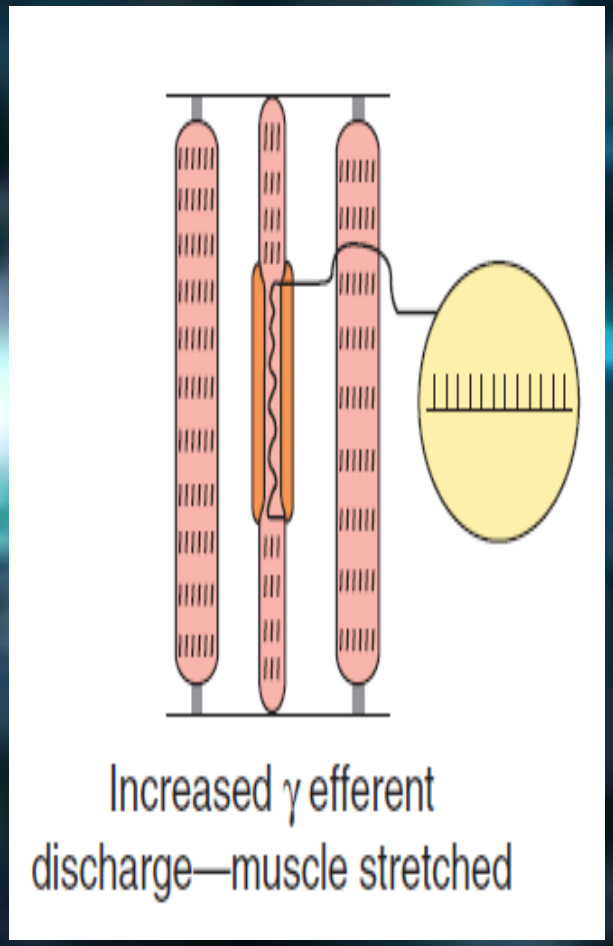
.

Value of stretch reflex

- They help maintain a normal posture
- They function to oppose sudden changes in muscle length
- Damping or smoothing of muscle contraction
- Generation of muscle tone







If the whole muscle is stretched during stimulation of the γ-motor neurons, the rate of discharge in sensory fibers is further increased.

Alpha- gamma COACTIVATION

Signals from the motor cortex to the alpha motor neurons, mostly transmitted to the gamma motor neurons simultaneously, an effect called coactivation.

-The purpose of Coactivation

- First, it keeps the length of the receptor portion of the muscle constant.

Otherwise receptor portion of the spindle would sometimes be flail and sometimes be overstretched, causing unsmooth muscle contractions

Damping functionof muscle spindle:-

. **the proper damping function of the muscle spindle, it is the stretch reflex ability to prevent oscillation or jerkiness of movements.**

-N.B/Signals from the spinal cord transmitted to a muscle in an unsmooth form, with increasing or decreasing intensity for few milliseconds, the muscle contraction will be jerky

-Muscle spindle reflexes make the contraction smooth, because the motor nerve to the muscle is excited at a slow frequency than the incoming signals from S.C

Muscle can contract by:-

1- Muscle stretch & Stimulation of alpha motor neurons by,therefore excites the receptor.

2- Stimulation of gamma motor neurons by supraspinal signals

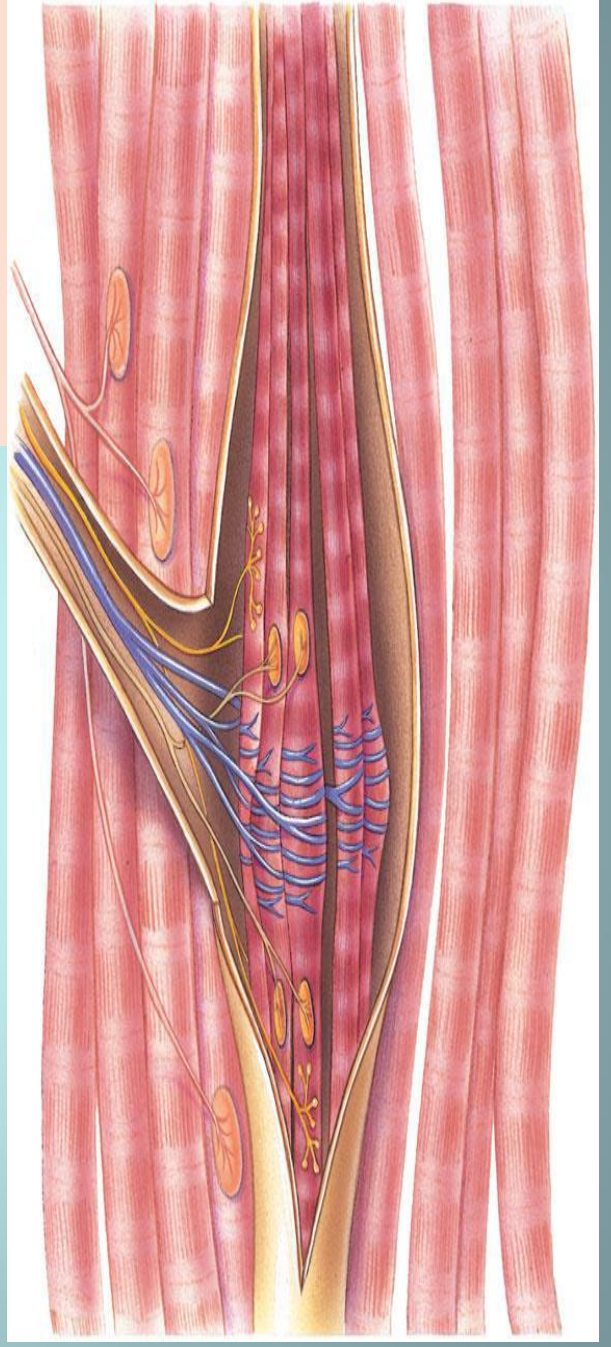
3- Co-activation of α-and γ-Motor Neurons.

How Are Muscle Spindles Activated?

Muscle spindles are stimulated by stretching of their mid-portion in two ways:

1. Lengthening of the whole muscle which stretches the mid-portion of the spindle and, therefore excites the receptor.

2.Contraction of the peripheral contractile portions of the spindle's intra-fusal fibers which stretches the mid-portions of the spindle & excites the receptor during γ-efferent discharge



Reciprocal inhibition with stretch reflex (Reciprocal innervation)

-AS IN KNEE JERK//Contraction of EXTENSOR of thigh causes >>>>>>>Relaxation of FLEXORS

-Reflex contraction of an agonistic muscle is accompanied by inhibition of the antagonist

-Impulses from stretched muscle>>>> SC to :-

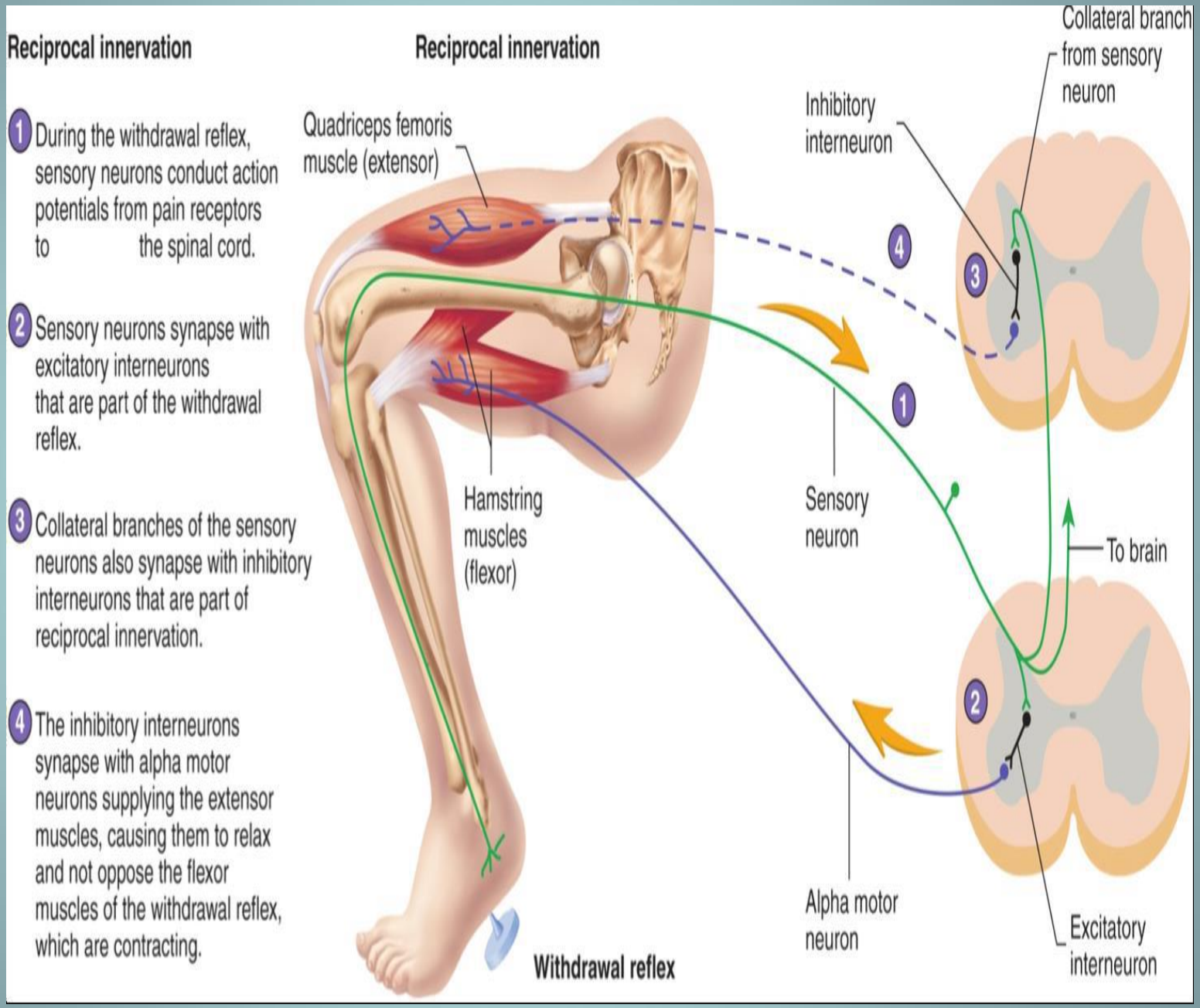
1-stimulate the motor neurons of the stimulated muscle to contract (by glutamate)

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

- Reciprocal innervation prevents conflict between opposing muscles and is vital in coordinating body movements)

Reciprocal innervation

1. During the withdrawal reflex, sensory neurons conduct action potentials from pain receptors to the spinal cord.
2. Sensory neurons synapse with excitatory interneurons that are part of the withdrawal reflex.
3. Collateral branches of the sensory neurons also synapse with inhibitory interneurons that are part of reciprocal innervation.
4. The inhibitory interneurons synapse with alpha motor neurons supplying the extensor muscles, causing them to relax and not oppose the flexor muscles of the withdrawal reflex, which are contracting.



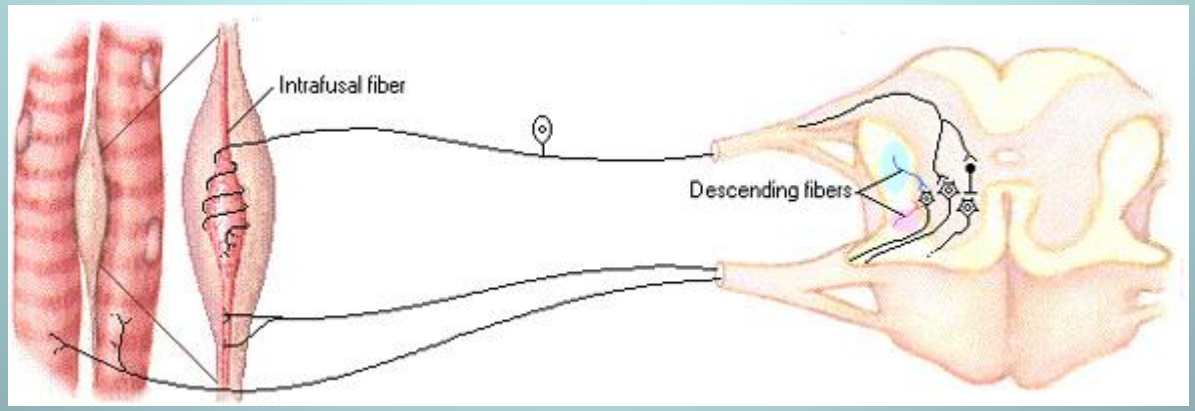
What is the Clinical Significance of Tendon Reflexes ?

They are carried out clinically to test the integrity of reflex arc.

- **A-reflexia** or **hypo-reflexia (hypo-tonia)** indicates that the reflex arc is interrupted at one of its components by:
- Lesions of lower motor neuron *e.g. poliomyelitis*
- Peripheral nerve lesions *e.g. peripheral neuropathy*
- Neuromuscular junction disorder *e.g. myasthenia gravis*
- Primary muscle disorder *e.g. myopathy*
- **Hyper-reflexia (hyper-tonia):** exaggerated deep reflexes.
- Upper motor neuron lesion.
- Anxiety

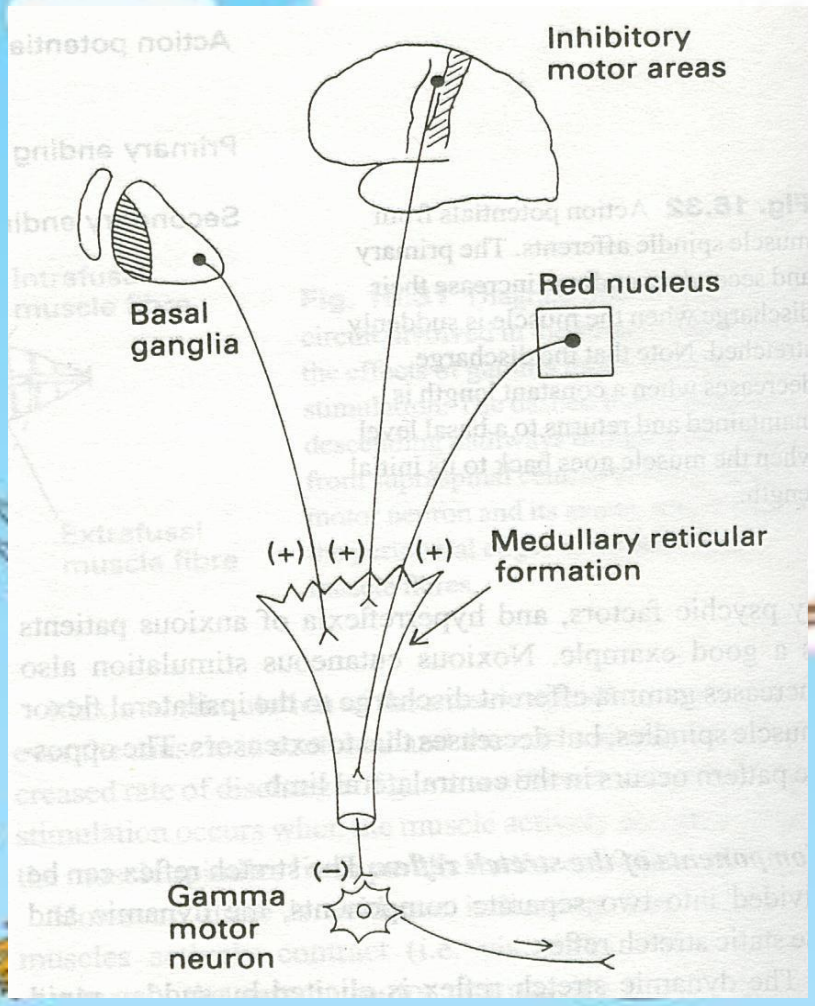
SUPRASPINAL REGULATION OF THE STRETCH REFLEX

- Stretch reflexes are subject to strong regulation by supraspinal centres, especially certain **motor centres in the brainstem and cerebral cortex.** These supraspinal centres send to gamma motor neurons through descending fibres

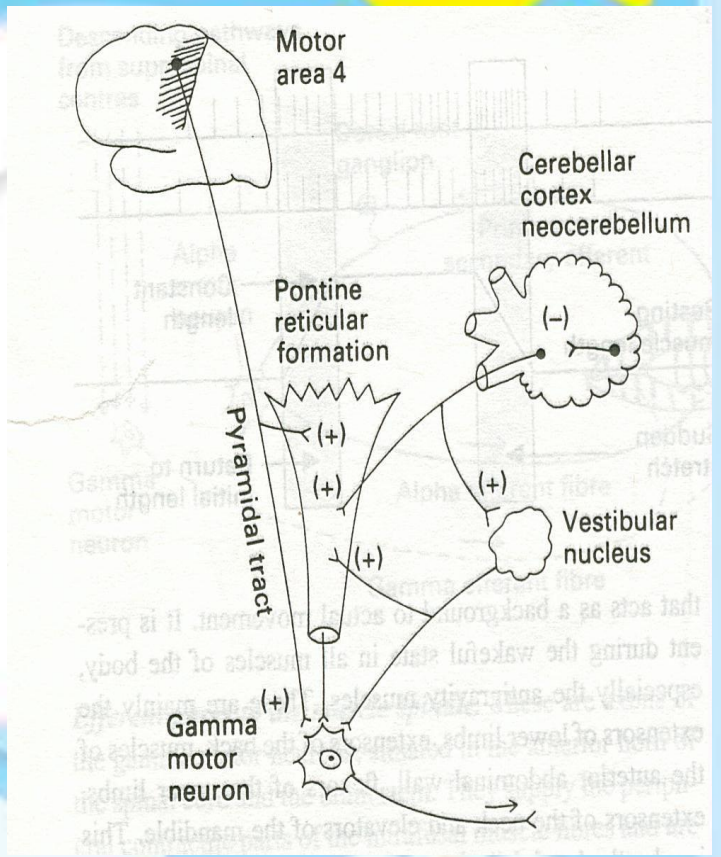


http://humanphysiology.tuars.com/program/section8/8ch3/s8ch3_20.htm

Inhibitory supra spinal centers to gamma motor

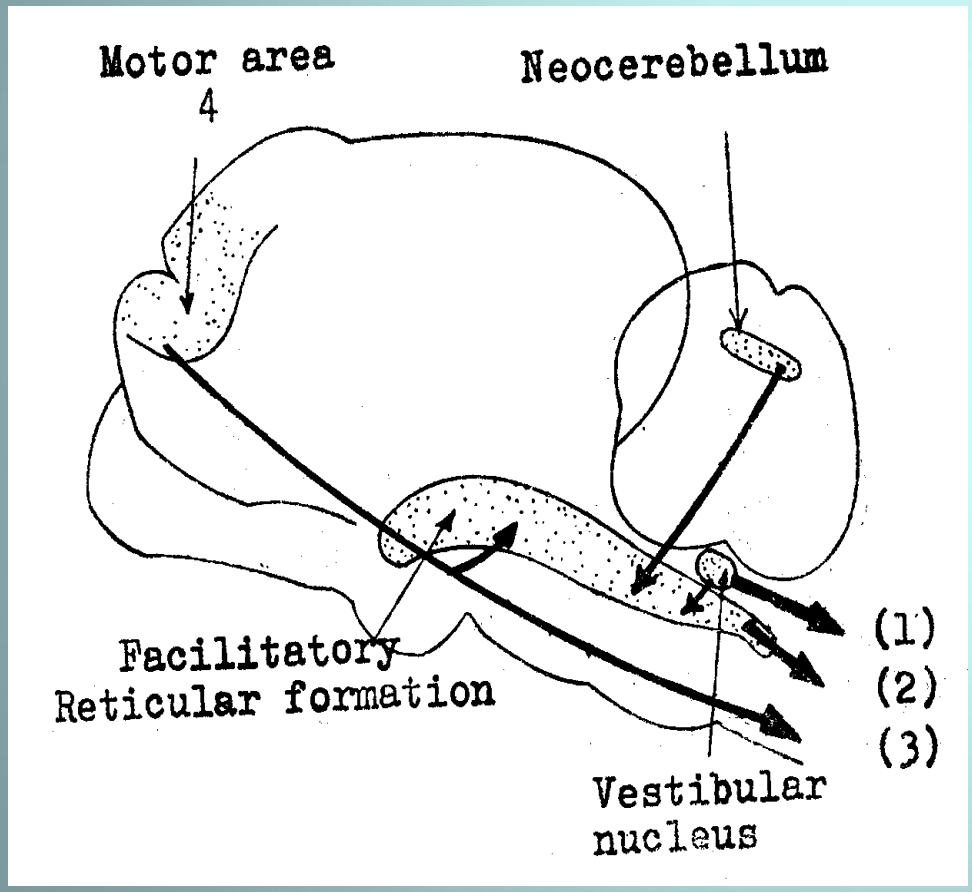


Facilitatory supra spinal centers to gamma motor neurons

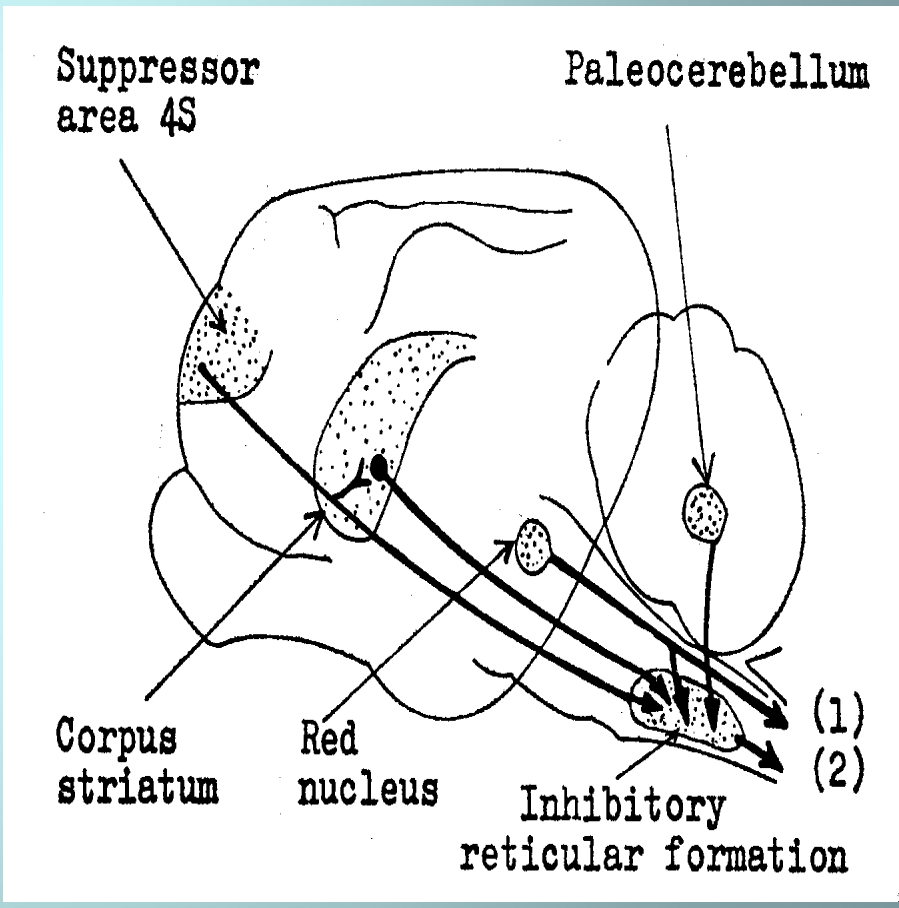


Supraspinal control of Stretch Reflex-1

Facilitatory Areas



Inhibitory Areas



Factors influence stretch reflex

(all act on gamma motor neurons)

Enhances

1-Suprspinal

- -Primary motor area4
- -Vestibular N
- -Pontine RF(bulboreticular)
- -Neocerebellum

2-Anxiety

3-Noxious painful stimuli

4-Jendrassik-manuver

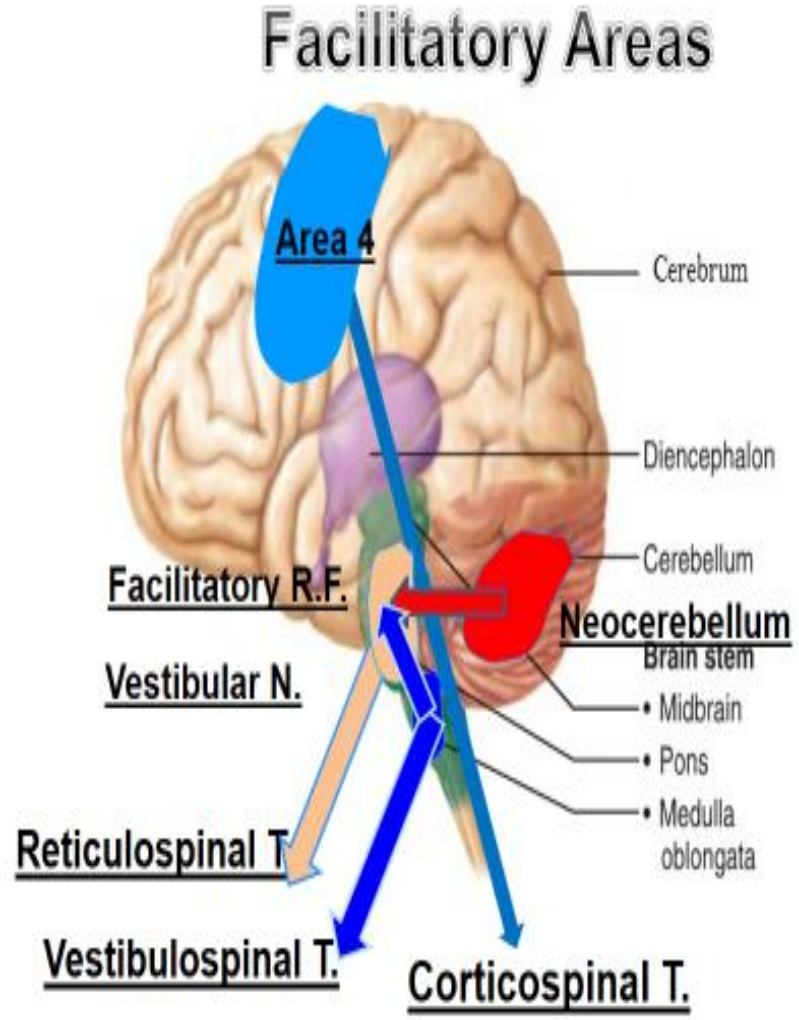
Inhibits

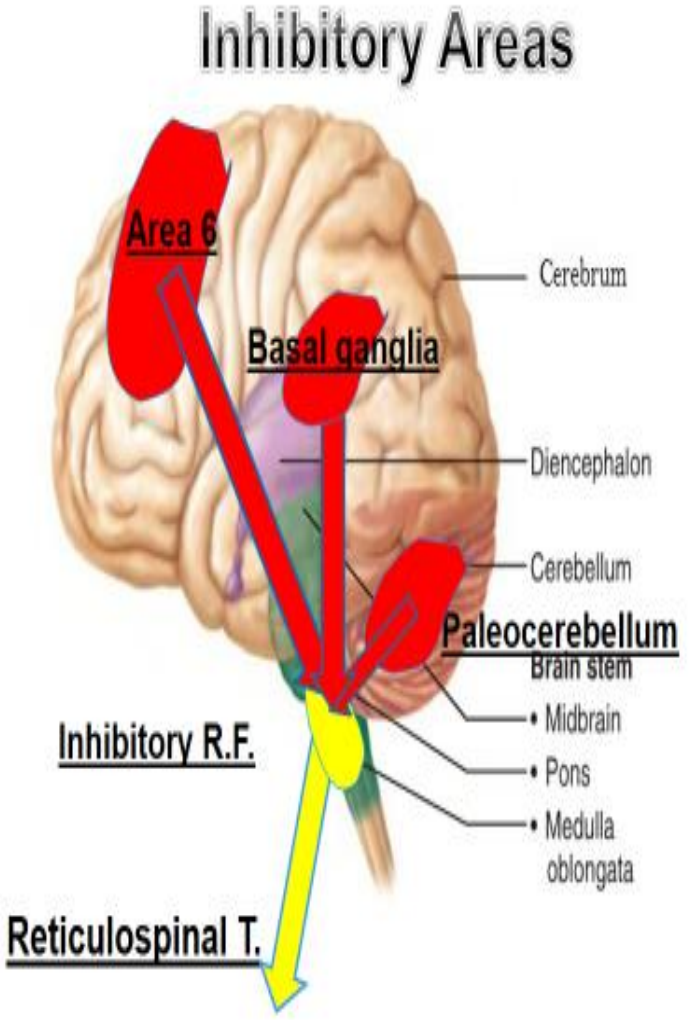
1-Supraspinal

- -Cortical (suppressor area4&Area 6)
- -Basal ganglia
- -Medullary RF
- -Red nucleus
- -paleocerebellum

2-Excessive stretch of muscle(golgi tendon reflex)

Supraspinal control of Stretch Reflex-2



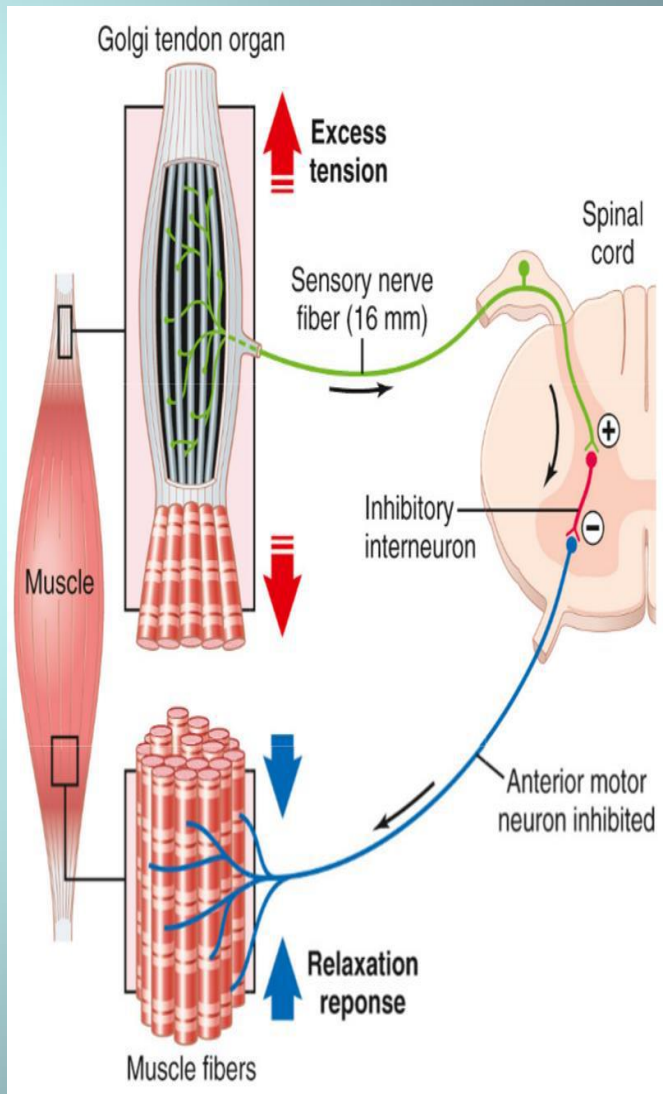


(Inverse Stretch Reflex)- The Golgi tendon reflex

- **It is Deep & polysynaptic reflex**
- **Opposite response to stretch reflex = Inverse Stretch Reflex).**

Mechanism/

Excessive tension in the muscle (by passive over-stretch of tendon or active muscle contraction) >>> cause muscle relaxation



Receptors of the Inverse Stretch Reflex are Golgi tendon organs

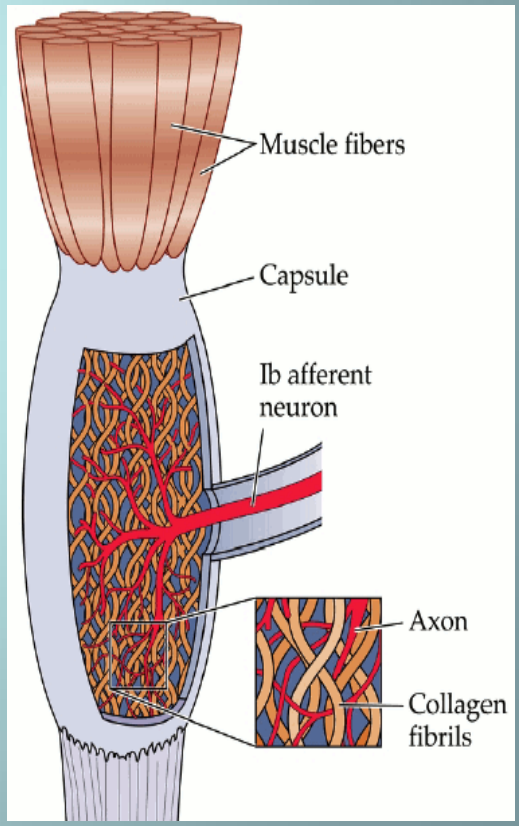
-

Golgi tendon organs (3-25) present in tendons , encapsulated sensory receptor ,through which muscle tendon fibers pass.

-About 10 to 15 muscle fibers are usually connected to each Golgi tendon organ, and the organ is stimulated when this small bundle of muscle fibers is "tensed" by sever contracting

-

- Transmit information about tendon tension or rate of change of tension.



Inhibitory Nature of the Golgi Tendon Reflex and Its Importance

-Stimulated golgi tendon organ by an increase in muscle tension if the muscle overstretch >>> impulses via fast Ib nerve fibers , large, rapidly conducting fibers (16 micrometers in diameter) >>>> SC >>> The local cord signal excites *inhibitory* interneuron (secrete Glycine)>> inhibit alpha motor neuron >>> negative feedback mechanism>>>>>muscle relaxation(lengthening reaction)

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

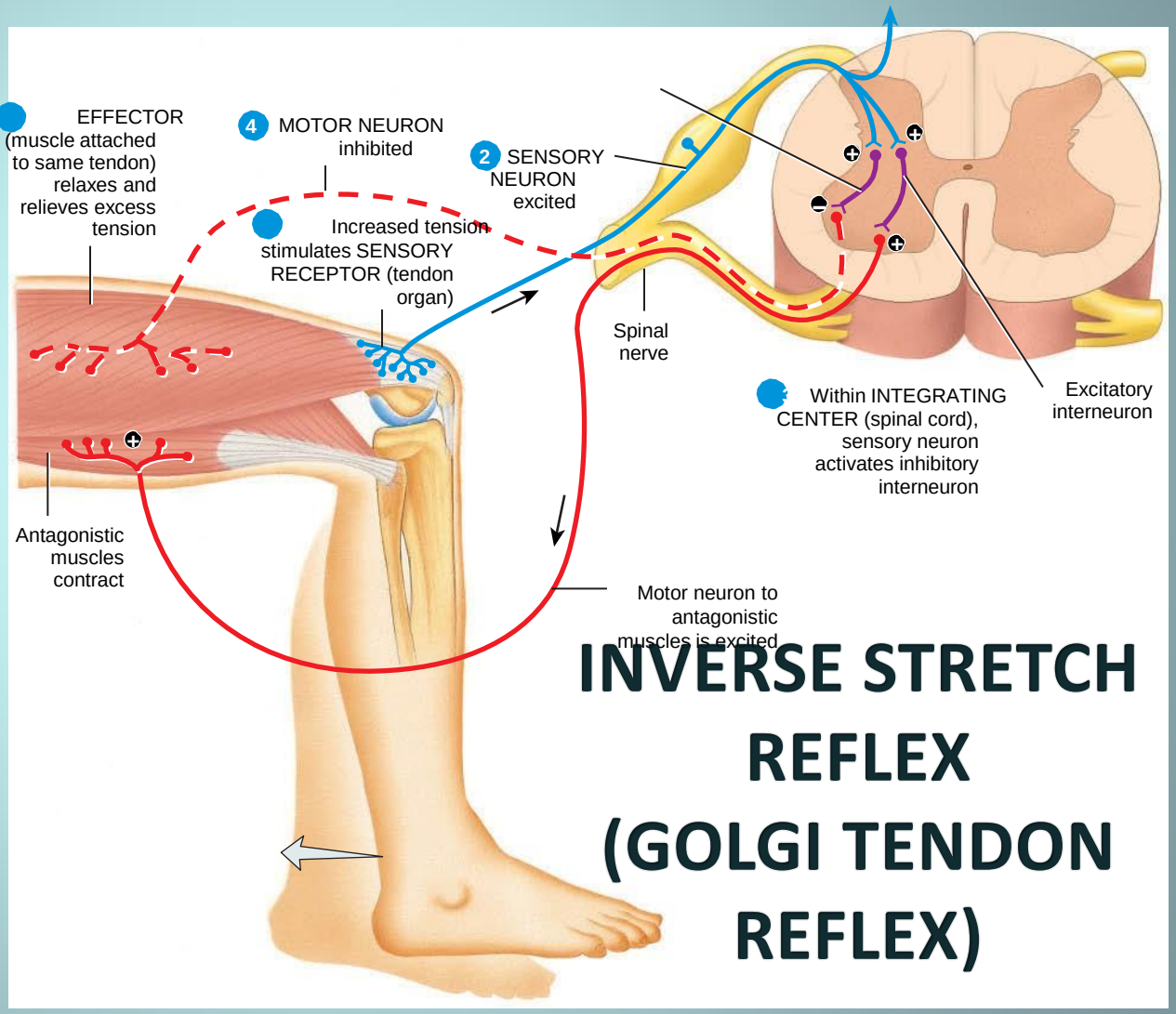
-Value/Protect muscle from rupture& tendon from avulsion& tear

UP TO A POINT, THE HARDER A MUSCLE IS STRETCHED, THE STRONGER IS THE REFLEX CONTRACTION.

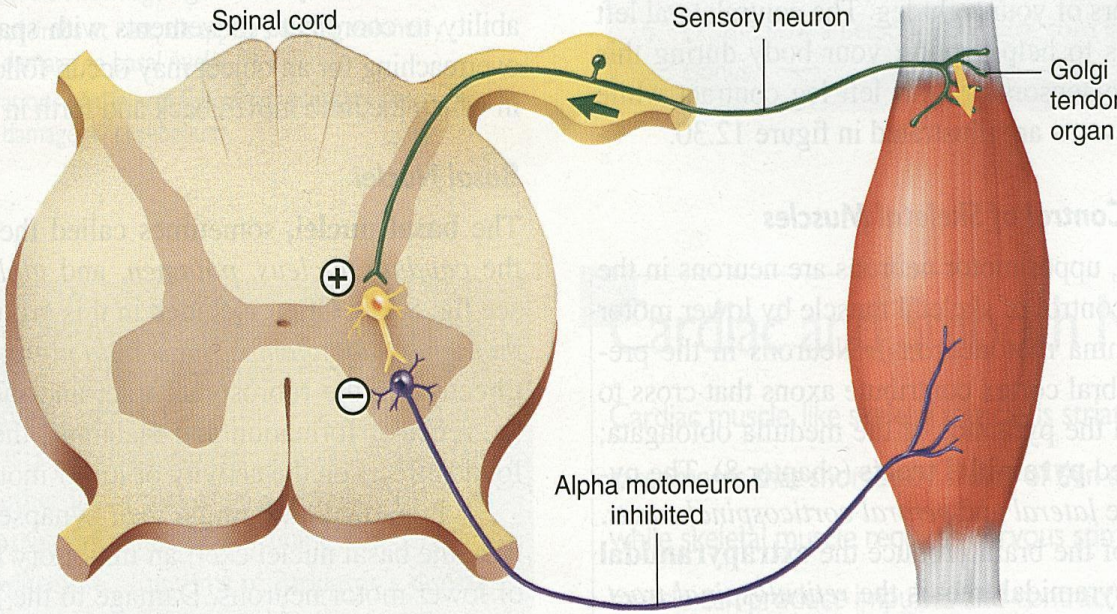
HOWEVER, WHEN THE TENSION BECOMES GREAT ENOUGH, CONTRACTION SUDDENLY CEASES AND THE MUSCLE RELAXES.

THIS RELAXATION IN RESPONSE TO STRONG STRETCH IS CALLED THE **INVERSE STRETCH REFLEX .**

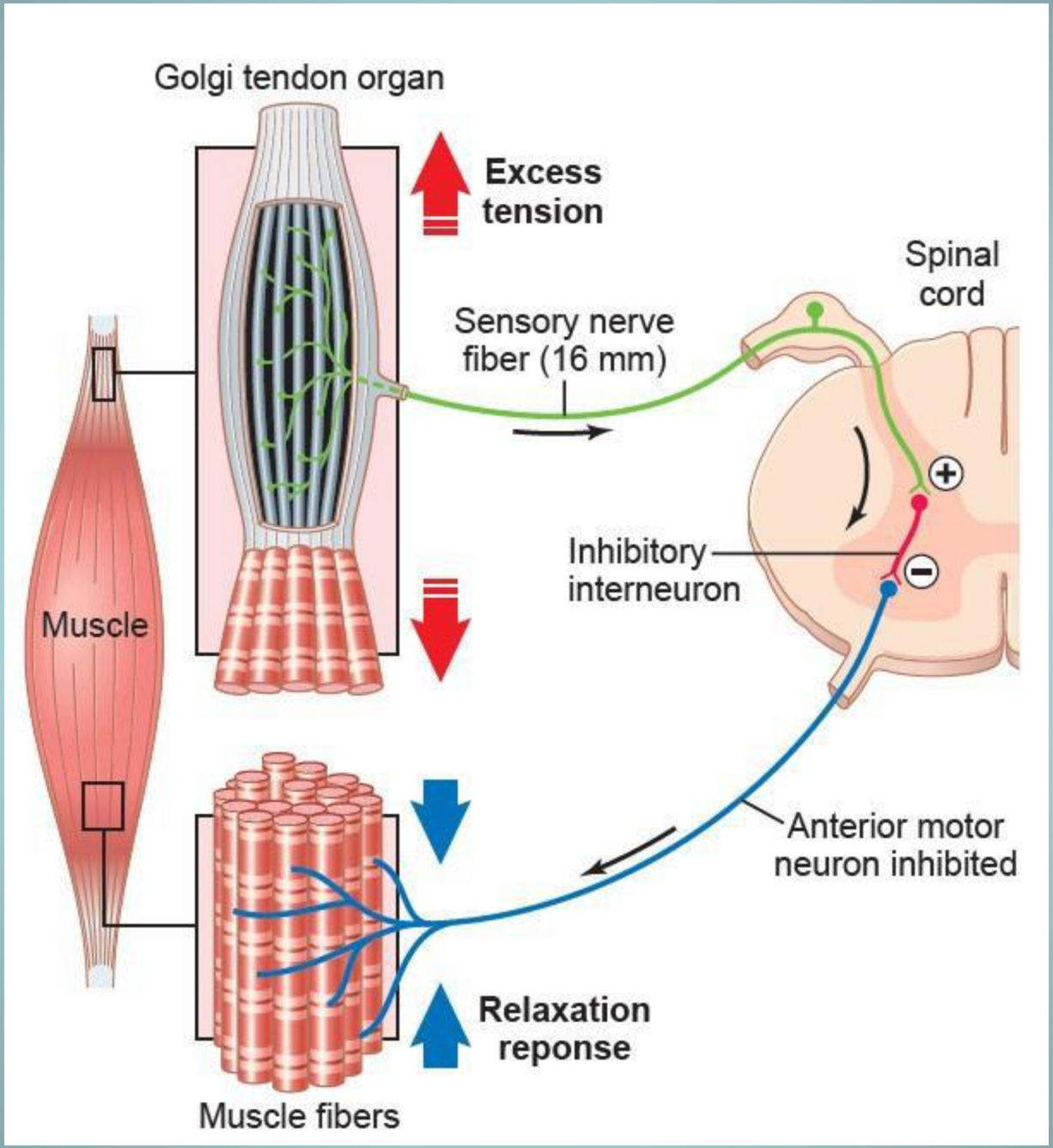
THE RECEPTOR FOR THE INVERSE STRETCH REFLEX IS IN THE **GOLGI TENDON ORGAN**



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.


Golgi tendon organ
Excess tension
Spinal cord
Sensory nerve fiber (16 mm)
Inhibitory interneuron
Muscle
Anterior motor neuron inhibited
Relaxation reponse
Muscle fibers

Comparison Between Stretch & Inverse Reflexes

	Stretch reflex	Inverse stretch reflex
STIMULUS	Increased muscle length	increased muscle tension
RESPONSE	Muscle contraction	Muscle relaxation
Receptor	Muscle spindles	Golgi tendon organs
AFFERENTS	Type Ia& II fibers	Type Ib fibers

SYNAPSES	Monosynaptic	Polysynaptic
RECEPROCAL INNERVATION Regulation	Inhibit antagonists through inhibitory interneurons	Excites antagonistic muscles through excitatory interneurons
PHYSIOLOGICAL SIGNIFICANCE	Regulate muscle length	Regulate muscle tension to prevent excessive tension increase& tendon avulsion
CLINICAL ASSESSMENT	Sudden tap of muscle causes brisk contraction muscle jerk	Overstretch of muscle-sudden muscle relaxation (lengthening reaction)