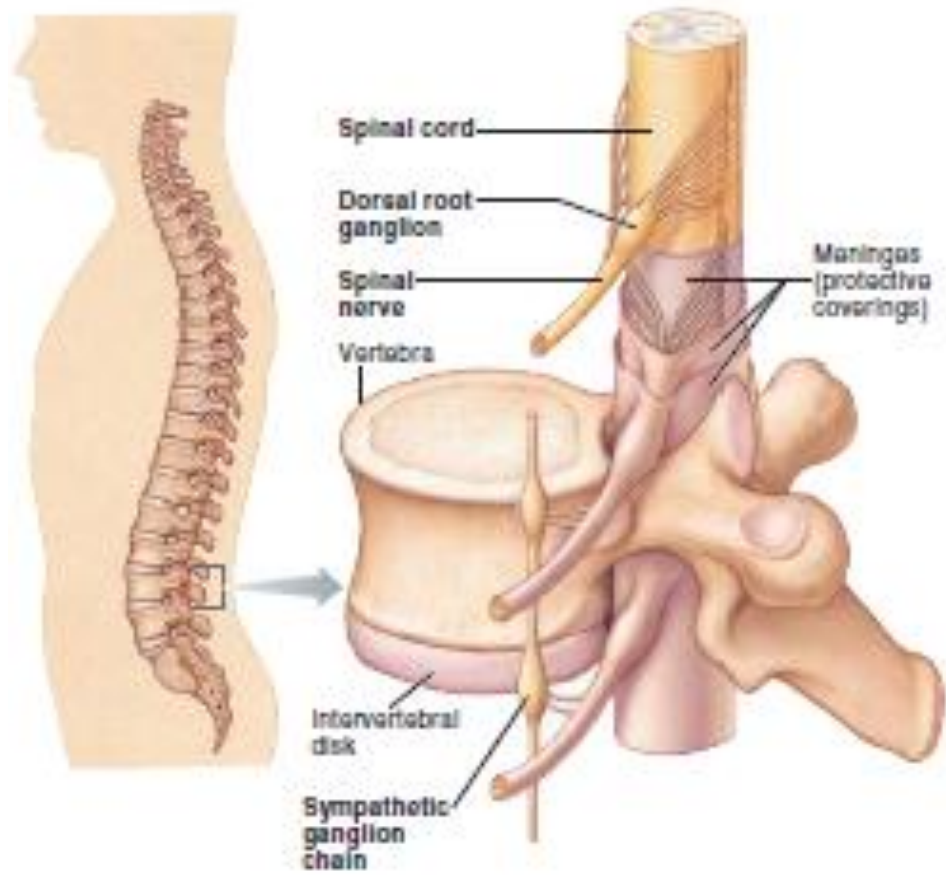


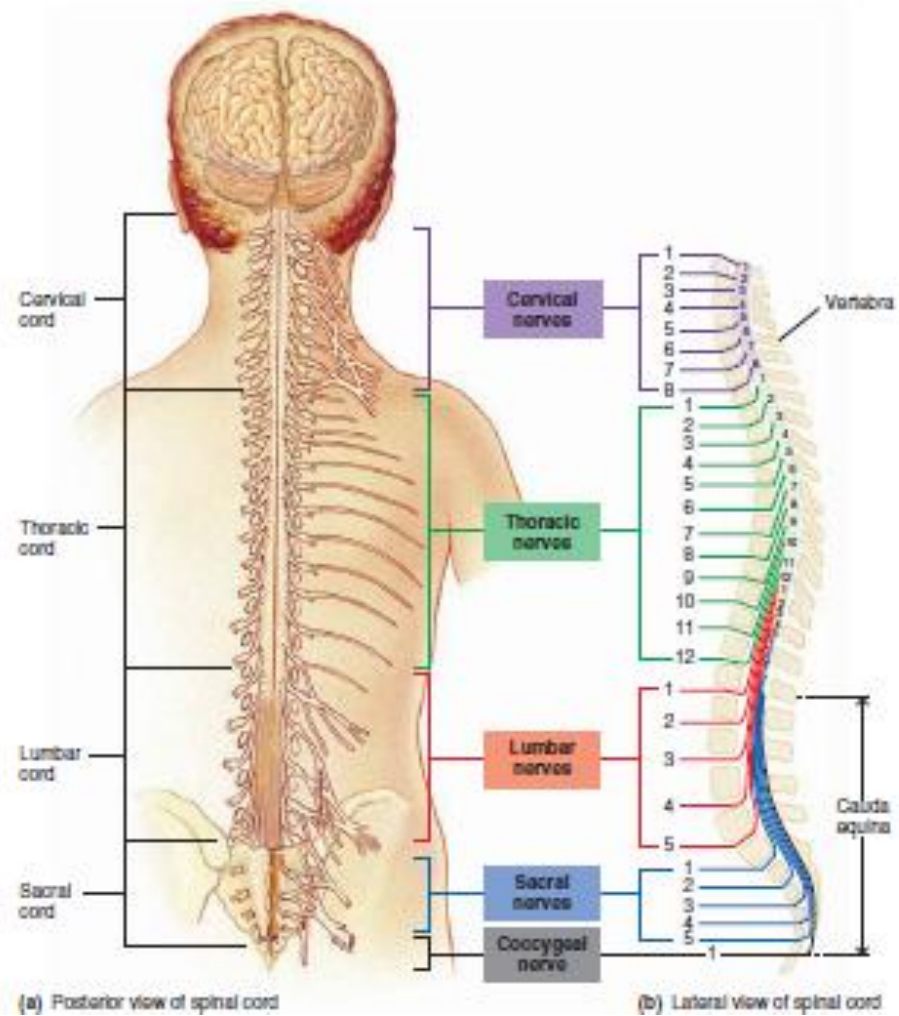
# **Human Physiology, Motor System**

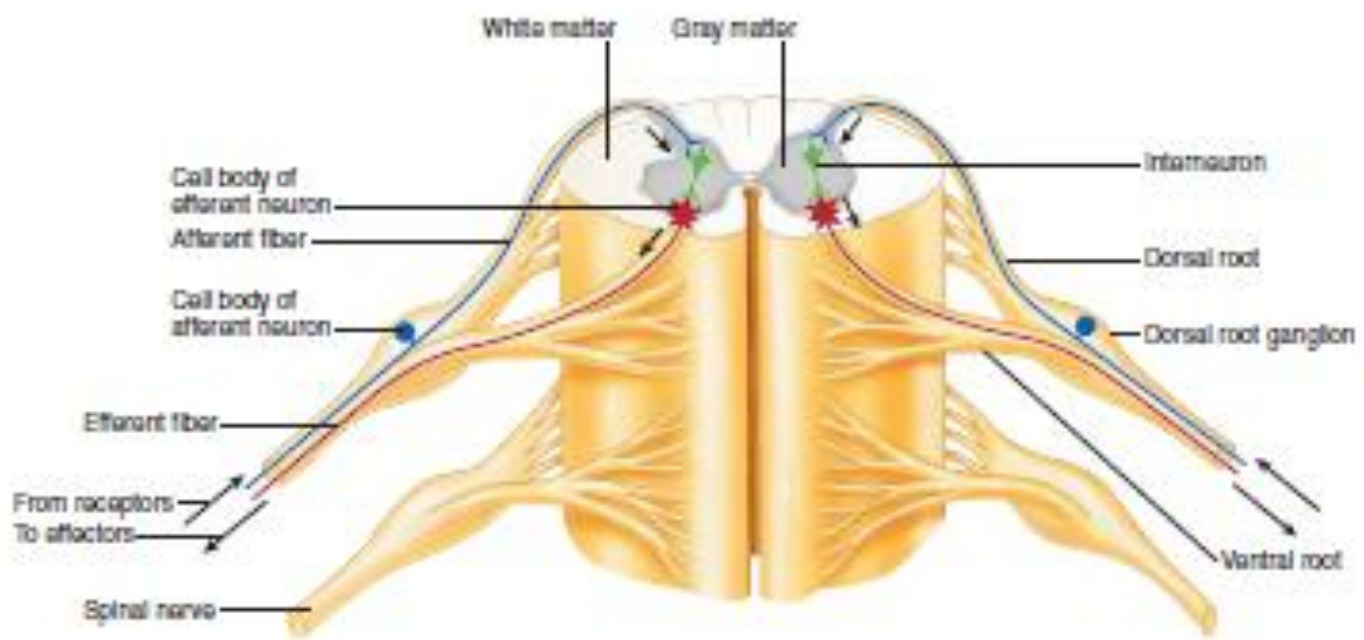
**Dr. Shahid Javed**  
MBBS; PhD

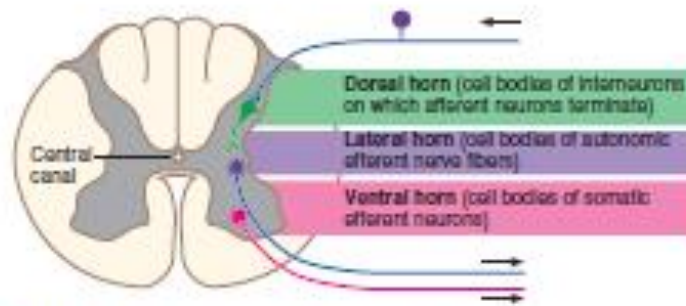
# Spinal Cord

- Spinal cord extends through the vertebral canal and is connected to the spinal nerves
- The white matter of spinal cord is organized into tracts
- Each horn of spinal cord houses a different type of neuronal cell body
- Spinal nerves carry both afferent and efferent fibers

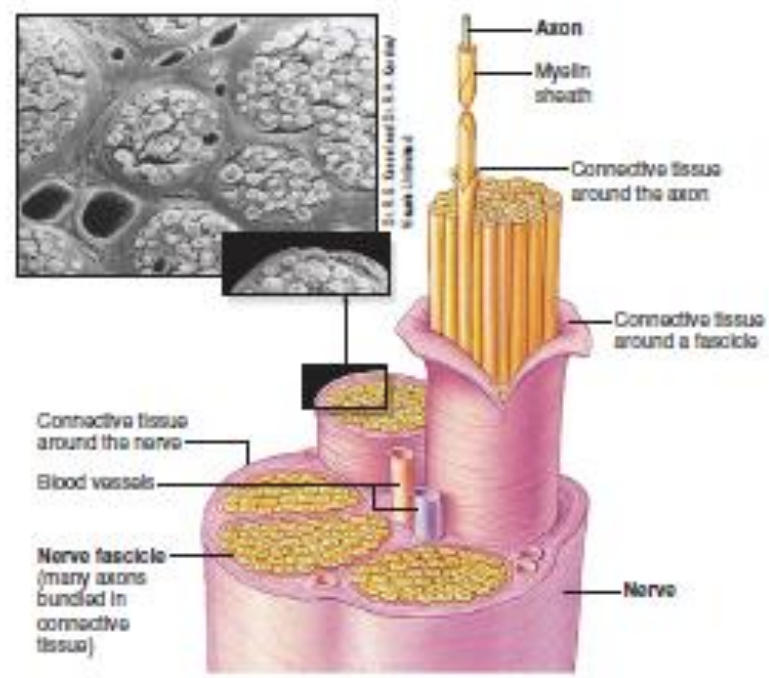








● FIGURE 5-29 Regions of the gray matter.



# ORGANIZATION OF SPINAL CORD FOR MOTOR FUNCTION

- Each segment of spinal cord has several million neurons in its grey matter
- Aside from sensory relay neurons, other neurons are motor neurons
  
- 2 types of lower motor neurons:
  - Anterior motor neurons
  - Interneurons

# ANTERIOR MOTOR NEURONS

- Located in anterior horns of cord grey matter
- Innervate skeletal muscle fibers
- 2 types:
  - A- alpha motor neurons
  - B- gamma motor neurons

## A. ALPHA MOTOR NEURONS

- Give rise to large type A alpha motor nerve fibers
- 14  $\mu\text{m}$  in diameter
- Innervate extrafusal muscle fibers
- Motor unit
- Inputs to alpha motor neurons

## B. GAMMA MOTOR NEURONS

- Give rise to smaller type gamma motor nerve fibers
- 5 $\mu\text{m}$  in diameter
- Innervate the special skeletal muscle fibers – intrafusal fibers – middle of the muscle spindle – control basic muscle tone



# INTERNEURONS

- Located in all areas of cord grey matter
- Are about 30 times as numerous as anterior motor neurons
- Are small and highly excitable
- They have many interconnections with one another and many of them directly synapse with anterior motor neurons
- These interconnections between interneurons and anterior motor neurons are responsible for most of the integrative functions of the spinal cord
- Function of the interneuron – integration and processing of information

# RENSHAW CELLS

- In anterior horn of grey matter
- These are inhibitory cells
- Stimulation of each motor neuron tends to inhibit adjacent motor neurons called lateral inhibition
- This is to focus or sharpen these signals

# Muscle receptors provide afferent information needed to control skeletal muscle activity

## MUSCLE SPINDLE

*Location* - distributed throughout the belly of skeletal muscle & send information to nervous system about muscle length

*Length* 3 – 10 mm

*Structure* - Intrafusal fibers

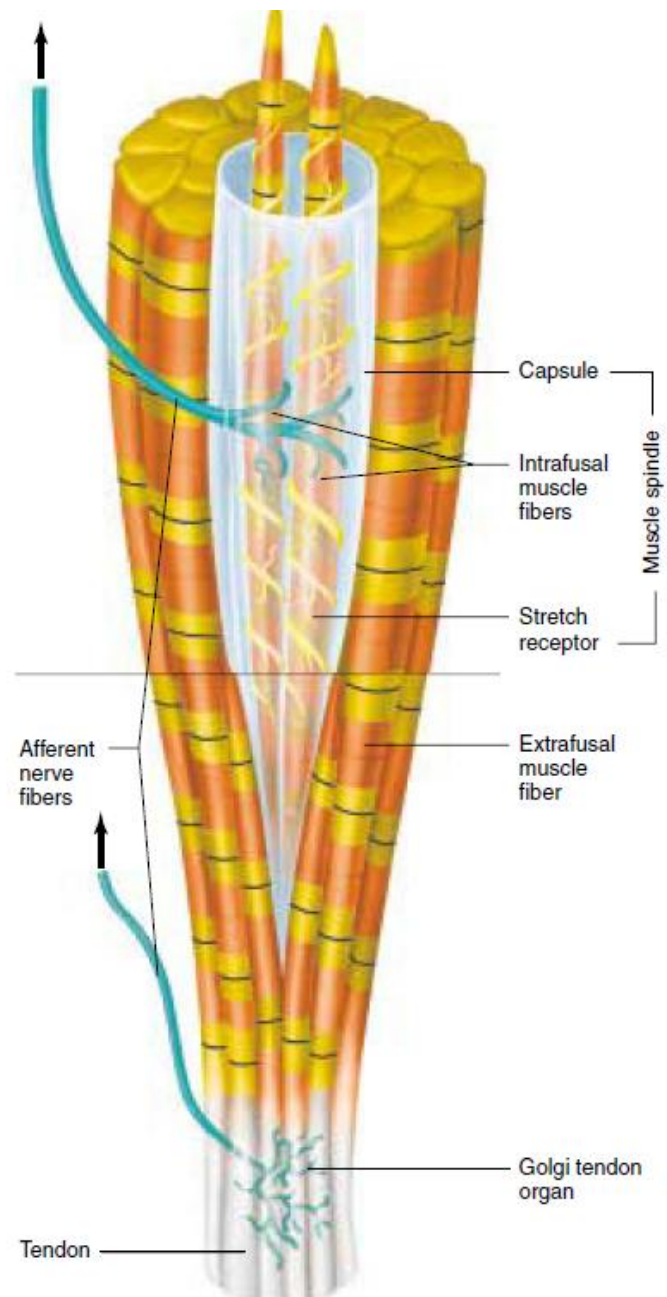
1. Nuclear bag fibers
2. Nuclear chain fibers

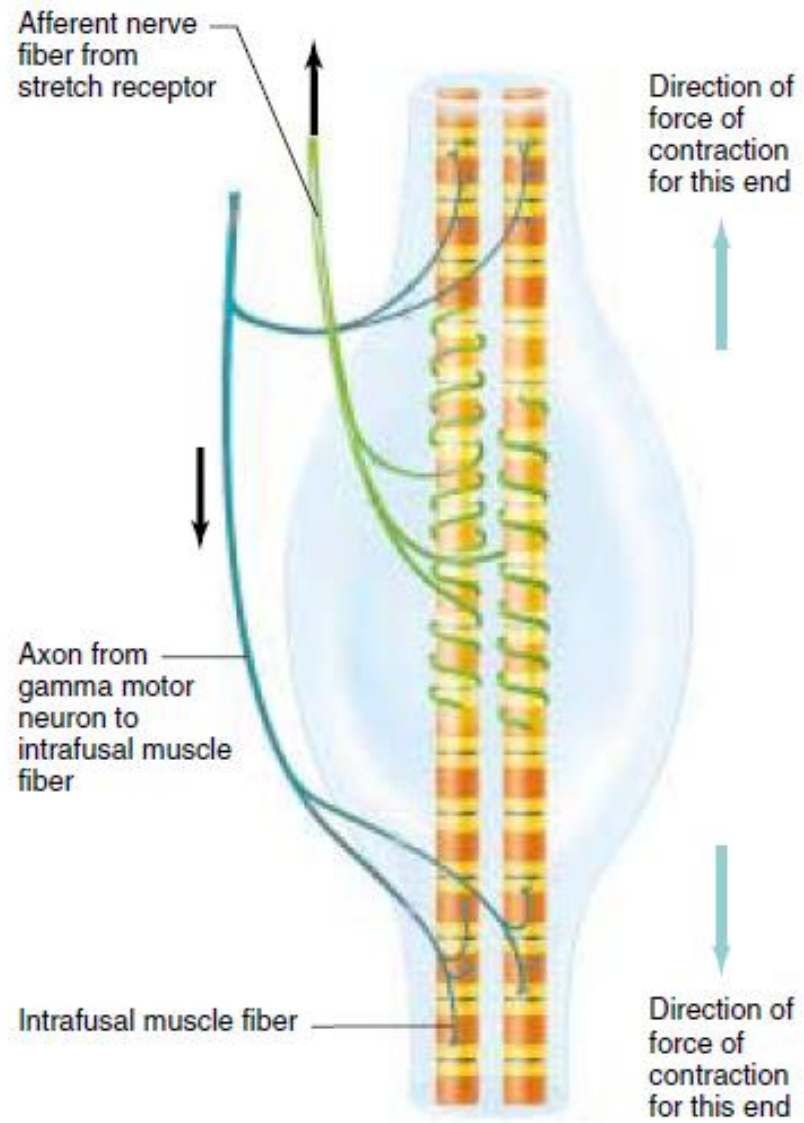
## ***Motor Innervation***

- Central portion of muscle spindle has few or no actin & myosin filaments
- It acts as sensory receptors
- End portion of muscle spindle has actin & myosin filaments
- End portion is excited by gamma efferent fibers (co-activation of gamma and alpha motor neurons is required)

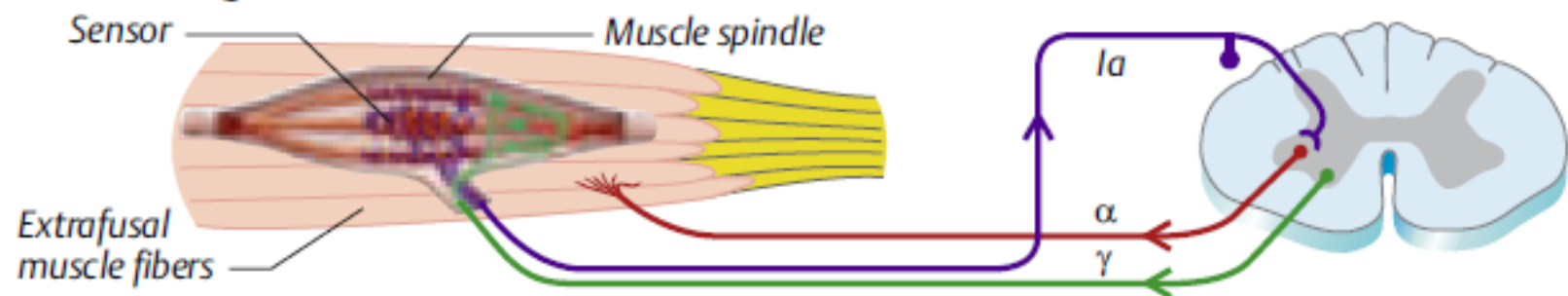
## ***Sensory Innervation***

- 2 types of sensory nerve fibers
  - primary endings or annulospiral endings
    - Diameter 17  $\mu\text{m}$
    - Conduction velocity 70-120 m/sec
  - secondary endings or flower spray endings
    - Diameter 8  $\mu\text{m}$

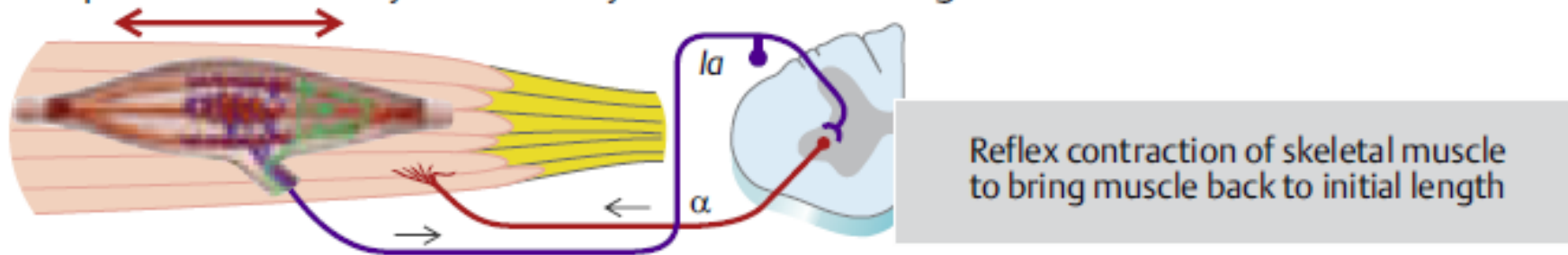




### 1 Initial length of muscle



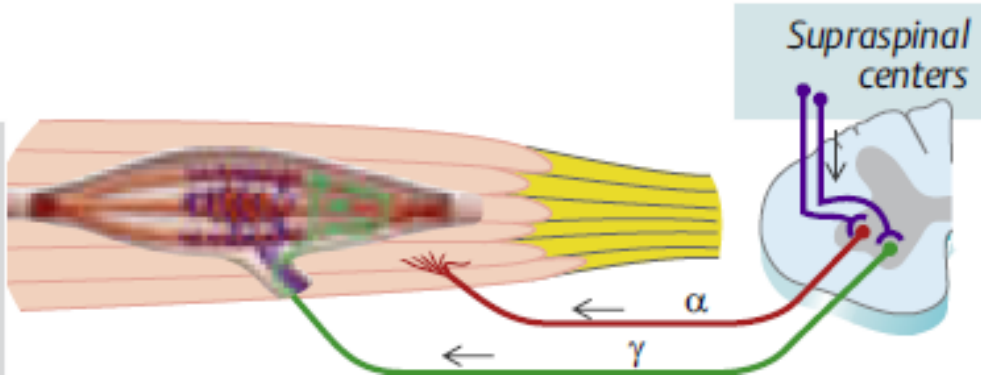
### 2 Spindle activated by "involuntary" muscle stretching

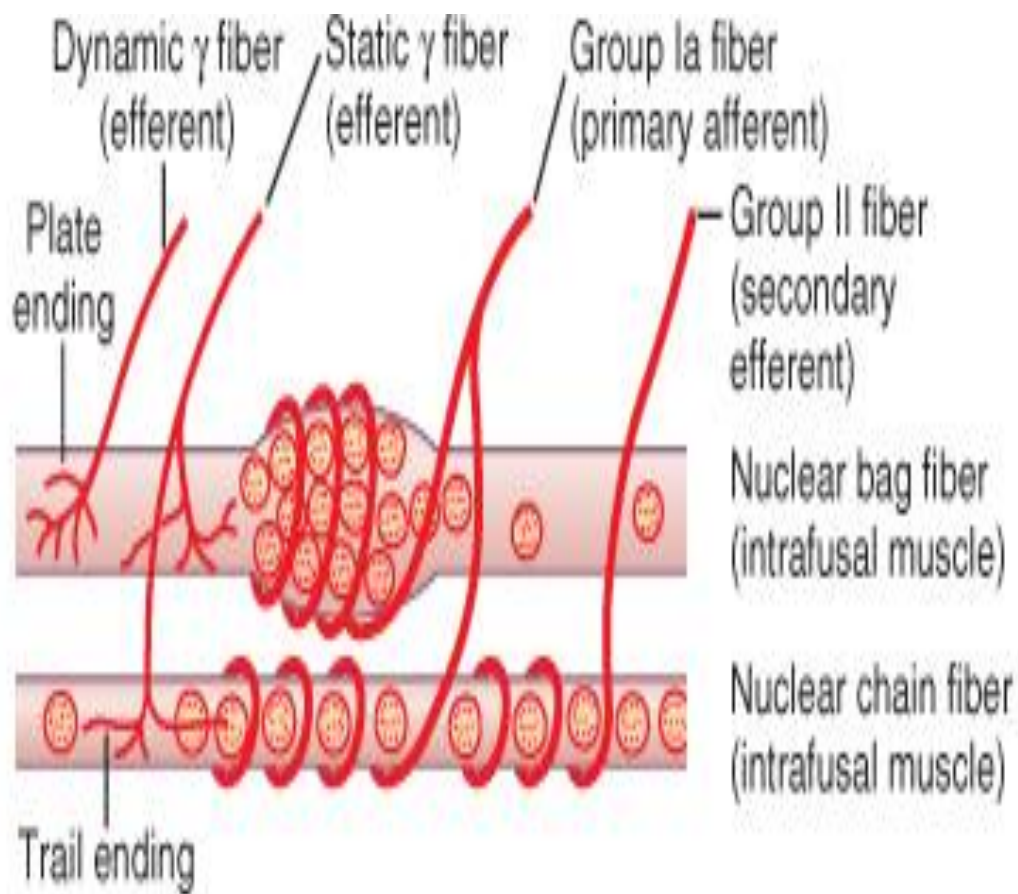


### 3 Supraspinal activation

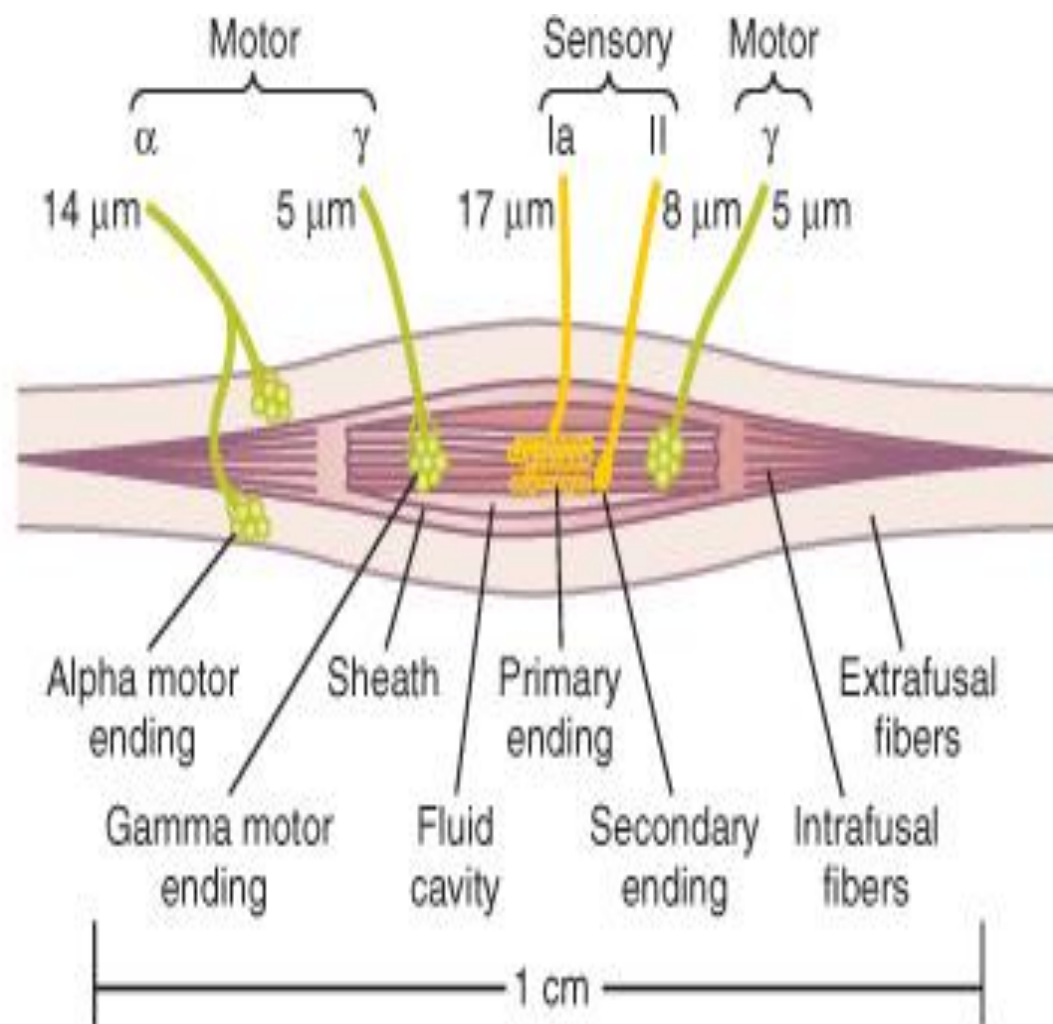
"Voluntary" change in muscle length with pre-setting (via  $\gamma$  fibers) of

- a set-point for length ( $\alpha/\gamma$  co-activation)
- an increased sensor sensitivity (fusimotor set)









## GOLGI TENDON ORGAN

- *Location* – at the junction of muscle with its tendon
- Encapsulated and 10-15 muscle fibers are usually connected to each golgi tendon organ
- *Stimulation* – by tension produced in the muscle either by contraction or the stretching of the muscle
- It has both dynamic and static response
- Sensory nerve fibers are Ib fibers with an average diameter of 16  $\mu\text{m}$

# Spinal Cord Reflexes

❖ The spinal cord is responsible for the integration of many basic reflexes

❖ Reflex arc

1- Sensory receptors

2- Afferent pathway

3- Integrating centre

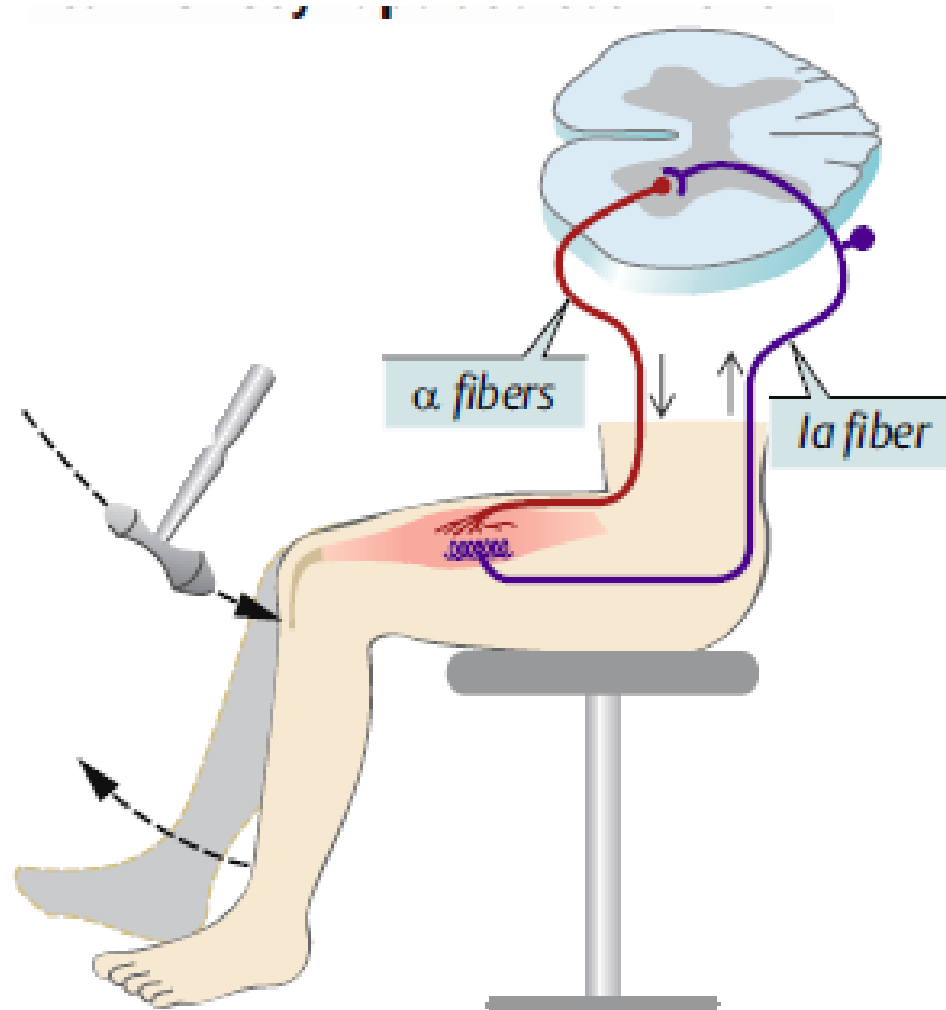
4- Efferent pathway

5- Effectors

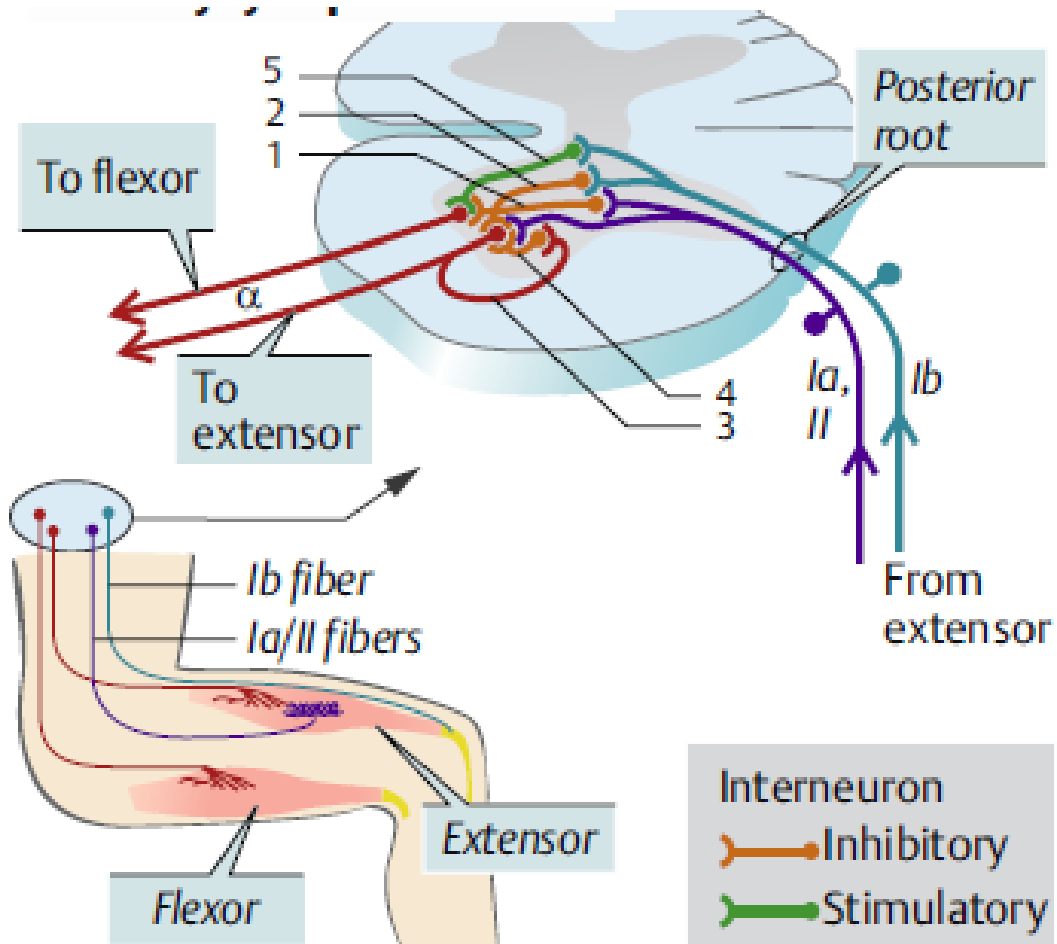
# Spinal Cord Reflexes

- Muscles stretch reflex
- Withdrawl reflex
- Flexor reflex or Nociceptive reflex or Pain reflex
- Crossed extensor reflex
- Golgi tendon Reflex

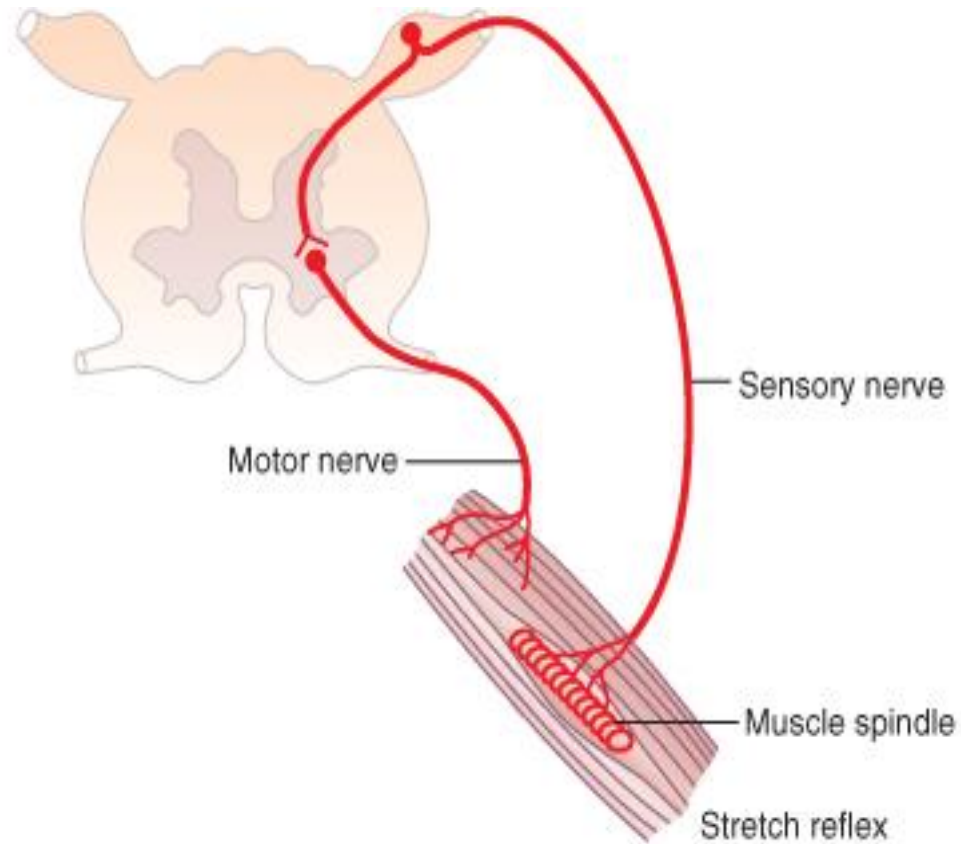
# Monosynaptic



# Polysynaptic



# Muscles stretch reflex



## FUNCTIONS OF STRETCH REFLEX

### Damping Function or Signal Averaging Function

- it is the ability to prevent oscillation or jerkiness of body movements
- Signals from spinal cord are often transmitted to a muscle in an unsmooth form
- Muscle spindle causes smoothening of muscle contraction

### Role in Voluntary Motor Activity

Whenever signals are transmitted from motor cortex to the alpha motor neurons, in most instances the gamma motor neurons are stimulated simultaneously called co-activation of alpha and gamma motor neurons



## FUNCTIONS OF STRETCH REFLEX

### Stabilizes body position during tense action

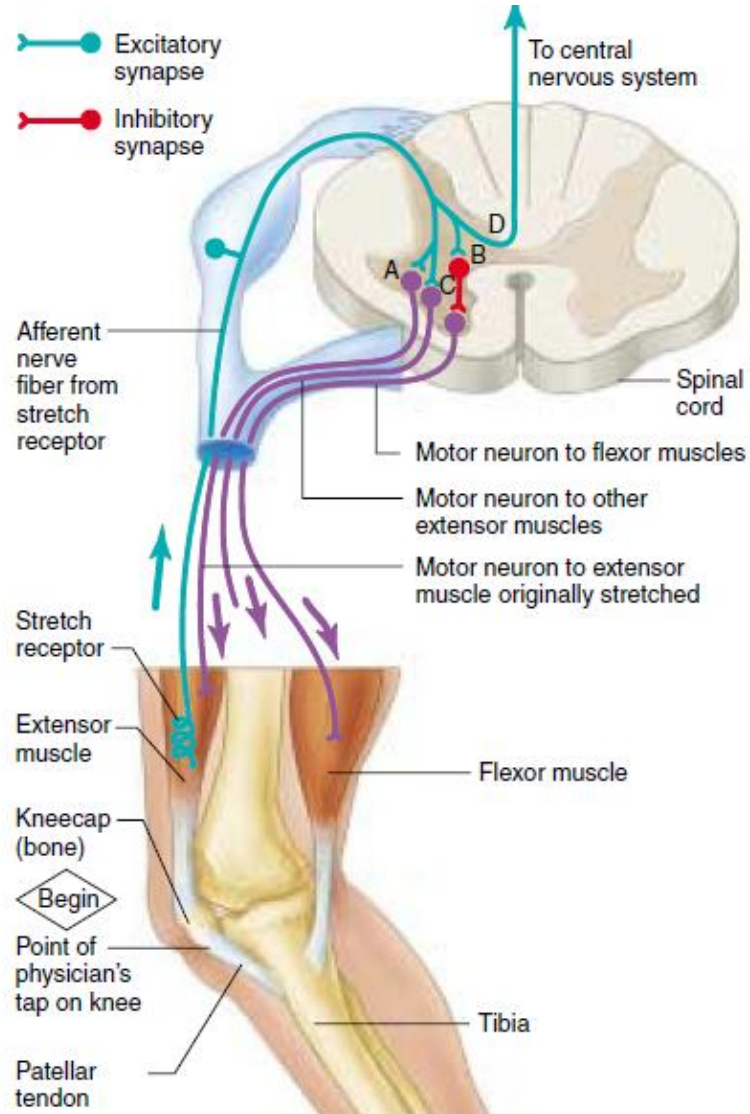
- Bulbo-reticular facilitatory region and its allied areas of brain stem transmit excitatory signals through the gamma nerve fibers to the intra-fusal fibers of muscle spindles
- Spindles on both sides of each joint are activated at the same time → reflex excitation of the skeletal muscles on both sides of the joint → produces tense muscle contractions opposing each other at the joint

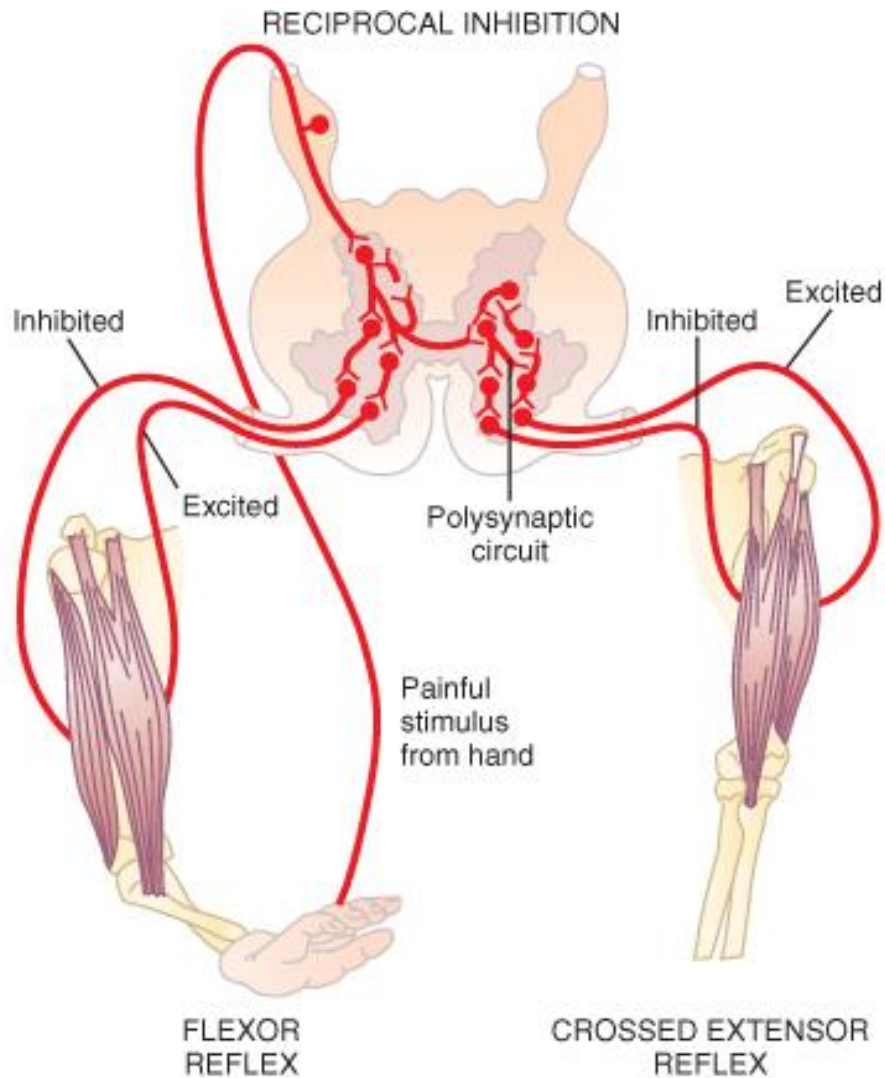
### Helps in motor control from higher levels of brain

# CLINICAL APPLICATIONS

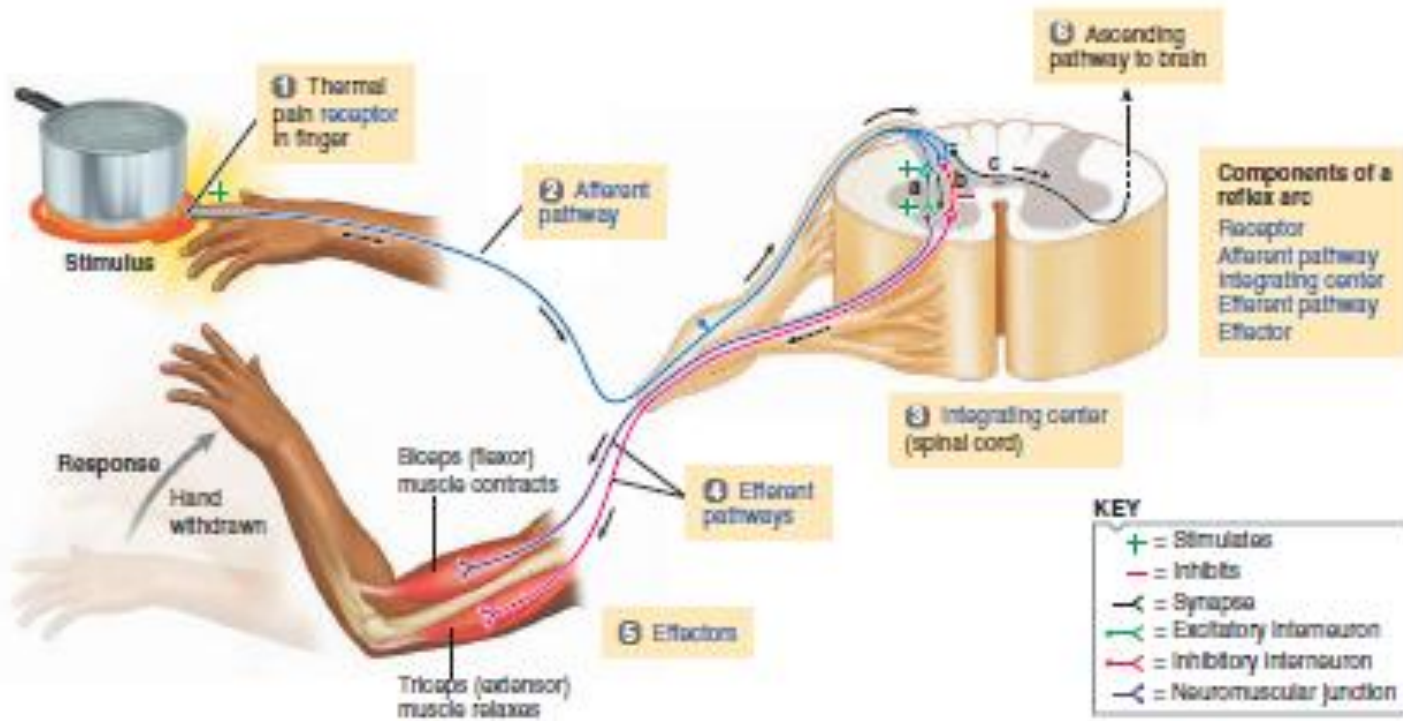
- Knee jerk
- Other muscle jerks
  - Exaggerated muscle jerks → large lesions in motor areas of cerebral cortex
  - clonus → oscillation of muscle jerks – it occurs only when the stretch reflex is highly sensitized by facilitatory impulses from the brain

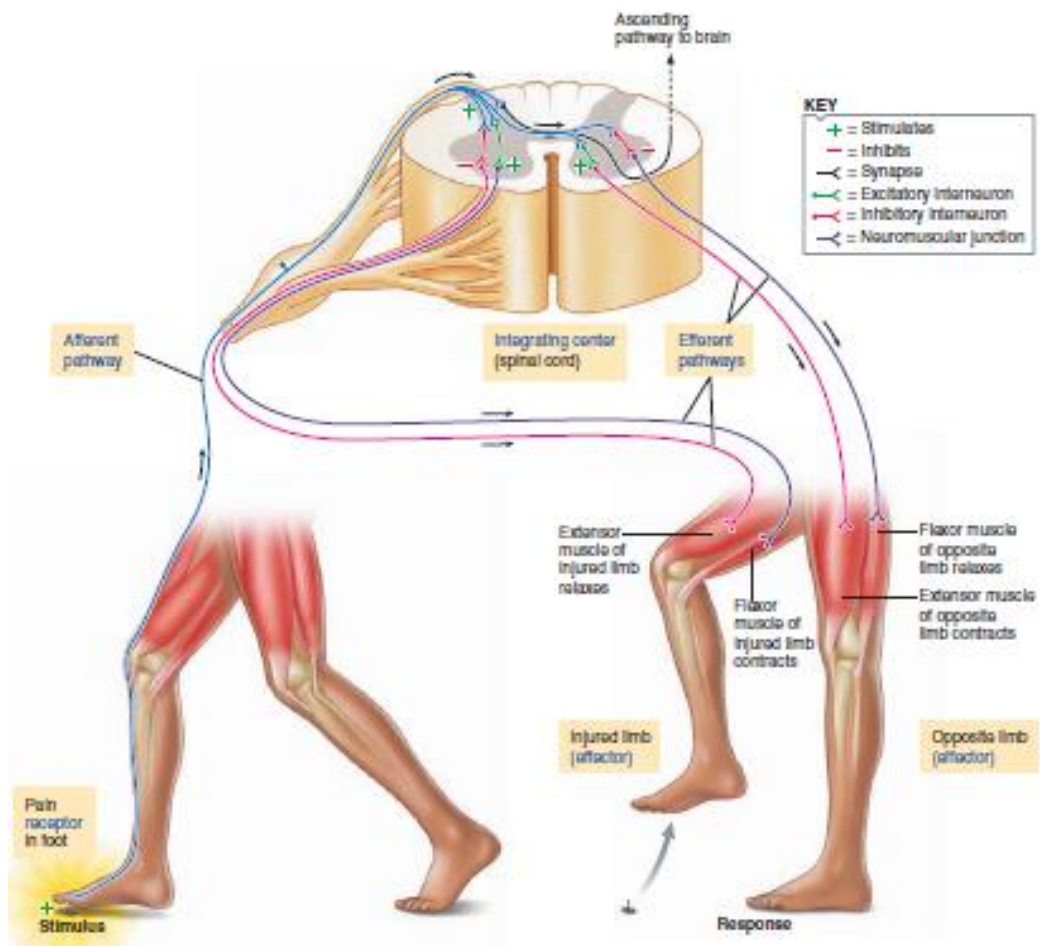
# Knee Jerk





- Withdrawl reflex
- Crossed extensor reflex
- Reflexes of posture & locomotion





# Autonomic reflexes in spinal cord

- Changes in vascular tone resulting from changes in local skin heat
- Sweating which results from localized heat on the surface of body
- Peritoneointestinal reflexes
- Evacuation reflexes
- Mass reflex



# Spinal Shock

- When the spinal cord is suddenly transected in the neck, at first, all cord functions, including cord reflexes immediately depressed to a point of complete silence, a reaction called spinal shock
- The reason for spinal shock
- Clinical features