

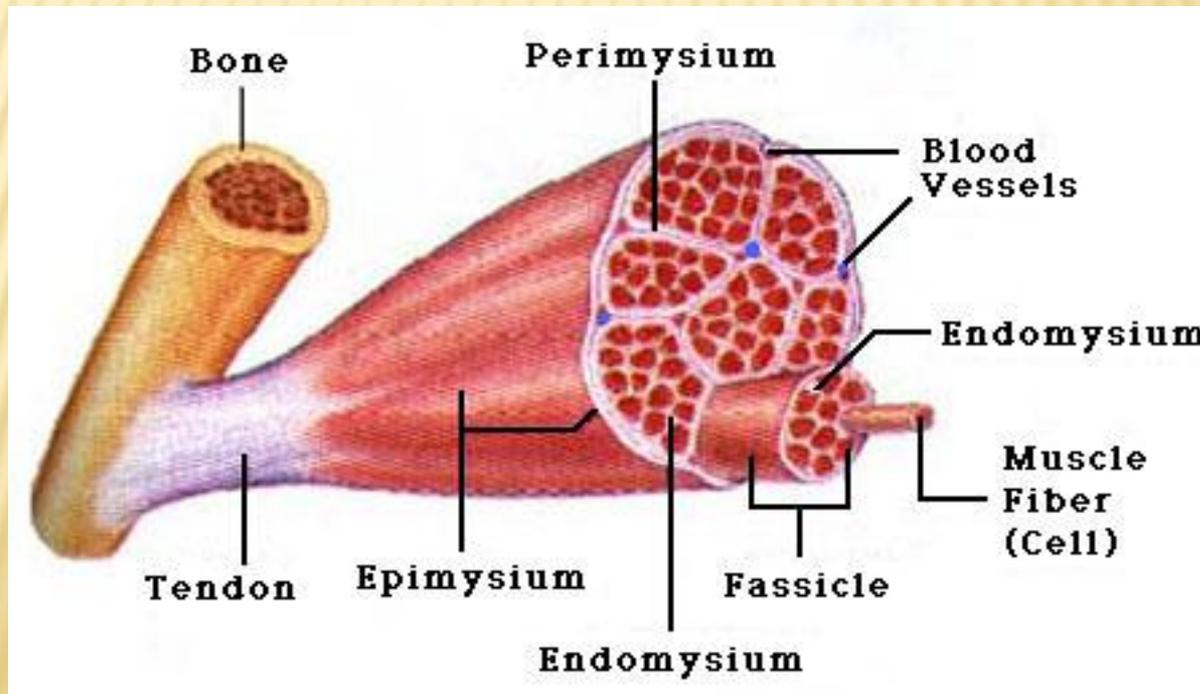
MUSCULAR SYSTEM

Individual muscles are the organs of the muscular system

CHAPTER 8

LAYERS OF CONNECTIVE TISSUE

- ✘ Epimysium- surrounds whole muscle (aka. deep fascia)
- ✘ Perimysium- separates fascicles
- ✘ Endomysium- surrounds each muscle fiber



SKELETAL MUSCLE FIBER

- ✘ *Sarco-* prefix meaning “flesh” (references structures in muscle); sarcolemma= cell membrane, sarcoplasm, sarcoplasmic reticulum
- ✘ *Myo-* prefix meaning “muscle”
- ✘ **Myofibril**= muscle contraction mechanism
 - + Actin=thin myofilament
 - + Myosin= thick myofilament
- ✘ **Sarcomere**= functional unit within a myofibril
 - + *Composed of myofilaments*

Myofibril= bundle of myofilaments

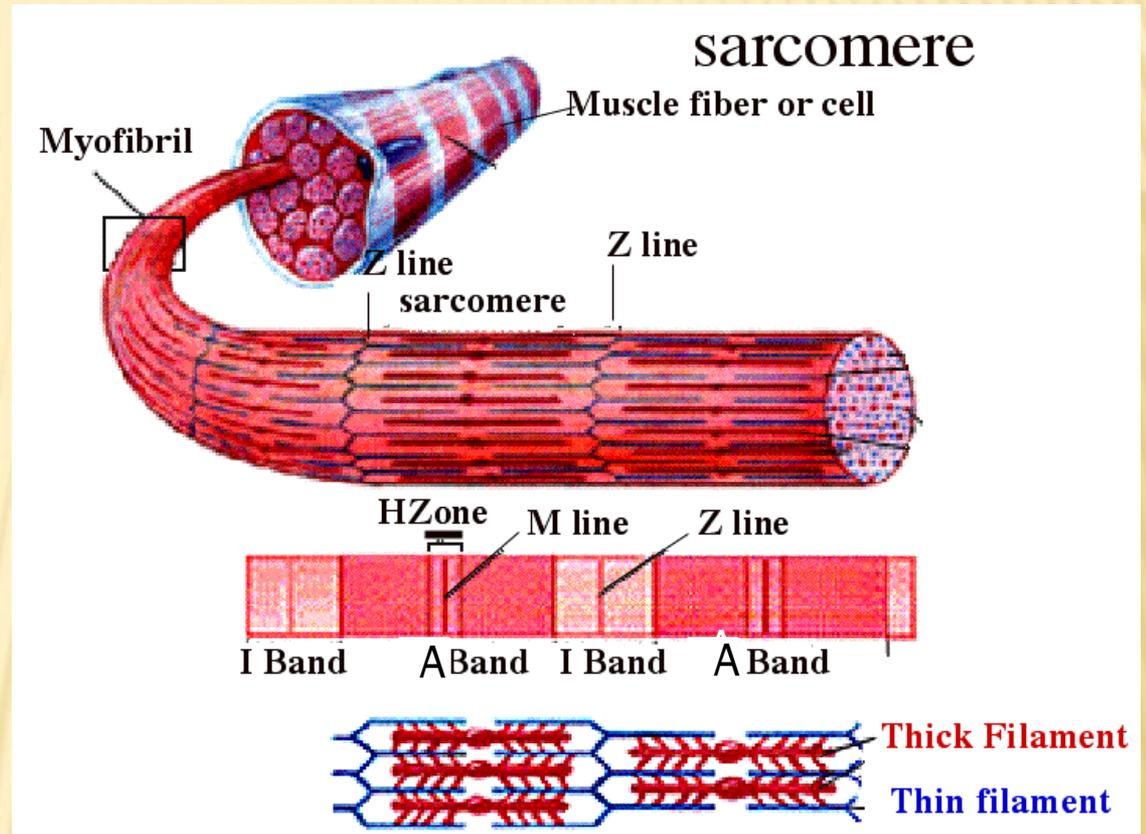
Actin

- thin myofilament (blue)
- I band

Myosin

- Thick myofilament (red)
- A band

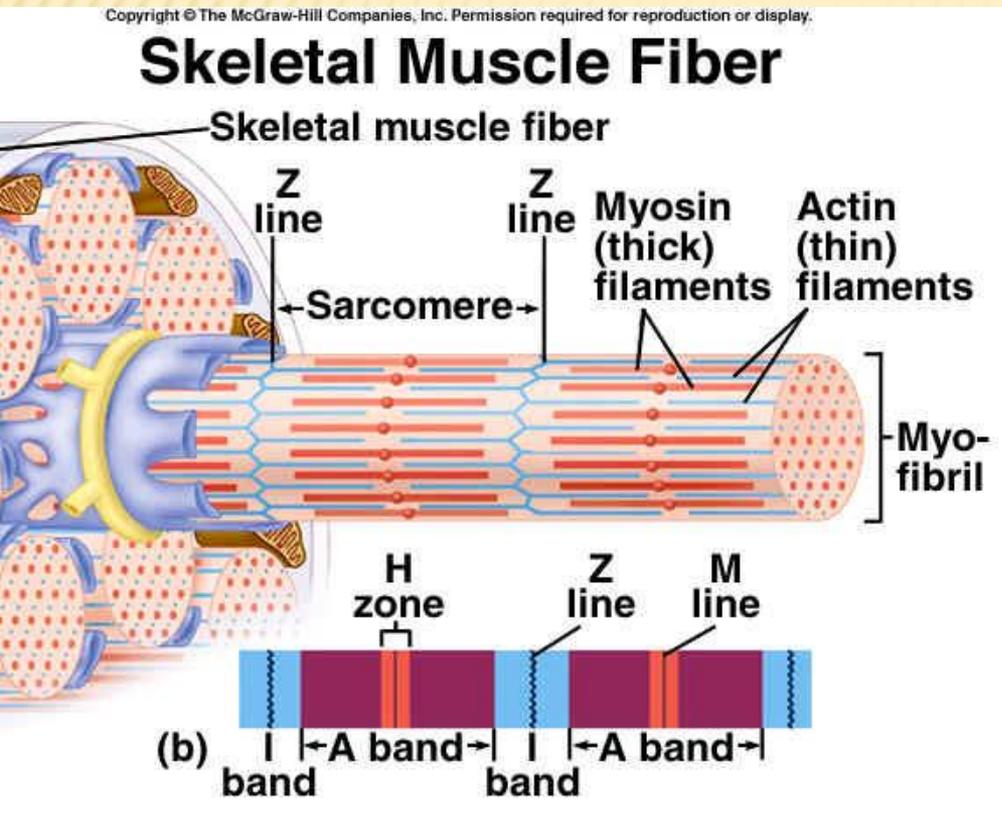
Sarcomeres lined up end to end
-Z lines separate each sarcomere



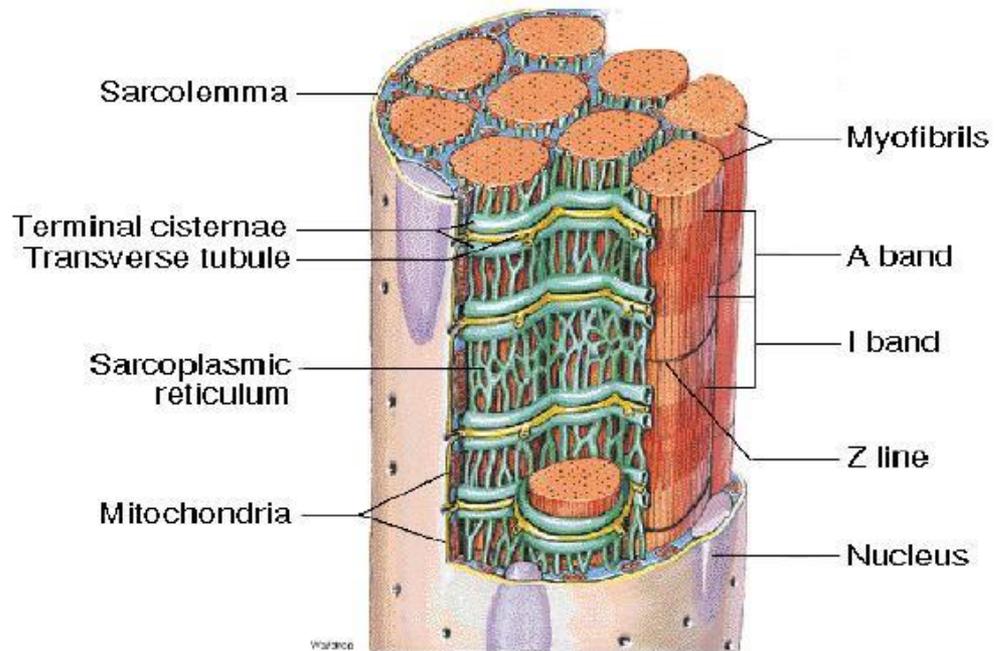
THIS IS SHOWING ONE MUSCLE FIBER, WITH MYOFIBRILS INSIDE

BELLY → FASCICLES → FIBERS → MYOFIBRILS → ACTIN & MYOSIN

- ✗ Channels involved in contraction mechanism
- ✗ Sarcoplasmic reticulum
 - + Runs parallel to fiber
- ✗ Transverse tubules (T tubules)
 - + Go through fiber



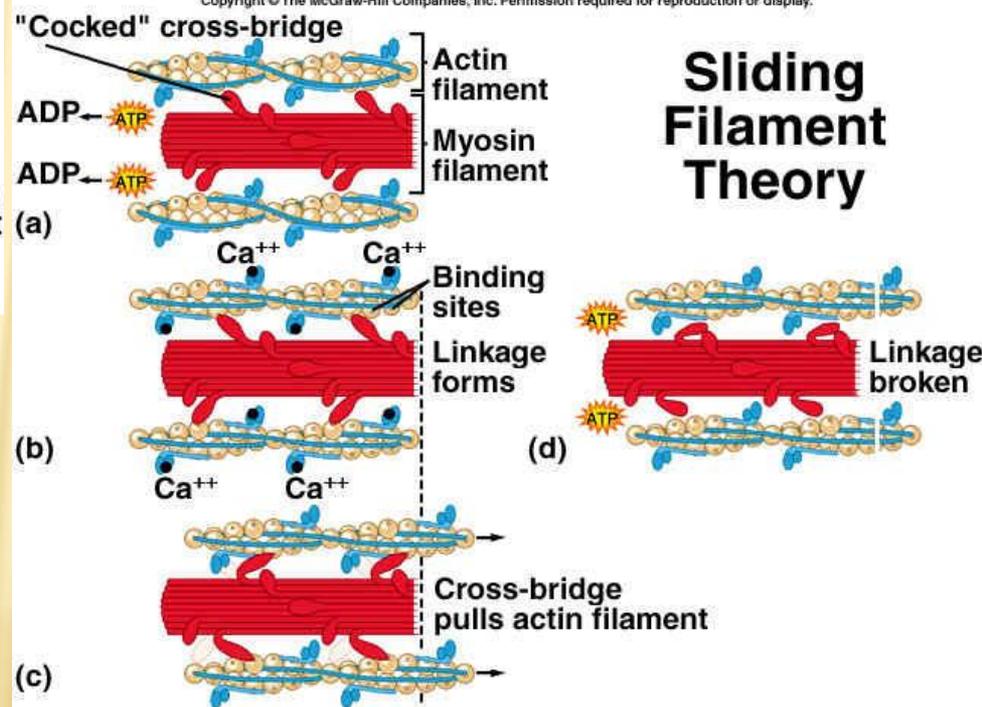
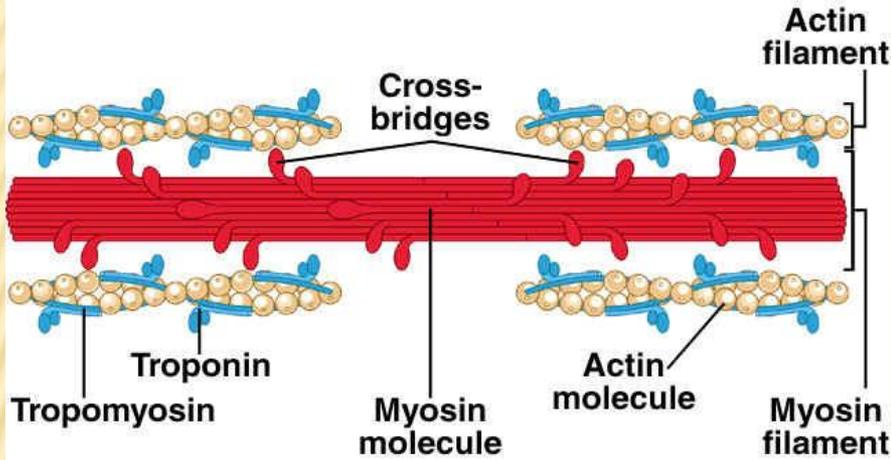
Sarcoplasmic Reticulum



MUSCLE CONTRACTION

- ✘ Sliding filament theory
- ✘ Interaction of myosin & actin
- ✘ Role of myosin
 - + Crossbridges link with actin
 - + Move like oars on a boat (or ratchet) to slide actin together (Z lines drawn together)
 - + Shortens sarcomere (muscle fiber)

Thick Filaments

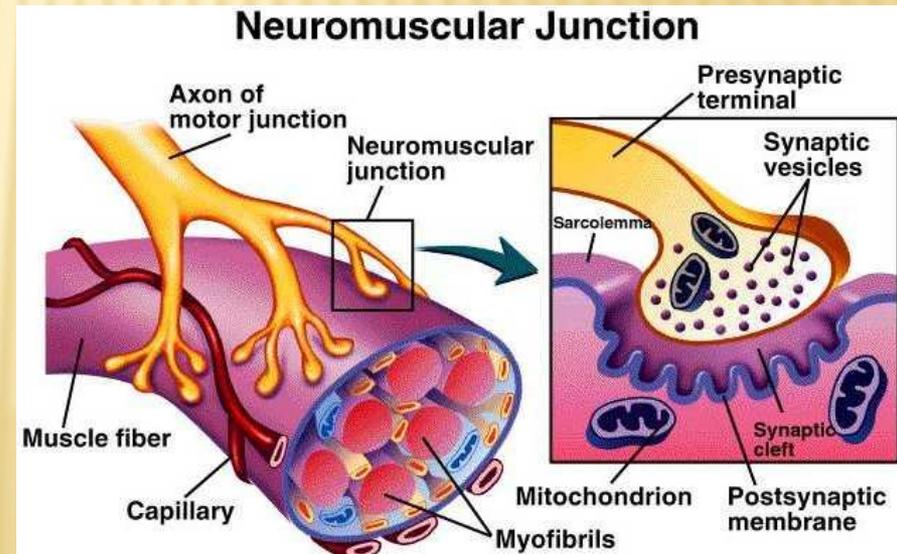
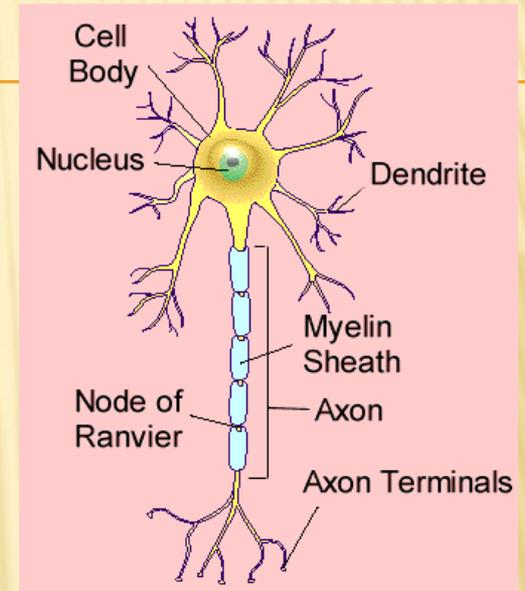


Notice ATP and Ca⁺⁺ requirement for linkage & ATP requirement for breaking of links

Motor neuron= nerve cell

NEUROMUSCULAR JUNCTION (AKA MOTOR END PLATE)

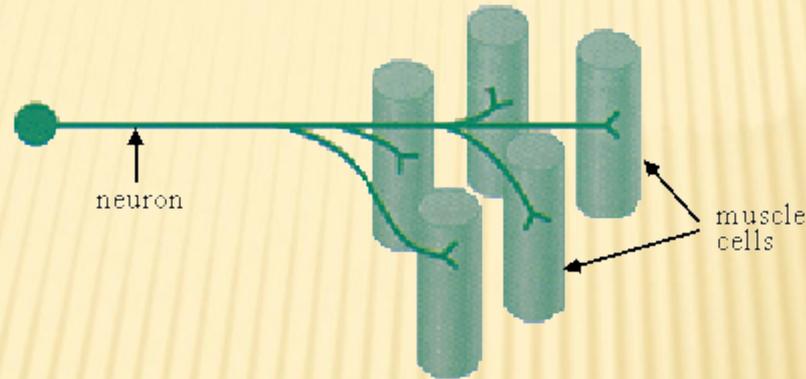
- ✗ Motor neuron & muscle fiber
- ✗ Neurotransmitters
(chemicals) secreted here
- + Synaptic end bulb of neuron
- + Chemicals released for stimulation (stored in vesicles)



MOTOR UNIT

MOTOR UNITS

The combination of the motor nerve cell (neuron) and all the muscle cells it innervates is known as a motor unit



When an electrical impulse travels down the axon, all muscle cells attached to the motor unit contract simultaneously

Motor unit averages 1 neuron with ~150 fibers (all contract/relax together)

*Total tension/force in a muscle can be varied by adjusting the number of motor units that are activated (known as **recruitment**)*

PRECISE/FINE VS. GROSS MOVEMENTS

Gross movements are large body movements, such as those in arms or legs. Fine movements are small movements, such as those in fingers, lips or eyes.

More or less fibers per motor unit??

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Motor Unit

Motor neuron

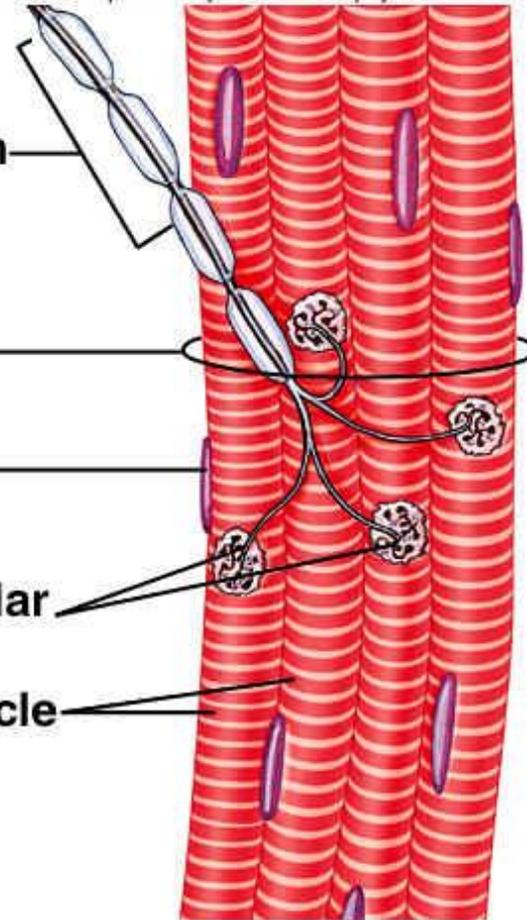
Motor unit

Muscle fiber nucleus

Neuromuscular junctions

Skeletal muscle fibers

(a)



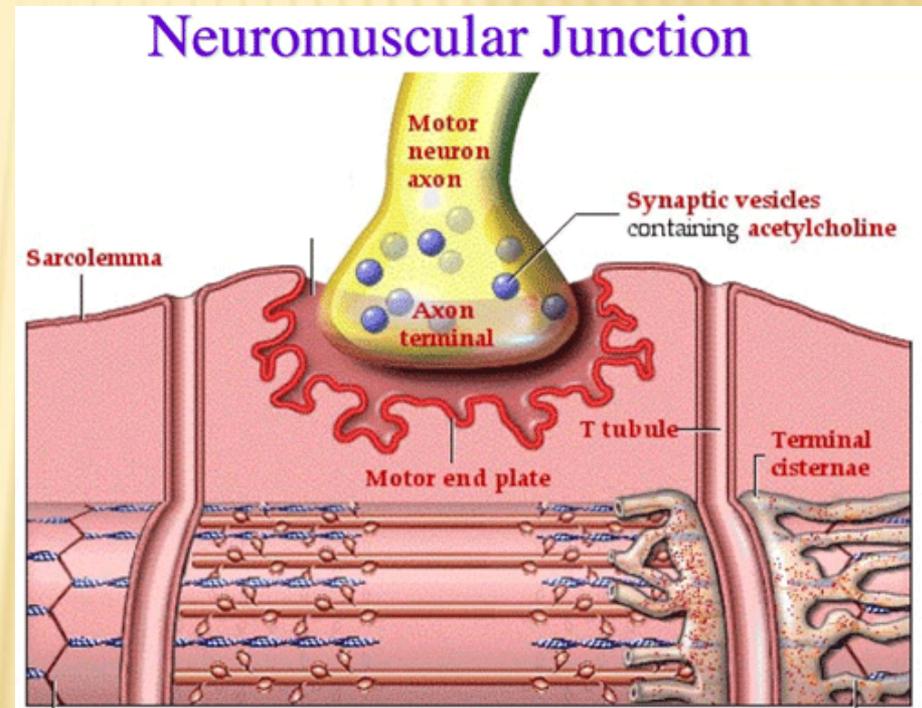
PHYSIOLOGY- STIMULUS

× Acetylcholine

- + Neurotransmitter
- + Released by vesicles due to nerve impulse

× Causes muscle impulse

- + *Change in permeability of sarcolemma to Ca^{++}*
- + *Starts muscle contraction*



MUSCLE IMPULSE- CONTRACTION

- ✘ SR releases calcium (Ca^{++}) ions into sarcoplasm
- ✘ Increased concentration causes actin & myosin to link (*activates crossbridges*)
- ✘ Sarcomere shortens
- ✘ Contraction continues until Ca^{++} ions are pumped back into SR by active transport (*see relaxation slide*)
- ✘ Also requires ATP energy

MUSCLE IMPULSE- RELAXATION

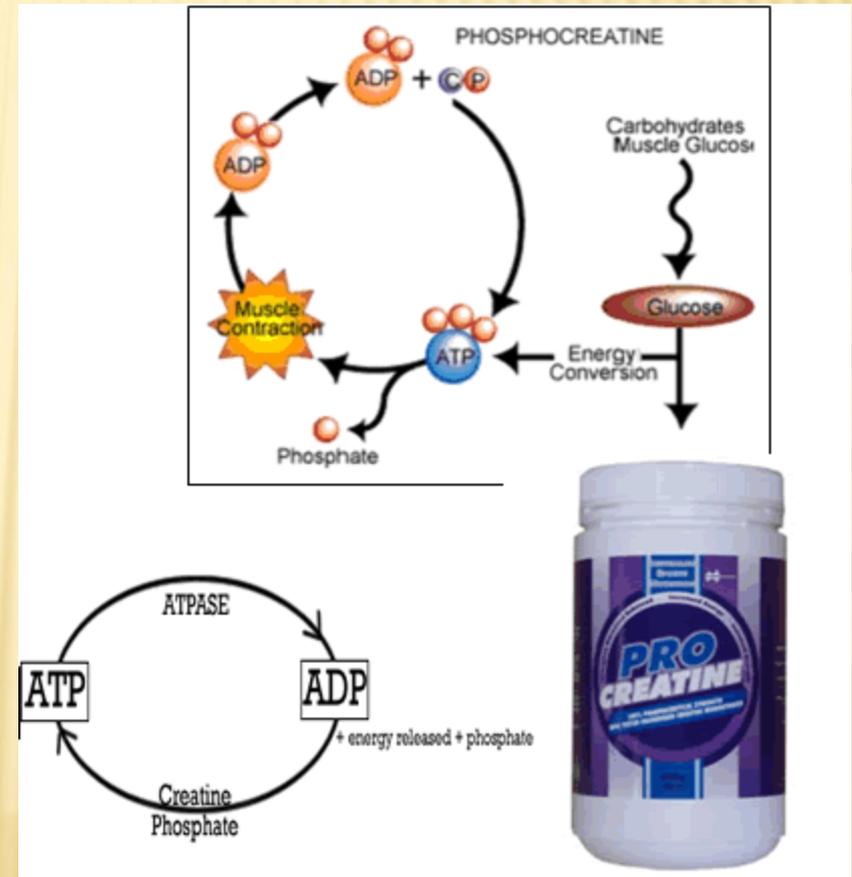
- ✘ Low concentration of Ca^{++} ions
- ✘ Linkages break (*ATP needed for this to occur also*)
- ✘ Cholinesterase (enzyme) decomposes acetylcholine
 - + Terminates nerve impulse conduction by starting active transport mechanism
 - + Prevents continued stimulation of muscle
- ✘ Muscle is now back to original length

ENERGY SOURCE- ATP

- ✗ Immediate, direct source
- ✗ $\text{ATP} \rightarrow \text{ADP} + \text{P} + \text{energy}$ for crossbridge activation & deactivation
 - + *ATPase (enzyme) allows ATP to break down to release its energy*
- ✗ Runs out quickly! More needs to be made...

ENERGY SOURCE- CREATINE PHOSPHATE

- ✗ Stores energy (only in muscle cells)
- ✗ Used to synthesize ATP when needed
 - + Phosphocreatine → creatine + P + energy
 - + That energy used to convert ADP to ATP
- ✗ Also runs out quickly!
What next??



ENERGY SOURCE

- ✘ Energy from ATP & creatine phosphate last ~15 seconds
- ✘ Then get it from breakdown of glycogen (stored glucose)
- ✘ *Aerobic cellular respiration can result in more ATP*

OXYGEN SUPPLY

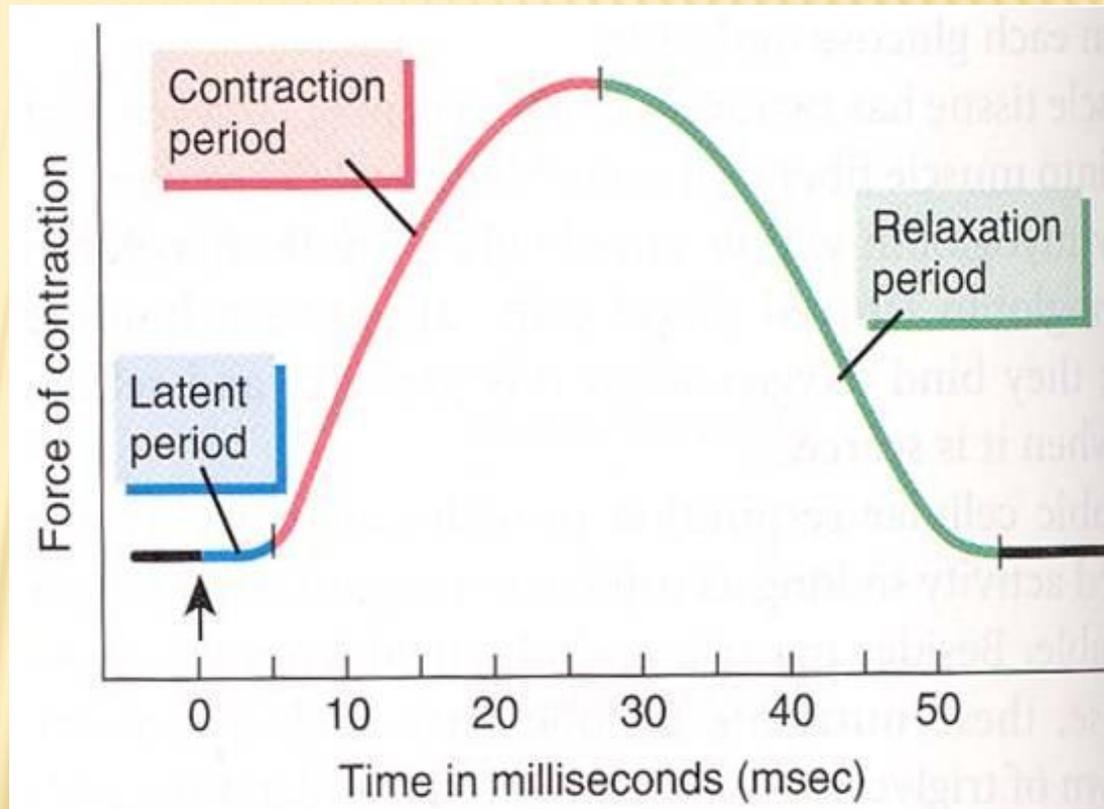
- ✘ Needed for cellular respiration
- ✘ Hemoglobin (red blood cells)
- ✘ Myoglobin (muscle cells)
 - + Reddish, brown pigment
 - + Temporary storage

ALL OR NONE PRINCIPLE (MUSCULAR RESPONSES)

- ✘ Individual fibers contract completely or not at all (all-or-none response)
- ✘ Threshold stimulus must be reached
 - + Weakest stimulus that will cause contraction
 - + *Different motor neurons respond to different levels of stimulation*
- ✘ Recruitment – more fibers = greater force of contraction
 - + *Small # of motor units w/low thresholds → few contract*
 - + *More w/higher thresholds → more contract with greater intensity of stimulation*

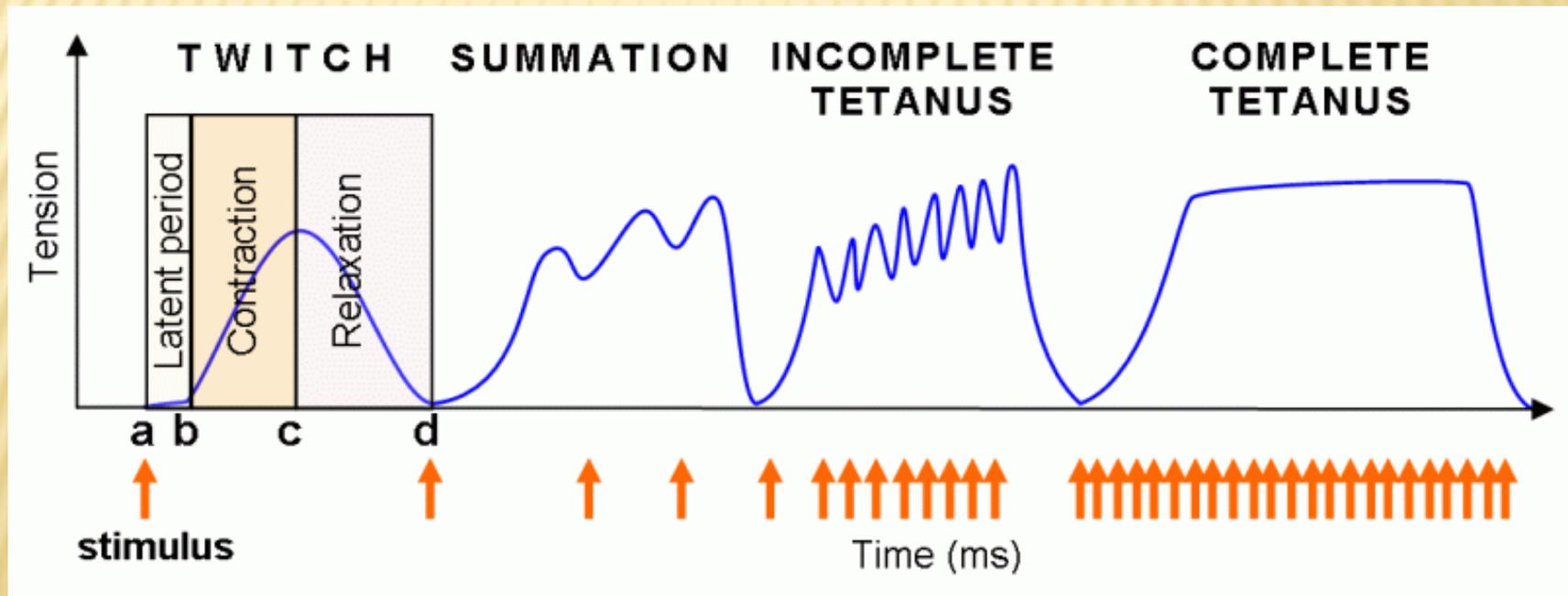
MYOGRAM- TWITCH CONTRACTION

- ✘ Single contraction
- ✘ Latent period
- ✘ Period of contraction
- ✘ Period of relaxation



TETANUS

- ✘ Sustained (tetanic) contraction
- ✘ Twitches combine



TONE & TREPPE

- ✘ Muscle tone (tonus)
- ✘ Treppe- muscle contracts more forcefully in response to same strength of stimulus after it has contracted several times
 - + *Athletic warm-up*
 - + *See last slide*