Lecture : 7

Stretch reflex and Golgi Tendon Reflex

Done By: Sarah Al-Abdualqader
Reviewed By: Yazeed Al-Husainy

Physiology Team

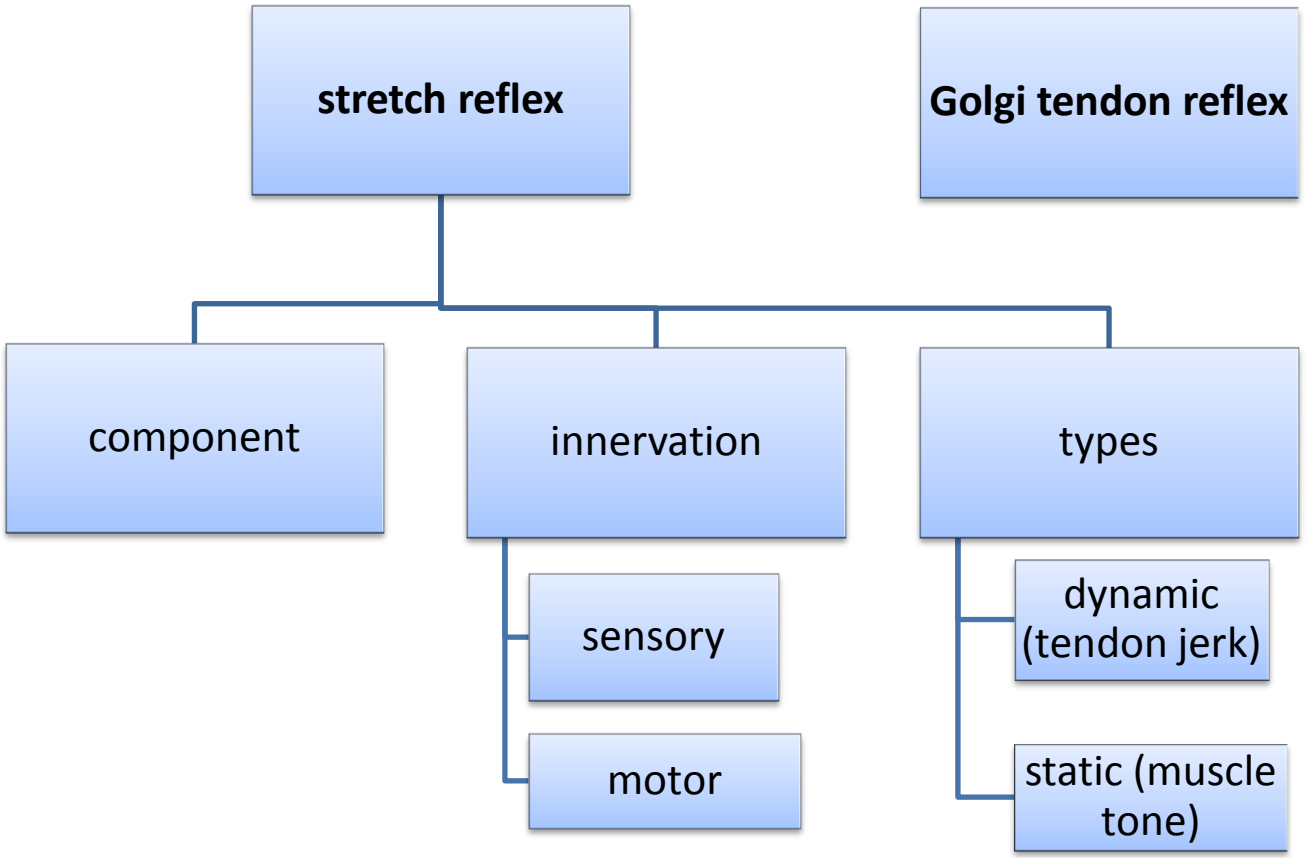
OBJECTIVES

At the end of this lecture, student should be able to describe:

-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**

Physiology Team

MIND MAP



■ Slides ■ Important ■ Doctor's Notes ■ Explanation ■ Boy's Slides

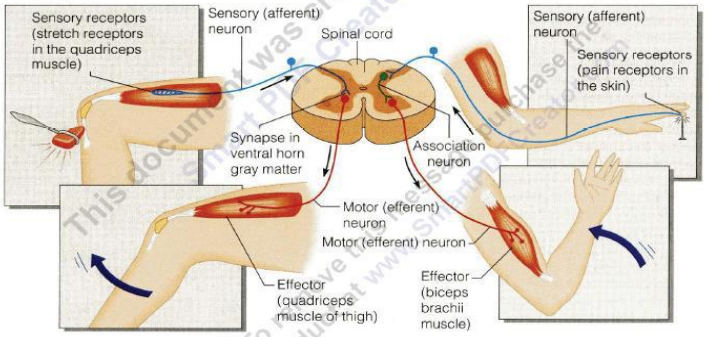
Stretch reflex

- **What is stretch reflex ?**
  - It is reflex contraction of muscle resulting from stimulation of the muscle spindle by stretch (co-activation of alpha & gamma)
  - **The function of stretch reflex is to protect the muscle from tear.** Also production & modulation (from moment to moment) of muscle tone .
  - **The knee jerk is an example. When you try tapping the patellar tendon, the quadriceps muscle will stretch. As a result the muscle will contract and shorten and forces the lower leg to extend.**

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

    It is for stretch only!

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



Stretch reflex

Stretch reflex :

- Deep-monosynaptic reflex
- Sudden stretch of a muscle → reflex contraction of the stretched muscle.

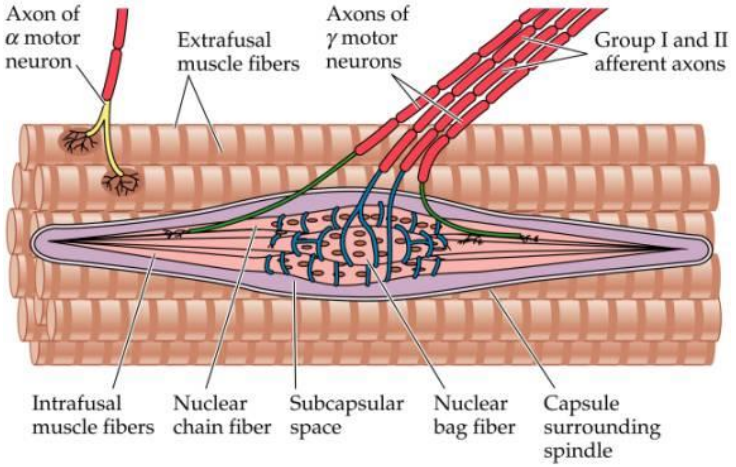
Components:

- **Receptor** : muscle spindle
- **Afferent** (annulospiral+ flower spray)
- **AHC** (Anterior Horn cell) (center)
- **Efferent** (motor nerve (alpha fibers 70% from AHCs to extrafusal muscle fibers) +gamma efferent (from gamma motor neurons 30% to muscle spindle intrafusal fibers)
- **Effector**/muscle

Stretch reflex receptor (Muscle Spindle)

Structure of muscle spindle:

Muscle spindle consists of 3-12 small muscle fibers (**intrafusal fibers**) within connective tissue capsule. parallel to extrafusal fibers & attached to it or to tendons.



Each intrafusal muscle fiber has:

- **Central** non-contractile area (receptor) "sensitive For stretch"
- **Peripheral** contractile area on each side of Central zone, it has Actin & Myosin

Types of intrafusal fibers:

- **Nuclear bag fibers:** 2/spindle

central area is dilated with group of nuclei

- **Nuclear chain fibers:** 4/spindle

Thinner & shorter

one line of nuclei in a chain in the receptor zone-bind to nuclear bag on each side

innervations

A) Sensory Afferent fibers

Central receptor area of the intrafusal muscle fibers is supplied by two types of afferent fibers:

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

- fast, encircle receptor areas of **both** nuclear bag **mainly** and nuclear chain fibers ,**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 fibers only**.
- Discharge throughout the period of muscle stretch, (**sustained stretch NOT SUDDEN**)(measure mainly muscle length).
- This response is known as the(**Static response**)

Physiology Team

B) Motor Efferent fibers to muscle spindle

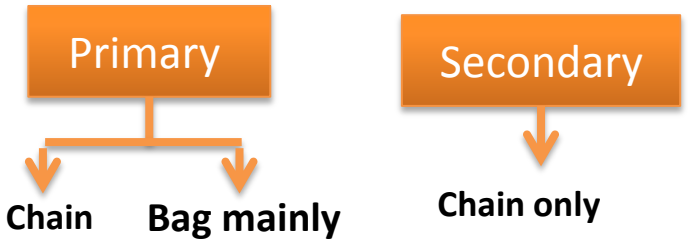
-Gamma motor neurons → gamma efferent → to the peripheral contractile parts of the intrafusal muscle fibers ,of two types:

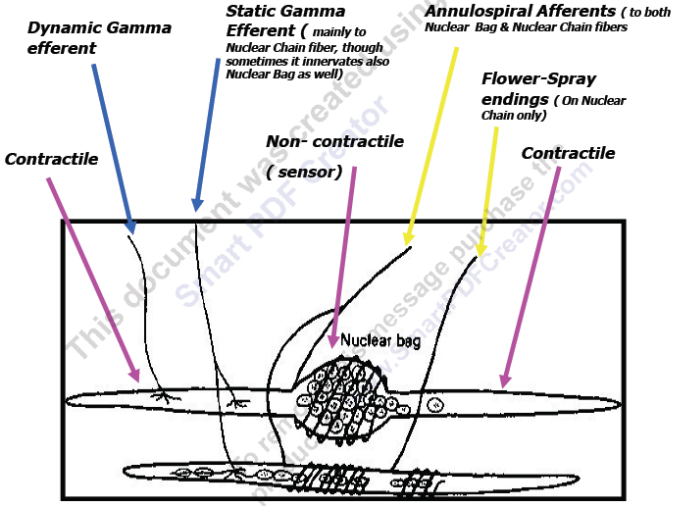
1-Plate endings:	2-Trail endings:
end mainly on the nuclear bag fibers (called Dynamic gamma efferent)	end mainly on nuclear chain fibers (called Static gamma efferent)

Remember!

*Nuclear bag fibers are supplied by primary endings only, & responsible for the dynamic response.

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





■ Slides ■ Important ■ Doctor's Notes ■ Explanation ■ Boy's Slides

Stretch reflex

Stretching of the muscle → Stretching extrafusal muscle fibers → Stretching intrafusal peripheral contractile fibers (nuclear bag & chain) → will stimulate **stretch receptor zone** (central)in intrafusal fiber (muscle spindle) → stimulation of **sensory** afferent endings encircling receptor area.

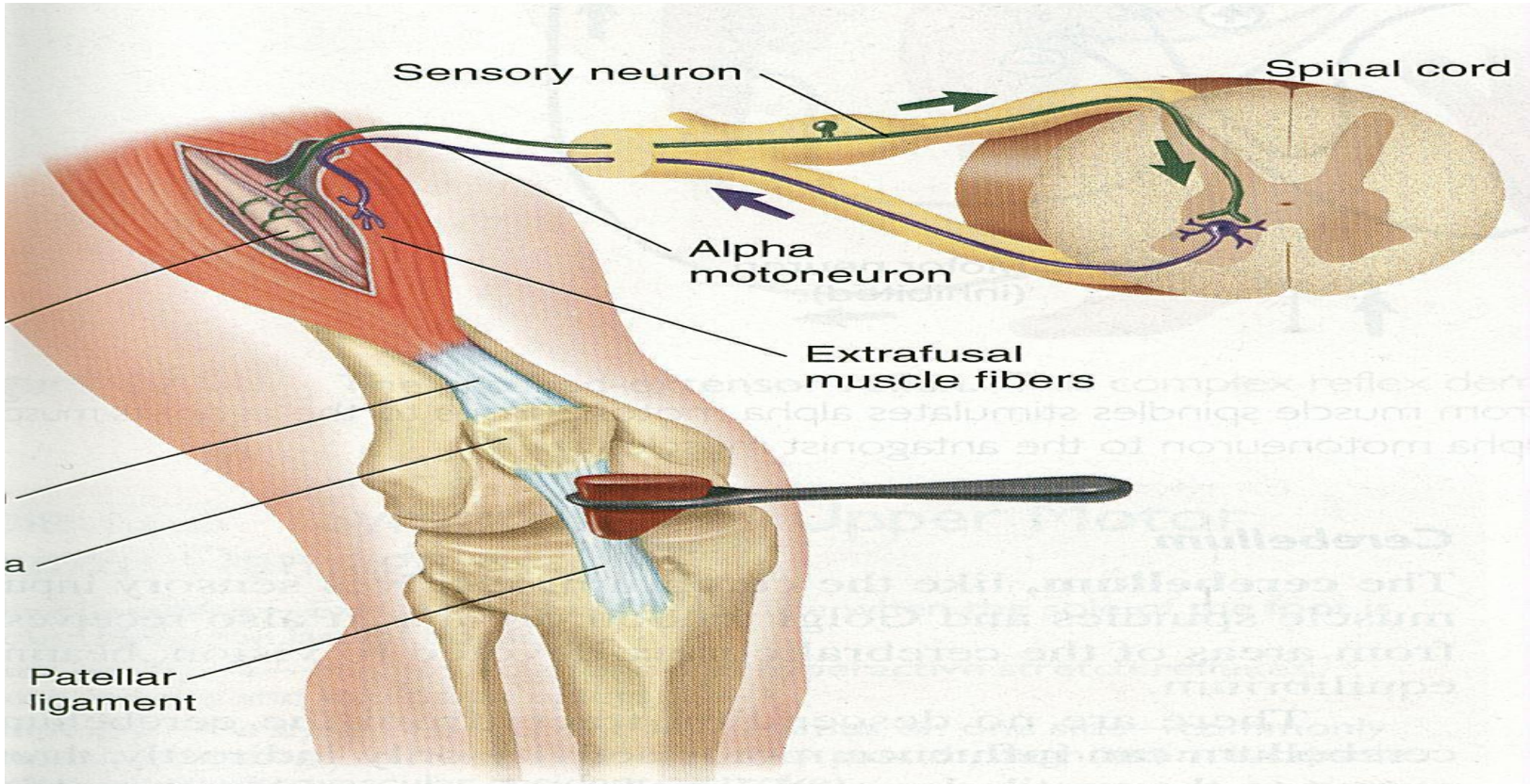
Afferent impulses goes to the spinal cord & stimulate:

1-alpha motor neurons,(70%) which send impulses to extrafusal ordinary muscle fibers to cause 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**

Types of responses
Component of stretch reflex

1-Dynamic stretch reflex (dynamic or phasic response)=DL/DT (length/time)	2-Static stretch reflex(static response) = DL (length only)
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) ***synchronous=motor units discharge all together**	**Maintained stretch** of muscle → stimulates **Nuclear chain fibers** to discharge with increased rate →Impulses in the secondary sensory nerve)(flower spray) → 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 tendon jerk (contraction followed by relaxation) (knee,biceps,triceps)	Basis of muscle tone
When muscle contract, it shortens, muscle spindle relax → no discharge of 1ry endings, and muscle relax	

Example of dynamic stretch reflex; knee jerk



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

Effect of gamma efferent discharge

1. Gamma effernt increase sensitivity of muscle spindle to stretch	
A) dynamic gamma efferent(plate endings which end mainly on the nuclear bag fibers , increase sensitivity of muscle spindle to rate of change of stretch as in sudden stretch to the muscle) Gamma motor neurons send impulses to the periphery of nuclear bag fibers → to contract the periphery	B) Static gamma efferent (Trail endings which end mainly on the nuclear chain fibers , increase sensitivity of muscle spindle to steady maintained stretch (all the time) Gamma motor neuron send impulses to the periphery of nuclear chain fibers → to contract the periphery

Physiology Team

Functions of muscle spindle

- keep CNS (mainly the spinal cord) informed about muscle length & rate or velocity of change in muscle 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. The muscle shorten to keep its length constant

Muscle contract by:

1-stimulation of alpha motor neurons by muscle stretch:	2-stimulation of gamma motor neurons
•Stretching the muscle bulk (**extrafusal** fibers) stretches the receptor (muscle spindle) • AP discharges in the spindle afferents (annulospiral or flower-spray)to Alpha Motor neuron, stimulating it, APs discharges from Alpha Motoneurons to motor nerve to the Extrafusal muscle fibers cause contraction of muscle bulk	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 annulospiralor or flower-spray fibers stimulate to Alpha Motoneuron causing extrafusal muscle fiber contraction .

Best contraction by stimulation of both alpha & gamma neurons

Reciprocal inhibition with stretch reflex

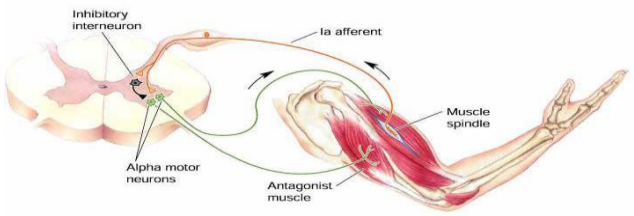
Reflex contraction of an agonistic muscle is accompanied by inhibition of the antagonist muscle

- Contraction of extensor of thigh cause relaxation of flexors (knee jerk)
- Contraction of biceps causes relaxation of triceps

Impulses from stretched muscle go to spinal cord to cause:

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

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



Physiology Team

Muscle Tone
(Static stretch reflex)

- **Definition**: resistance of muscle to stretch
- Stimulus for muscle tone: Is Stretch of skeletal muscle between origin Stimulus for muscle tone-and insertion
- Present in antigravity muscle (extensors of lower limb, back, neck, flexor of upper limb, muscle of abdominal wall and elevator of mandible
- If lost → **low** gamma efferent discharge to muscle → **hypotonic** or flaccidity
- If increased → **high** Gamma efferent discharge to muscle → **hypertonic** or spastic muscle

Factors influence stretch reflex (all act on gamma motor neurons)

Enhances	Inhibits
1-Suprspinal: -Primary motor area4 -Vestibular Nuclei (Deep cerebellar nuclei) -Pontine reticular formation (RF) -Neocerebellum	1-Supraspinal: -Cortical (suppressor area4&Area 6) -Basal ganglia -Medullary RF -Red nucleus -paleocerebellum
2-Anxiety	2-Excessive stretch of muscle(golgi tendon reflex)
3-Noxious painful stimuli	
4-Jendrassik-manuver: **A distracting maneuver in which the patient hooks the flexed fingers of two hands together and forcibly tries to pull them apart, used to overcome the voluntary suppression of reflexes. While the tension is being exerted, the lower extremity reflexes are tested.**	Cerebellar cortex exerts an inhibitory influence on the stretch reflex. cerebellar lesions in humans are characterized by hypotonia, due to deep cerebellar nuclei invovement .

Physiology Team

The Golgi tendon reflex (inverse stretch reflex)

important

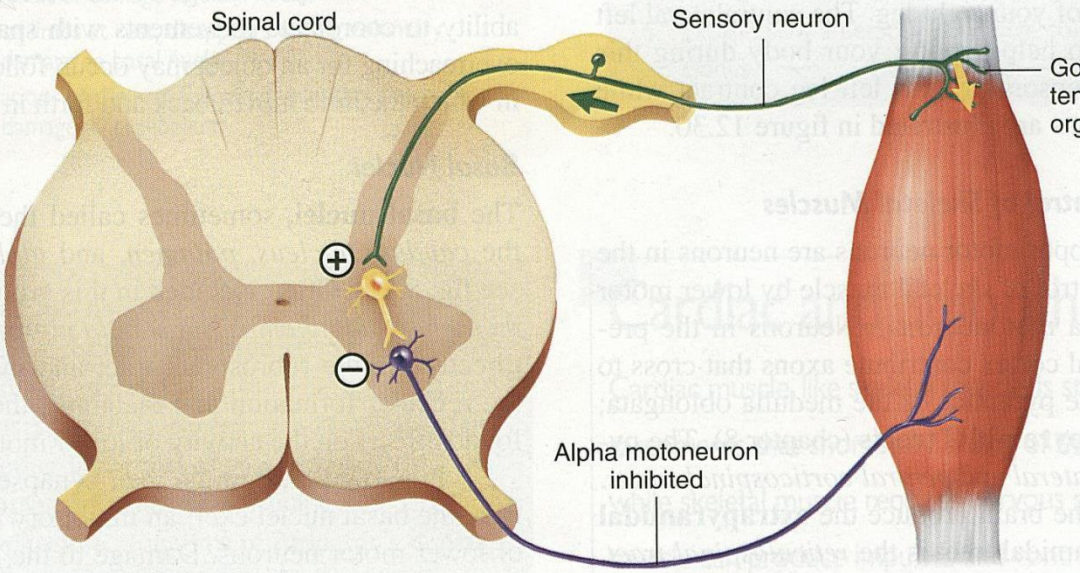
- **Deep & polysynaptic reflex**
- **opposite response to stretch reflex**
- **Excessive tension in the muscle (by passive over-stretch of tendon or active muscle contraction) → cause muscle relaxation**

When the muscle is overstretched the tension will increase (stimulus) therefore the muscle will relax (action)

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

- stimulated Golgi tendon organ will send impulses via fast Aα fibers to the spinal cord → excitation of inhibitory interneuron secrete **Glycine** inhibitory → inhibit alpha motor neuron → muscle relaxation
- Also stimulate excitatory interneuron to antagonist.(reciprocal innervations)
- 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.

Physiology Team

SUMMARY

- Stretch reflex is reflex contraction of muscle resulting from stimulation of the muscle spindle by stretch either sudden or sustained stretch, maintained by the tonic discharge of gamma efferents .
- Muscle spindle is the receptor for stretch & consists of 3-12 intrafusal fibers each fiber has a central non-contractile area & peripheral contractile area.
- Two types of intra fusal fibers; nuclear bag & nuclear chain fibers
- Two types of afferent sensory fibers; primary & secondary.
- Dynamic stretch reflex = basis of tendon jerk
- Static stretch reflex = basis of muscle tone
- There is reciprocal inhibition with stretch reflex
- Stretch reflex is deep-monosynaptic reflex while the golgi tendon reflex is deep & polysynaptic.
- Useful Channel: http://www.youtube.com/user/HAPProf/videos

Type of Reflex (Example)	Number of Synapses	Stimulus for Reflex	Sensory Afferent Fibers	Responses
Stretch reflex (knee jerk)	One	Stretch (lengthening) of the muscle	Ia	Contraction of the muscle
Golgi tendon reflex (clasp knife)	Two	Contraction (shortening) of the muscle	Ib	Relaxation of the muscle

Physiology Team

QUESTIONS

1- nuclear bag fibers are supplied by _____ & responsible for _____ ?

a) Primary ending – static response b) primary ending – dynamic response

c) Primary & sensory ending – dynamic response

2- when the muscle stretches suddenly it will ___ ?

a) Contracts synchronously B) relaxes synchronously

c) Contracts asynchronously

Answers:

1-B

2-A

Physiology Team

THE END

If there are any Problems or Suggestions,
Feel free to contact:

Physiology Team Leaders

Mohammed Jameel & Khulood Al-Raddadi

432100187@student.ksu.edu.sa
432200235@student.ksu.edu.sa

THANK YOU