

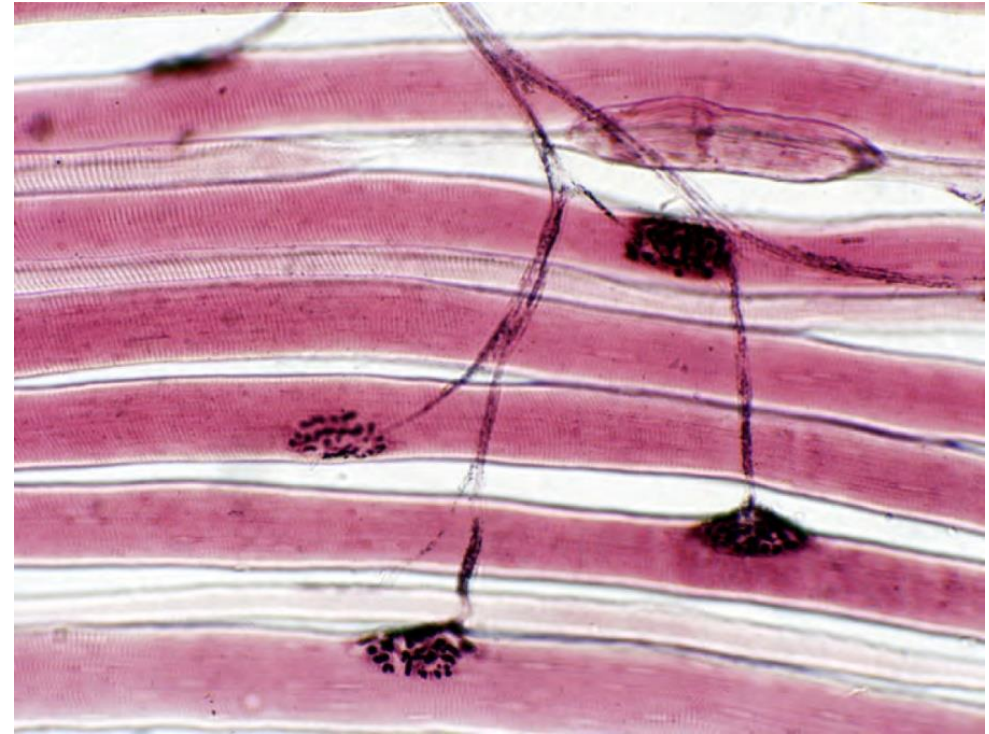
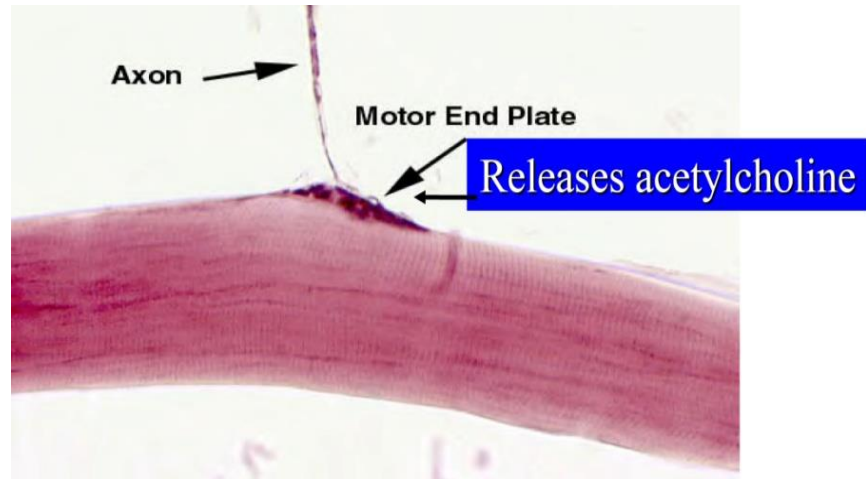
# Neuromuscular junction and Molecular basis of skeletal muscle contraction

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**VETS30015 / VETS90121**

# Neuromuscular Junction

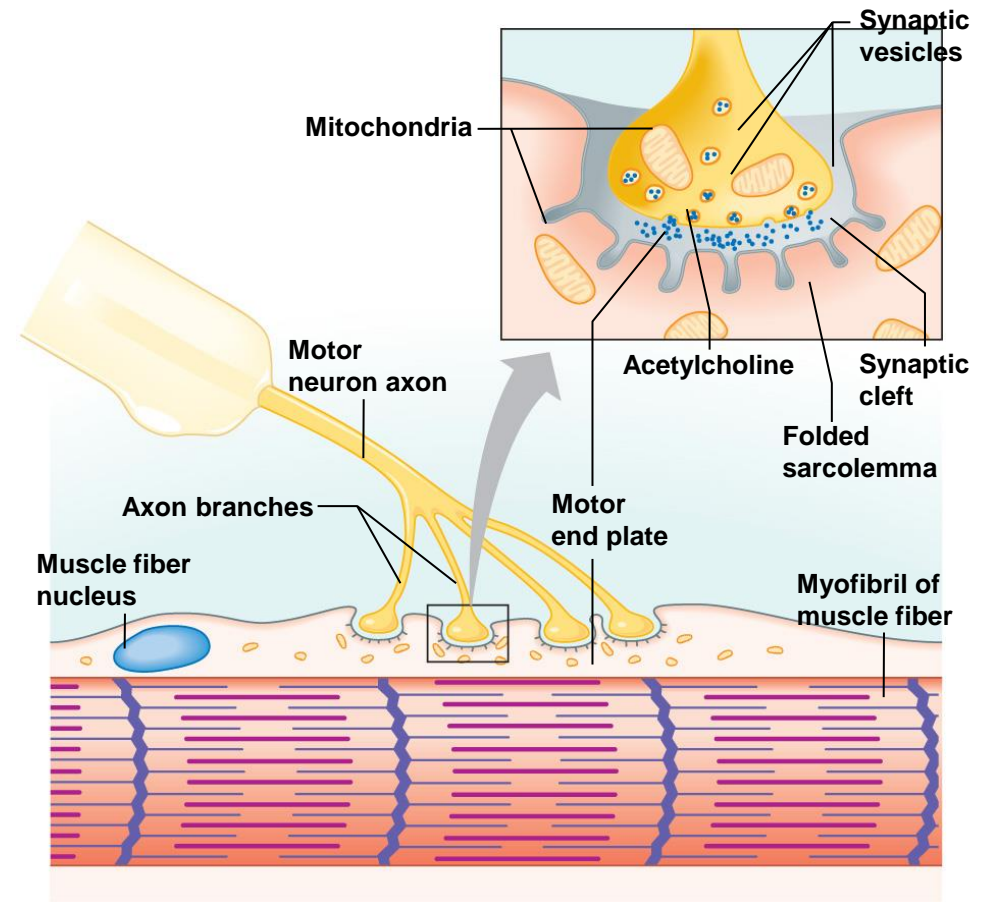


# Neuromuscular Junction

- Also known as NMJ or myoneural junction
- Site where an axon and muscle fiber meet

## Parts to know:

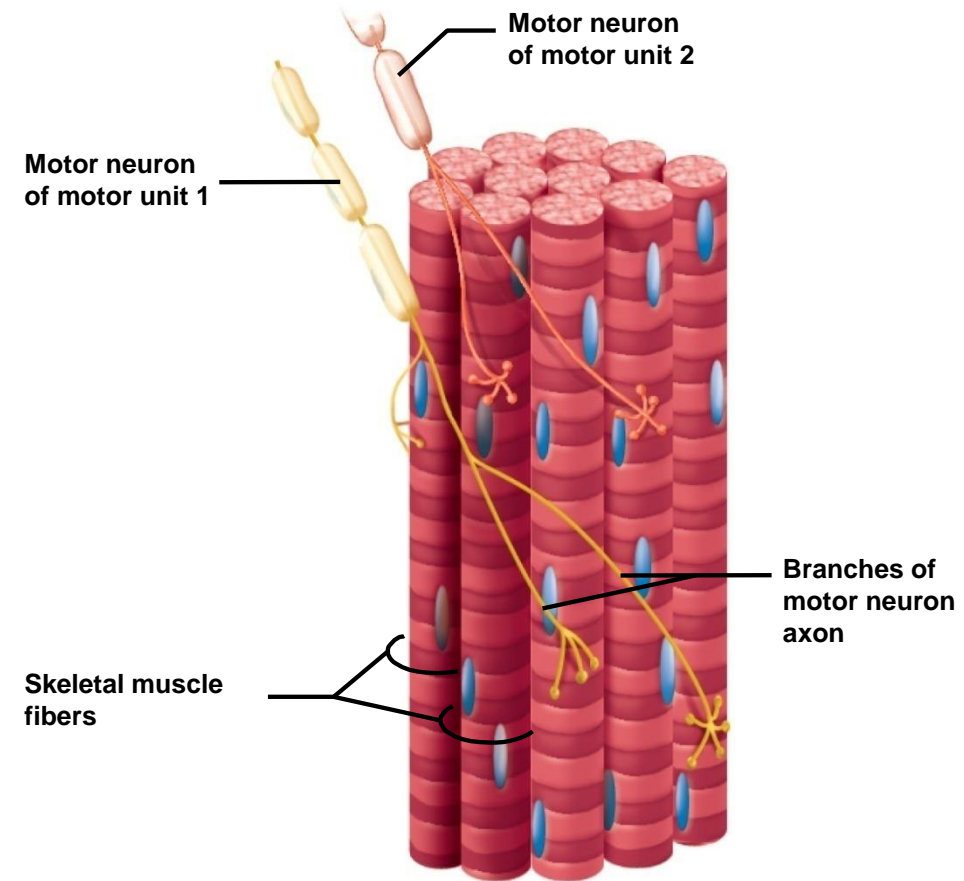
- Motor neuron
- Motor end plate (synapse)
- Synaptic cleft
- Synaptic vesicles
- Neurotransmitters



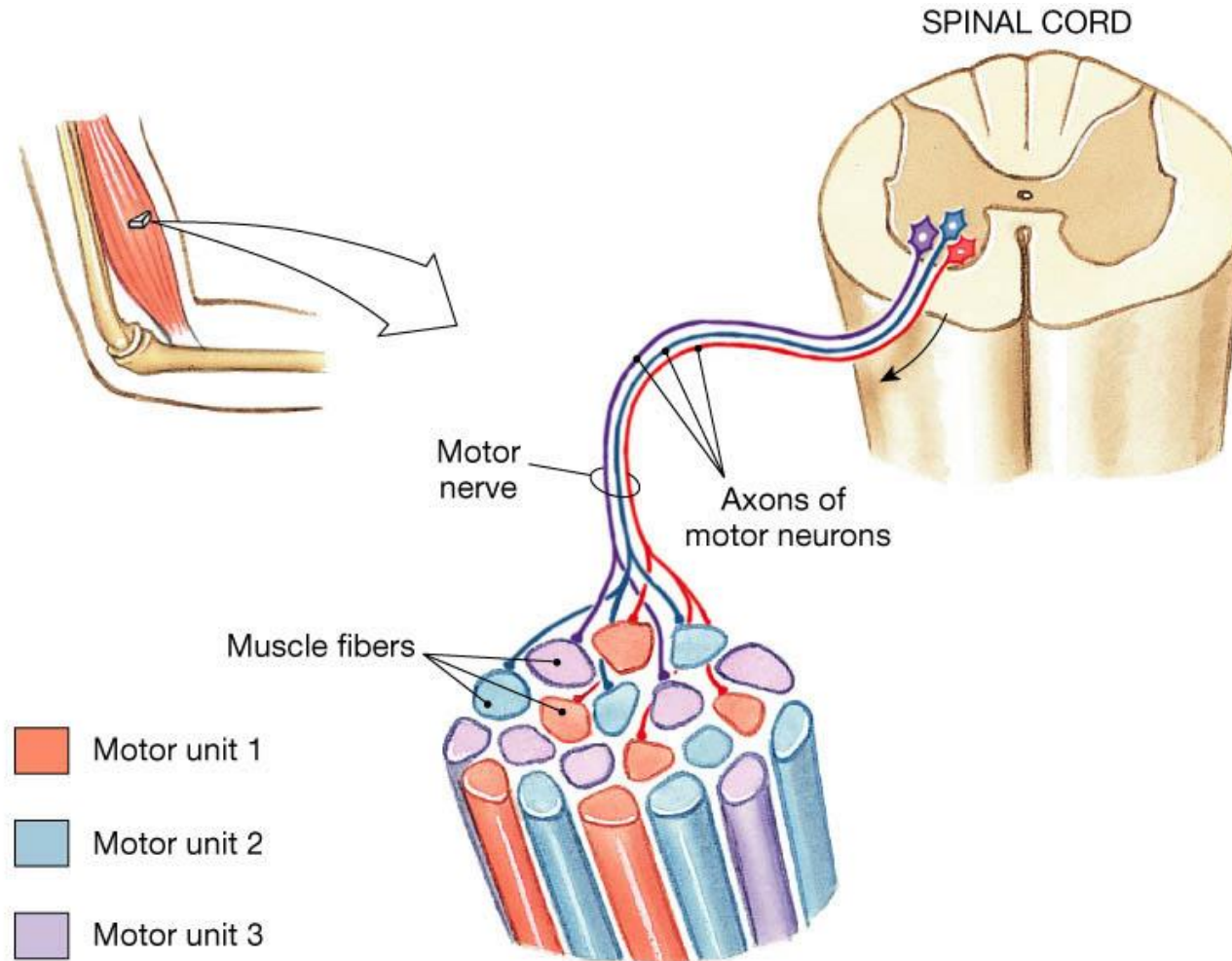


# Motor Unit

- Single motor neuron and all muscle fibers controlled by the motor neuron
- As few as four fibers
  - As many as 1000's of muscle fibers

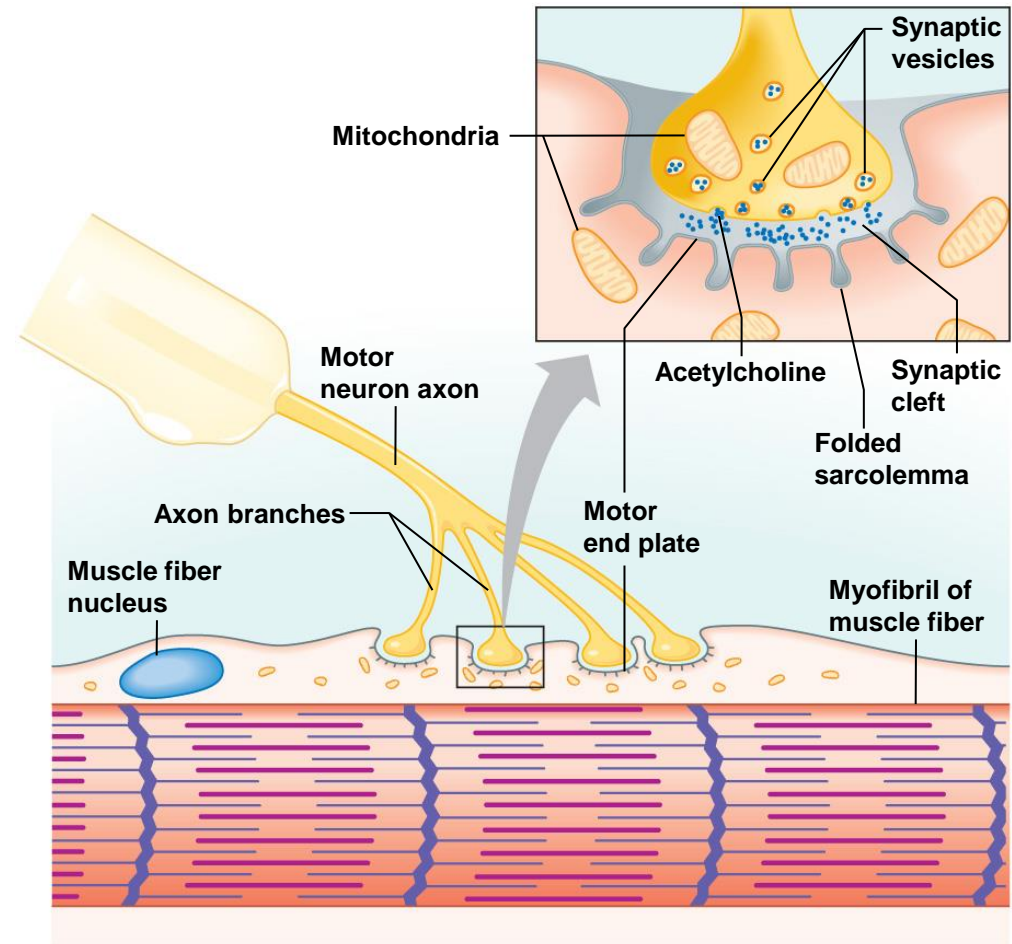


# Motor Unit

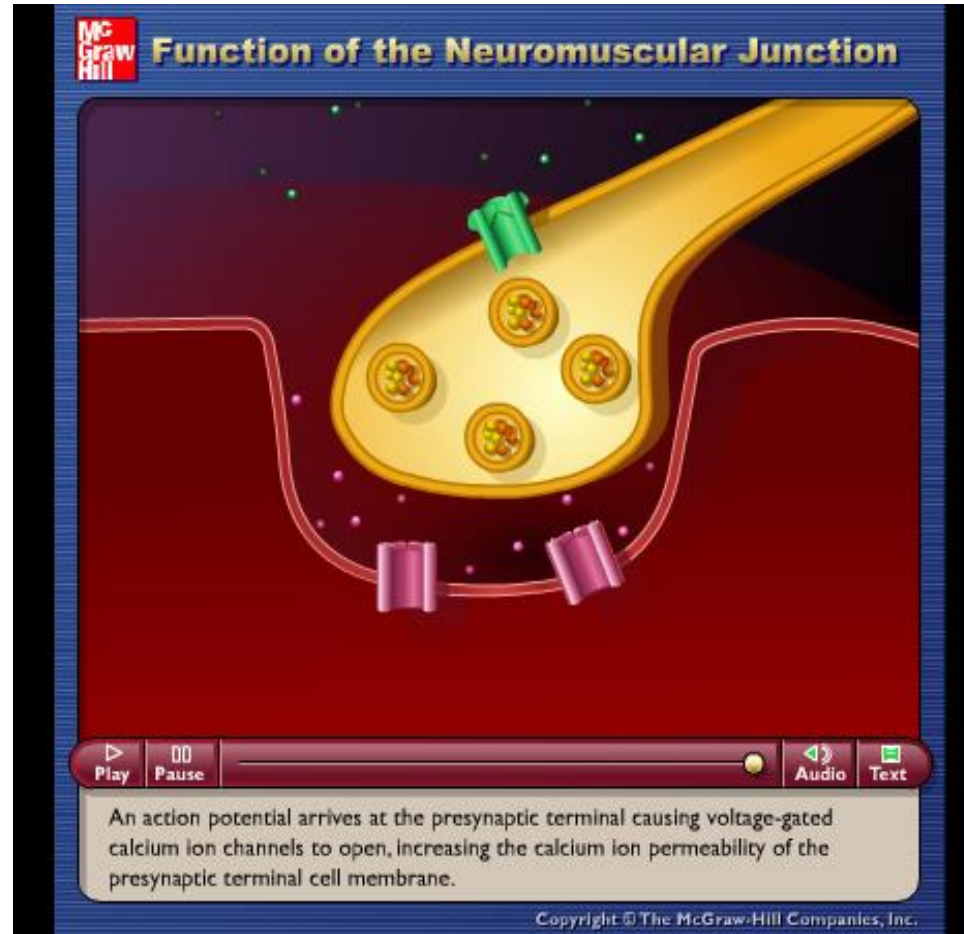


# Stimulus for Contraction

- Acetylcholine (ACh)
- Nerve impulse causes release of ACh from synaptic vesicles
- ACh binds to ACh receptors on motor end plate
- Generates a muscle impulse
- Muscle impulse eventually reaches the SR and the cisternae

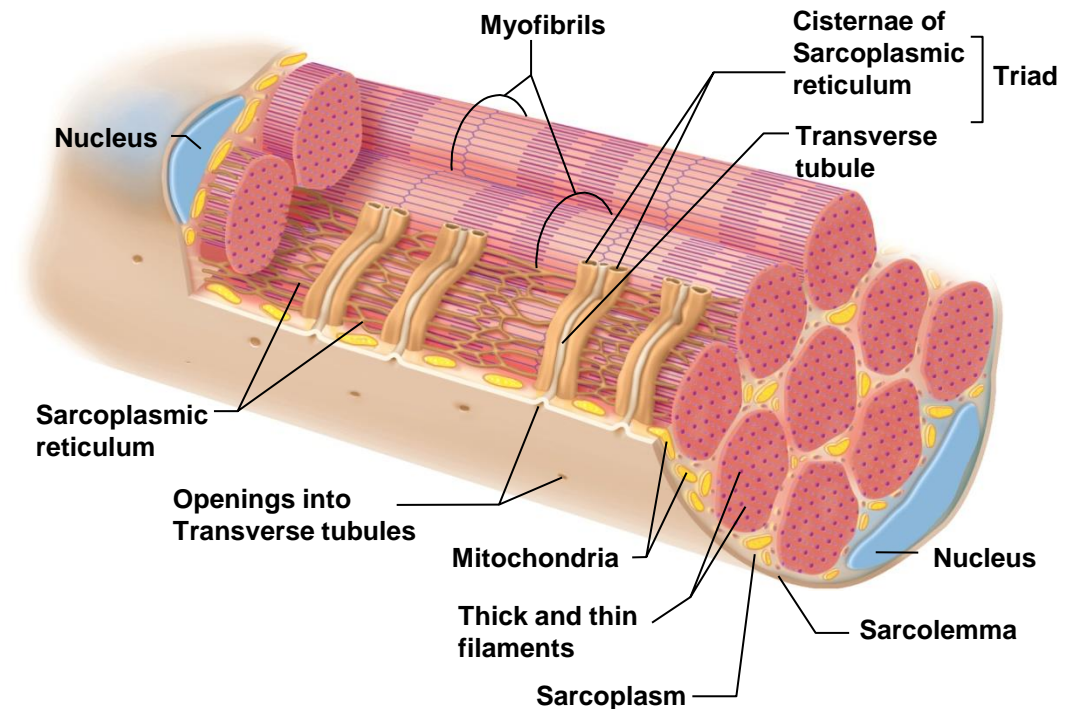


# Animation: Function of the Neuromuscular Junction



# Skeletal Muscle Fibers

- Sarcolemma
- Sarcoplasm
- Sarcoplasmic reticulum (SR)
- Transverse ('T') tubule
- Triad
  - Cisternae of SR
  - T tubule
- Myofibril
- Actin myofilaments
- Myosin myofilaments
- Sarcomere

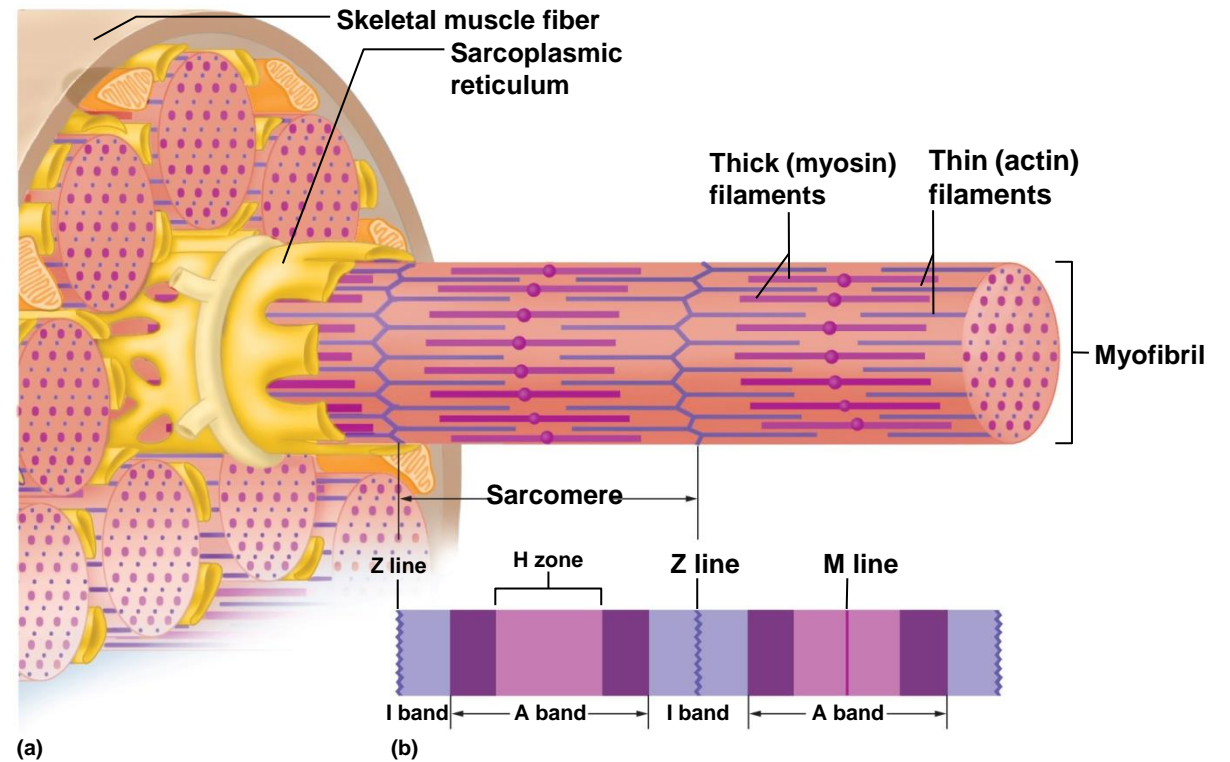


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# Skeletal Muscle Contraction

- Movement within the myofilaments
- I band (thin)
- A band (thick and thin)
- H zone (thick)
- Z line (or disc)
- M line



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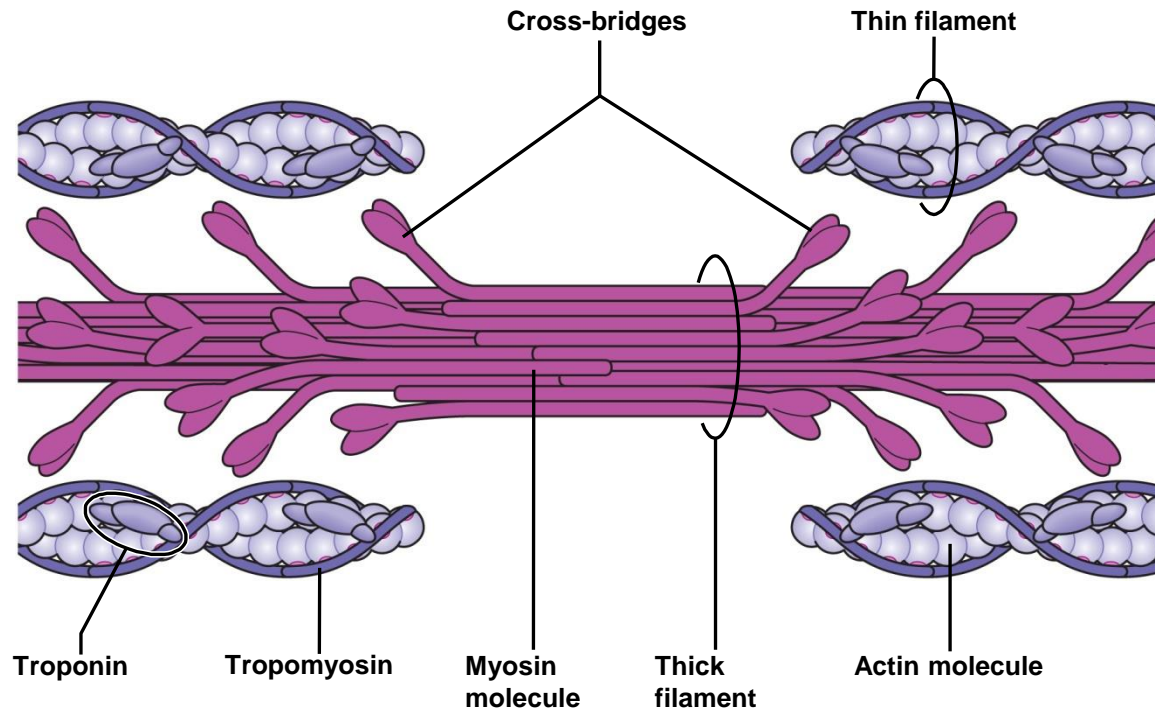
# Myofilaments

- **Thick myofilaments**

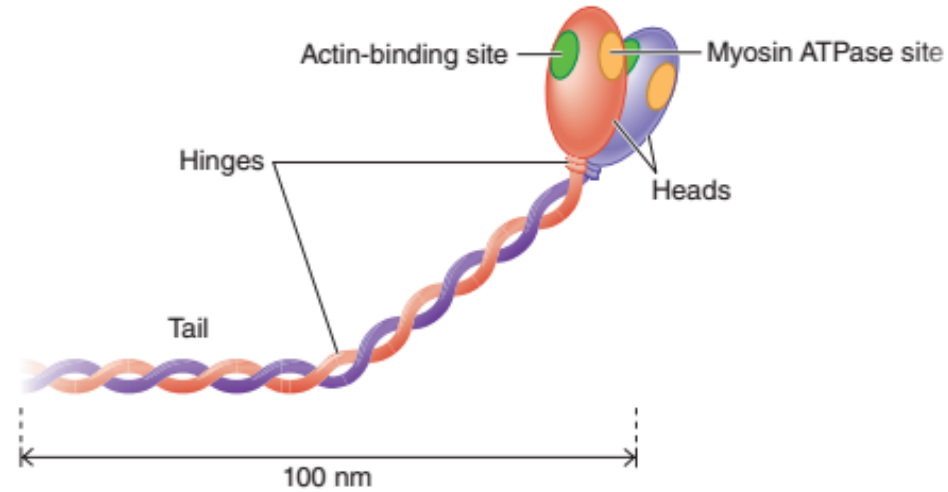
- Composed of myosin protein
- Form the cross-bridges

- **Thin myofilaments**

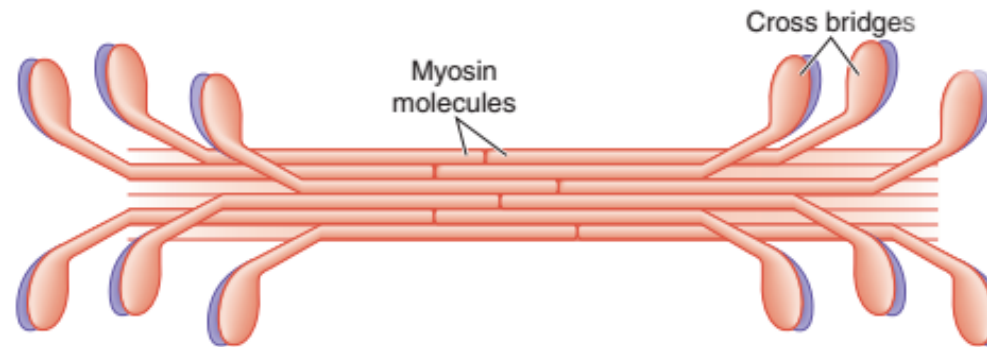
- Composed of actin protein
- Associated with troponin and tropomyosin proteins



# Thick Myofilaments

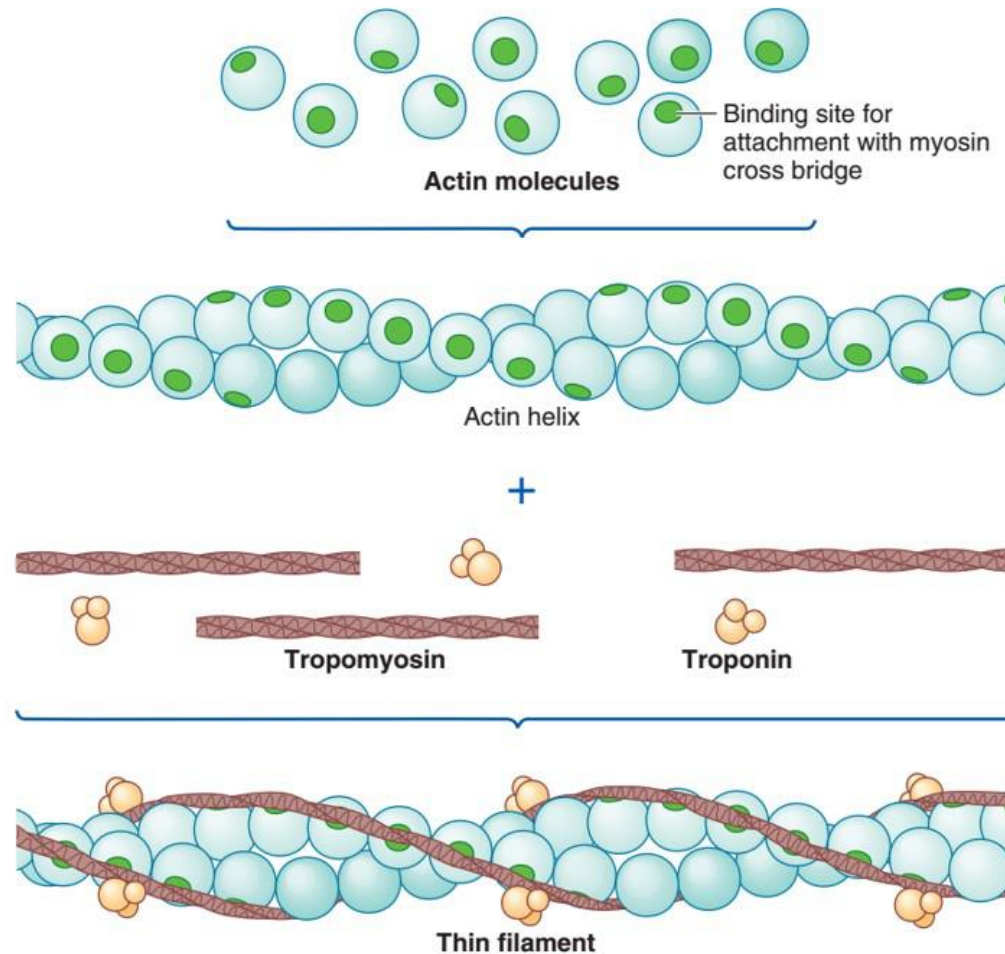


(a) Myosin molecule



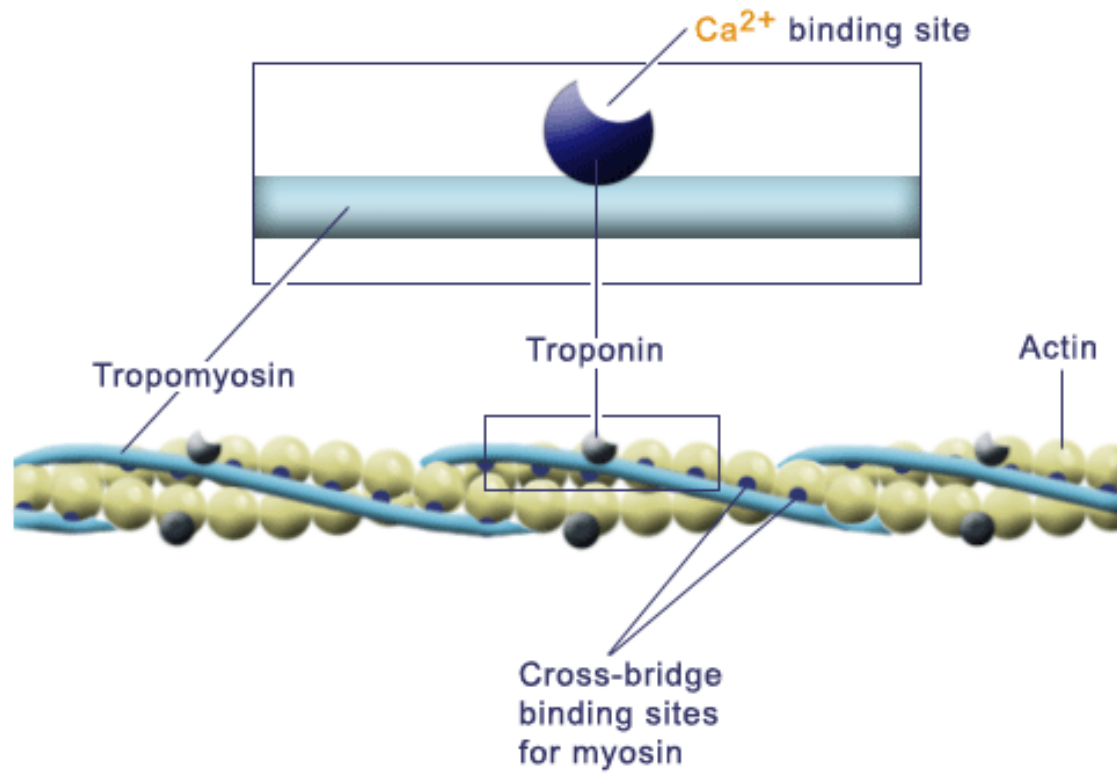
(b) Thick filament

# Thin Myofilaments



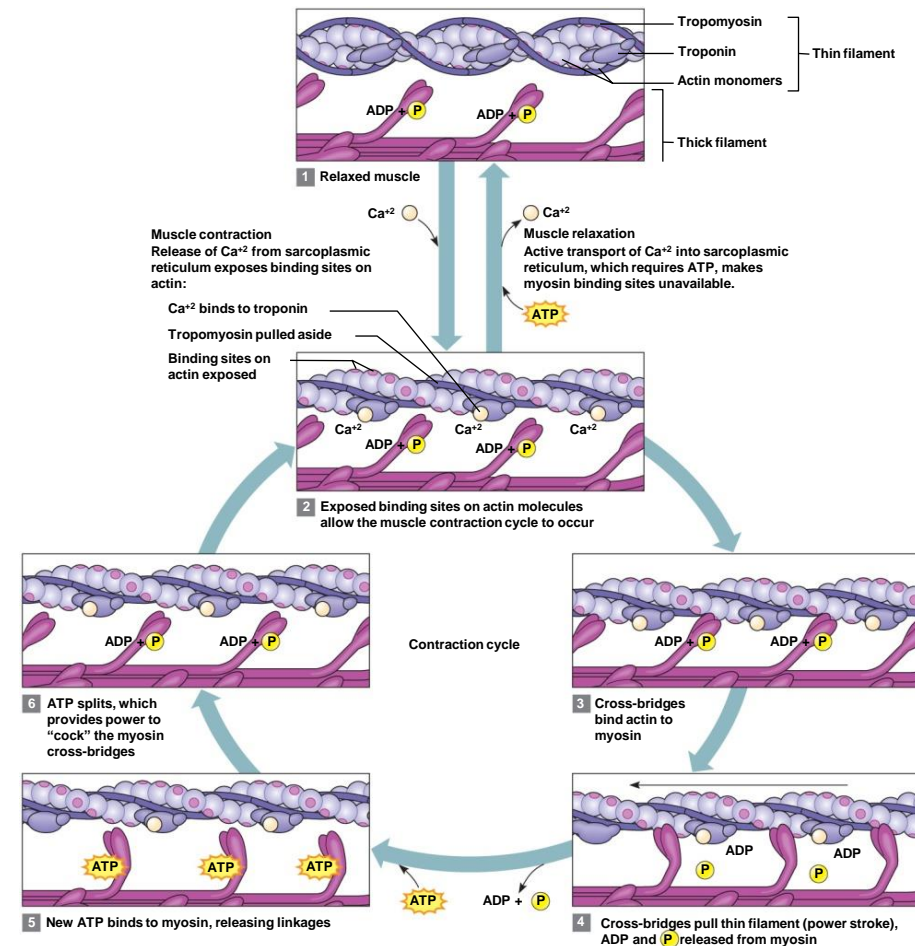


# Thin Myofilaments

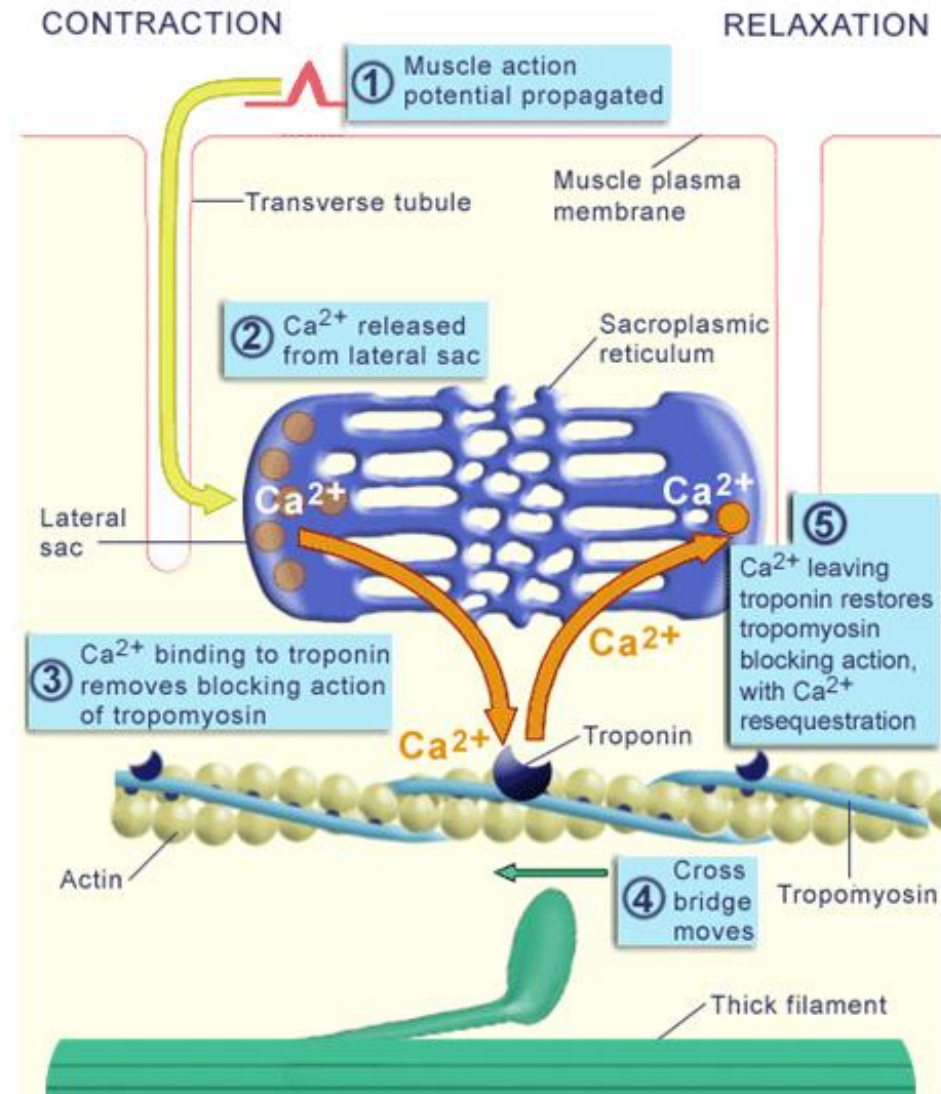


# Excitation-Contraction Coupling

- Muscle impulses cause SR to release calcium ions into cytosol
- Calcium binds to troponin to change its shape
- The position of tropomyosin is altered
- Binding sites on actin are now exposed
- Actin and myosin molecules bind via myosin cross-bridges

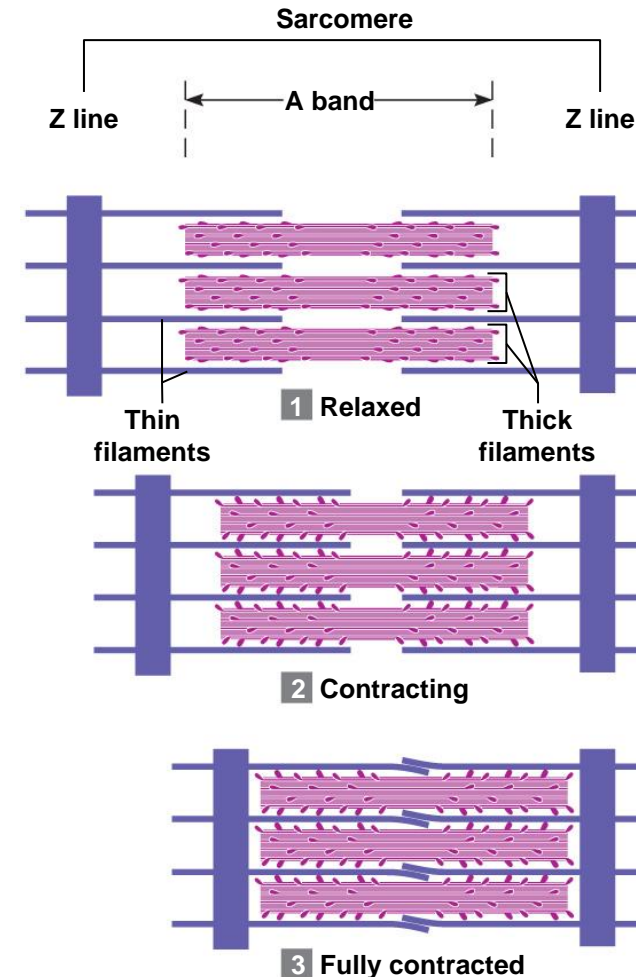


# Summary Role of Calcium



# The Sliding Filament Model of Muscle Contraction

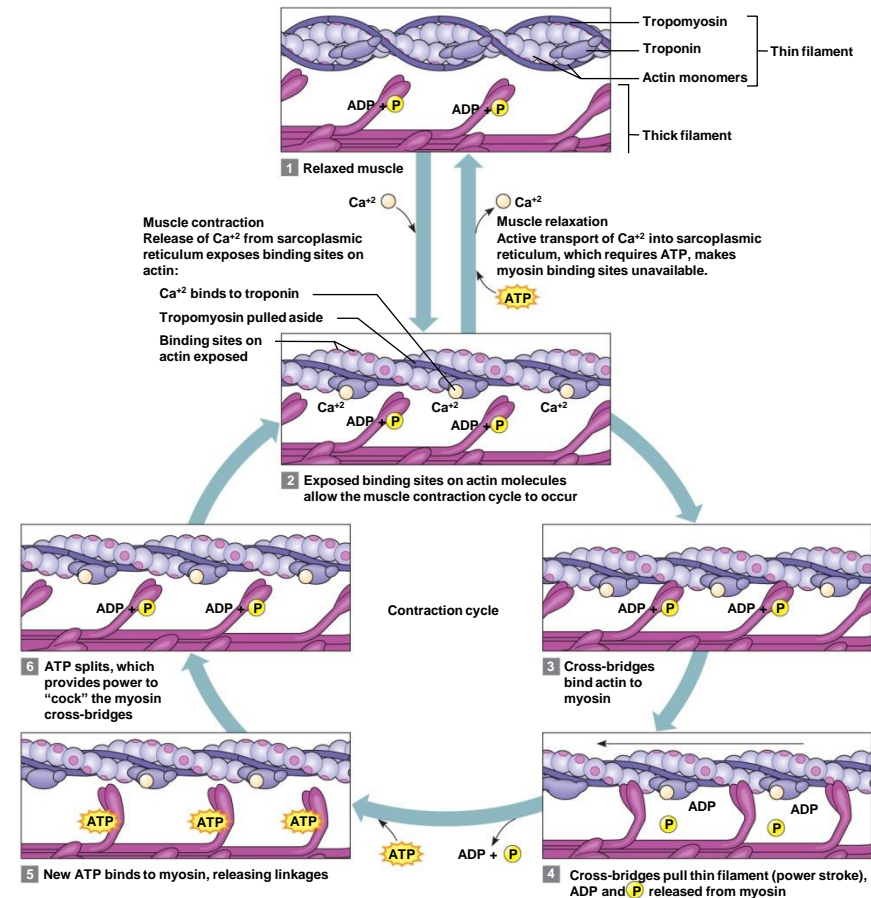
- When sarcomeres shorten, thick and thin filaments slide past one another
- H zones and I bands narrow
- Z lines move closer together





# Cross Bridge Cycling

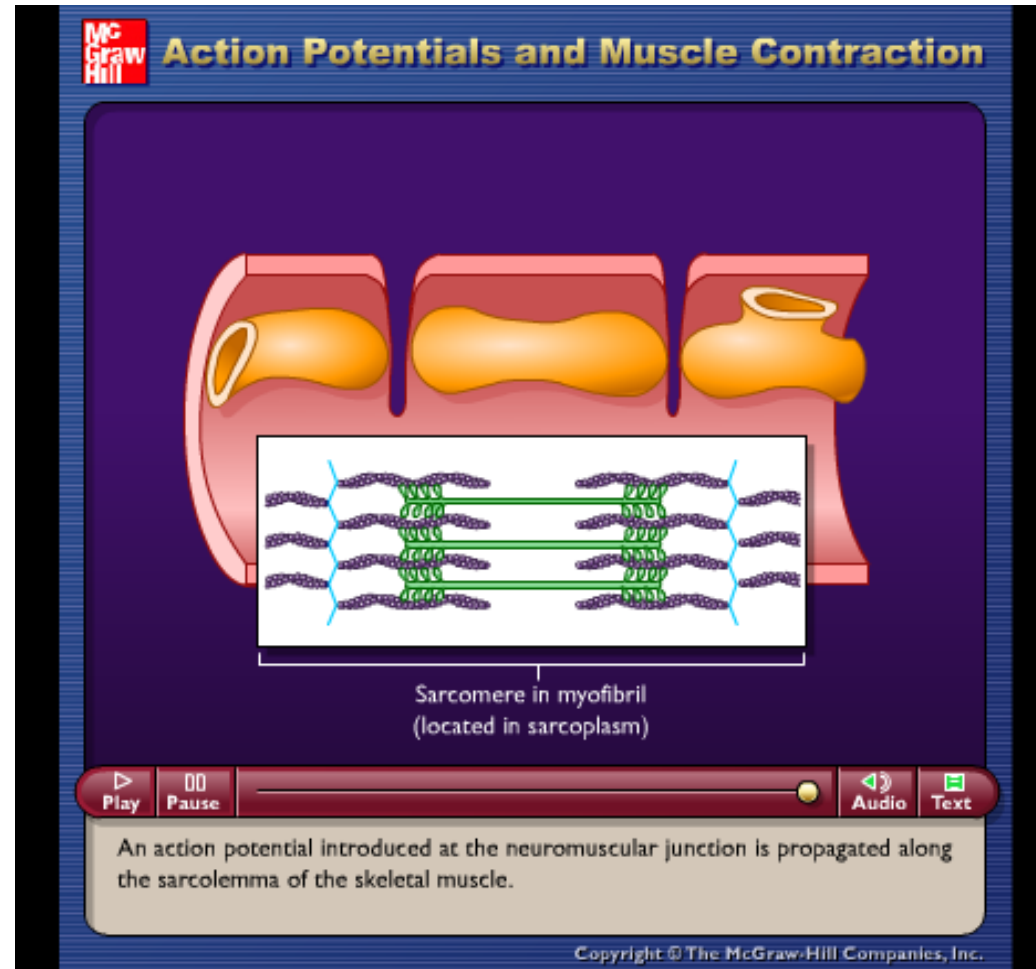
- Myosin cross-bridge attaches to actin binding site
- Myosin cross-bridge pulls thin filament
- ADP and phosphate released from myosin
- New ATP binds to myosin
- Linkage between actin and myosin cross-bridge break
- ATP splits
- Myosin cross-bridge goes back to original position
- ATP splits



# Relaxation

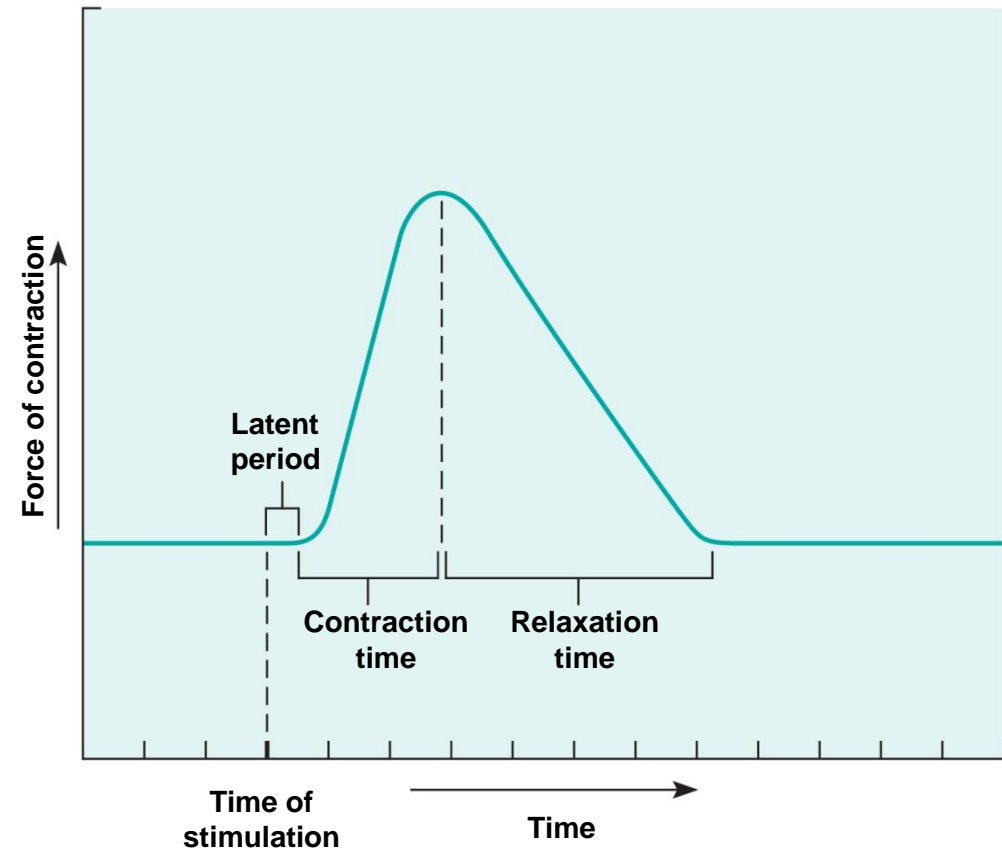
- Acetylcholinesterase – rapidly decomposes Ach remaining in the synapse
- Muscle impulse stops
- Stimulus to sarcolemma and muscle fiber membrane ceases
- Calcium moves back into sarcoplasmic reticulum (SR) by SERCA (SERCA – sarcoplasmic/endoplasmic reticulum  $\text{Ca}^{2+}$ -ATPase pump)
- Myosin and actin binding prevented
- Muscle fiber relaxes

# Animation: Action Potentials and Muscle Contraction



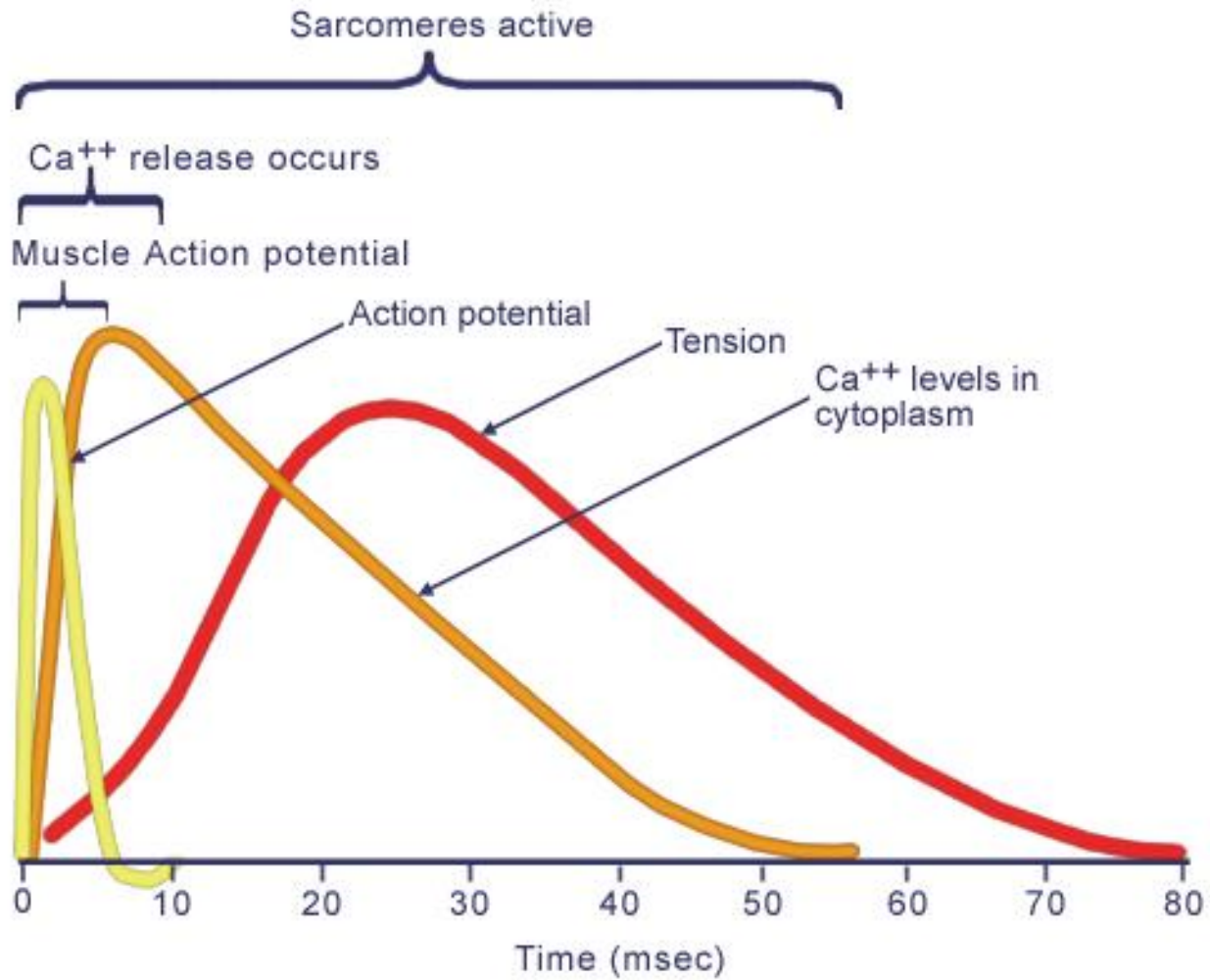
# Recording of a Muscle Contraction

- Recording a Muscle Contraction
  - **Twitch**
    - Latent period
    - Period of contraction
    - Period of relaxation
  - Refractory period
  - All-or-none response

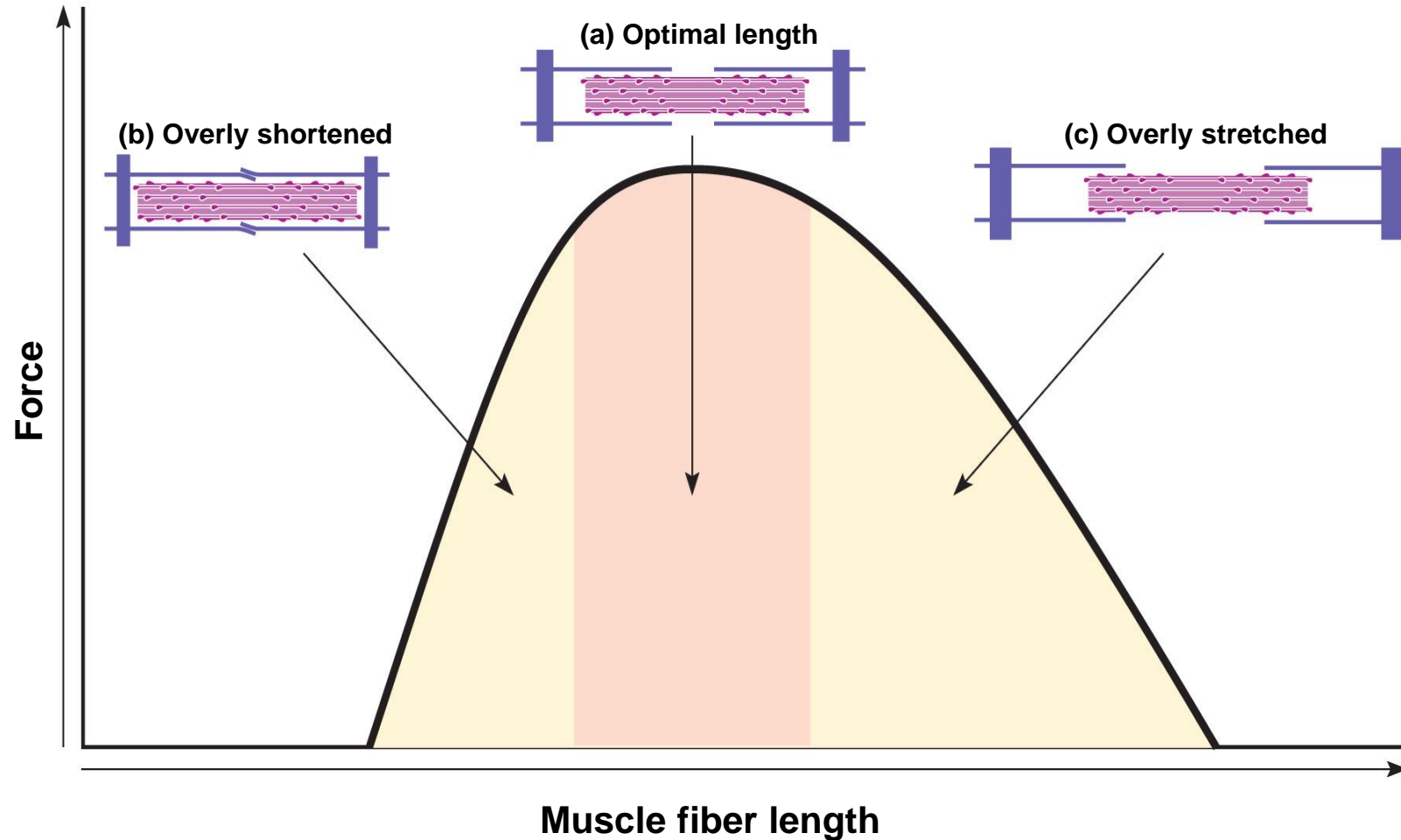




# Summary

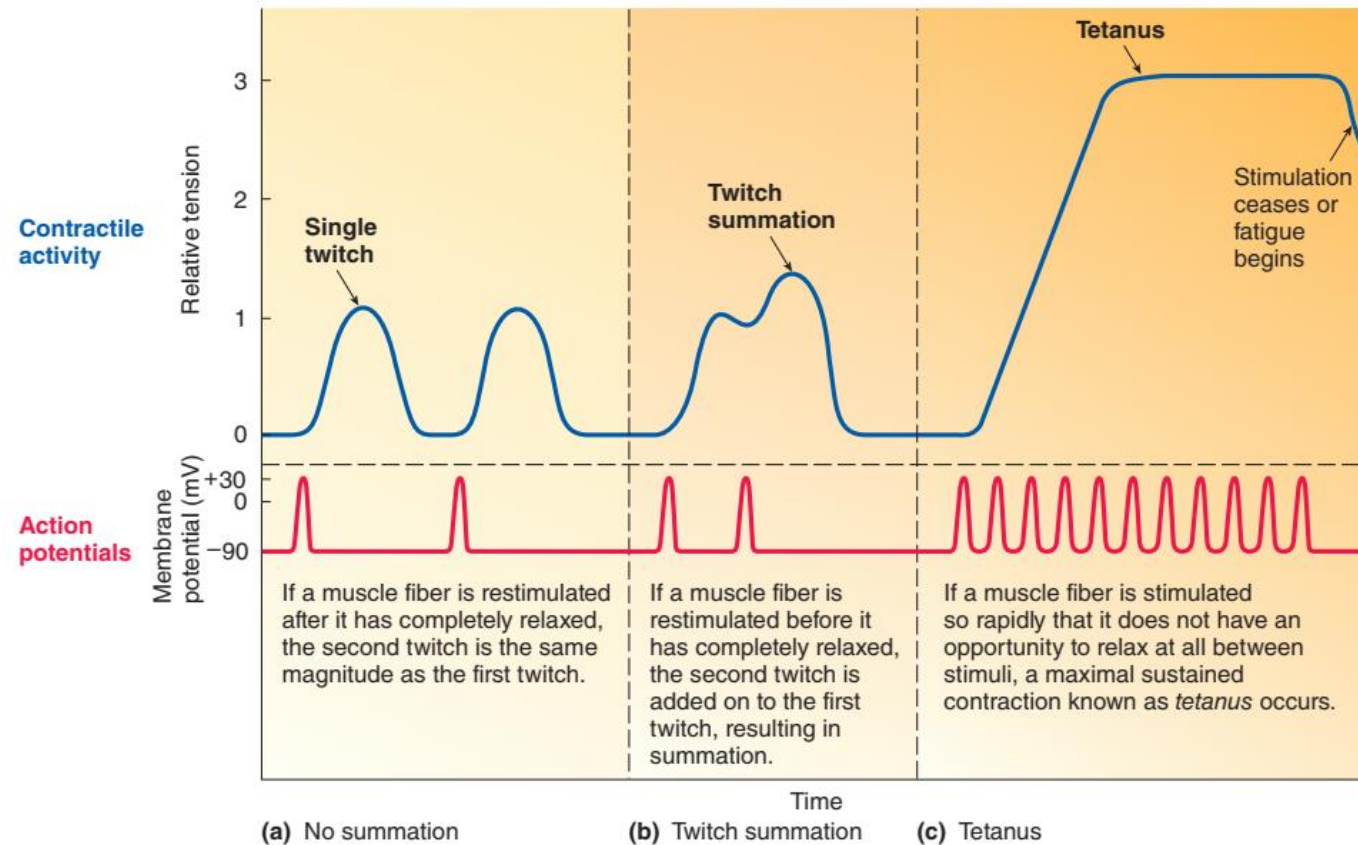


# Length-Tension Relationship



# Summation

- Process by which individual twitches combine
- Produces sustained contractions
- Can lead to tetanic contractions

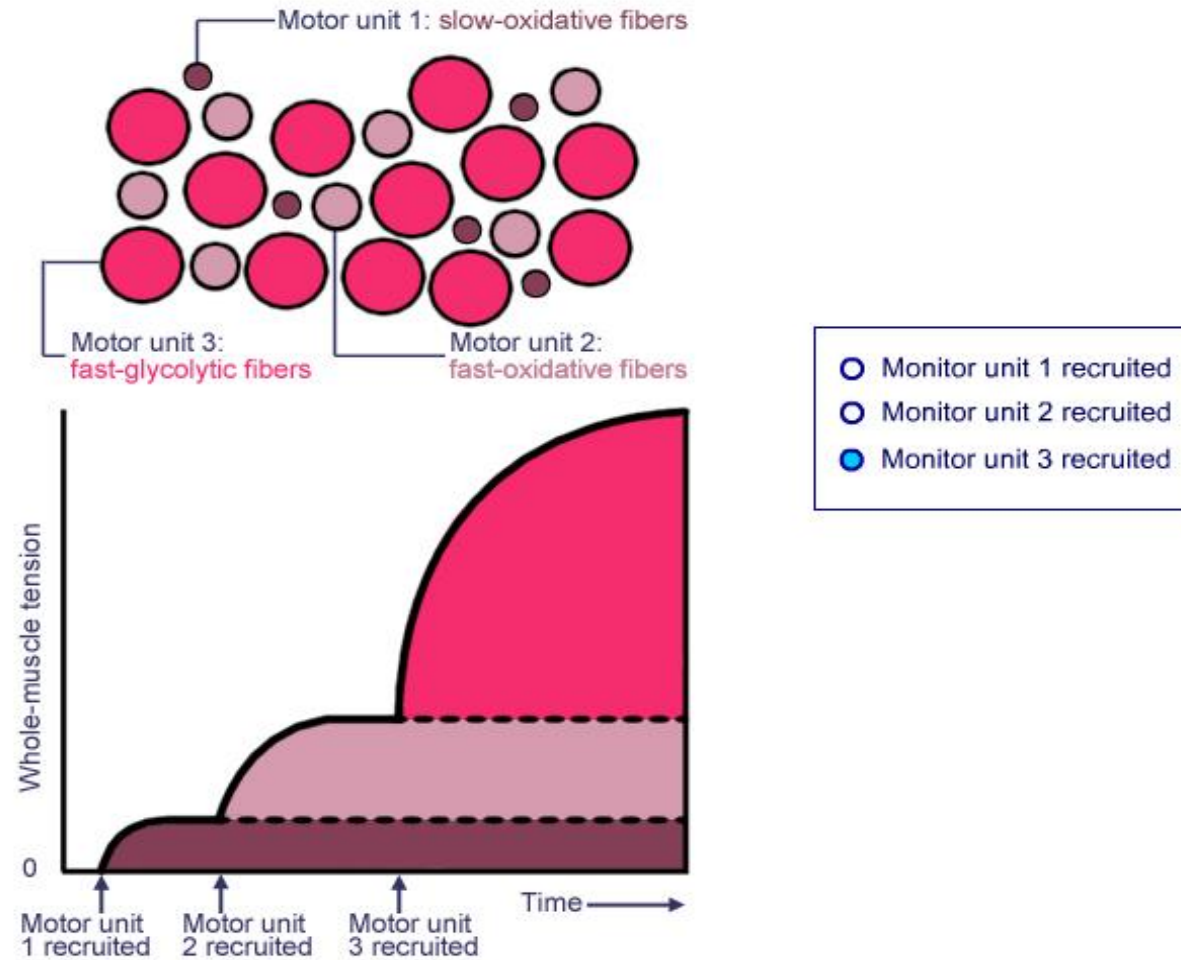


# Recruitment of Motor Units

- **Recruitment** - increase in the number of motor units activated for contraction
- Whole muscle composed of many motor units
- More precise movements are produced with fewer muscle fibers within a motor unit
- As intensity of stimulation increases, recruitment of motor units continues until all motor units are activated



# Recruitment of Motor Units



# Sustained Contractions

- Smaller motor units (smaller diameter axons) - recruited first
- Larger motor units (larger diameter axons) - recruited later
- Produce smooth movements

# Fast Twitch and Slow Twitch Muscle Fibers

- **Slow-oxidative fibers** (Type I)
  - Always oxidative
  - Resistant to fatigue
  - Red fibers
  - Most myoglobin
  - Good blood supply
- **Fast-oxidative fibers** (Type IIa)
  - Intermediate fibers
  - Oxidative
  - Intermediate amount of myoglobin
  - Pink to red in color
  - Resistant to fatigue
- **Fast glycolytic fibers** (Type IIb)
  - White fibers (less myoglobin)
  - Poorer blood supply
  - Susceptible to fatigue

# The end

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