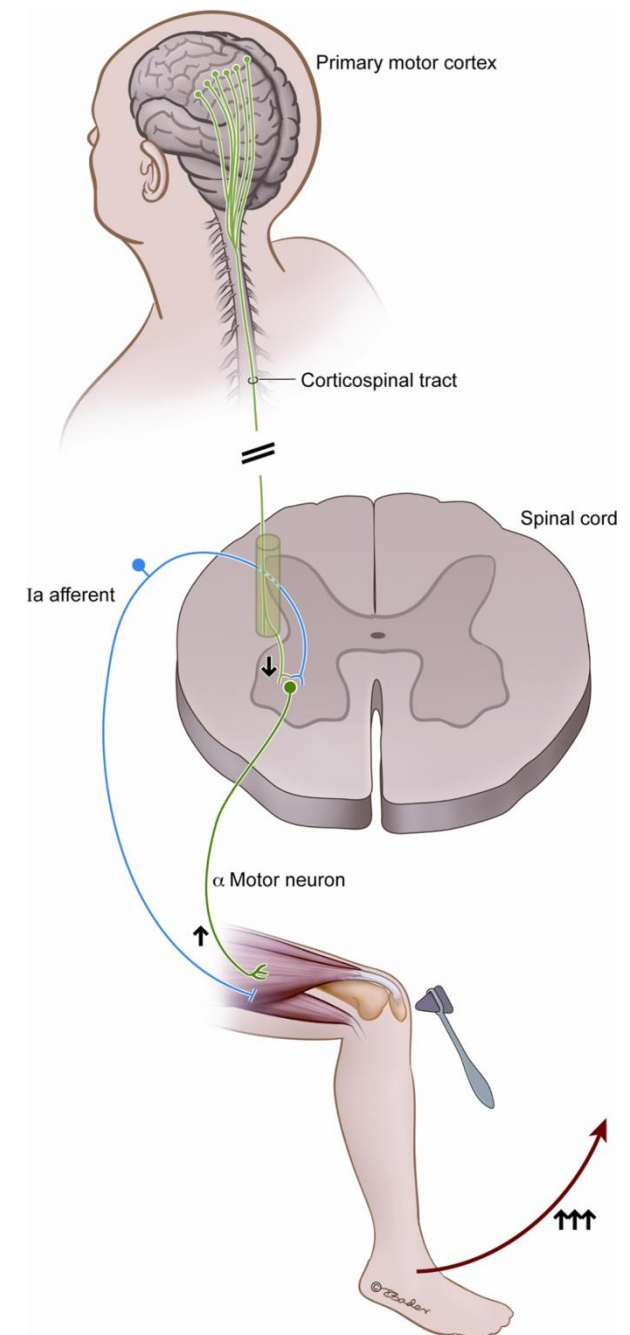


12

Motor system I

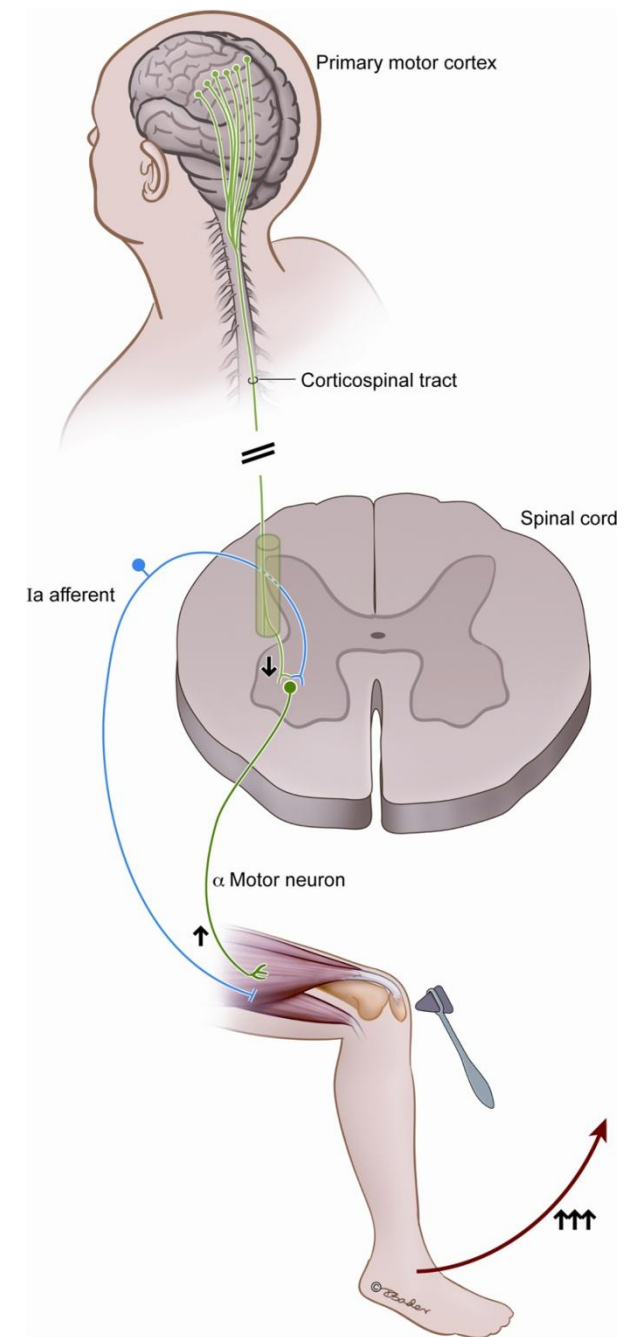
Introduction

- Skeletal muscle contraction is initiated by lower motor neuron



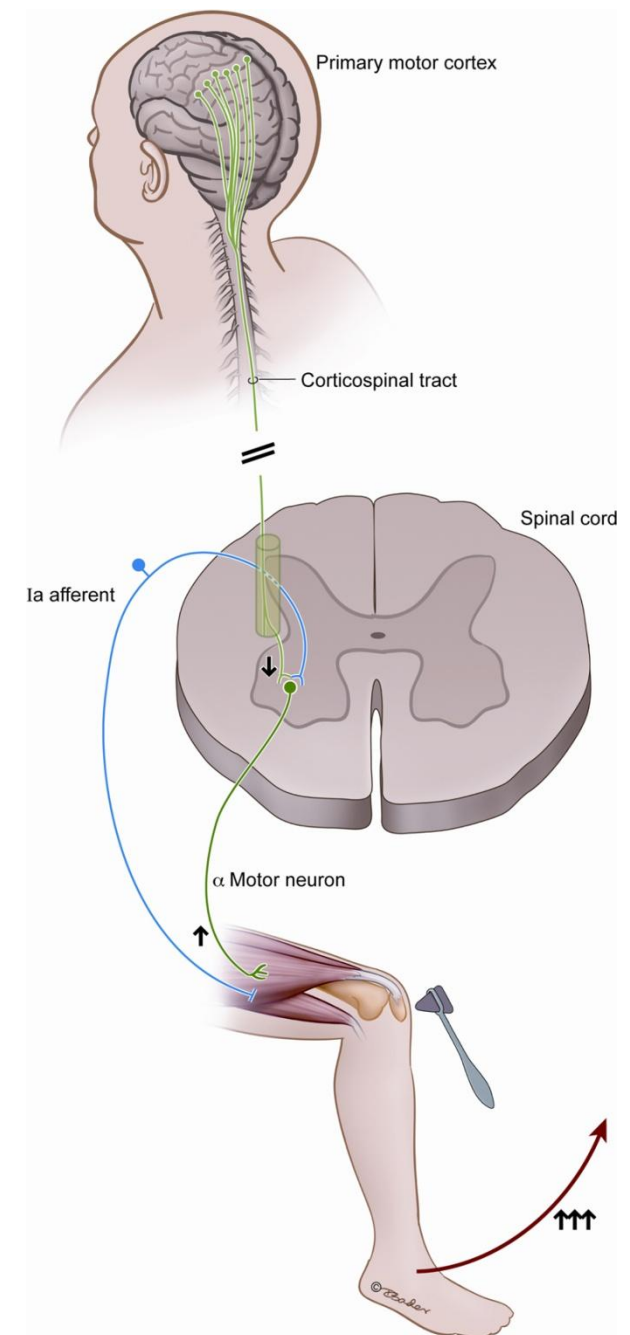
Introduction

- Skeletal muscle contraction is initiated by lower motor neuron
- Lower motor neuron is a part of local reflex circuits



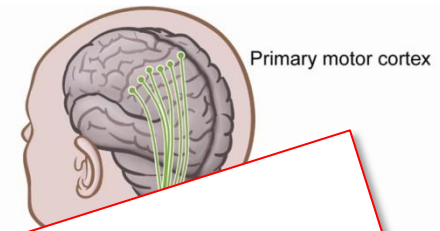
Introduction

- Skeletal muscle contraction is initiated by lower motor neuron
- Lower motor neuron is a part of local reflex circuits
- The information from several sources is integrated in the lower motor neuron
 - Higher levels of CNS
 - Upper motor neuron, tectum, n. ruber, brain stem
 - Proprioception



Introduction

- Skeletal muscle contraction is initiated by lower motor neuron
- Lower motor neuron regulates the activity of local reflex circuits, according to the demands of the higher regions of the CNS

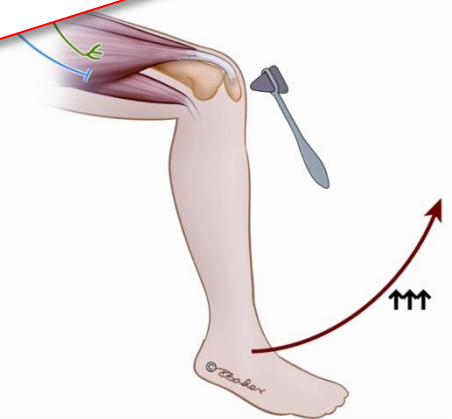


Spinal cord

Lower motor neuron regulates the activity of local reflex circuits, according to the demands of the higher regions of the CNS

Reception

stimulation, h.

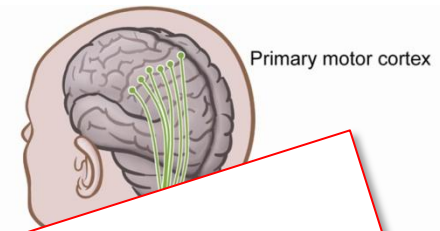


Introduction

- Skeletal muscle contraction is initiated by lower motor neuron
- Lower motor neuron regulates the activity of local reflex circuits, according to the demands of the higher regions of the CNS

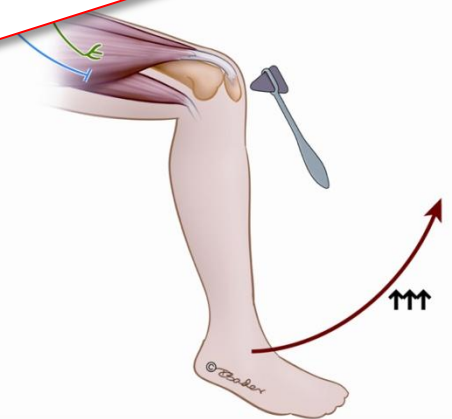
Lower motor neuron regulates the activity of local reflex circuits, according to the demands of the higher regions of the CNS

Proprioception is crucial for the regulation of local circuit activity



Primary motor cortex

Spinal cord



Lower motor neuron

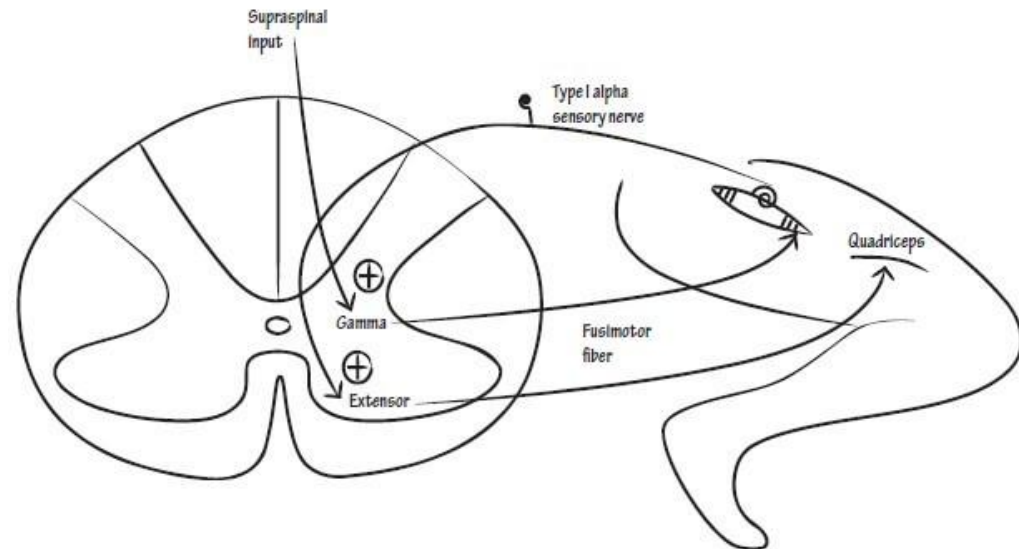
- **α motoneuron**

- Innervation of contractile elements
- Extrafusal fibers
- Muscle contraction

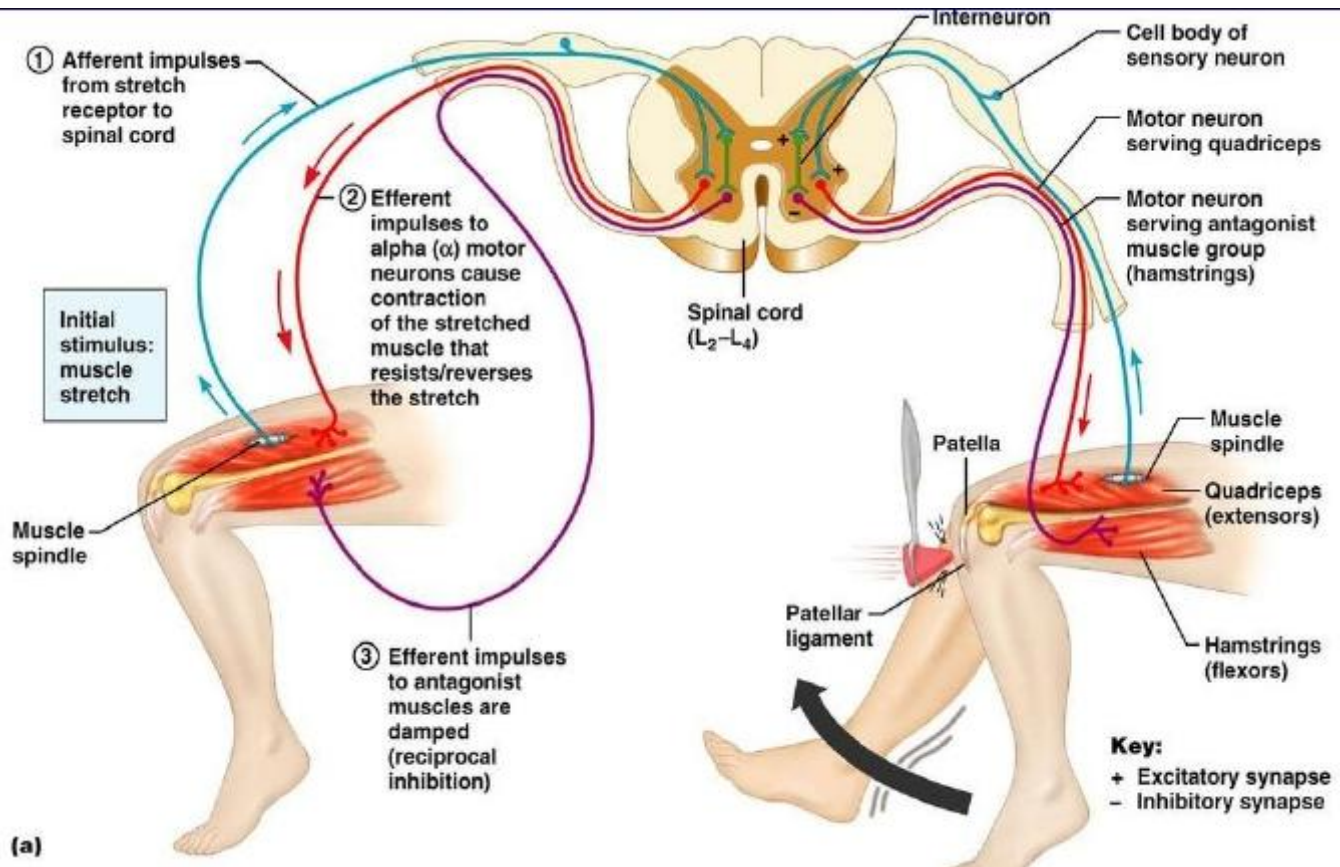
- **γ motoneuron**

- Innervation of muscle spindles
- Intrafusal fibers
- Alignment of muscle spindles
- Gamma loop

- **β motoneuron**

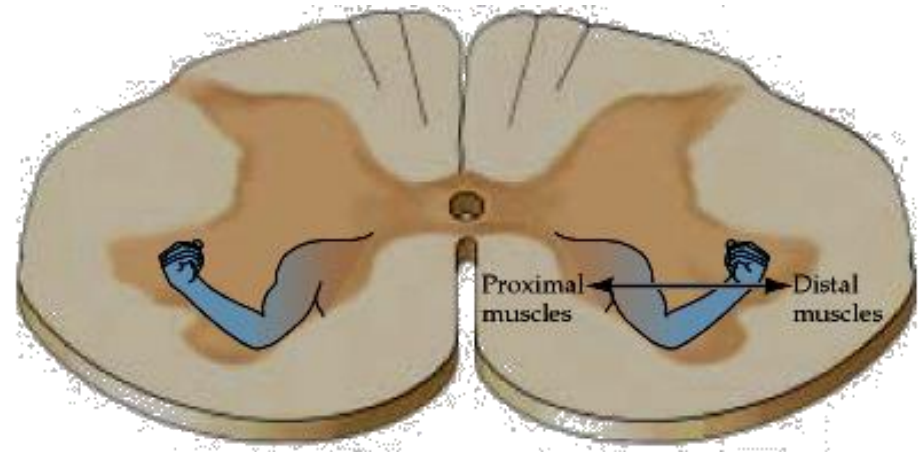
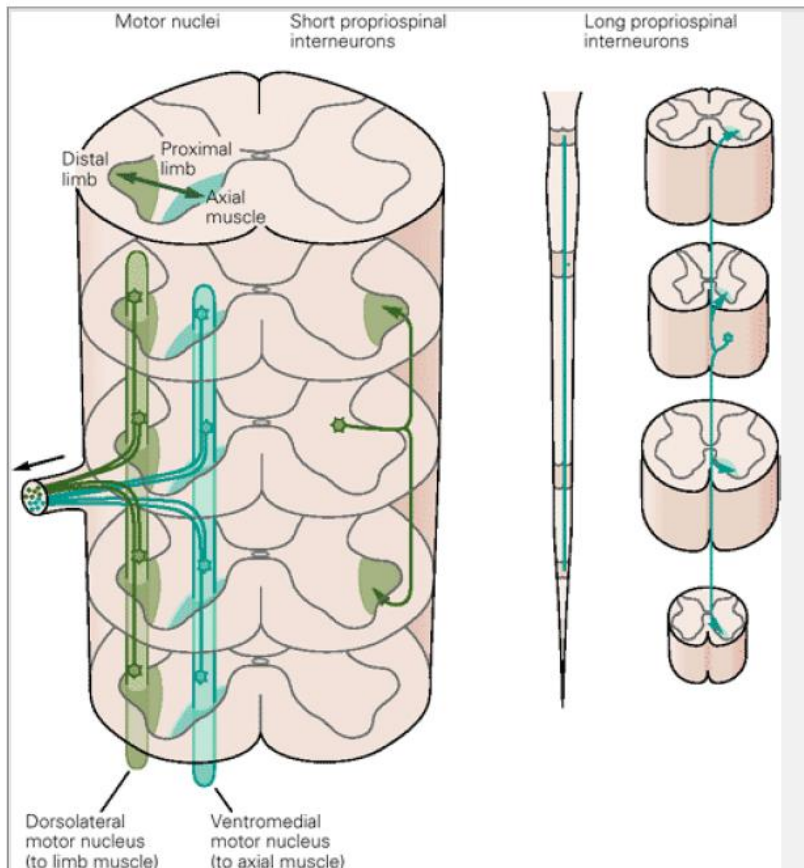


Stretch reflex



Lower motor neuron

Topography



Motor unit

- A typical muscle is innervated by about 100 motoneurons which are localized in motor nucleus

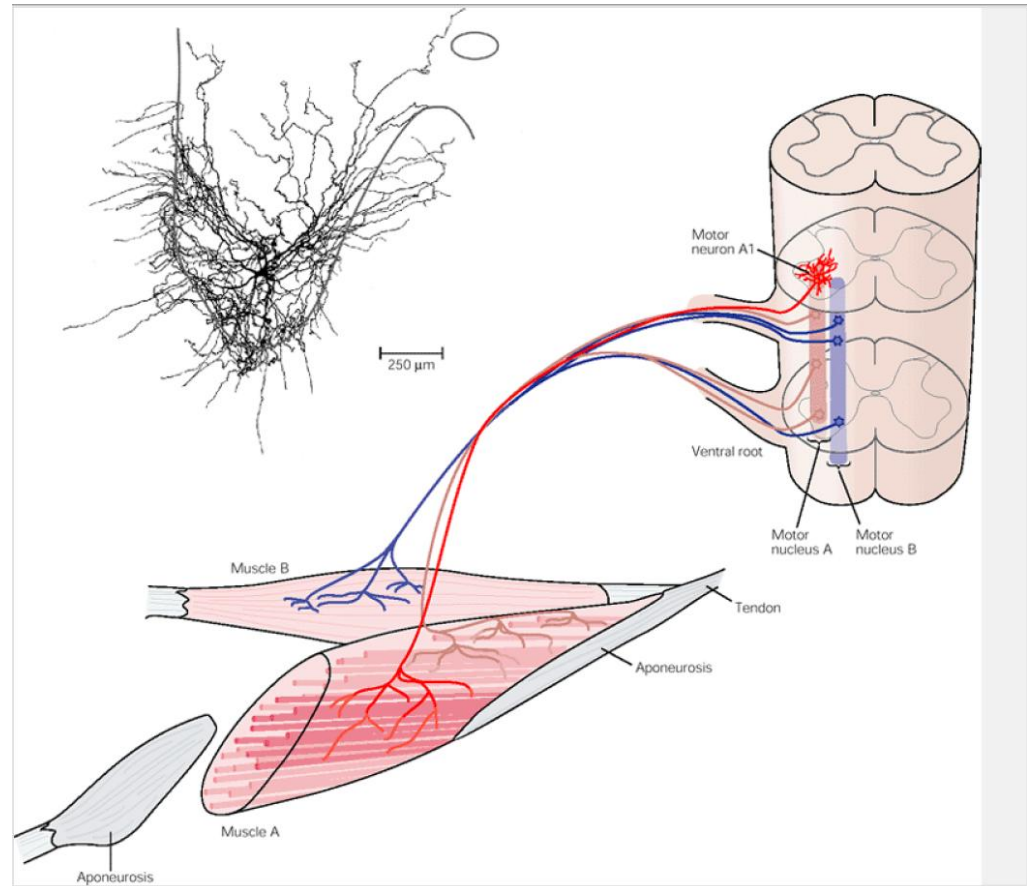


Figure 24-1 A typical muscle consists of many thousands of muscle fibers working in parallel and organized into a smaller number of motor units.

Motor unit

- A typical muscle is innervated by about 100 motoneurons which are localized in motor nucleus
- Each motoneuron innervate from 100 to 1000 muscle fibers and one muscle fiber is innervated by a single motoneuron

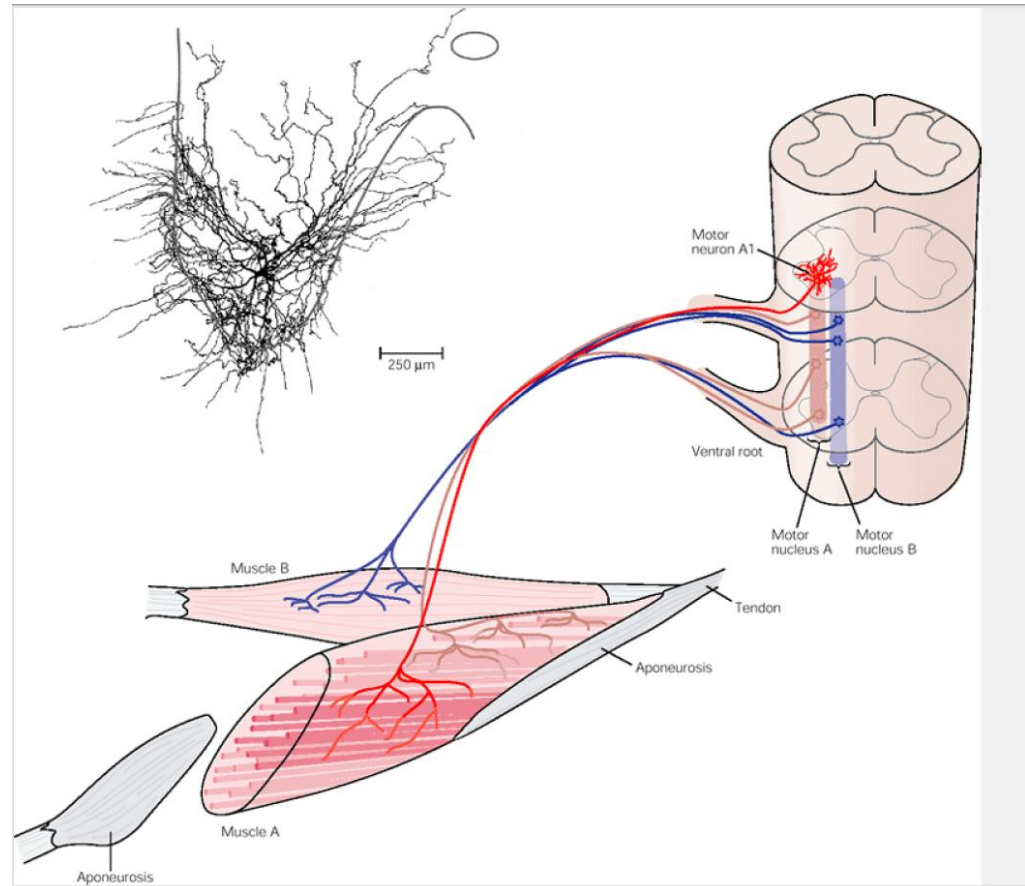


Figure 24-1 A typical muscle consists of many thousands of muscle fibers working in parallel and organized into a smaller number of motor units.

Motor unit

- A typical muscle is innervated by about 100 motoneurons which are localized in motor nucleus
- Each motoneuron innervate from 100 to 1000 muscle fibers and one muscle fiber is innervated by a single motoneuron
- The ensemble of muscle fibers innervated by a single neuron and corresponding motoneuron constitutes the motor unit

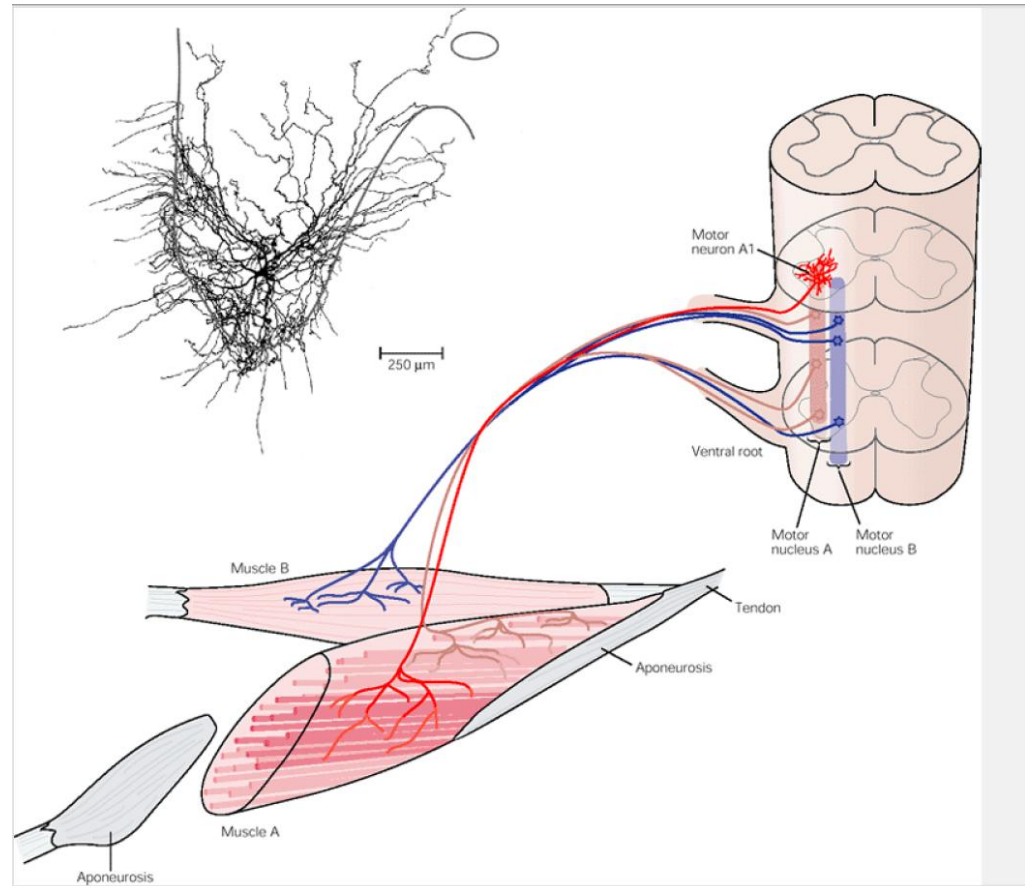
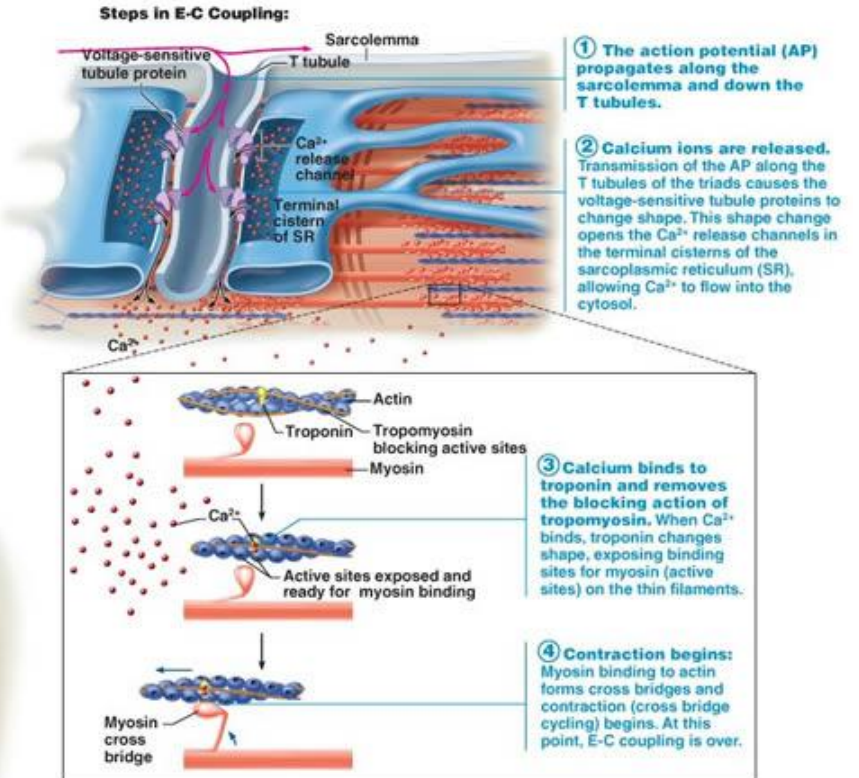
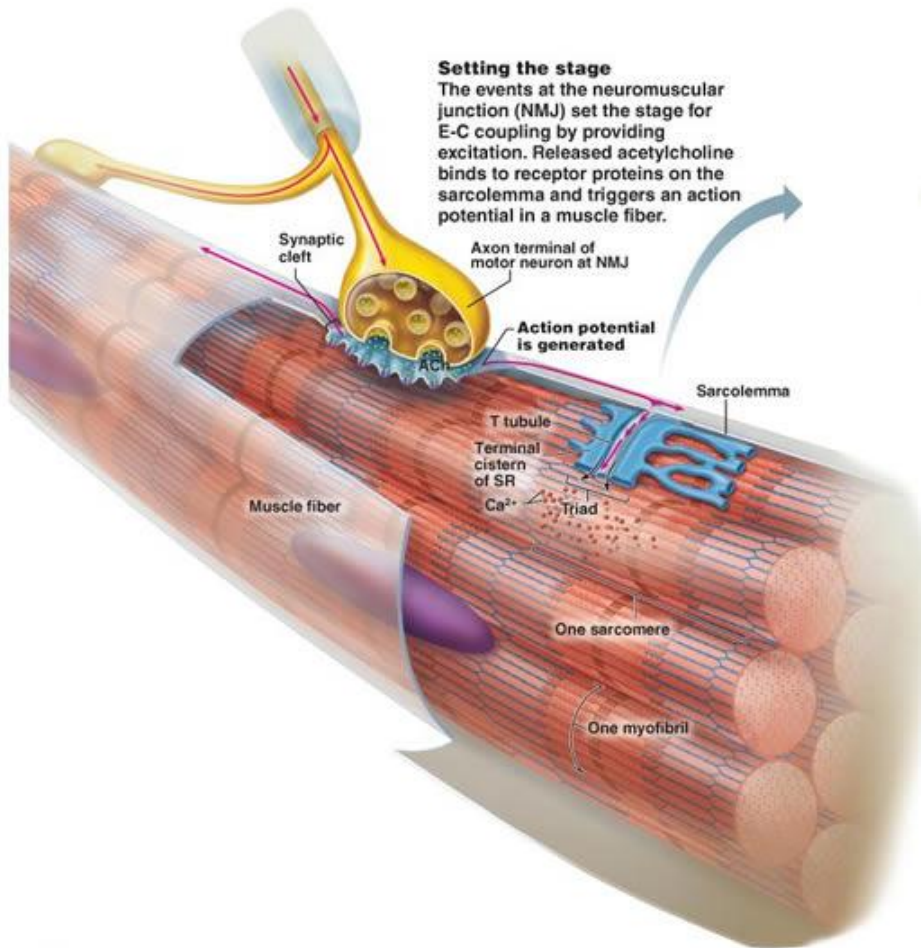
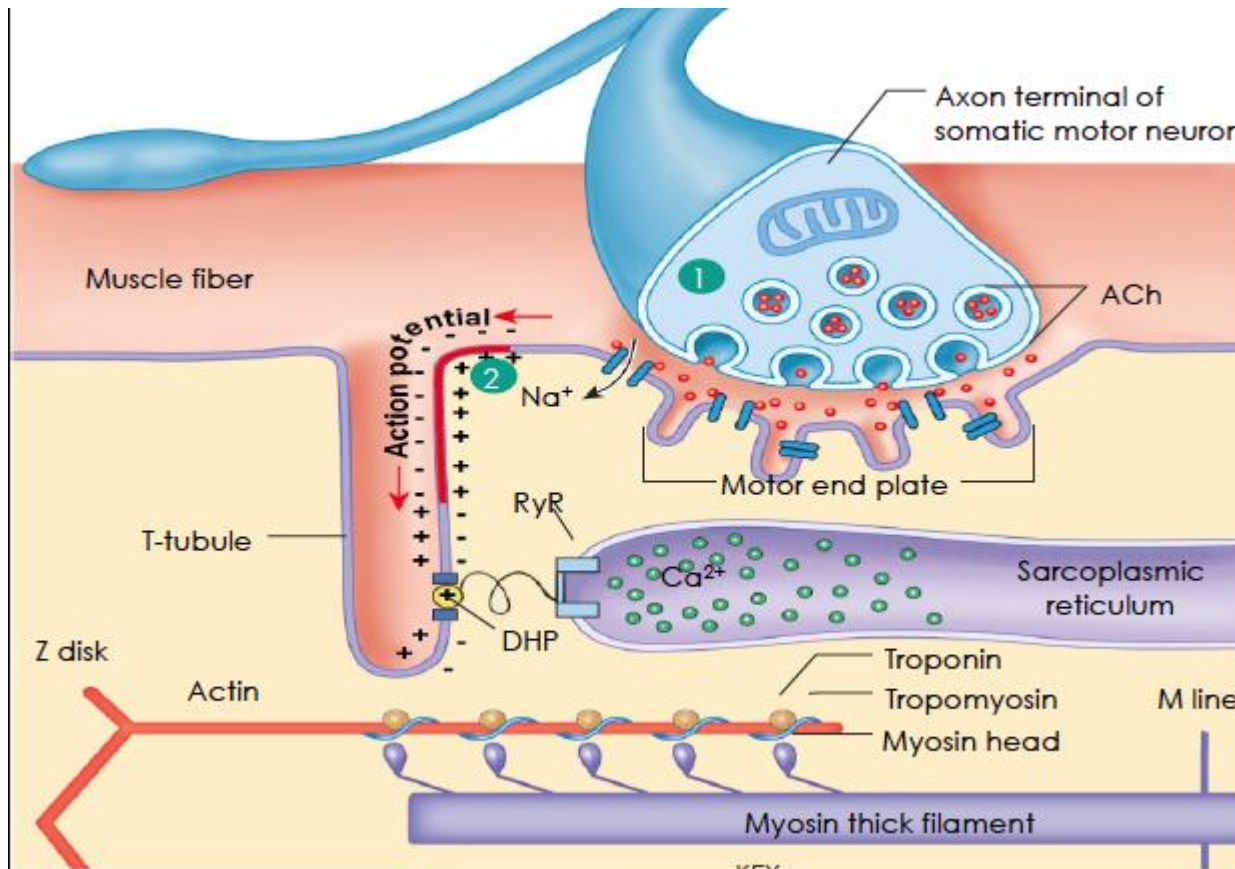


Figure 24-1 A typical muscle consists of many thousands of muscle fibers working in parallel and organized into a smaller number of motor units.

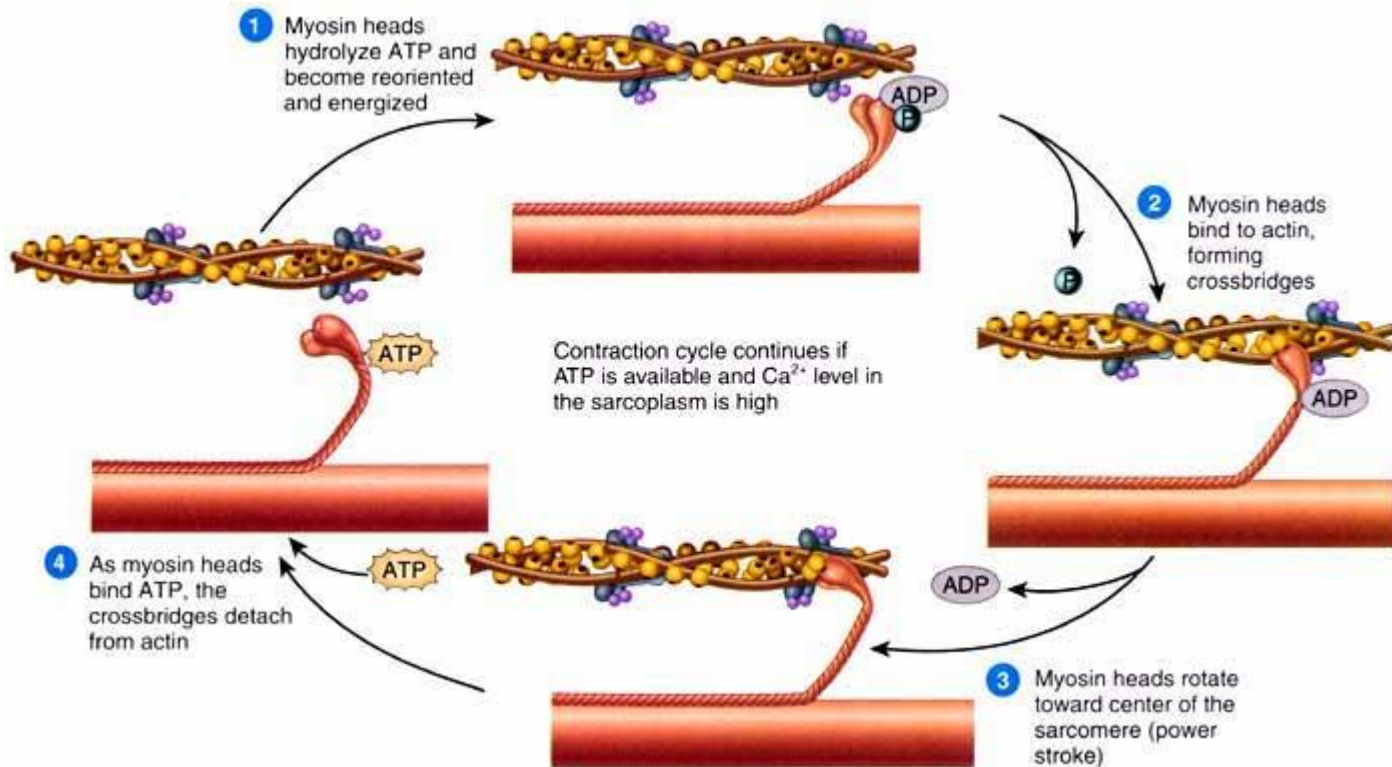
Neuromuscular junction



Neuromuscular junction

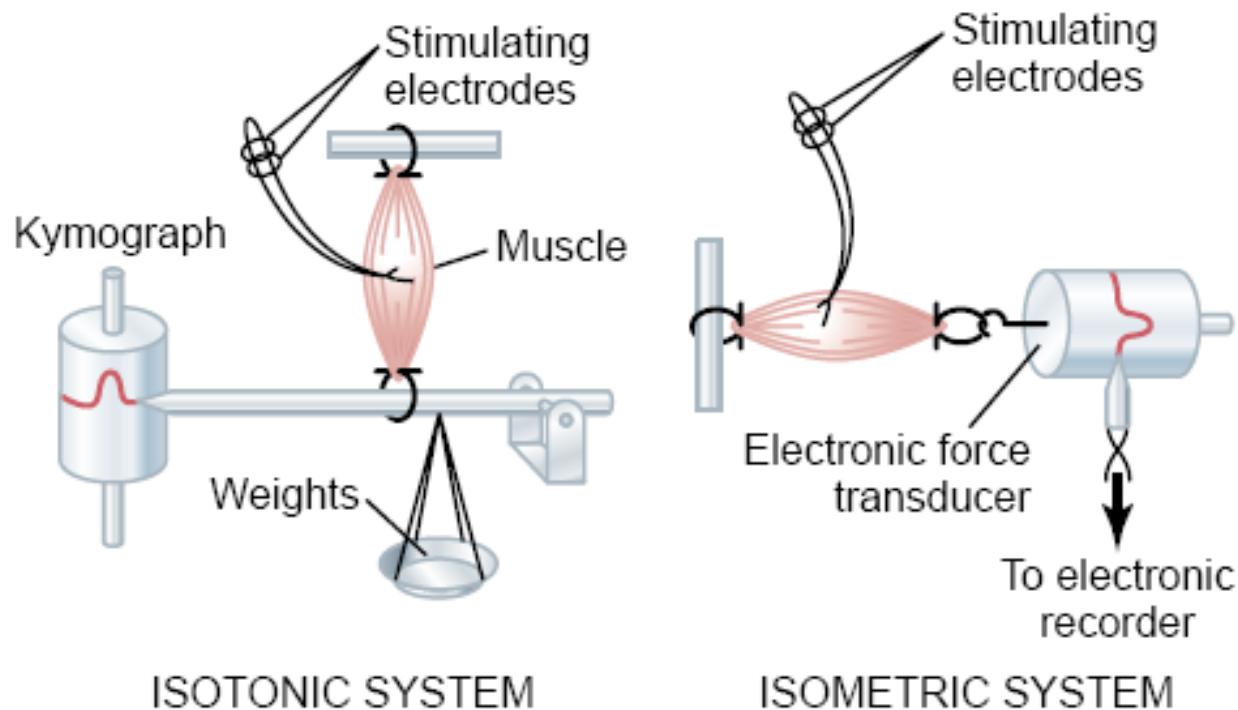


Muscle fibers



Types of muscle contraction

- Isotonic contraction
 - Constant tension
 - The muscle shortens during contraction
- Isometric contraction
 - Muscle does not shorten during contraction



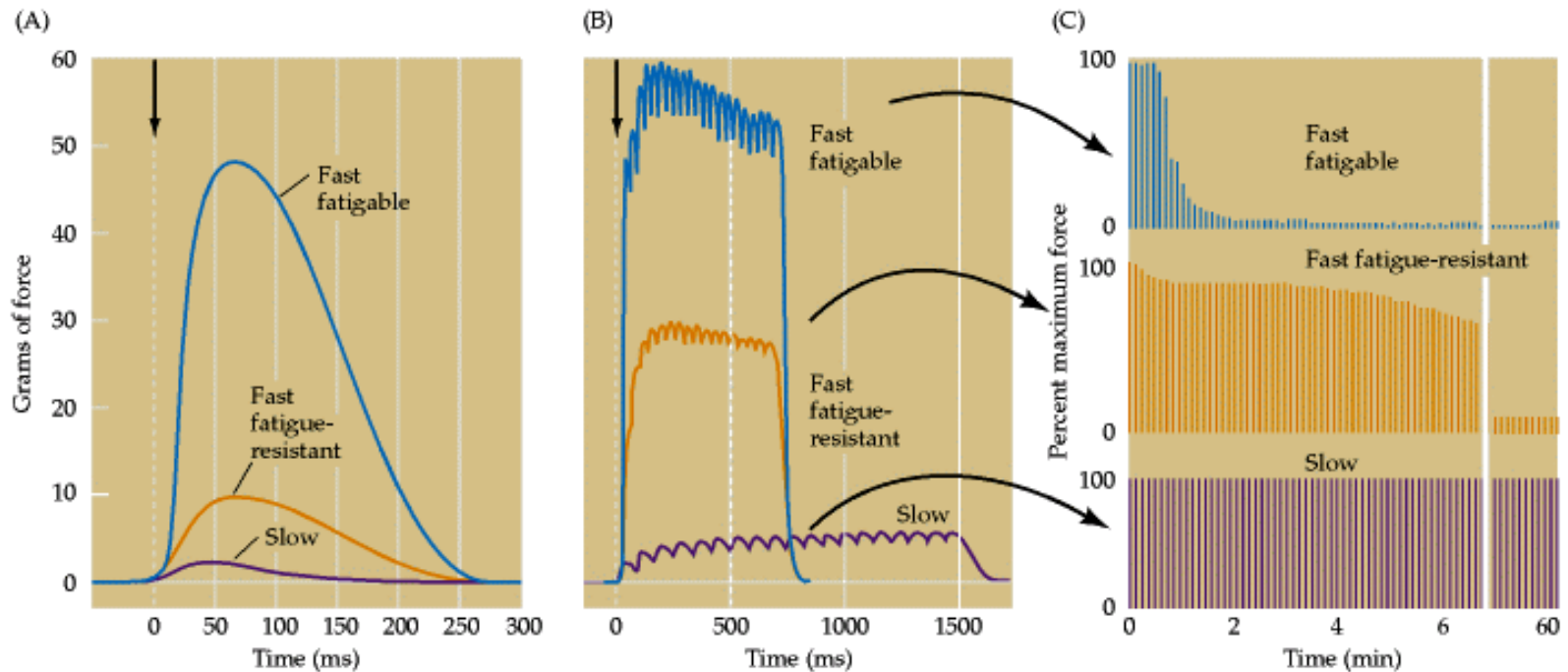
Types of muscle fibers

Fast fibers

- Performance
- Fast fatigue-resistant – normal performance
- Fast fatigable – high performance

Slow fibers

- Endurance
- Fatigue resistant



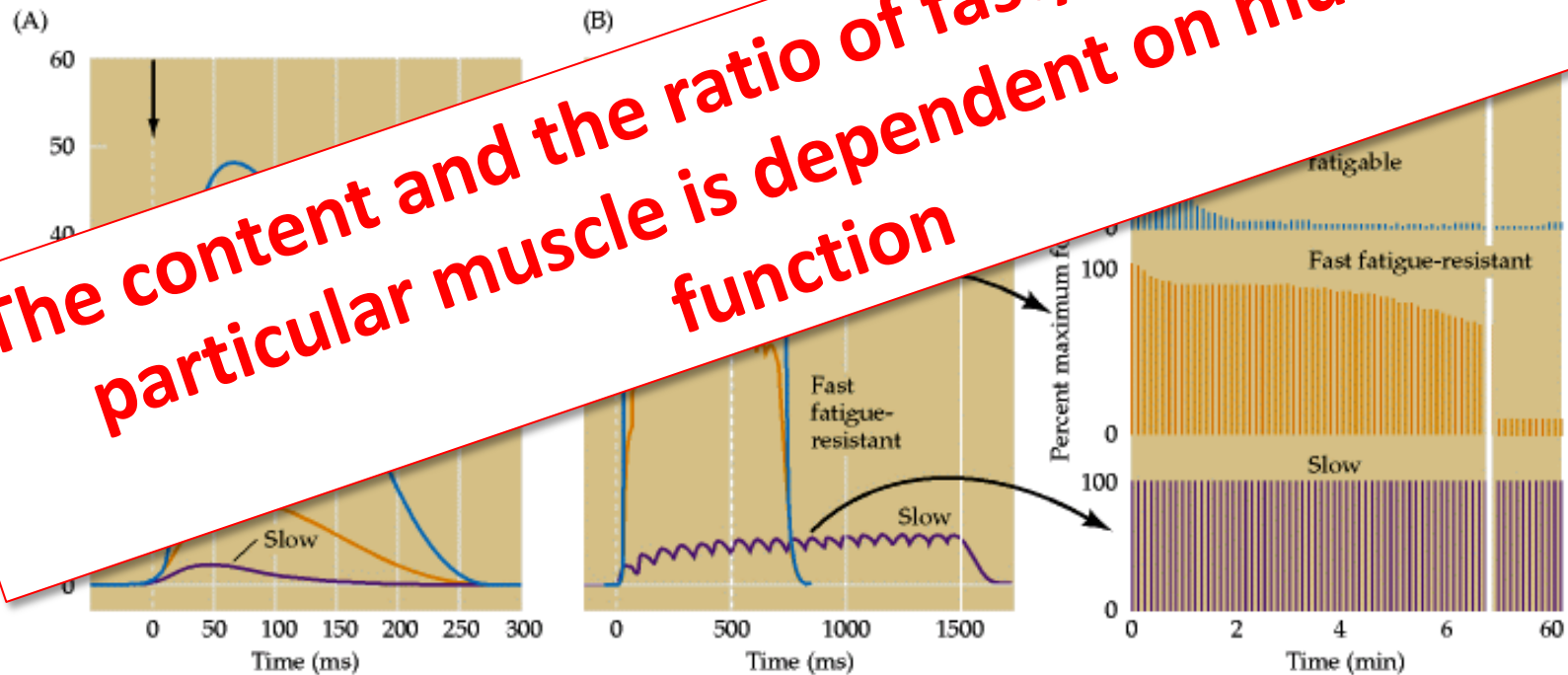
Types of muscle fibers

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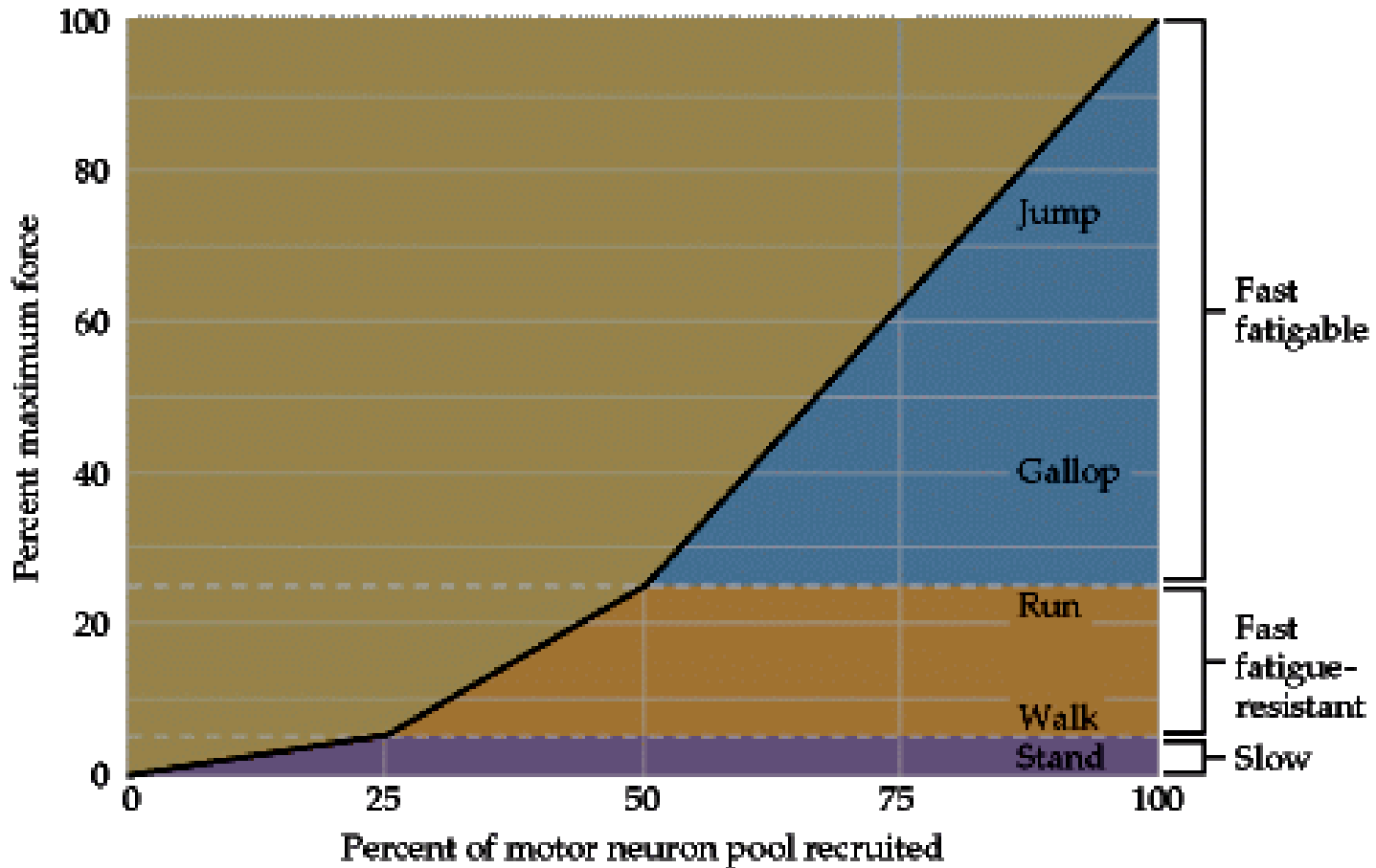
- Endurance



The content and the ratio of fast/slow fibers in particular muscle is dependent on muscle function

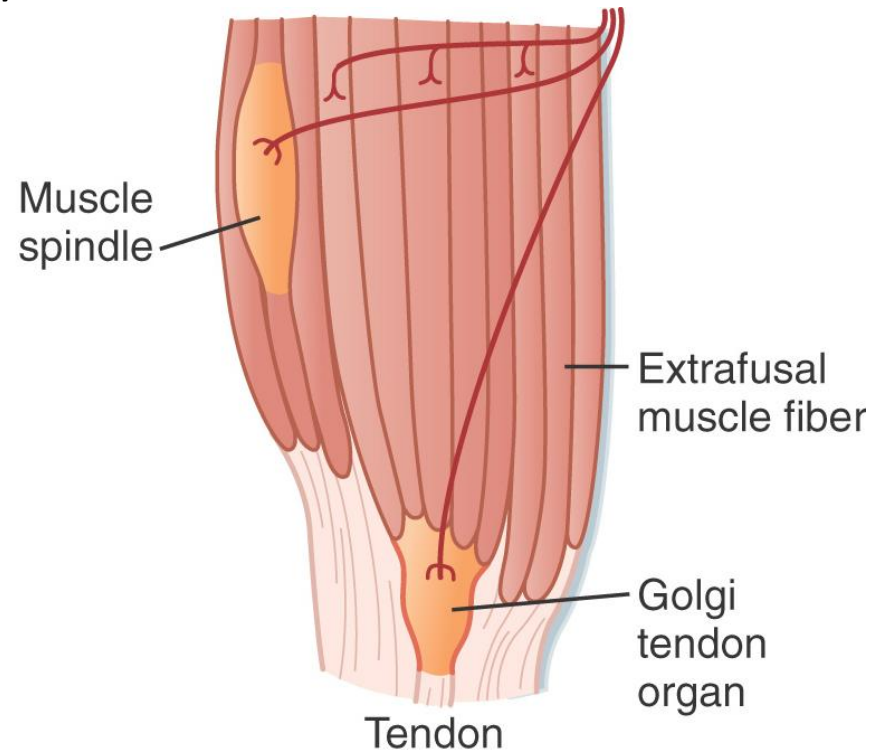
The recruitment of motor neurons

m. gastrocnemius in a cat



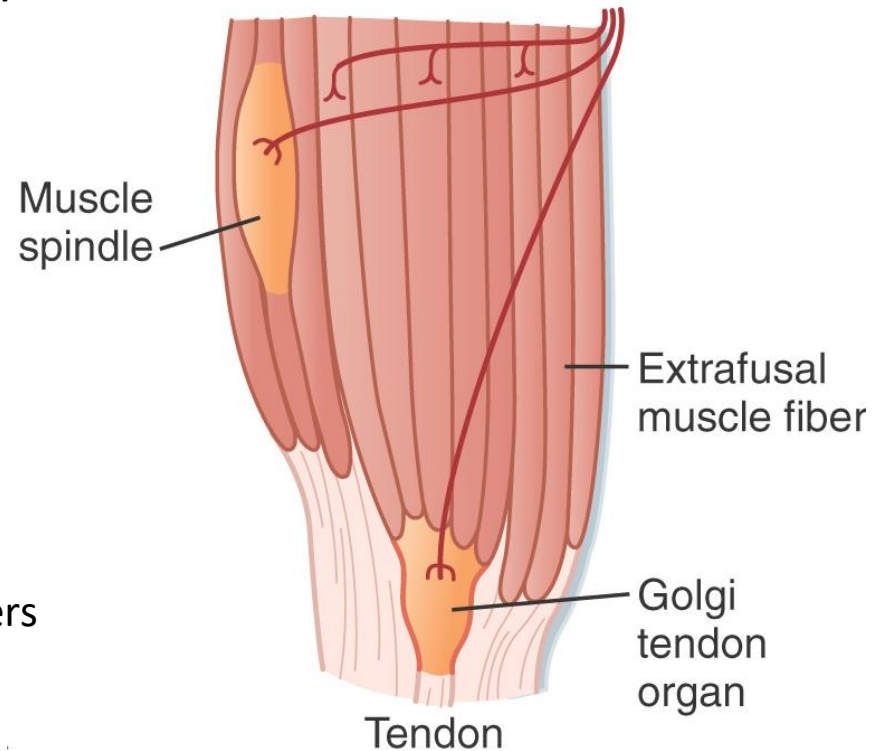
Proprioception

- Information about the position of body parts in relation to each other
(The sum of information about lengths of particular muscles)
- Information about movement
(The force and speed of muscle contraction)
- Reflex regulation of muscle activity



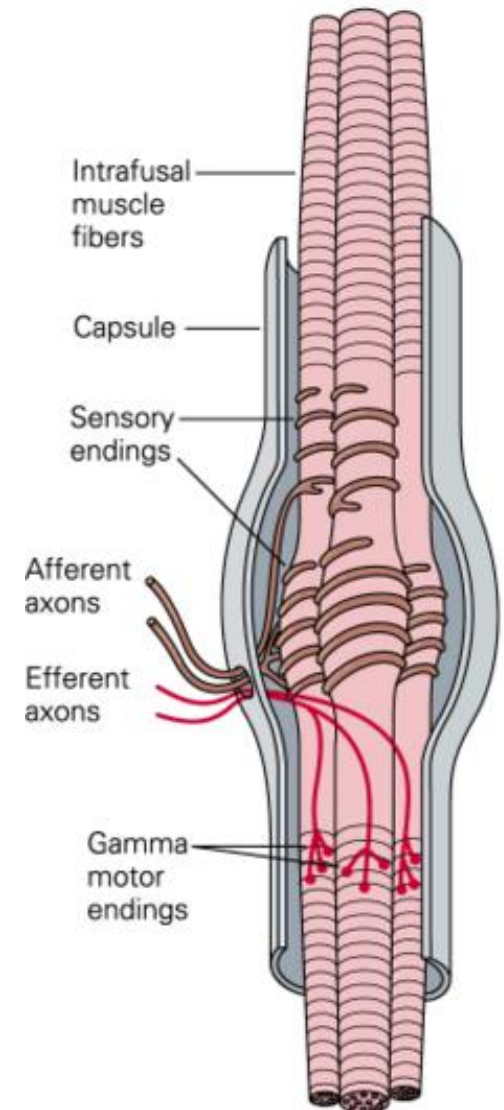
Proprioception

- Information about the position of body parts in relation to each other
(The sum of information about lengths of particular muscles)
- Information about movement
(The force and speed of muscle contraction)
- Reflex regulation of muscle activity
- Muscle spindles
 - Lie in parallel with extrafusal muscle fibers
- Golgi tendon organ
 - Arranged in series with extrafusal muscles



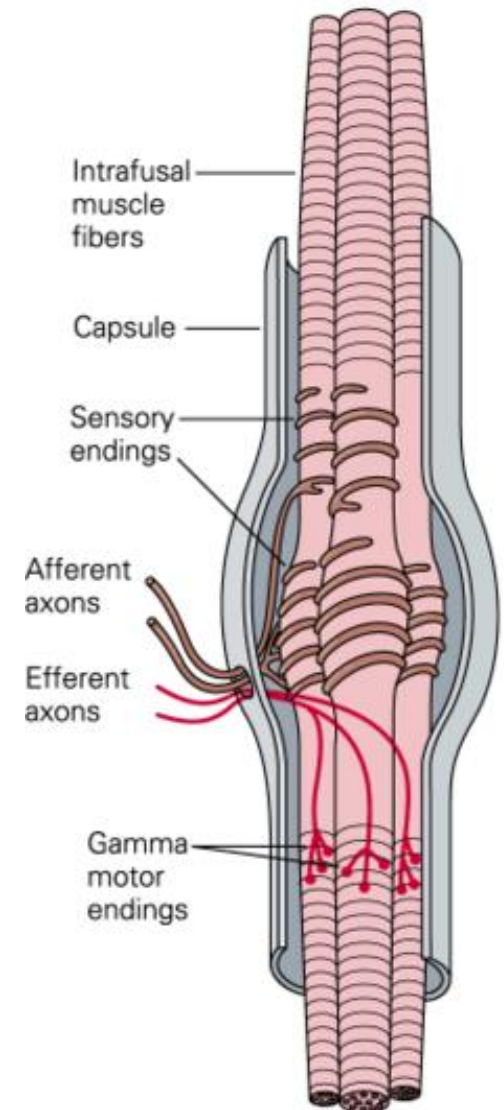
Muscle spindles

- No-force generating contractile structures
- The contractility is for spindle length adjustment



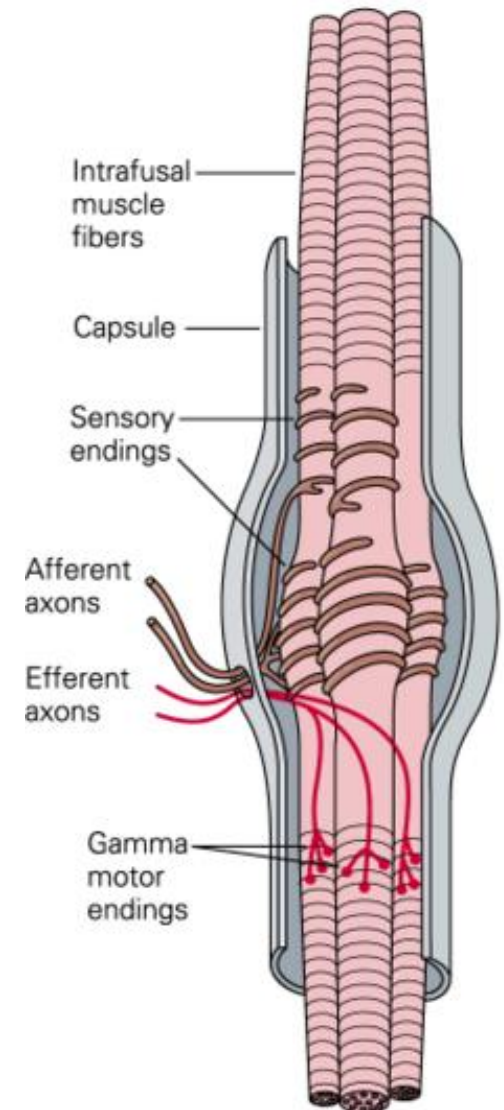
Muscle spindles

- No-force generating contractile structures
- The contractility is for spindle length adjustment
- Encapsulated structure filled with a fluid
- Intrafusal fibers



Muscle spindles

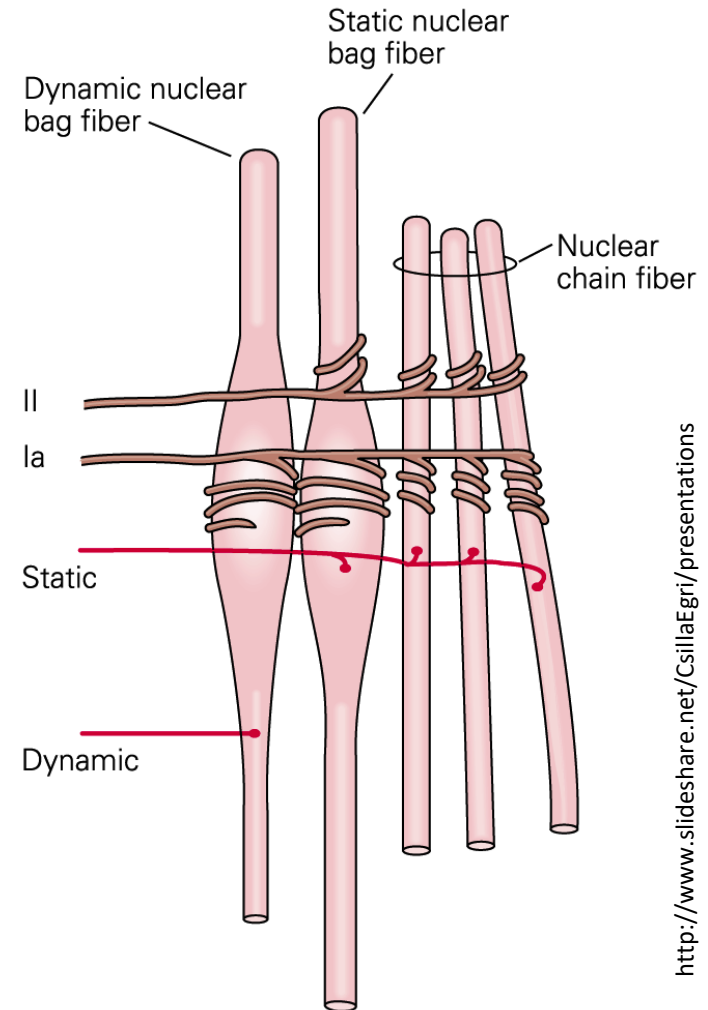
- No-force generating contractile structures
- The contractility is for spindle length adjustment
- Encapsulated structure filled with a fluid
- Intrafusal fibers
 - Lie in parallel with extrafusal muscle fibers (Stretch/shorten along with extrafusal fibers)
 - Efferent connections (into muscle spindle)
 - γ motoneuron
 - Afferent connections (from muscle spindle)
 - Information about change in muscle length
 - Reflex regulation of the α motoneuron activity



Muscle spindle

- Static fibers
- Dynamic fibers

B Intrafusal fibers of the muscle spindle

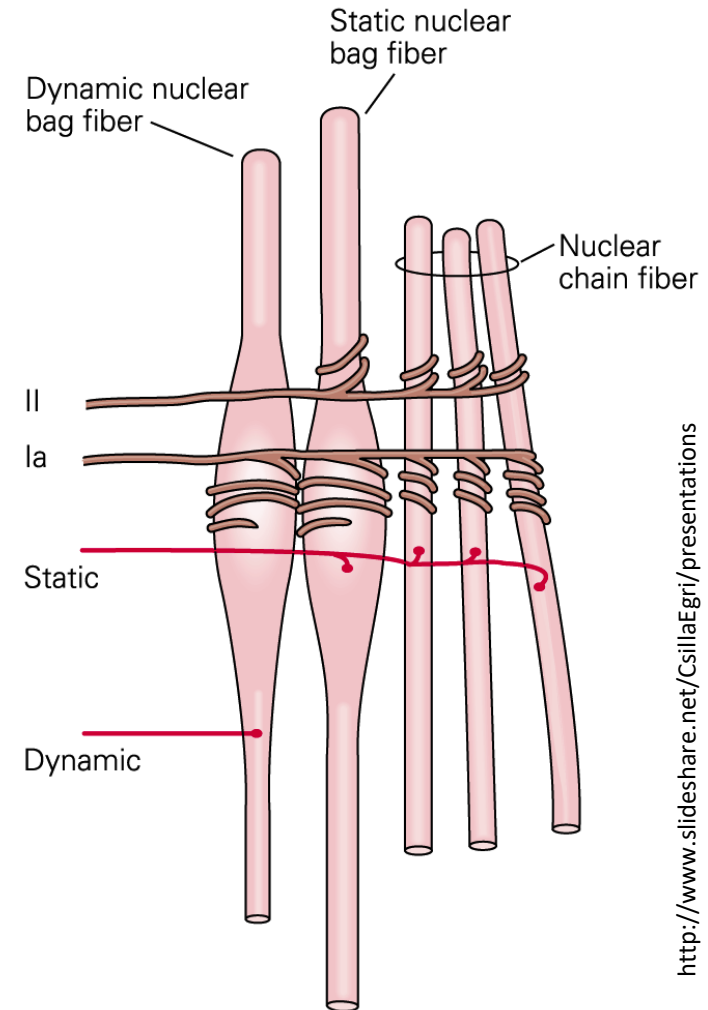


– Spindle length adjustment

Muscle spindle

- Static fibers
- Dynamic fibers
- Afferent connections (from spindle)
 - II – static fibers
 - Information about muscle length (position)
 - Ia – static and dynamic fibers
 - Information about muscle length and contraction (movement)
 - Reflex regulation of the α motoneuron activity

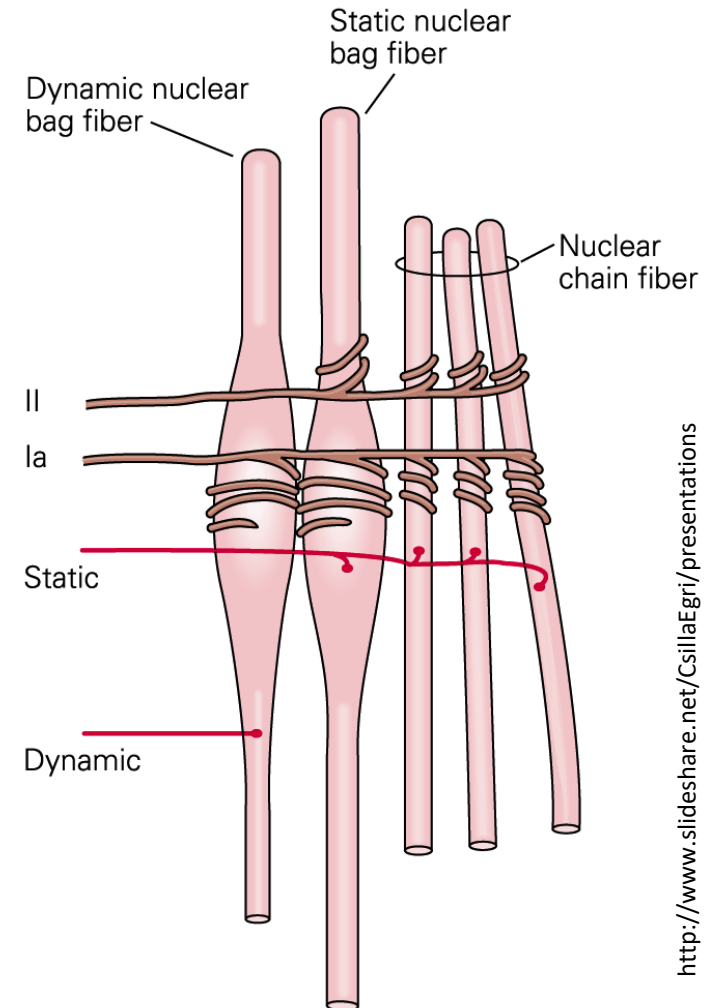
B Intrafusal fibers of the muscle spindle



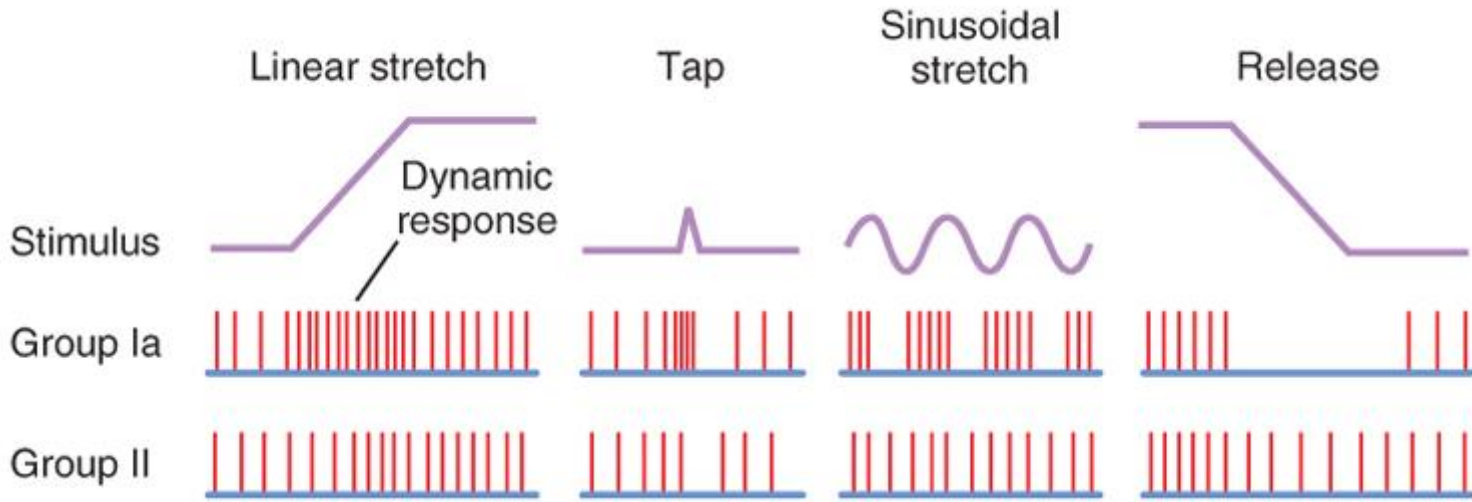
Muscle spindle

- Static fibers
- Dynamic fibers
- Afferent connections (from spindle)
 - II – static fibers
 - Information about muscle length (position)
 - Ia – static and dynamic fibers
 - Information about muscle length and contraction (movement)
 - Reflex regulation of the α motoneuron activity
- Efferent connections (into spindle)
 - Static γ motoneurons
 - Dynamic γ motoneurons
 - Spindle length adjustment

B Intrafusal fibers of the muscle spindle



Afferent signaling from muscle spindles



II – Static fibers

- Static response

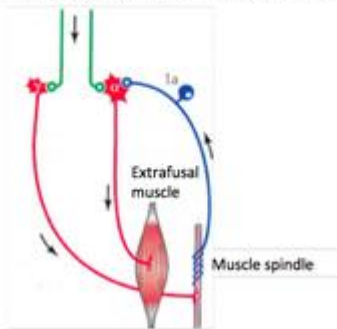
Ia – Static and dynamic fibers

- Static and dynamic response

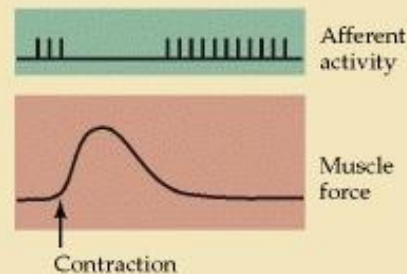
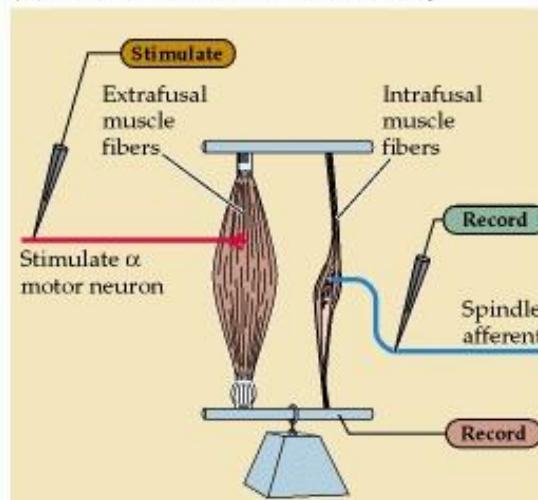
Efferent signaling into the muscle spindle

- γ motoneurons adjust the length of intrafusla fibers
- Regulation of sensitivity
- α and γ coactivation

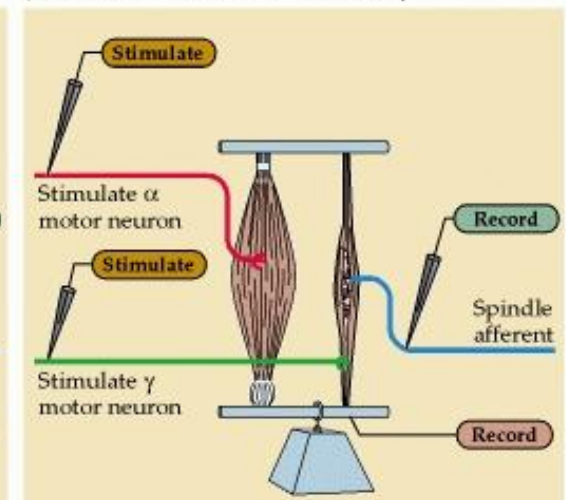
The CNS co-activates alpha and gamma motoneurons



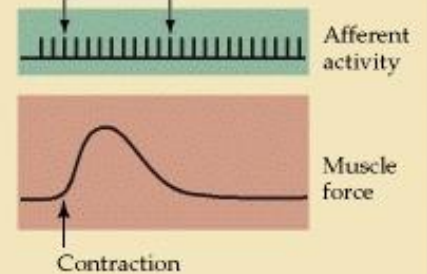
(A) α Motor neuron activation without γ



(B) α Motor neuron activation with γ

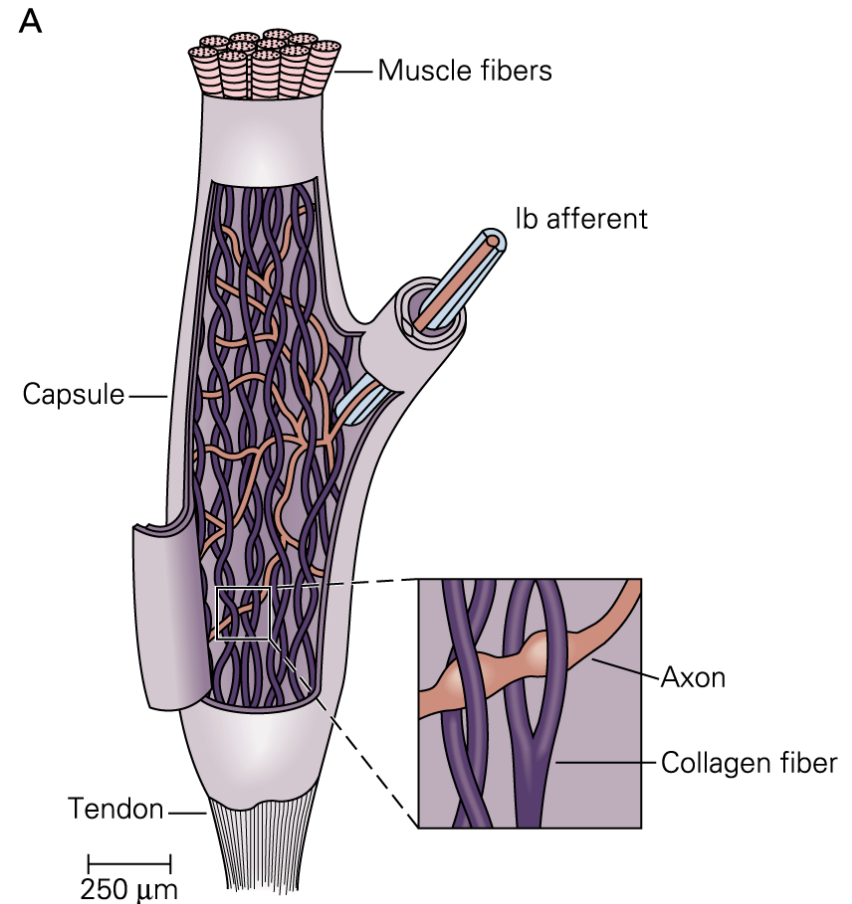


Ia response "filled in"

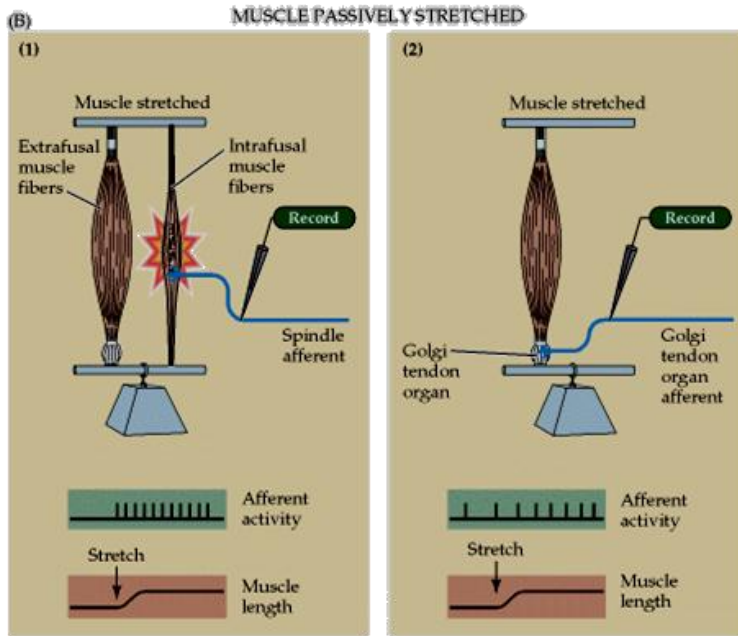


Golgi tendon organs

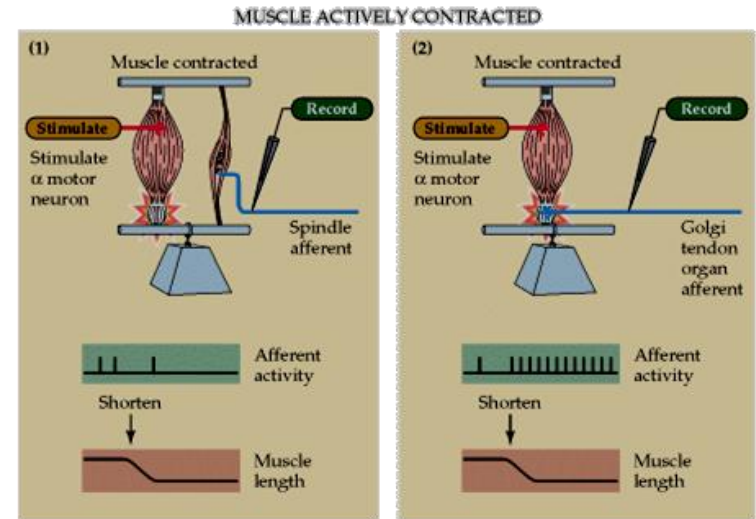
- Non-contractile encapsulated structures
- Collagen fibers
- Ia fibers
- Mechanoreception
- Arranged in series with extrafusal muscles
- Information about changes in tendon tension/force
- Reflex regulation of the α motoneuron activity



Reaction of muscle spindles and the Golgi tendon organs to muscle fiber stretch/contraction

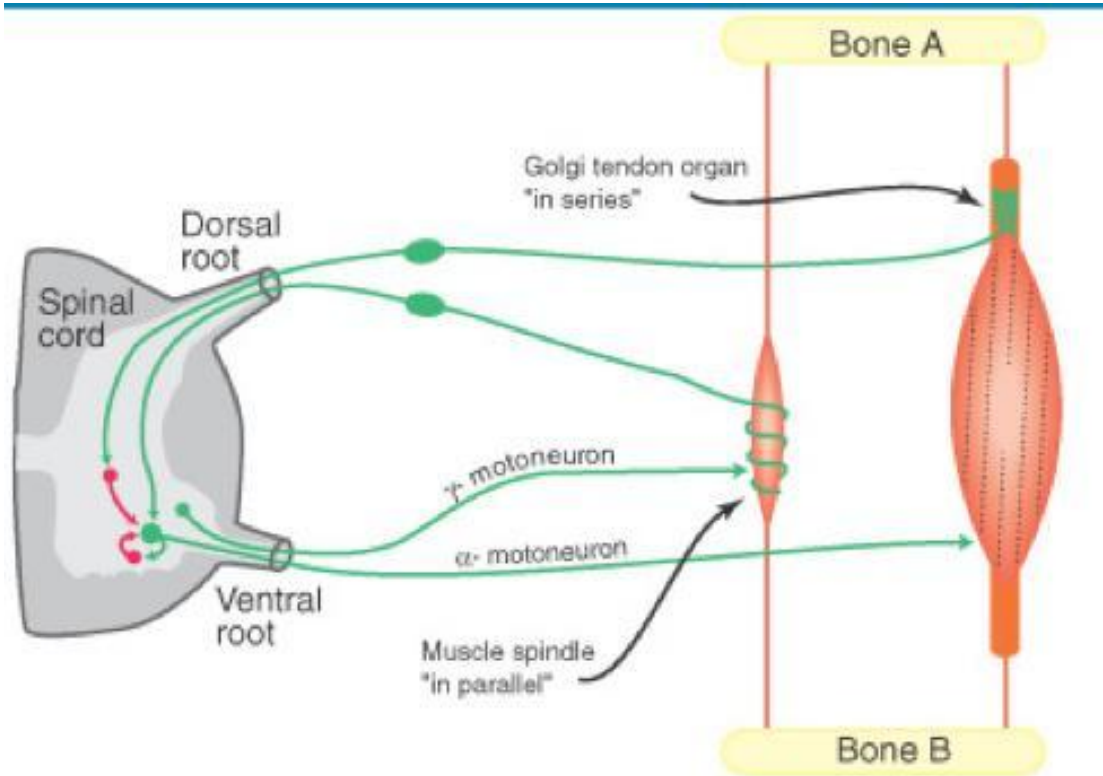


Stretch (passive)
Muscle spindles reaction



Contraction (active)
Golgi tendon organ reaction

Recapitulation



http://images.persianblog.ir/559630_iXFiuRo0.jpg