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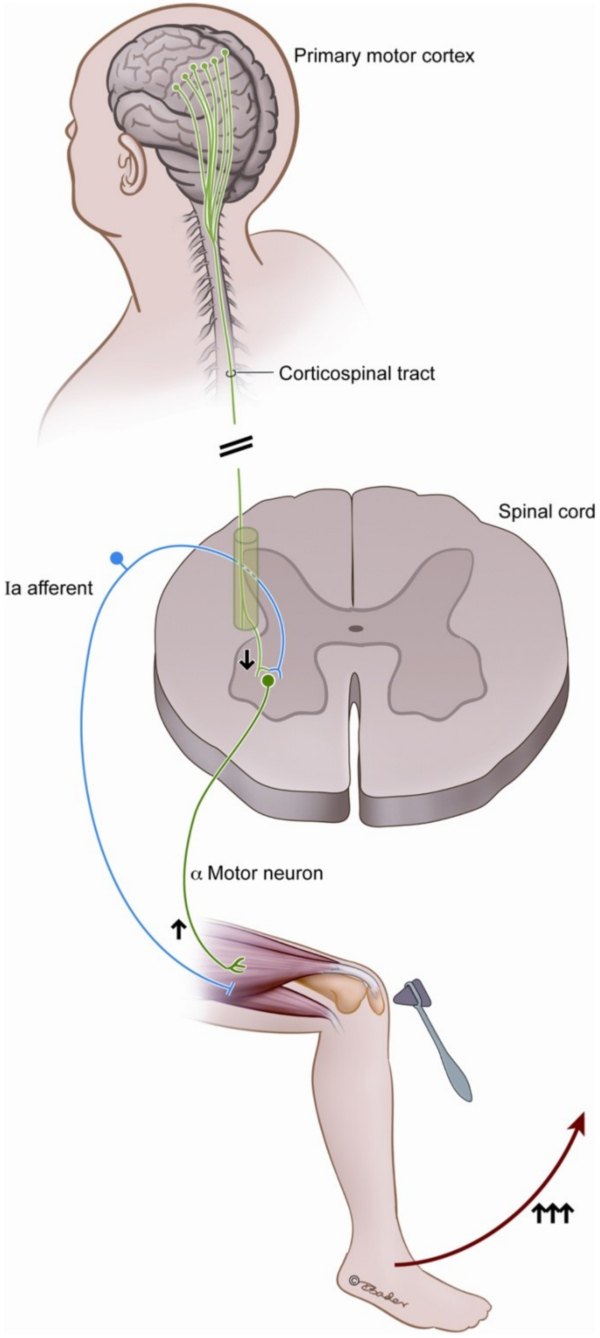
11

Motor system I

Introduction

- Skeletal muscle contraction is initiated by lower motor neuron



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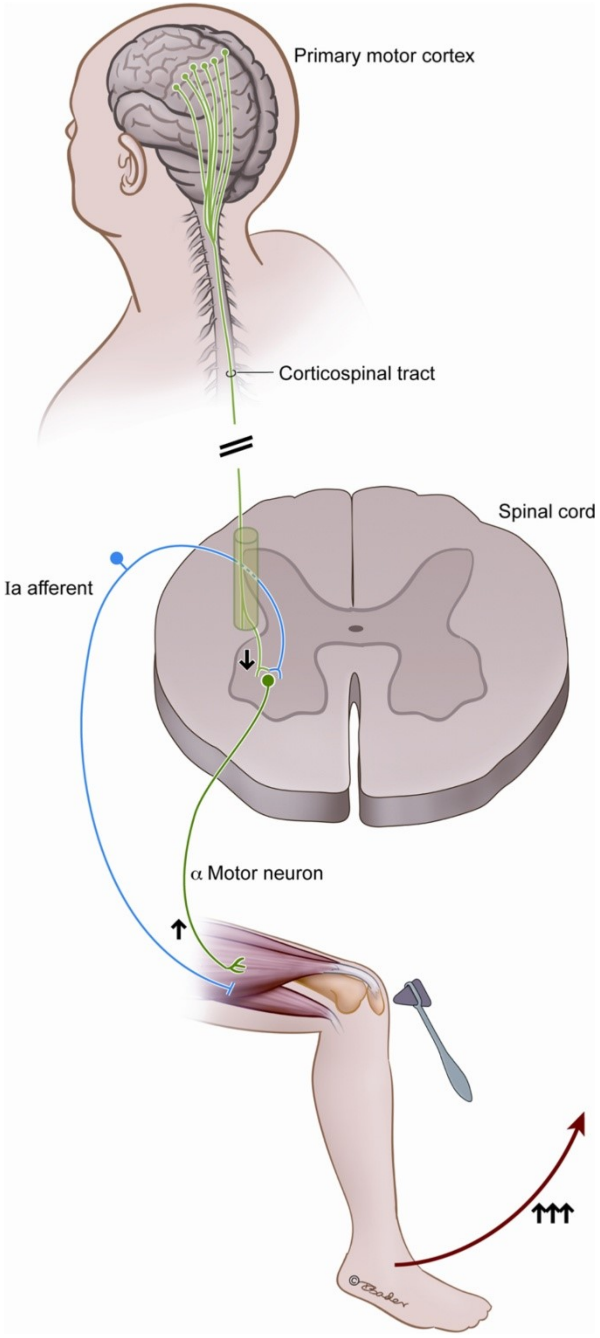
Introduction

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



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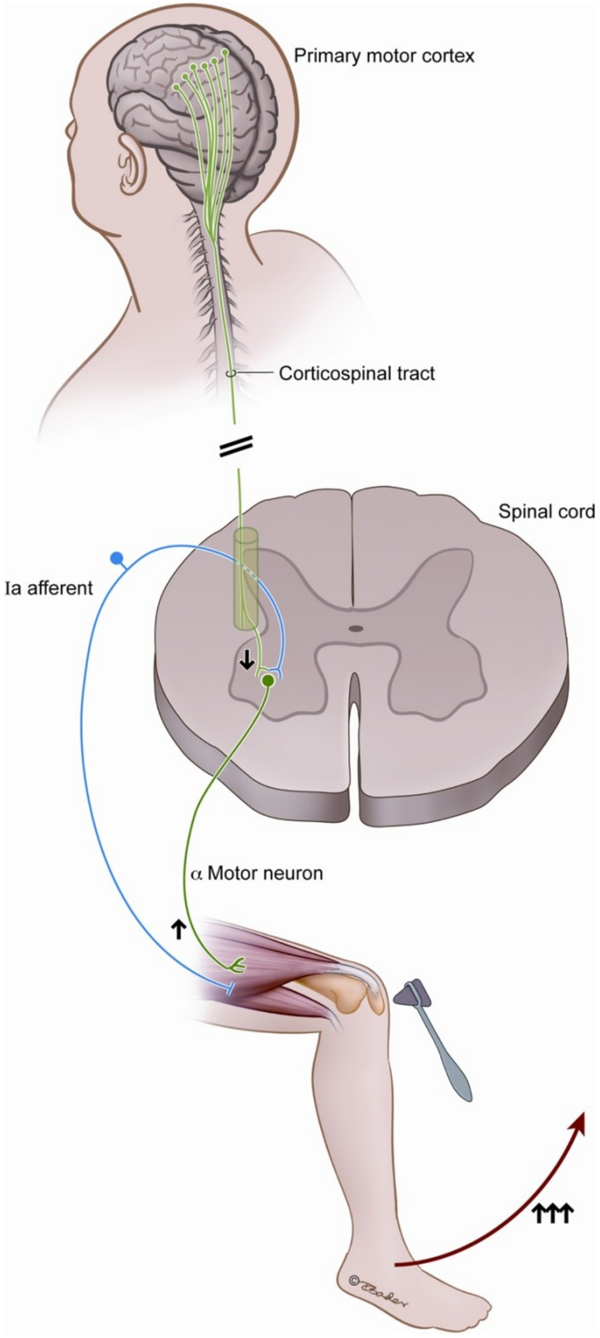
Introduction

- 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



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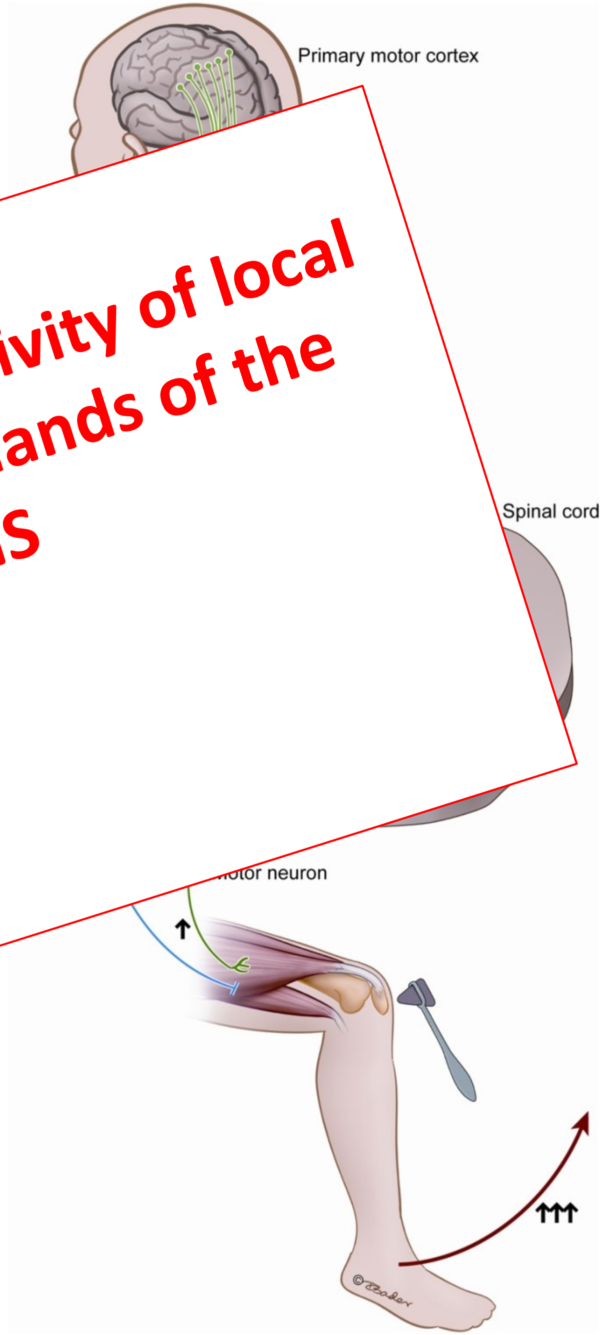
Introduction

- Skeletal muscle contraction is initiated l
lower motor neuron
- Lower motor
reflex
- The info
integrat
  - Highe
    - Upp
rube
  - Proprioce

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



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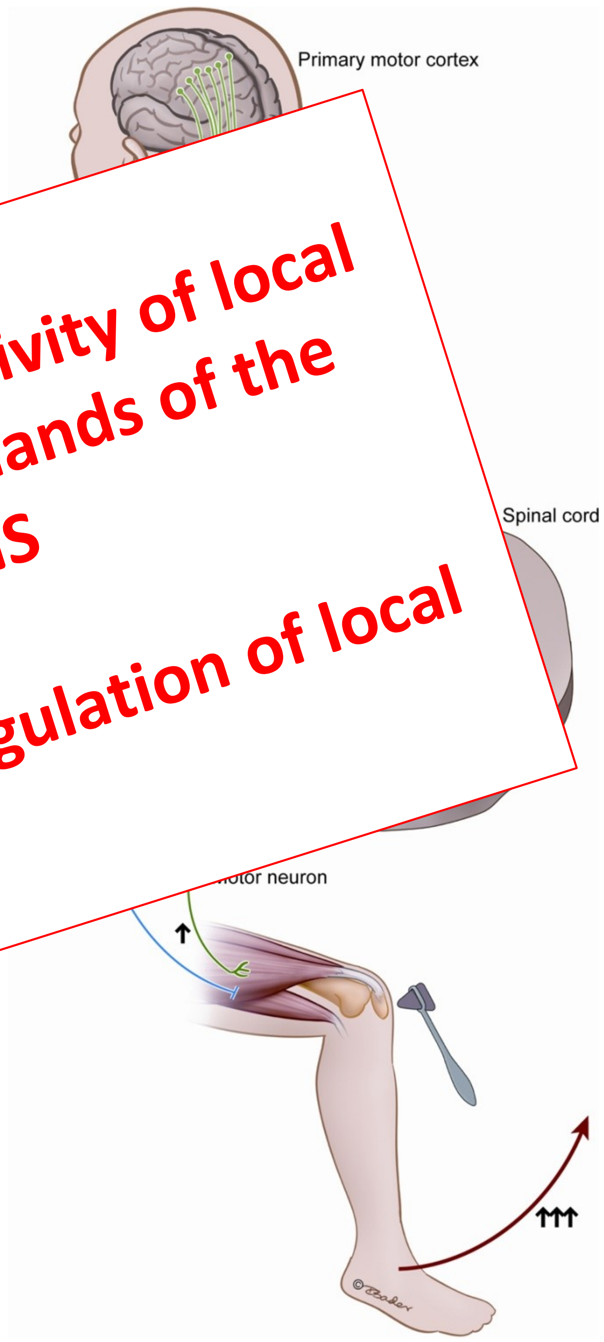
Introduction

- Skeletal muscle contraction is initiated l... lower motor neuron
- Lower motor... reflex...
- The info... integrat...
  – Highe...
    ➢ Upp... rube...
  – Propriocе...

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



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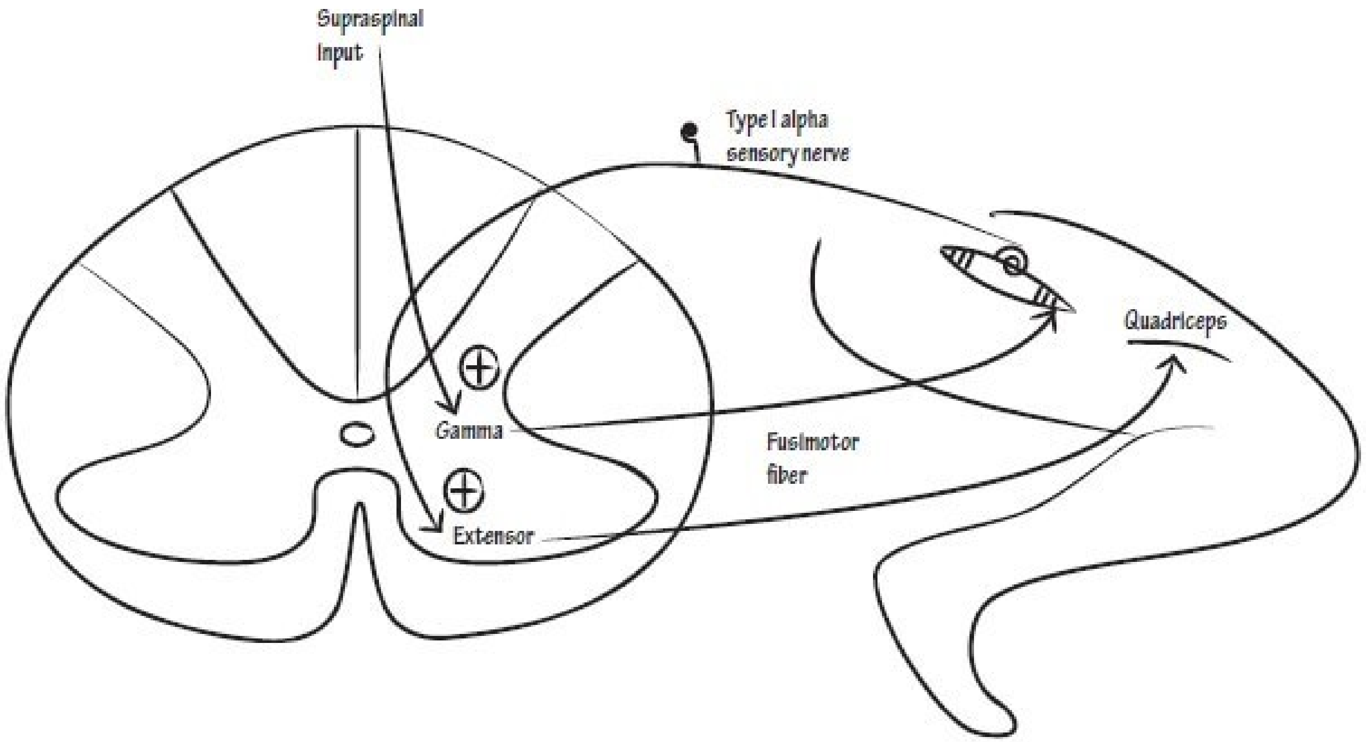
Lower motor neuron

- **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**
  - **Both extrafusal and intrafusal fiberrs**



http://epomedicine.com/wp-content/uploads/2016/07/gamma-loop.jpg

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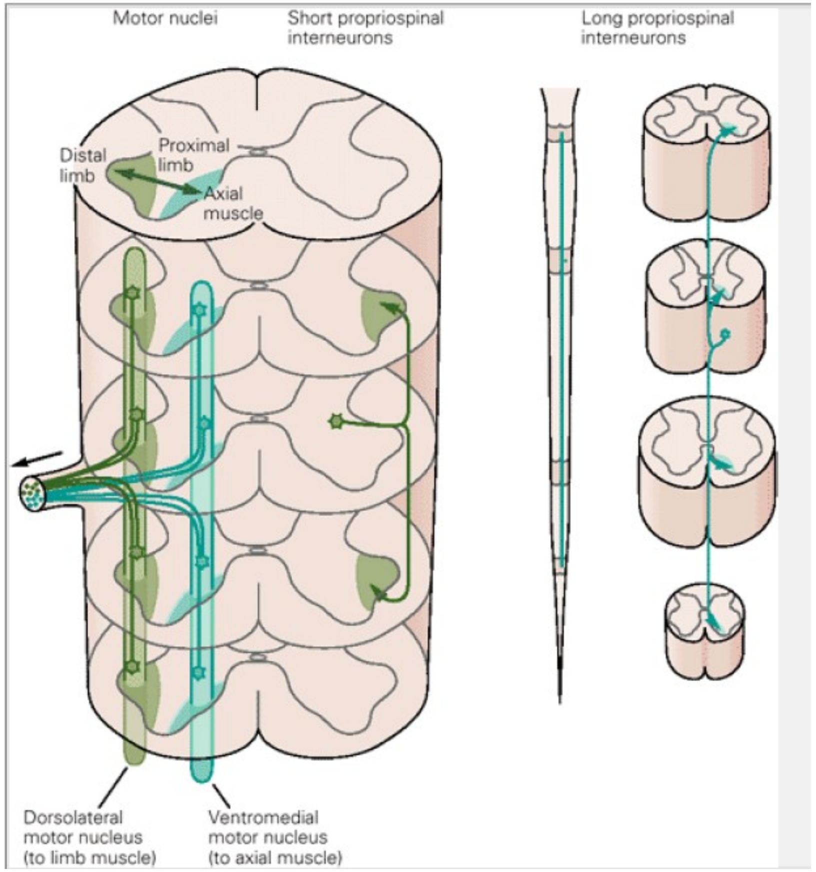
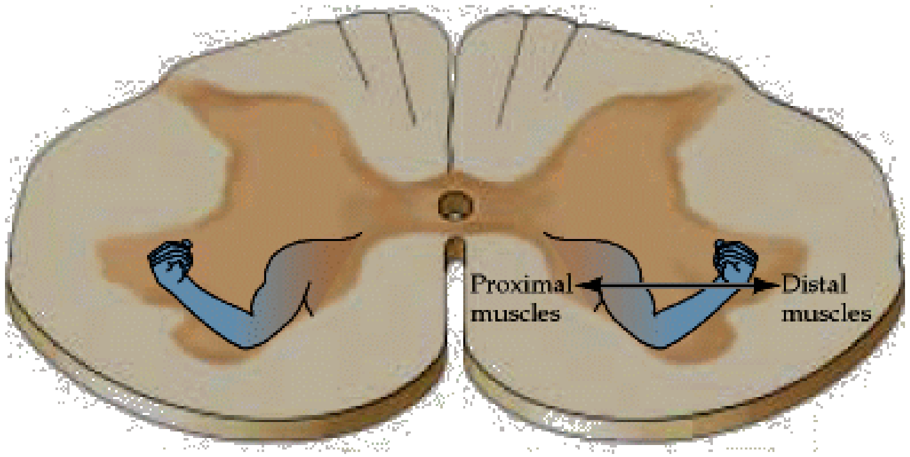
Lower motor neuron

Topography





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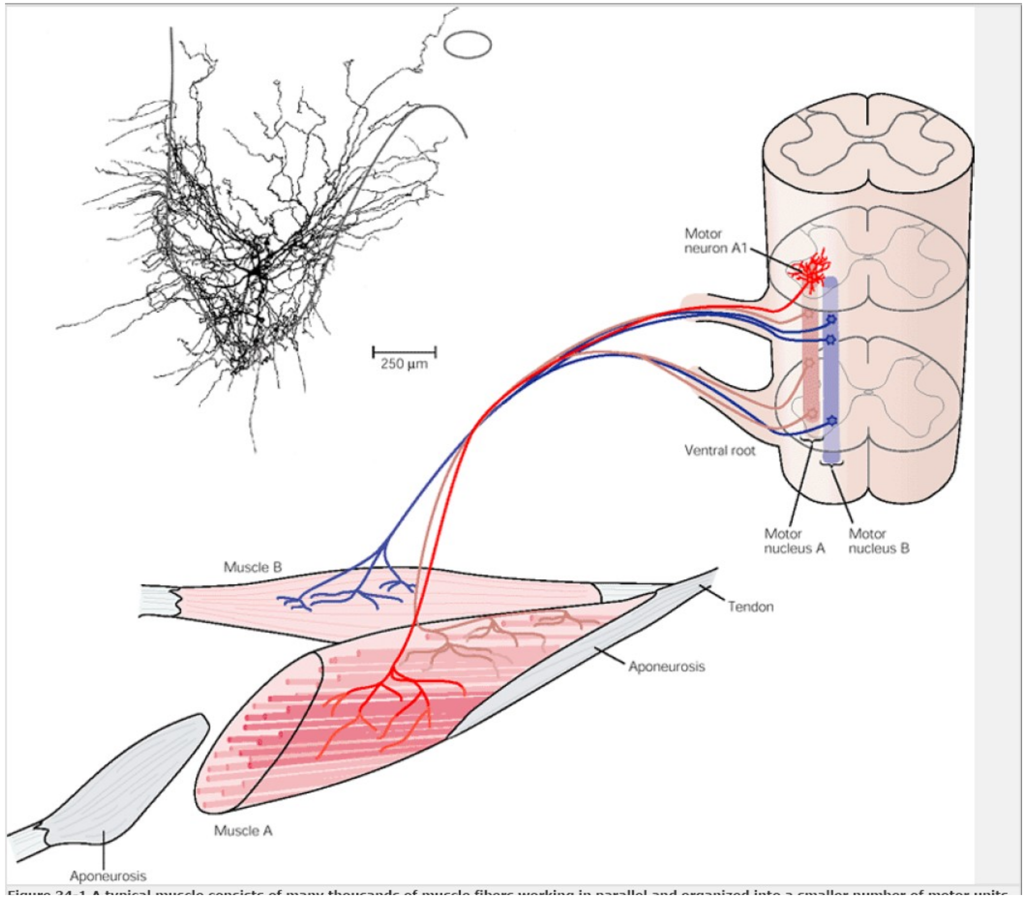
Motor unit

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



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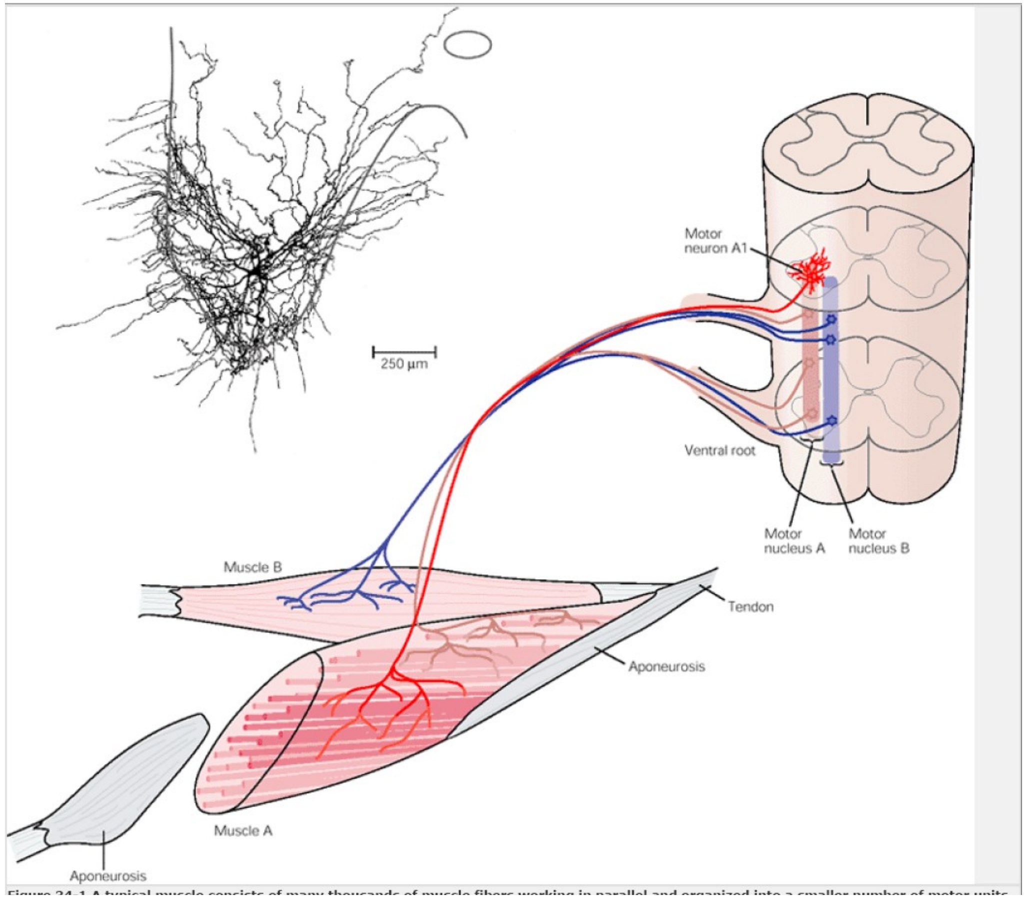
Motor unit

- 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



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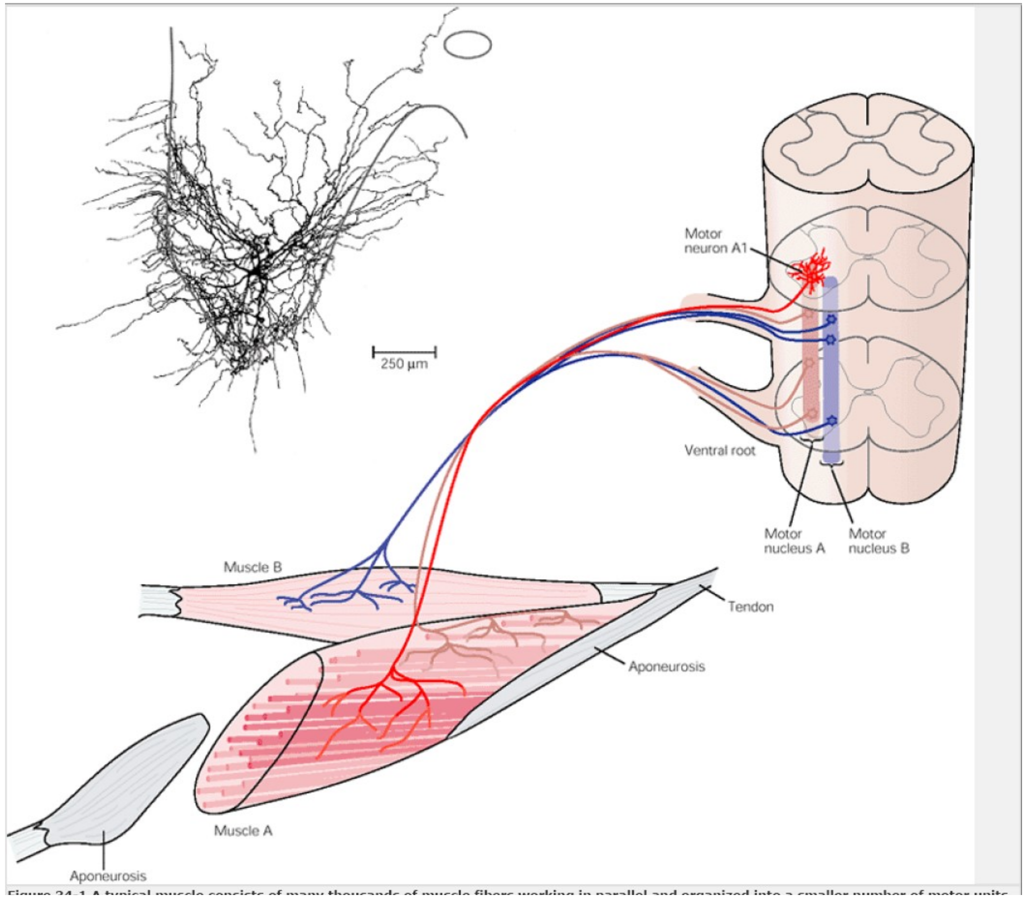
Motor unit

- 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



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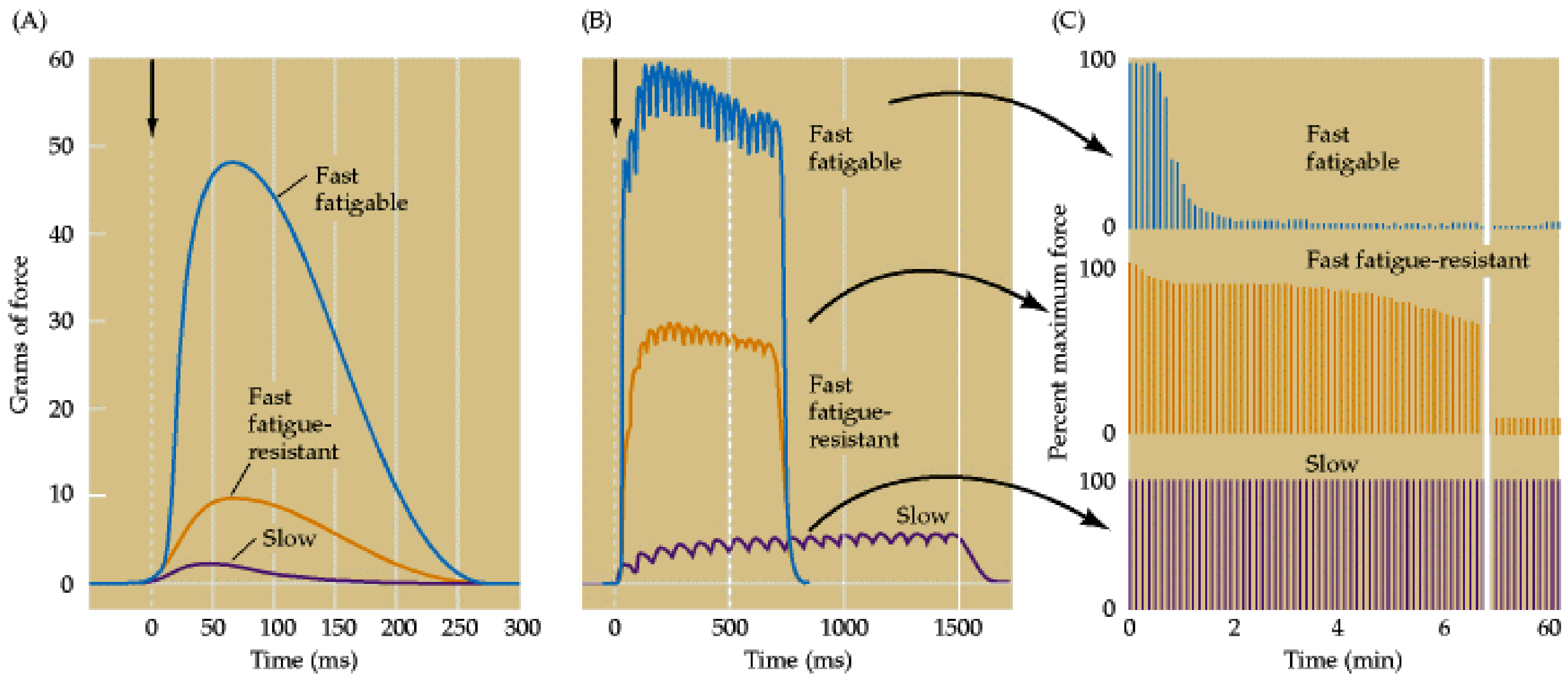
Types of muscle fibers

Fast fibers

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

Slow fibers

- Endurance
- Fatigue resistant



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Types of muscle fibers

Fast fibers

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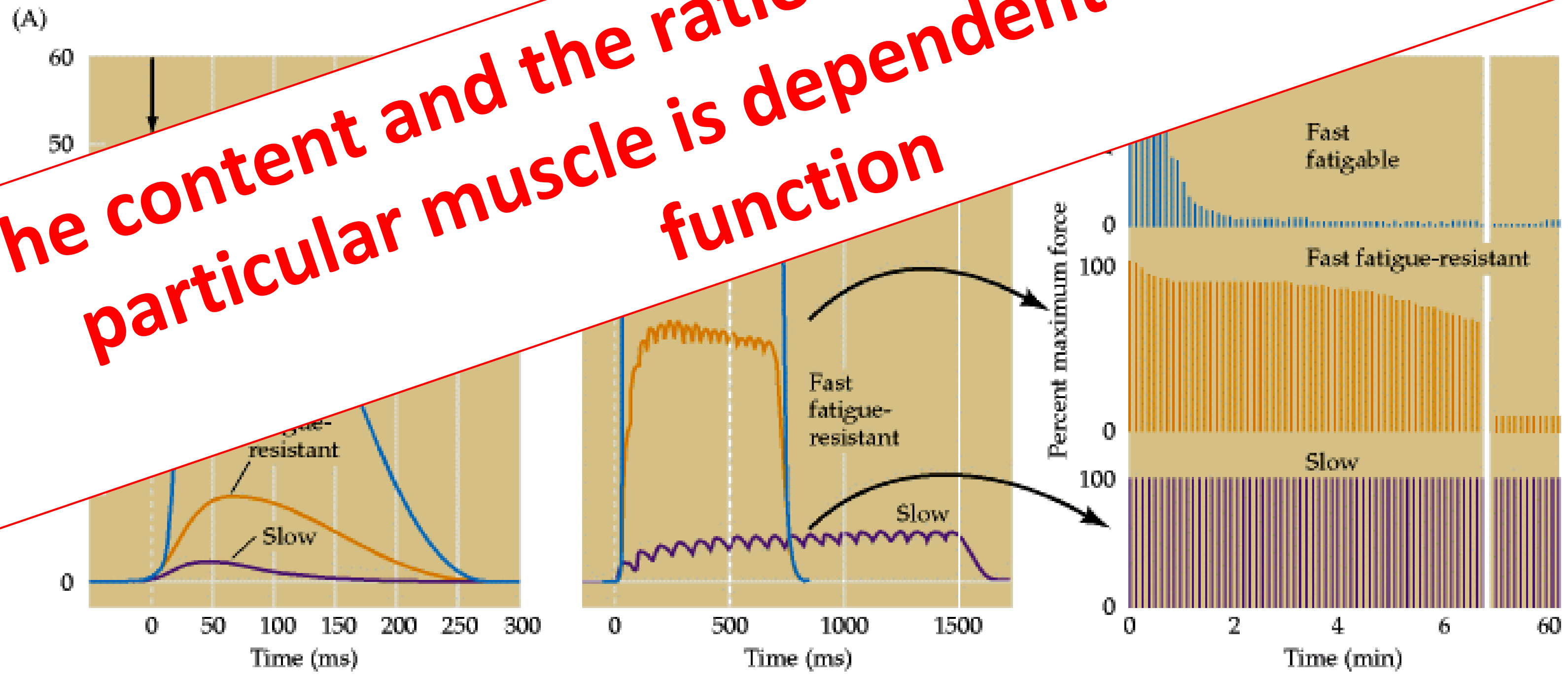
Slow fibers



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

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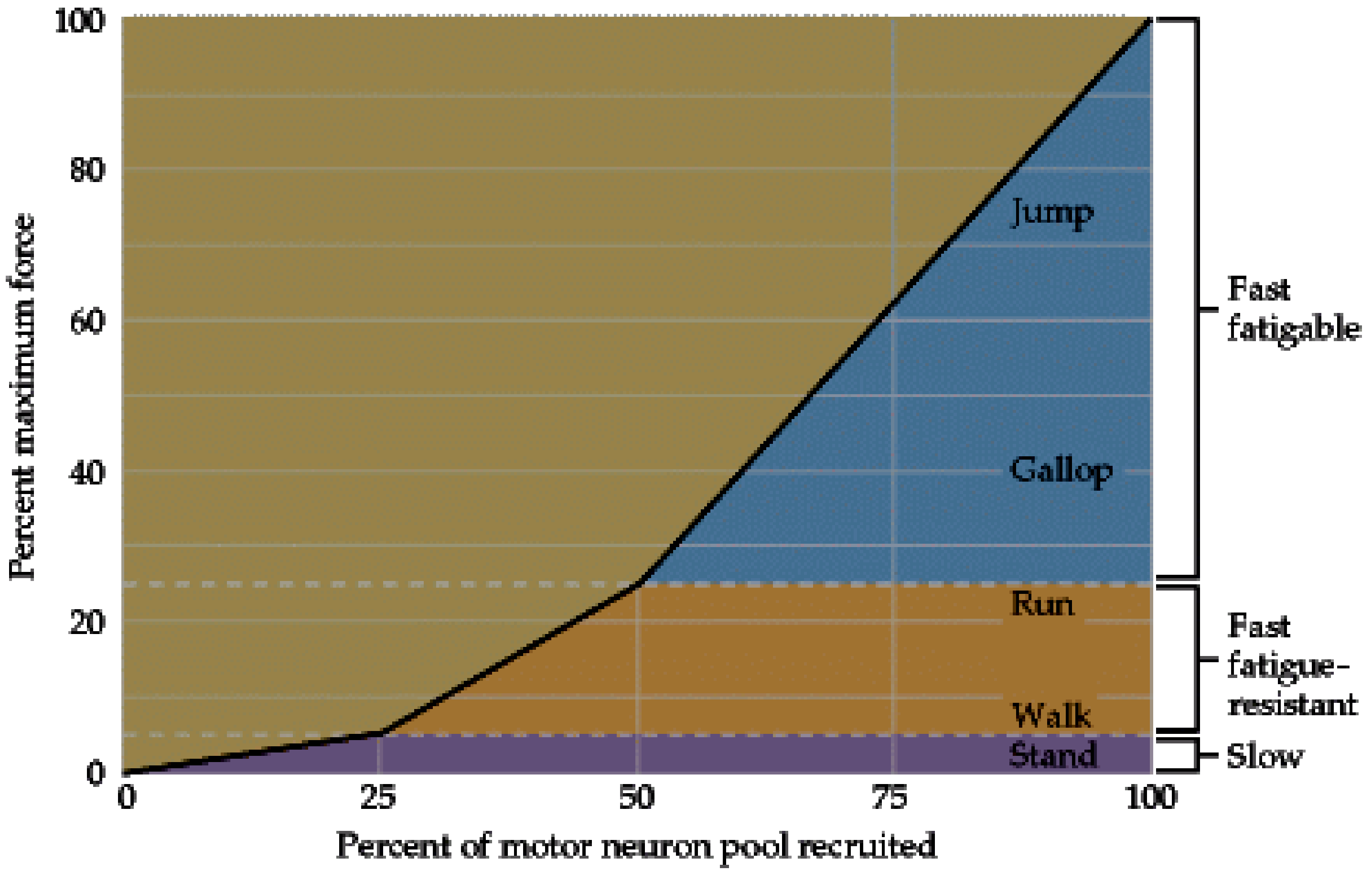
The recruitment of motor neurons

m. gastrocnemius in a cat



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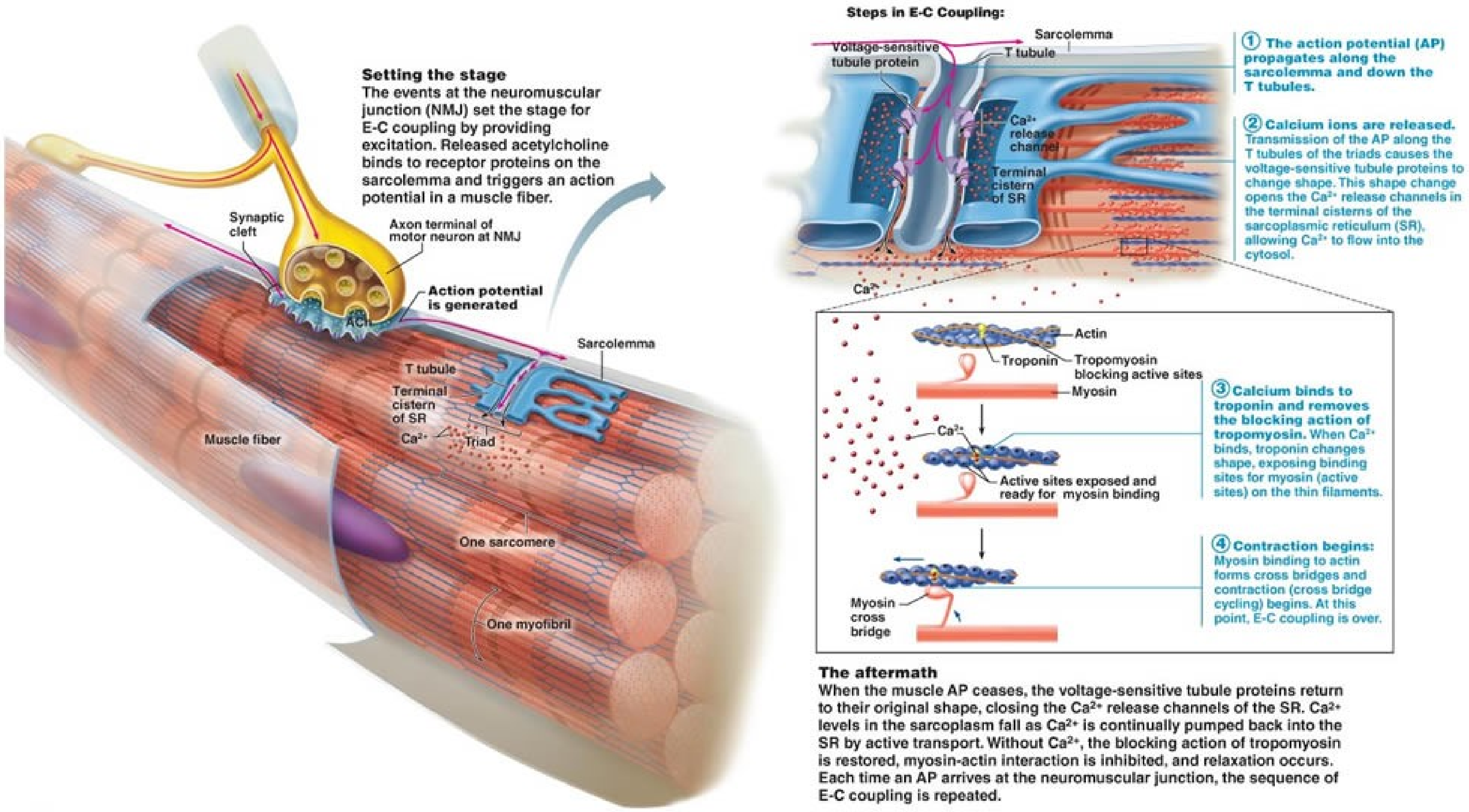
Neuromuscular junction



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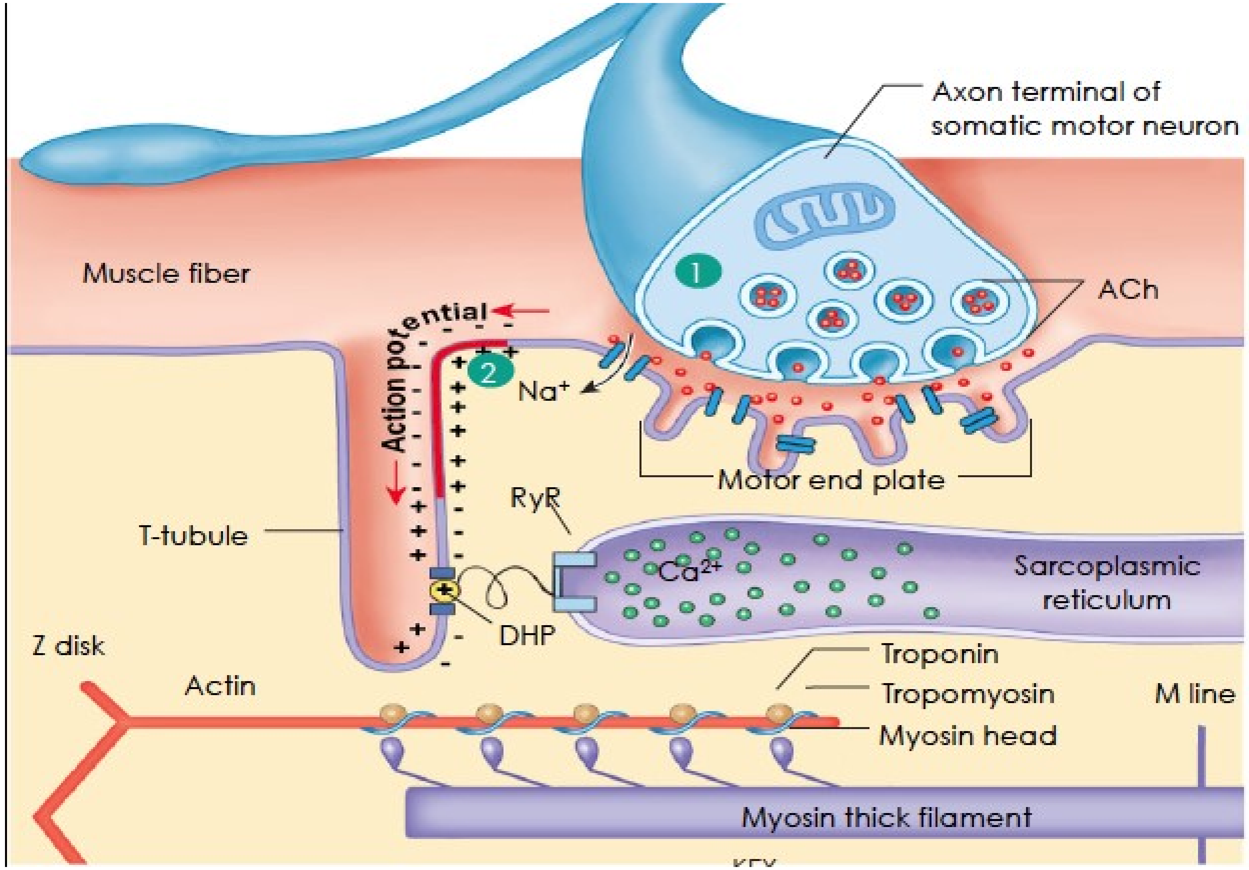
Neuromuscular junction



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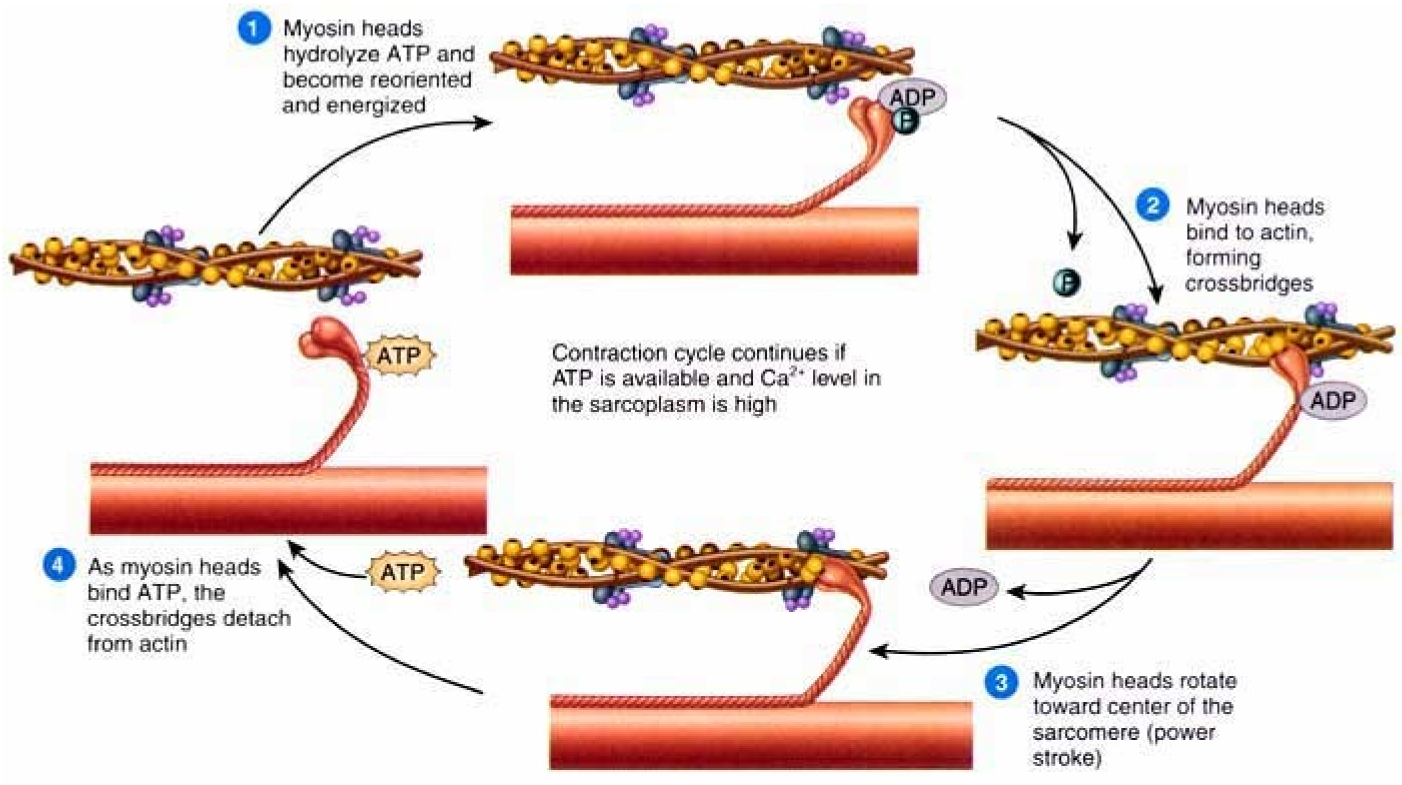
Muscle fibers



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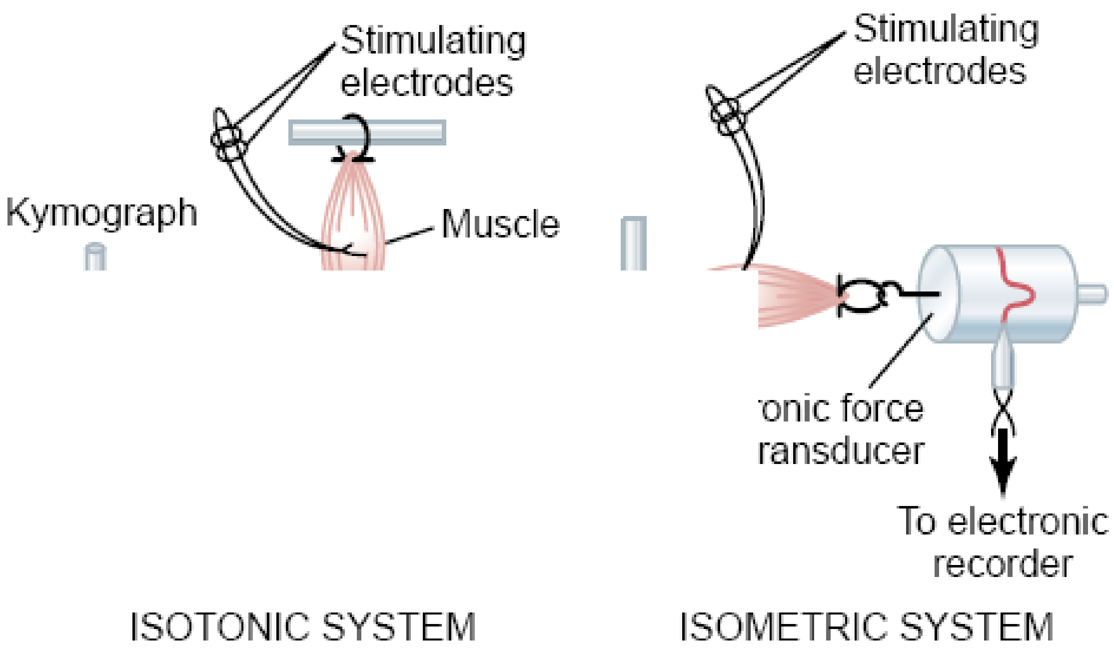
Types of muscle contraction

- Isotonic contraction
  - Constant tension
  - Concentric x excentric contraction
- Isometric contraction
  - Constant length



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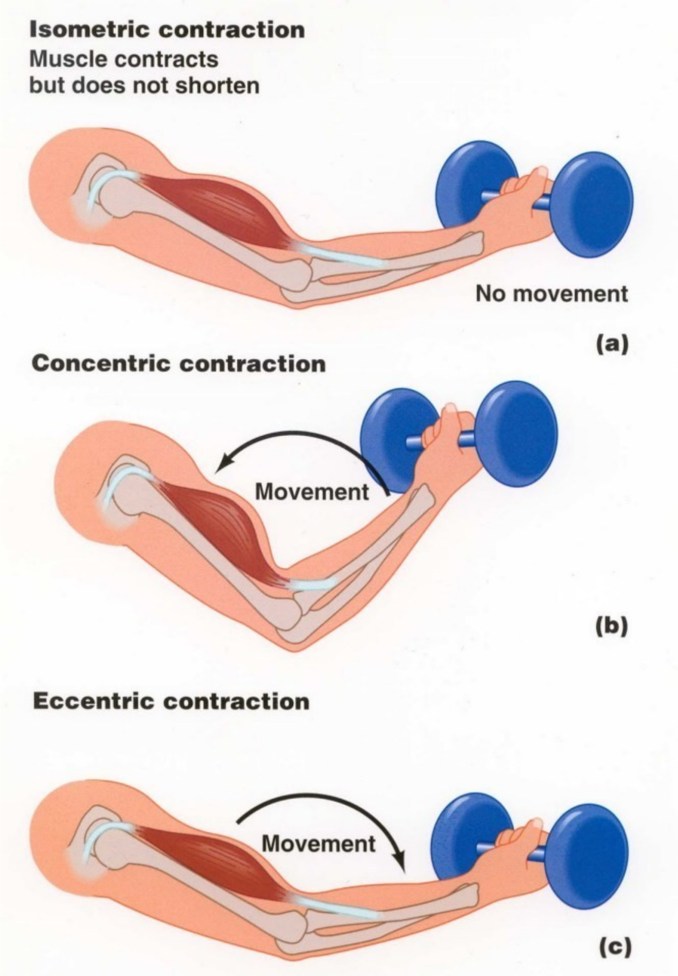

https://i0.wp.com/colebradburn.com/wp-content/uploads/2013/02/contractions.jpg

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Proprioception

- Information about the position of body parts in relation to each other

  (The sum of information about lengths of particular muscles)

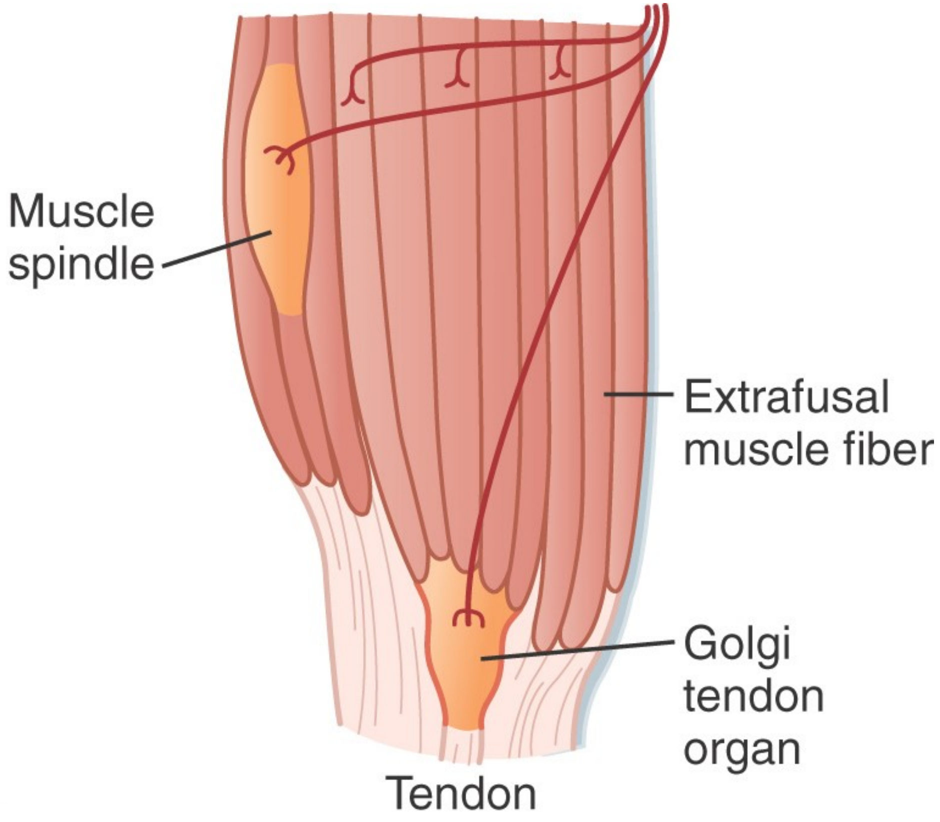
- Information about movement

  (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



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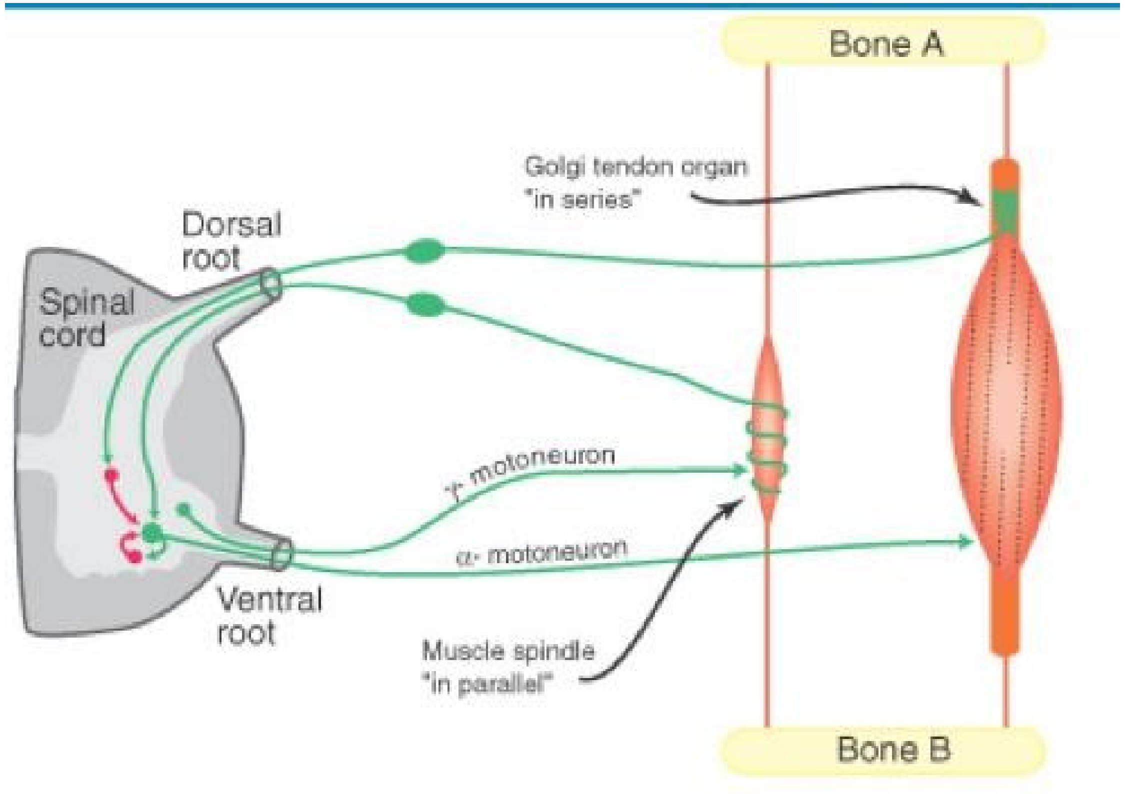
Muscle spindle and Golgi tendon organ



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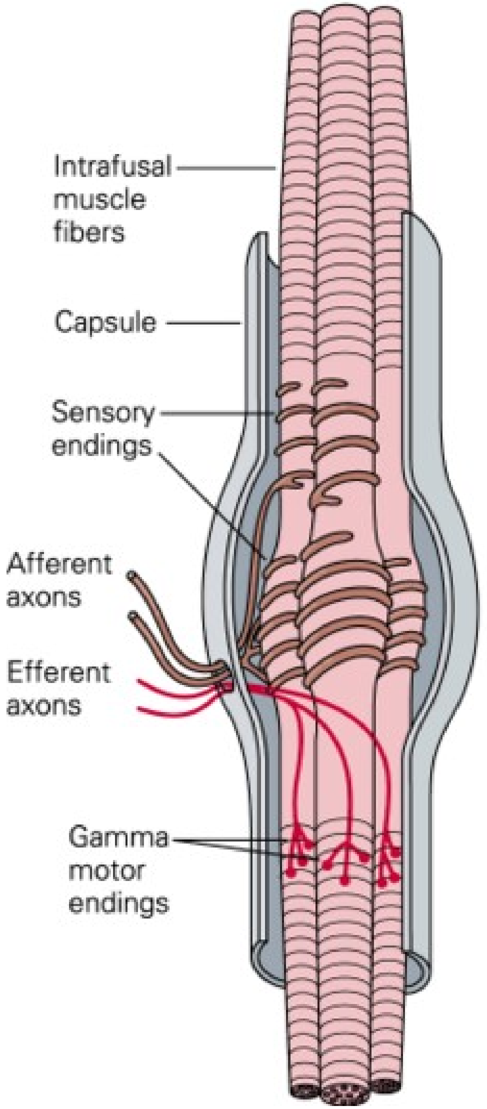
Muscle spindles

- Nno-force generating contractile structures
- The contractility is for spindle length adjustment
- Encapsulated structure filled with a fluid
- Intrafusal fibers



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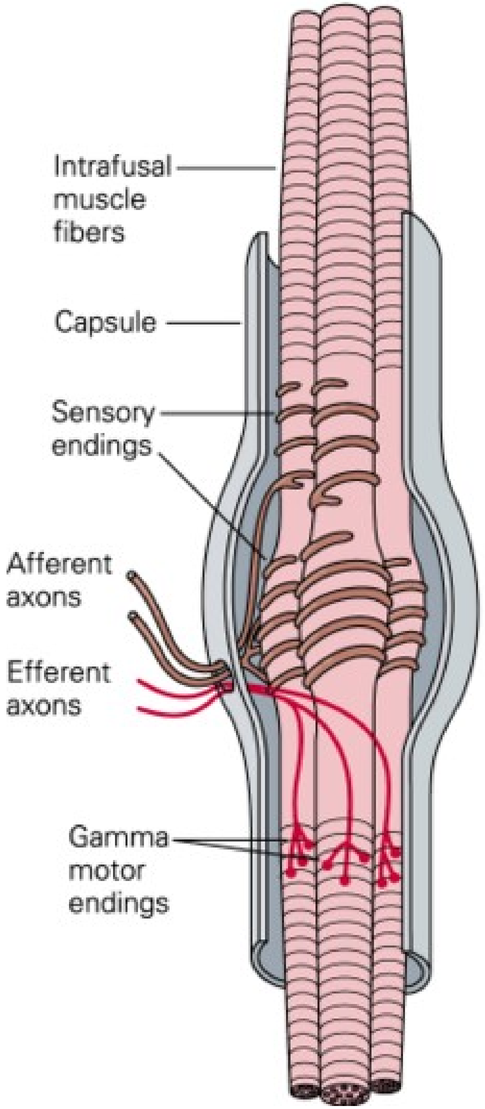
Muscle spindles

- Nno-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



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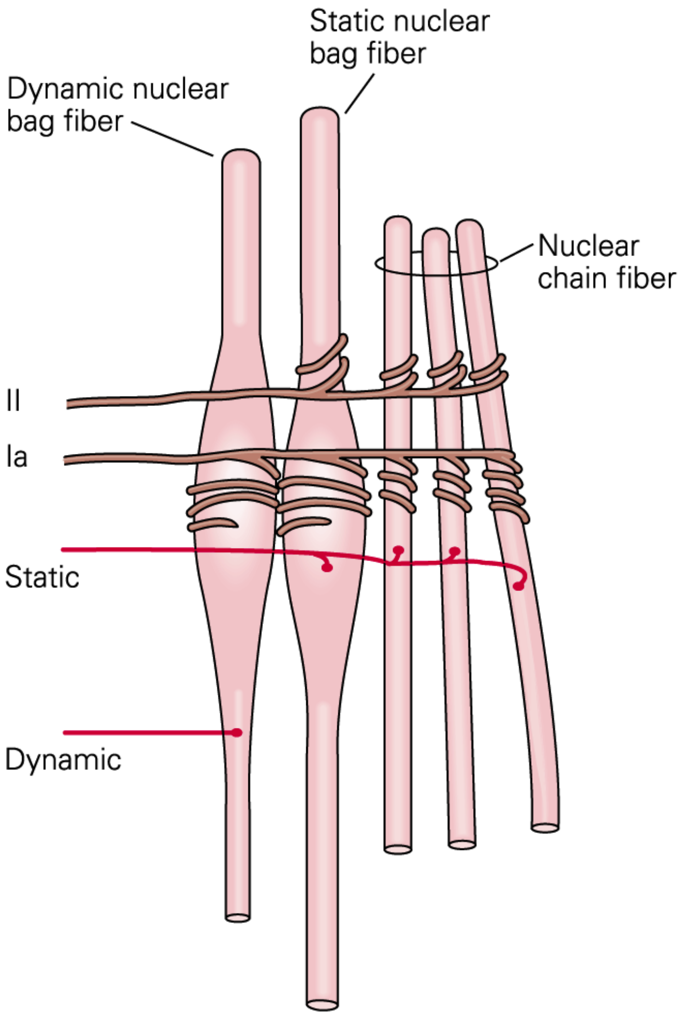
Muscle spindles

- 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



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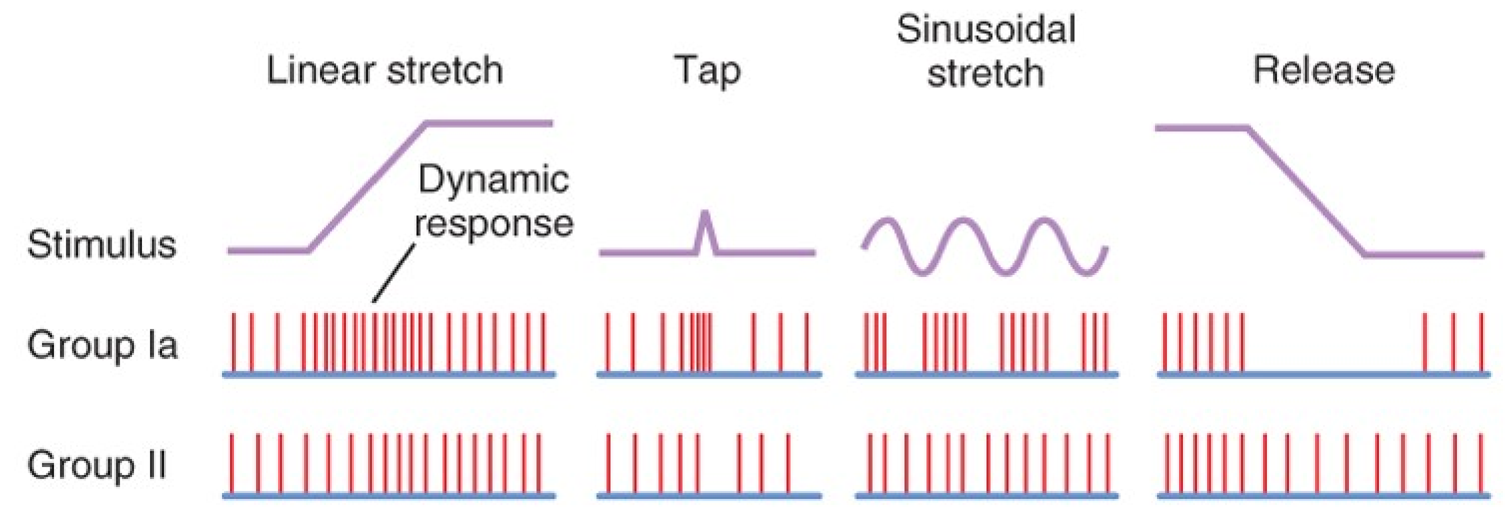
Afferent signaling from muscle spindles



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II – Static fibers

- Static response

Ia – Static and dynamic fibers

- Static and dynamic response

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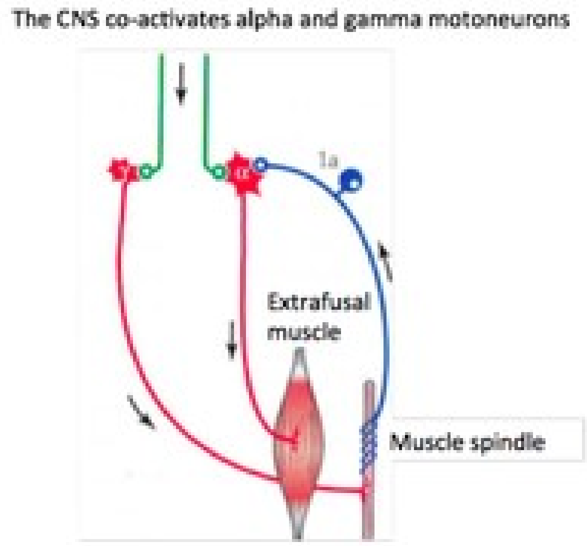
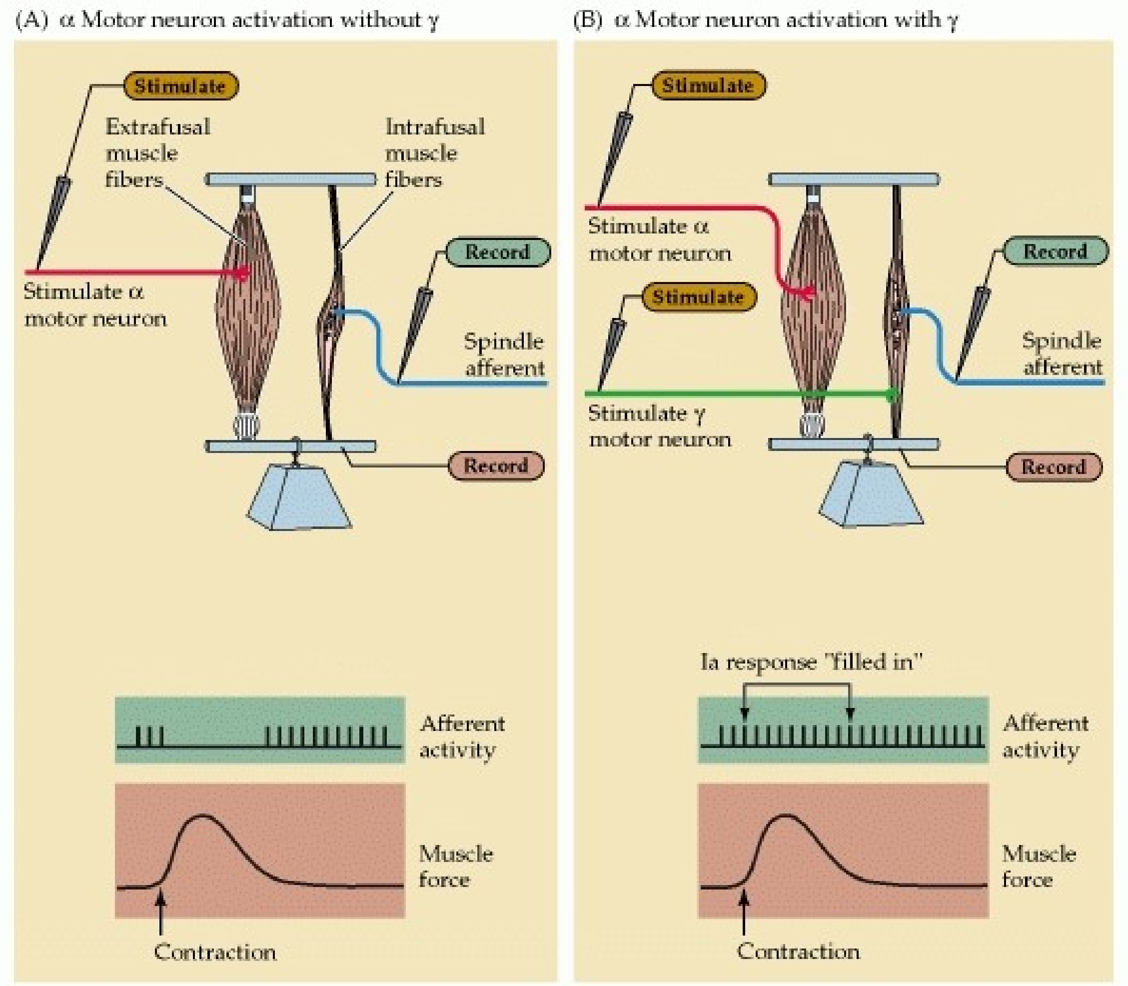
Efferent signaling into the muscle spindle

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





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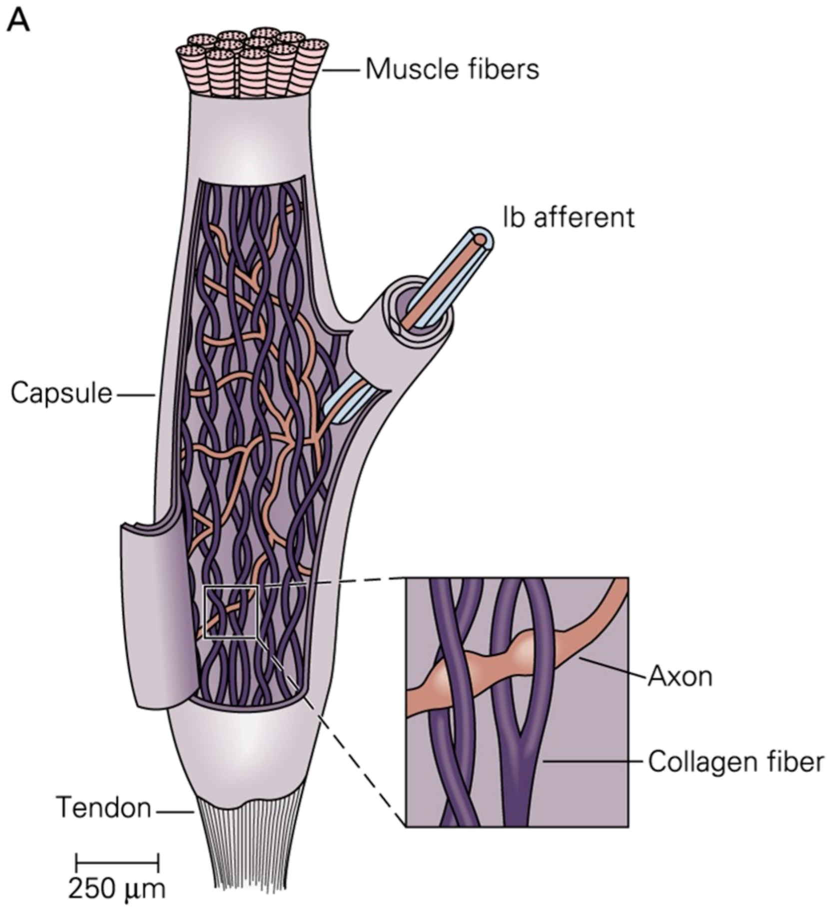
Golgi tendon organs

- 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



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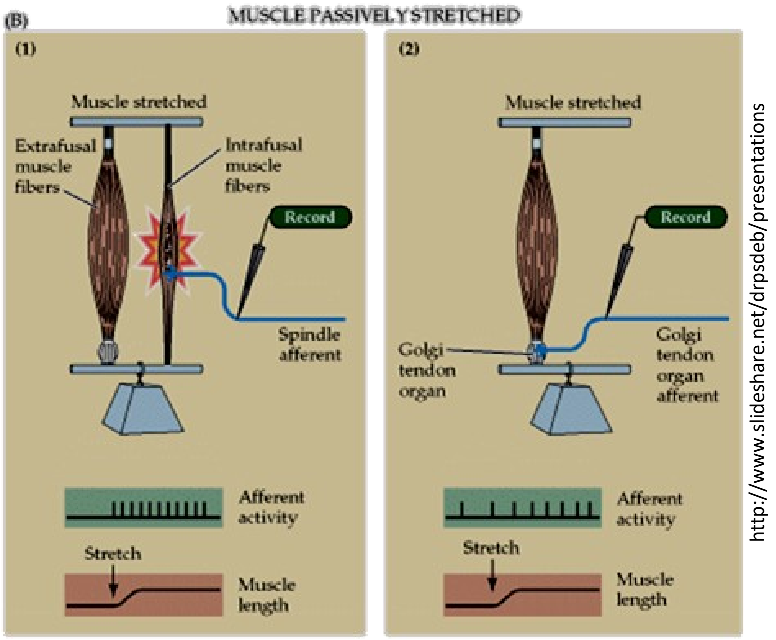
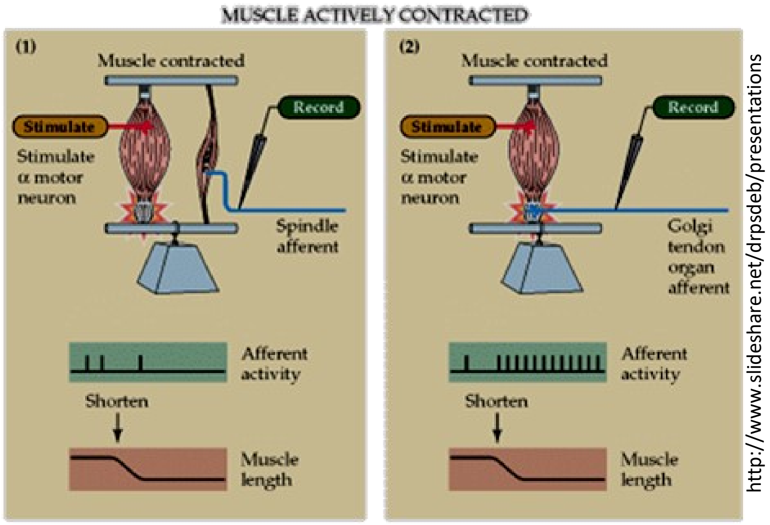
Reaction of muscle spindles and the Golgi tendon organs to muscle fiber stretch/contraction





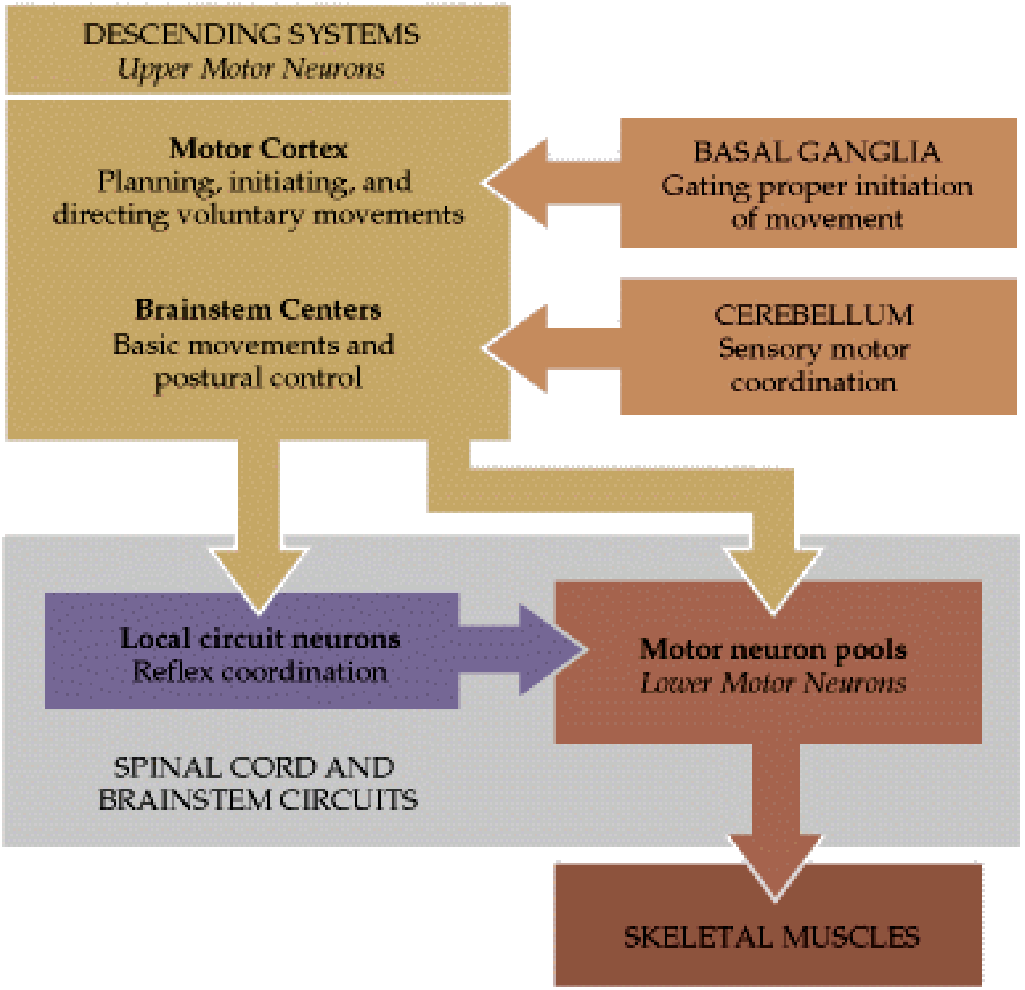
Stretch (passive)

Muscle spindles reaction

Contraction (active)

Golgi tendon organ reaction

Hierarchic organization of motor system



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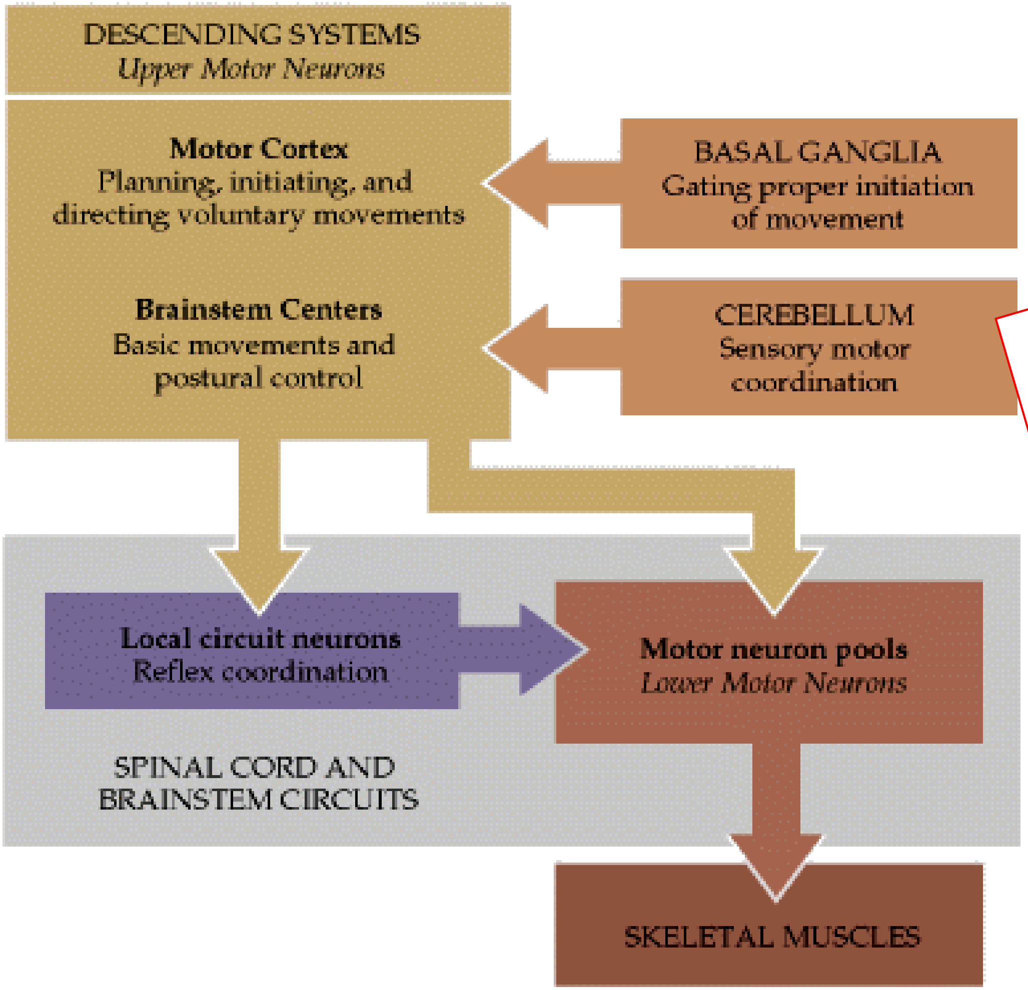
Hierarchic organization of motor system



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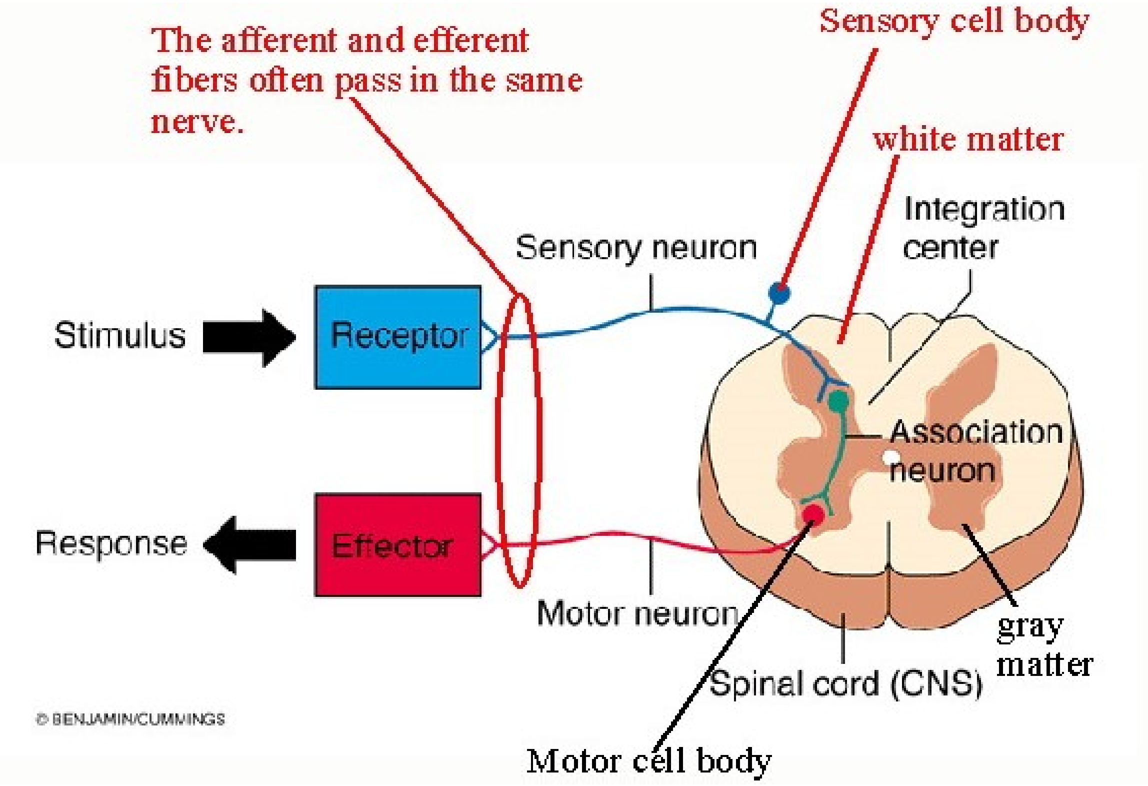
Reflex

- Reflex movement
  - Stereotype (predictable)
  - Involuntary

- Proprioceptive
- Exteroceptive

- Monosynaptic
- Polysynaptic

- Monosegmental
- Polysegmental



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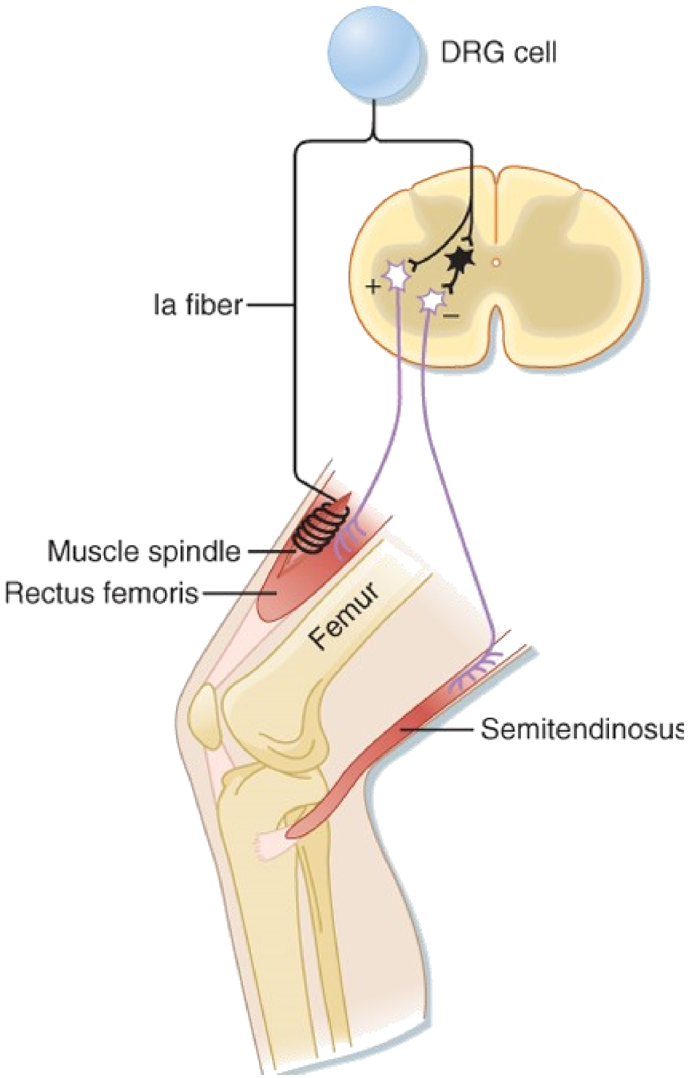
Proprioceptive reflexes

- **Myotatic reflex**
  - Monosynaptic
  - Monosegmental
  - Muscle spindle
  - ➢ Homonymous muscle - activation
  - ➢ Antagonist muscle - inhibition
- ✓ Phasic response (Ia)
  - Protection against overstretch of extrafusal fibrers
- ✓ Tonic response (Ia a II)
  - Maintains muscle tone



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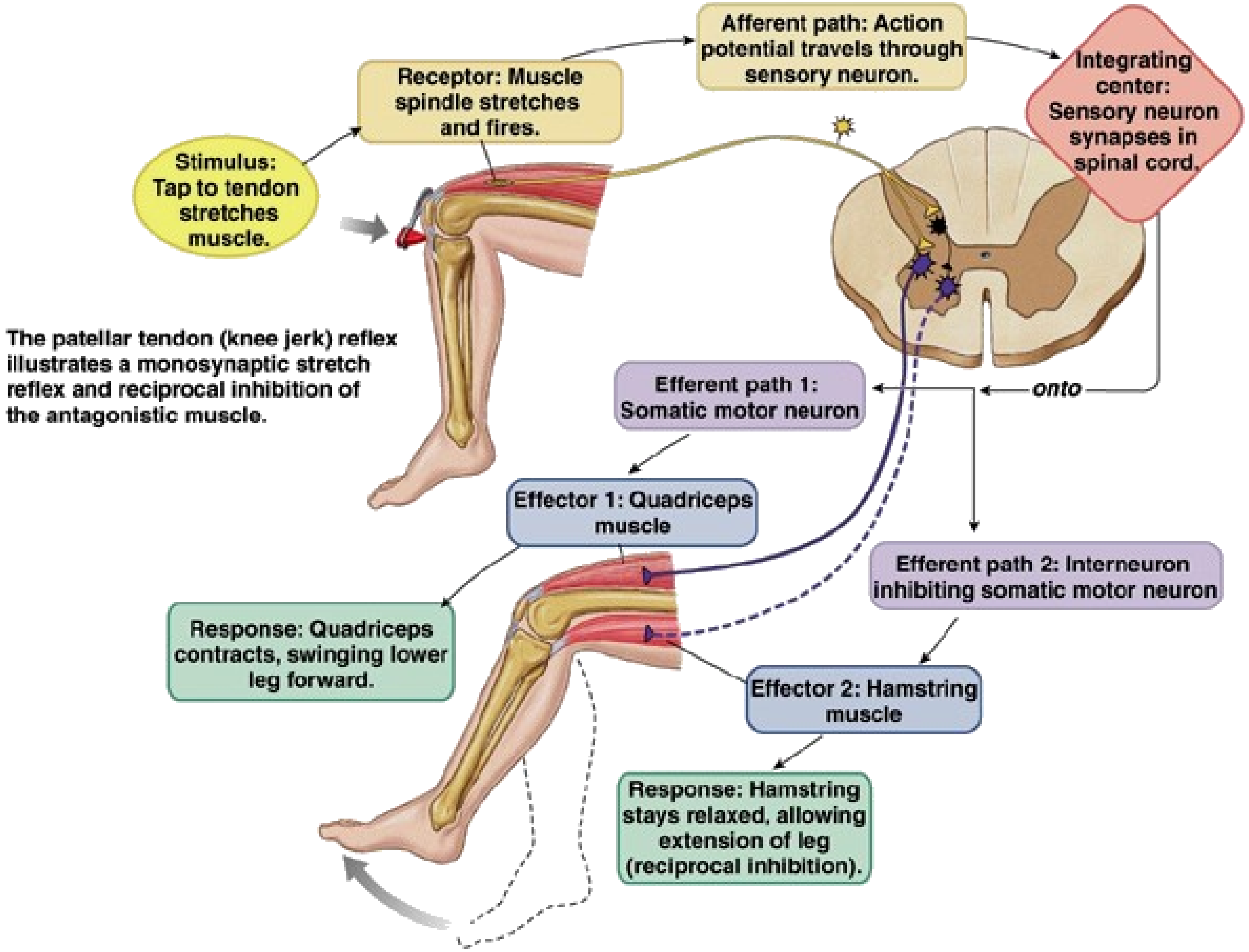

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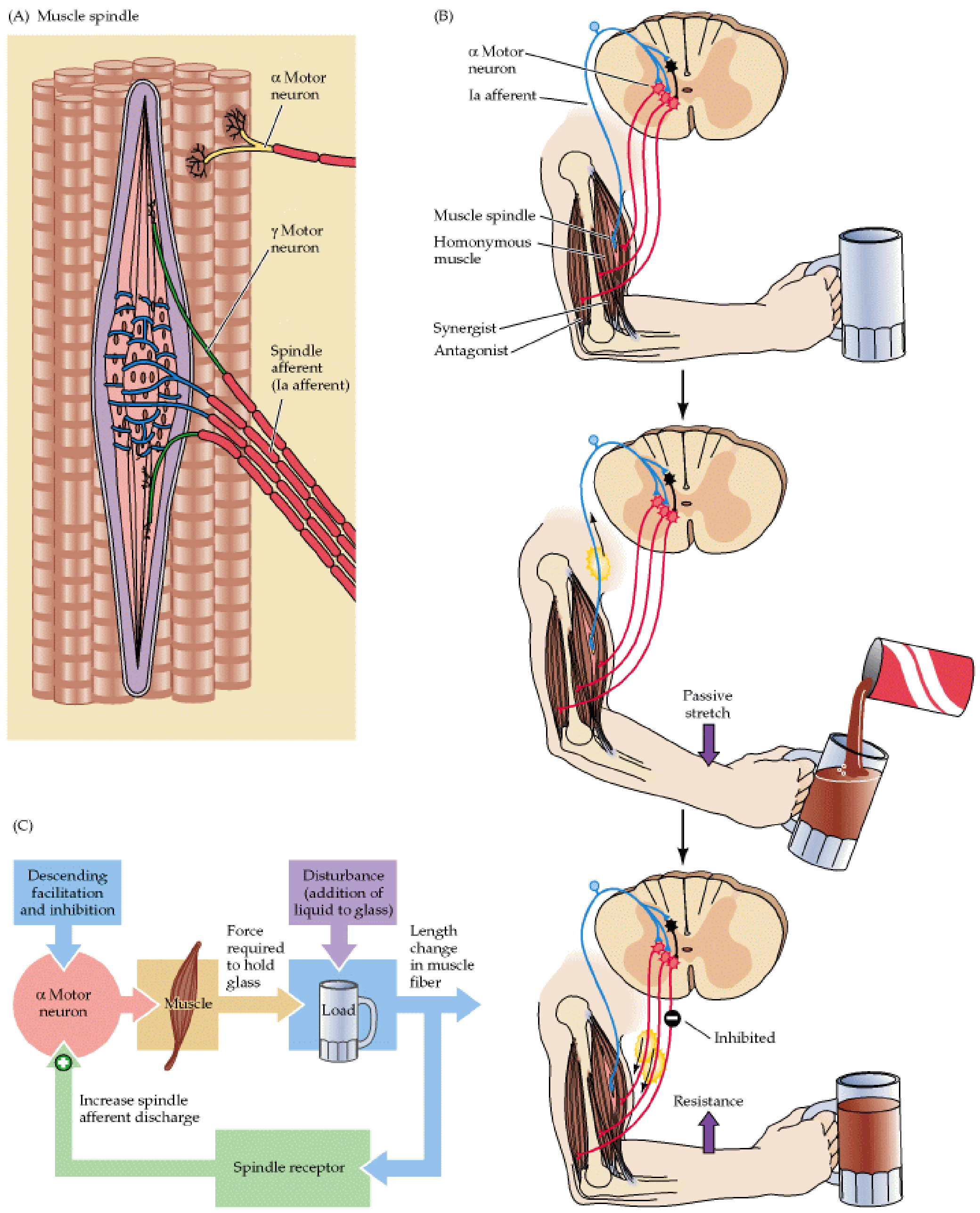

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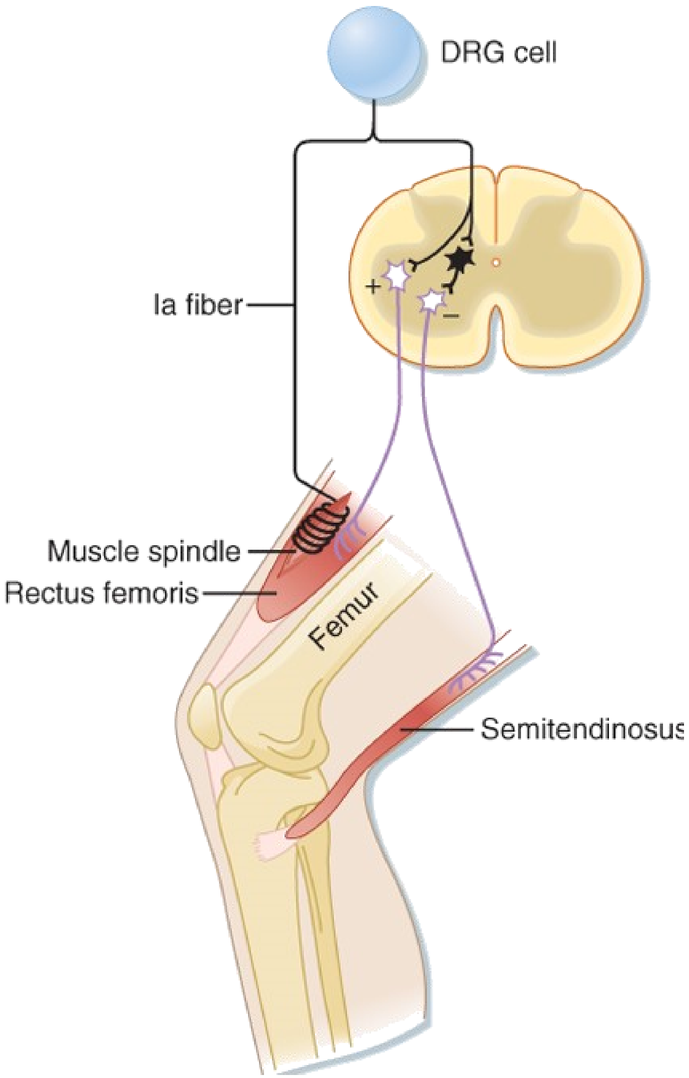
Proprioceptive reflexes

- **Inverse myotatic reflex**
  - Monosegmental
  - Disynaptic/polysynaptic
  - Golgi tendon organ

  ➢ Homonymous muscle – inhibition
  ➢ Antagonist muscle– activation

✓ Protection against muscle damage caused by extensive force



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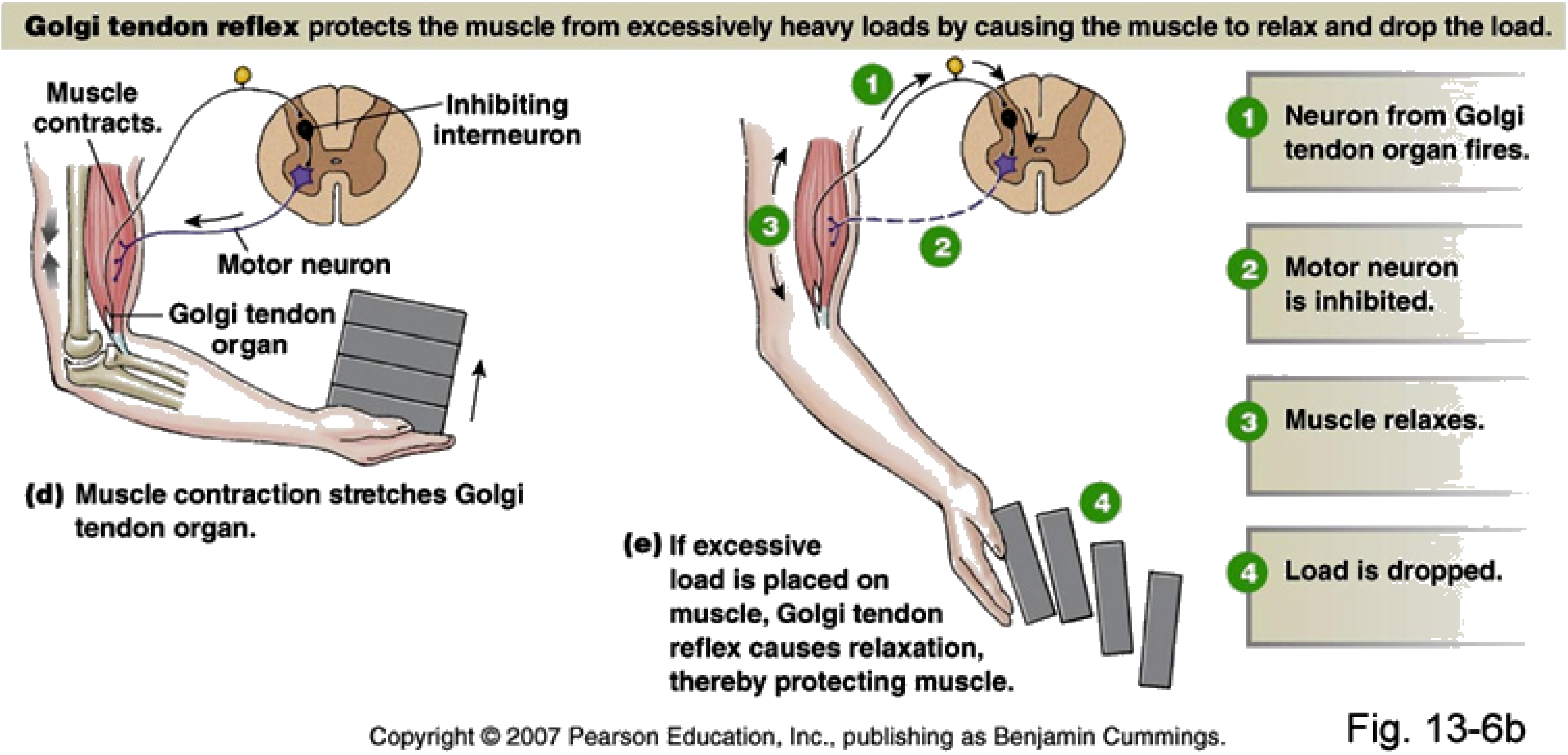

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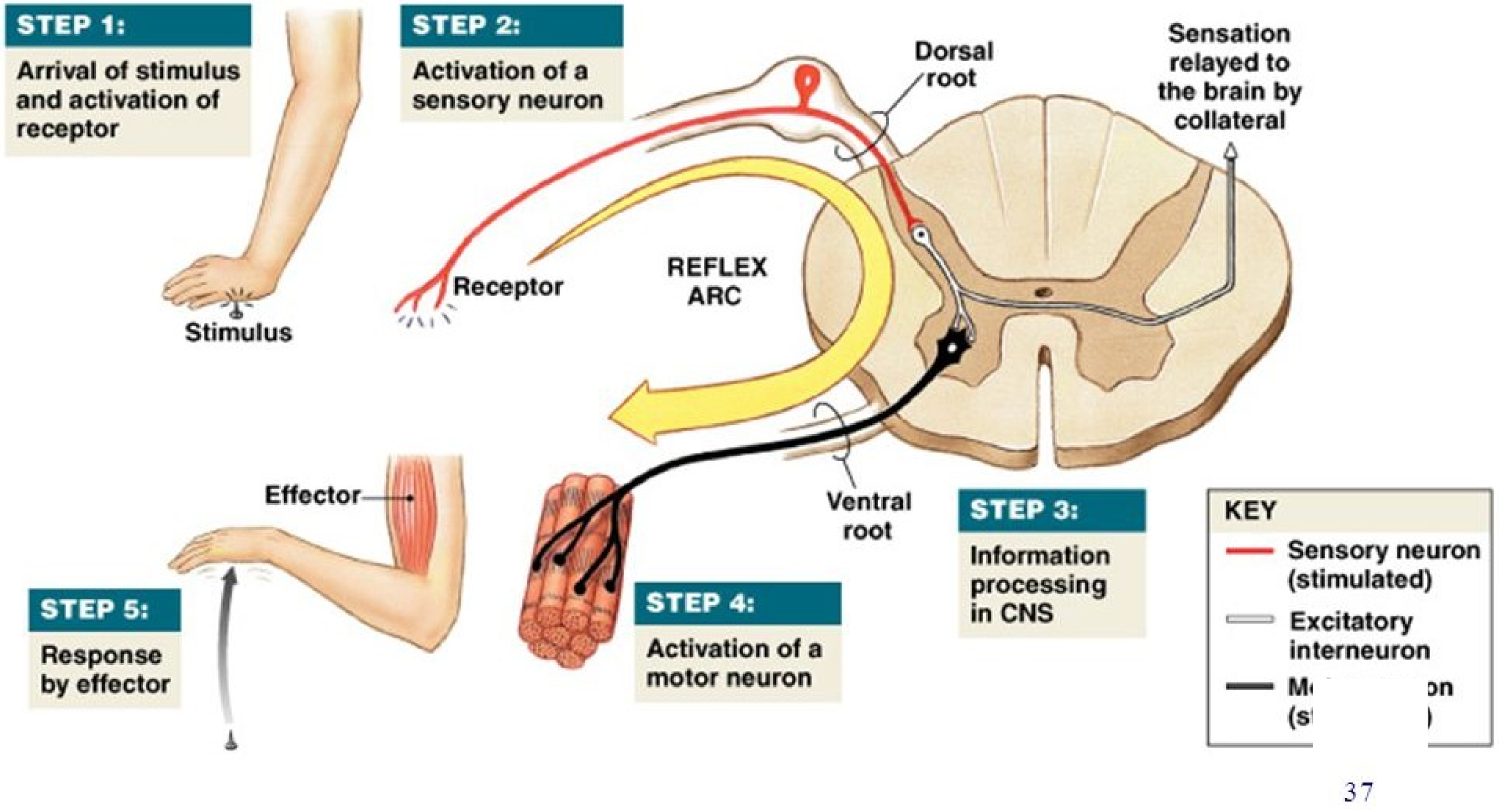
Exteroceptive reflexes

- Polysynaptic
- Polysegmental



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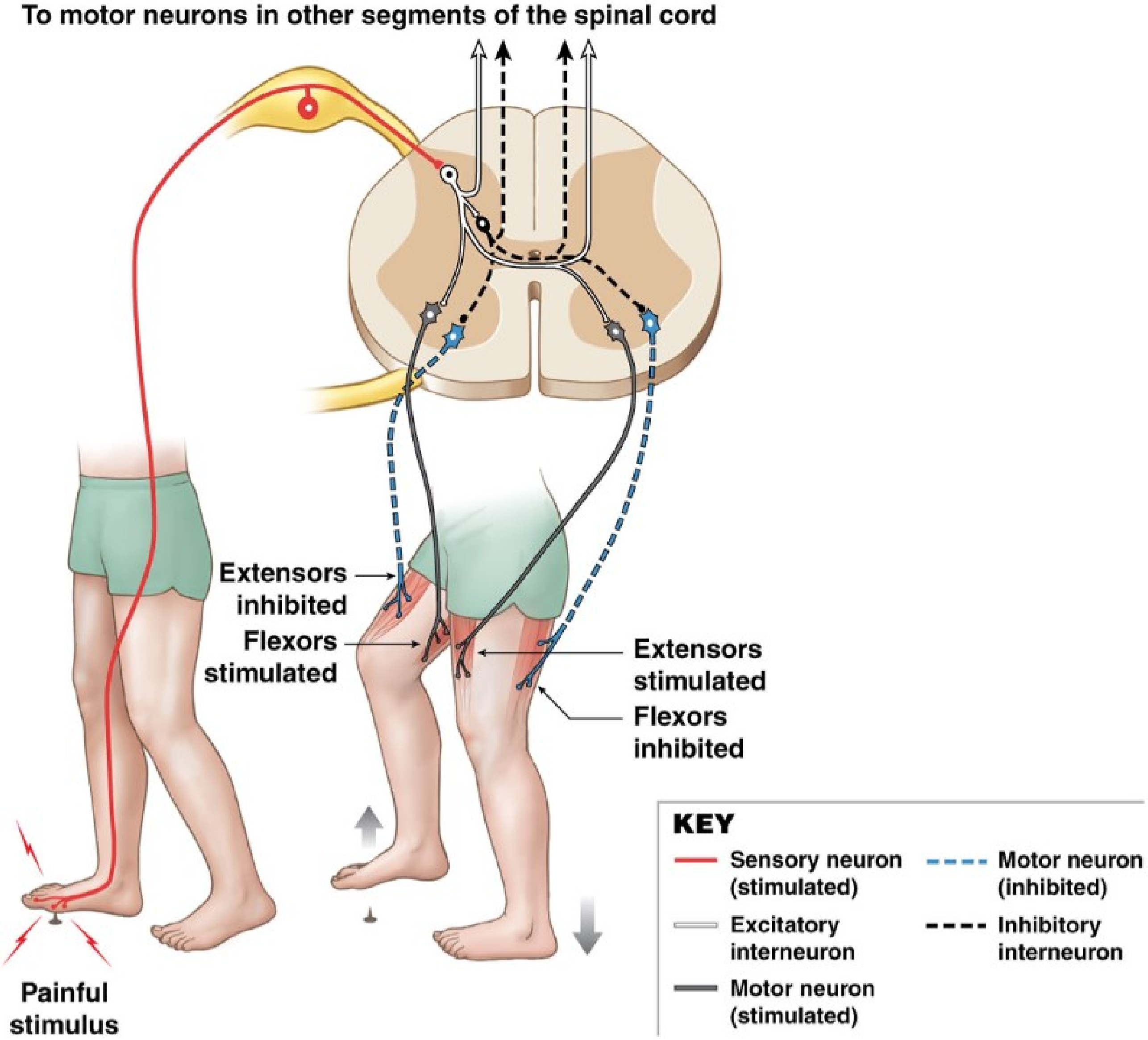
Exteroceptive reflexes

- Polysynaptic
- Polysegmental



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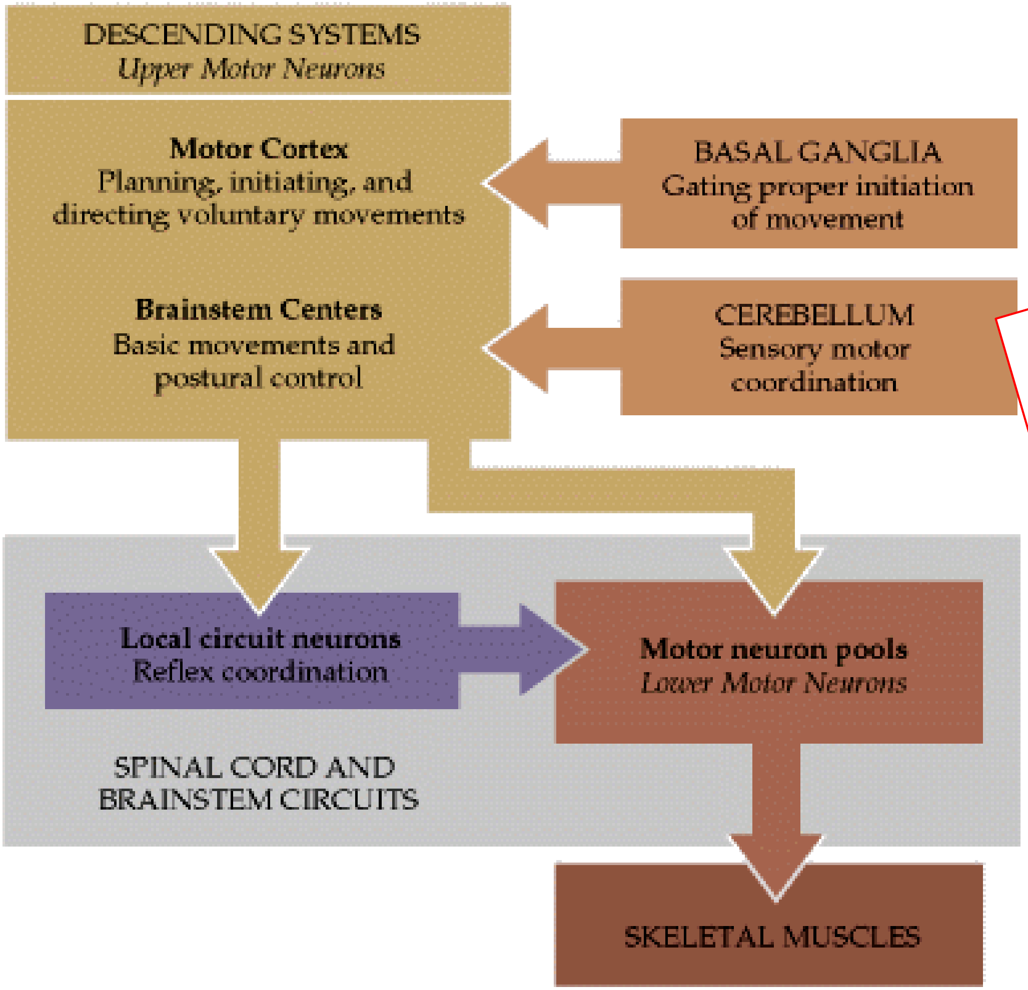
Hierarchic organization of motor system



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Reflex movement
Rhythmic movement
Voluntary movement

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79. Upper and lower motor neuron, neuromuscular junction, muscle contraction

- Upper and lower motor neuron localization and function
- Lower motor neuron
  - Only the structure responsible for muscle contraction
  - Part of local reflex circuit
  - Overview of structures and main pathways controlling lower motor neuron (protprioception, higher leves of CNS including upper motor neuron, medial system, lateral system tr. corticospinalis, sorticobulbaris…)
  - Types of lower motor neurons (alpha, gamma, beta)
- Upper motor neuron
  - Primary motor cortex, homunculus
- Motor unit definition
- Neuromuscular junction descrition
- Muscle contraction description

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80. Hierarchic organization of motor system – reflex vs. voluntary motor activity

- Hierarchy of movement
  - Reflex – economical, uniform, protective, fast
  - Rhytmic – economical solution for complex uniform actions (breathing, walking…)
  - Voluntary – non-economical, unique, relatively slow
- Classification and description of reflexes
- Fixed action pattern and rhythmic movement (definition and examples)
- Voluntary motor control
  - Overview of structures involved in planning and execution of voluntary motor activity
  - Motor cortex organization (primary, premotor and supplementray motro cortex…)
  - Brief description of pyramidal tract

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