

Exam II is coming! I'll be ready!!...



BI 121 Exam II!



BI 121 Lecture 14

I. Announcements Last Lab 6, Pulmonary Function Testing + optional notebook ✓ this Thurs. **Exam II Wed, Dec 7, 8 am Q?**

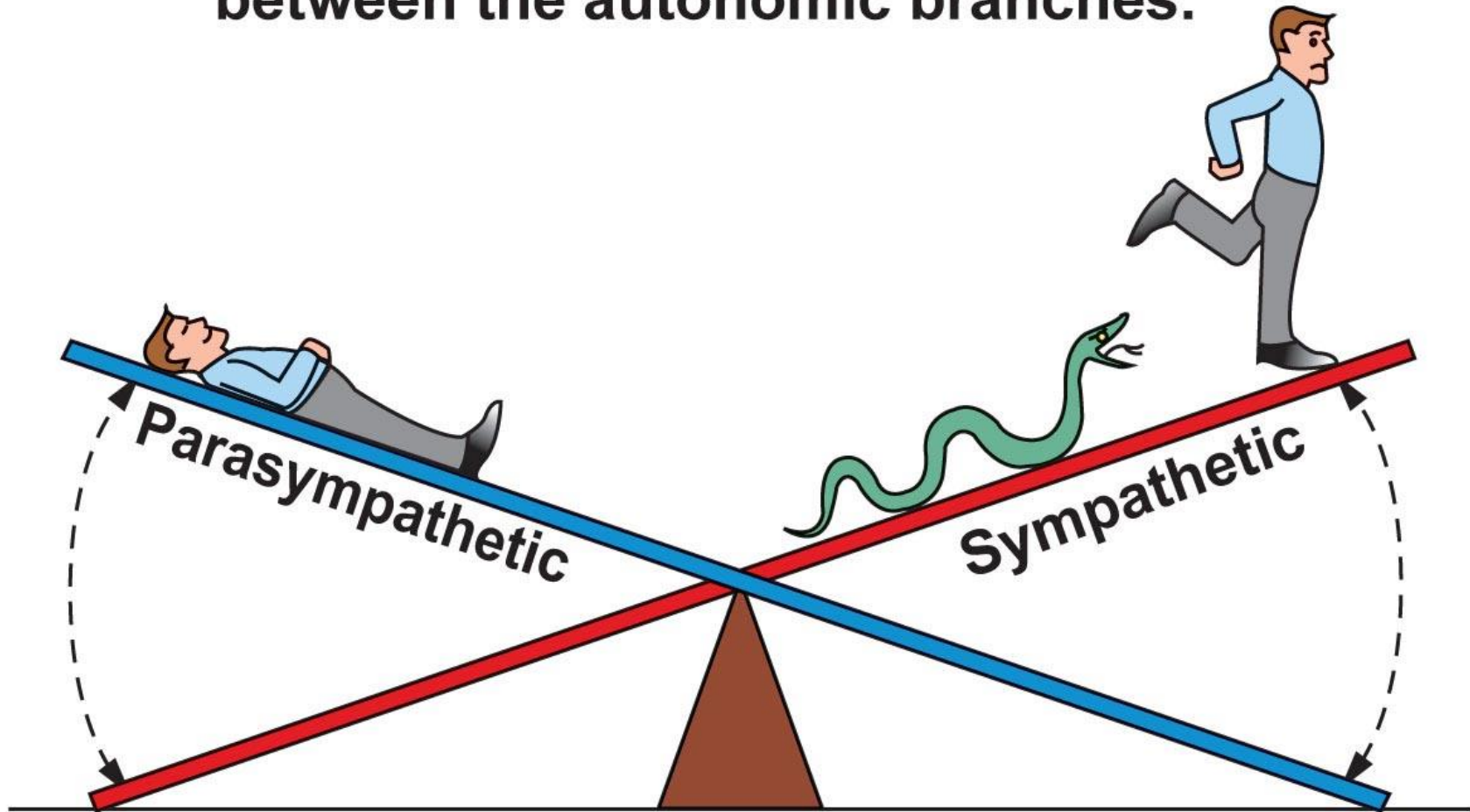
II. Nervous System Connections LS 7

- A. Autonomic NS: Branches, neurotransmitters, receptors, actions, fight-or-flight stories ch 7 pp 179-85
- B. Why are nerve & muscle unique? ch 4 p 71
- C. How do excitable cells signal? ch 3 pp 62-7; ch 4 pp 74-83
- D. How does the signal cross the nerve-muscle gap?
ch 7 p 185-92 fig 7-5 p 190
- E. What do black widow spider venom, botulism/Botox?, curare & nerve gas have in common? LS fig 7-5 p 190

III. Muscle Structure-Function & Adaptation LS ch 8 + DC Mod 12

- A. Muscle types: cardiac, smooth, skeletal LS fig 8-1 pp 194-6
- B. How is skeletal muscle organized? LS fig 8-2, DC fig 12-2
- C. What do thick filaments look like? LS fig 8-4, DC fig 12-4
- D. Thin filaments? Banding pattern LS fig 8-5, 8-3, 8-7
- E. How do muscles contract? LS fig 8-6, 8-10
- F. What's a cross-bridge cycle? LS fig 8-11 +...

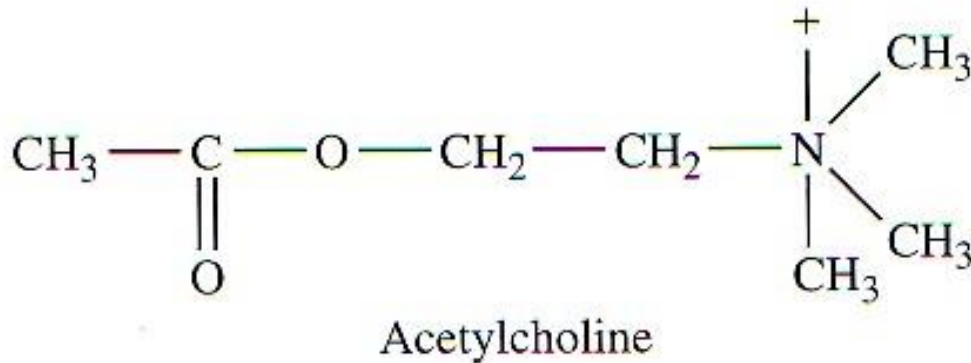
Homeostasis is a dynamic balance between the autonomic branches.



**Rest-and-digest:
Parasympathetic
activity dominates.**

**Fight-or-flight:
Sympathetic activity
dominates.**

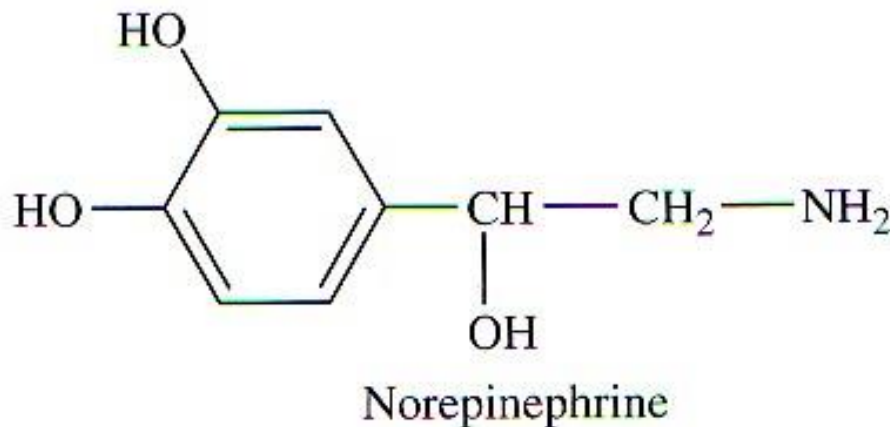
Autonomic Neurotransmitters & Receptors



Cholinergic

Nicotinic

Muscarinic

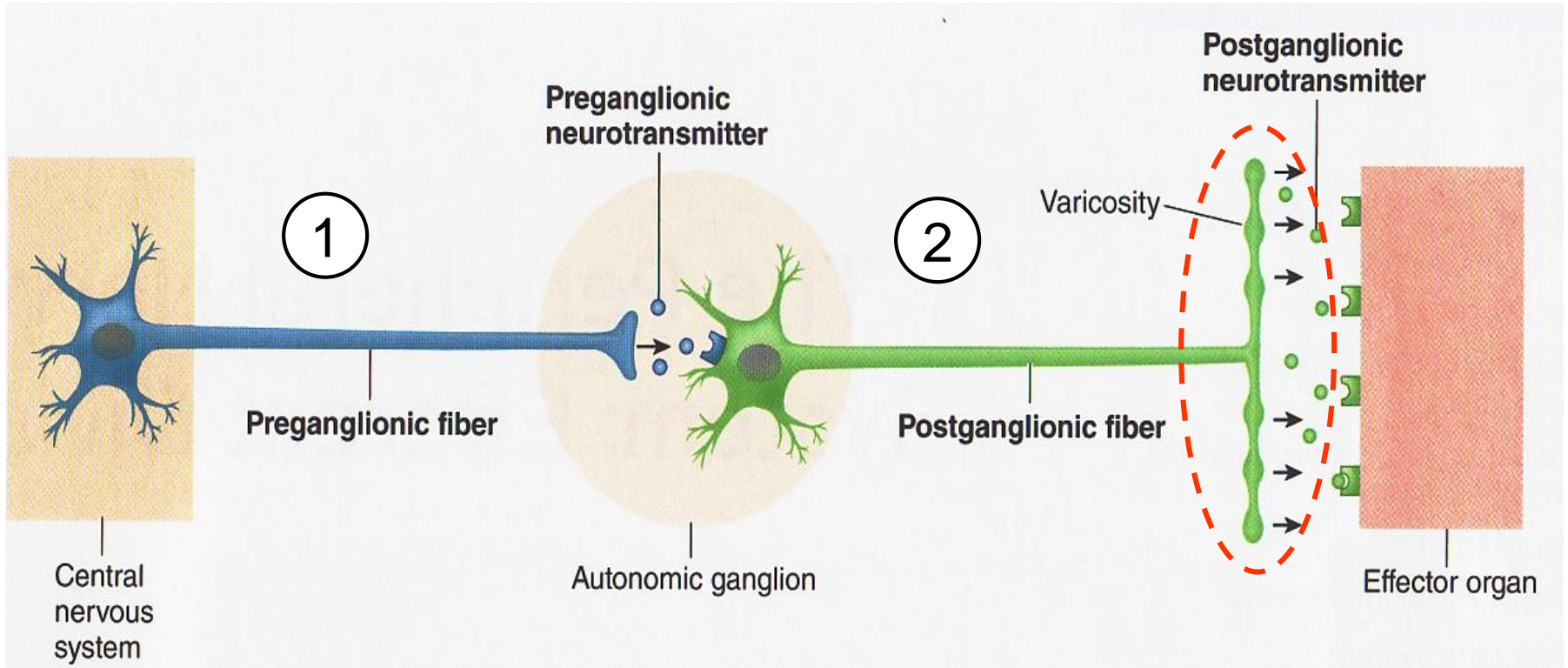


Adrenergic

α = Alpha

β = Beta

Autonomic Nerves: *Two Chain Pathway* with *Post-Ganglionic Varicosities*



Nicotine activates both Sympathetic & Parasympathetic post-ganglionic neurons!

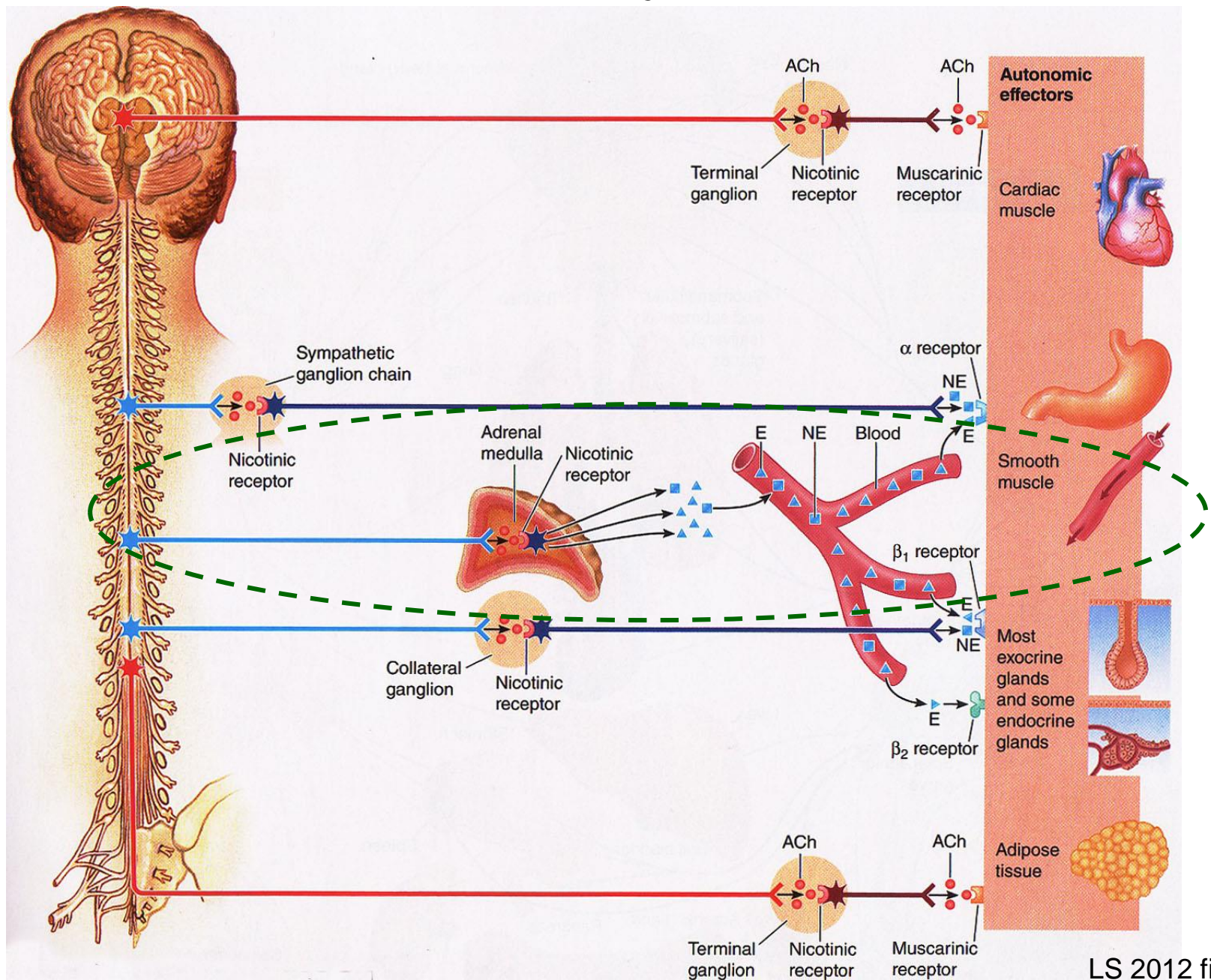
Problem?



Like hammering the gas pedal & brake at the same time!!



Autonomic Nervous System Innervation



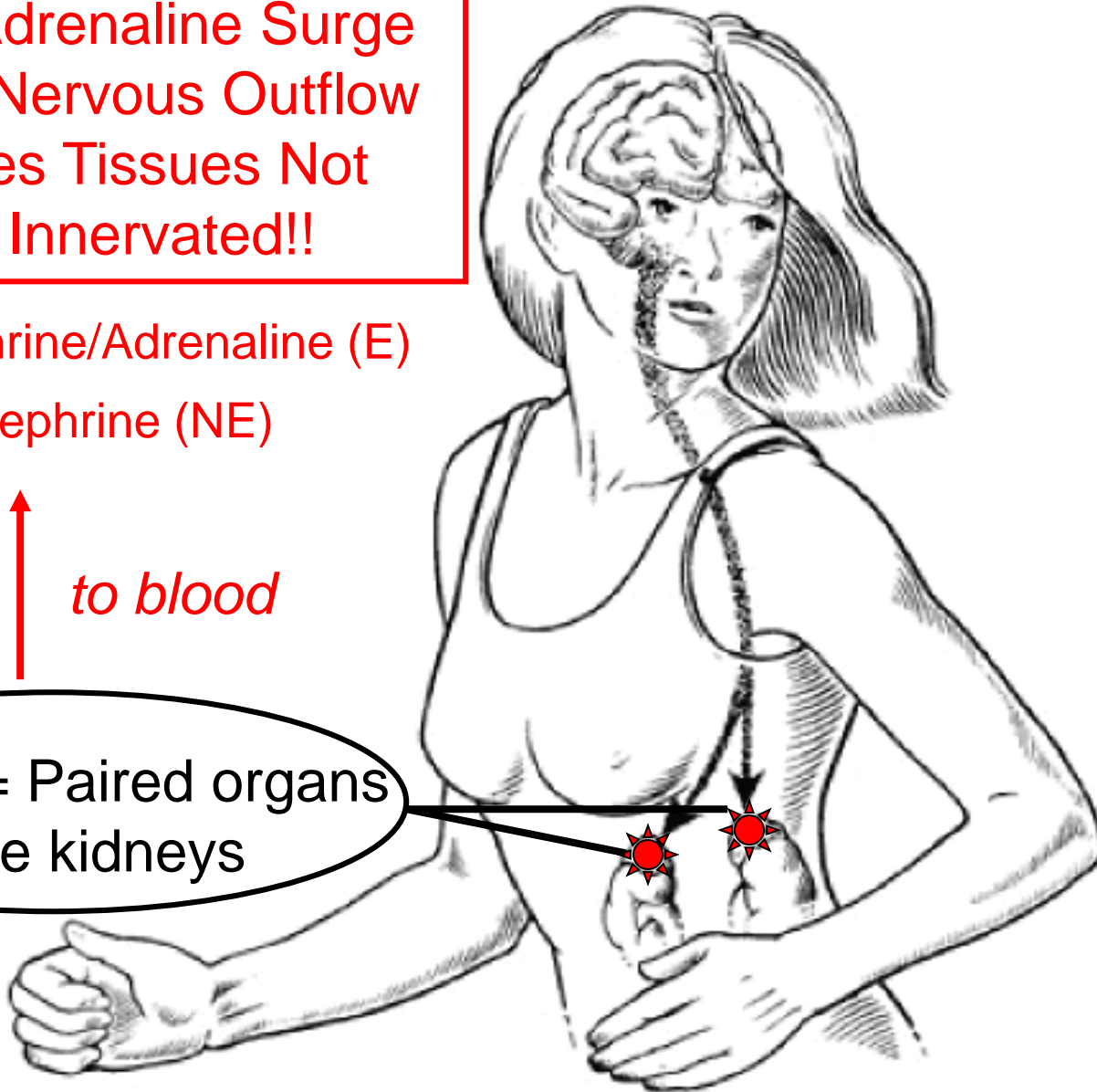
**In Sympathetic
Fight-or-Flight why
is it important to
activate the
adrenals?**

Hormonal Adrenaline Surge
Reinforces Nervous Outflow
& Accesses Tissues Not
Directly Innervated!!

80% Epinephrine/Adrenaline (E)
20% Norepinephrine (NE)

Output ↑ *to blood*

Adrenals = Paired organs
above kidneys



▲ Table 7-1 Effects of Autonomic Nervous System on Various Organs

Organ	Effect of Sympathetic Stimulation	Effect of Parasympathetic Stimulation
Heart	Increases heart rate and increases force of contraction of the whole heart	Decreases heart rate and decreases force of contraction of the atria only
Blood Vessels	Constricts	Dilates vessels supplying the penis and the clitoris only
Lungs	Dilates the bronchioles (airways)	Constricts the bronchioles
Digestive Tract	Decreases motility (movement) Contracts sphincters (to prevent forward movement of tract contents) Inhibits digestive secretions	Increases motility Relaxes sphincters (to permit forward movement of tract contents) Stimulates digestive secretions
Urinary Bladder	Relaxes	Contracts (emptying)
Eye	Dilates the pupil Adjusts the eye for far vision	Constricts the pupil Adjusts the eye for near vision
Liver (glycogen stores)	Glycogenolysis (glucose is released)	None
Adipose Cells (fat stores)	Lipolysis (fatty acids are released)	None
Exocrine Glands		
<i>Exocrine pancreas</i>	Inhibits pancreatic exocrine secretion	Stimulates pancreatic exocrine secretion (important for digestion)
<i>Sweat glands</i>	Stimulates secretion by sweat glands important in cooling the body	Stimulates secretion by specialized sweat glands in the armpits and genital area
<i>Salivary glands</i>	Stimulates a small volume of thick saliva rich in mucus	Stimulates a large volume of watery saliva rich in enzymes
Endocrine Glands		
<i>Adrenal medulla</i>	Stimulates epinephrine and norepinephrine secretion	None
<i>Endocrine pancreas</i>	Inhibits insulin secretion	Stimulates insulin secretion
Genitals	Controls ejaculation (males) and orgasm contractions (both sexes)	Controls erection (penis in males and clitoris in females)
Brain Activity	Increases alertness	None

Fight-or-Flight Stories!



or



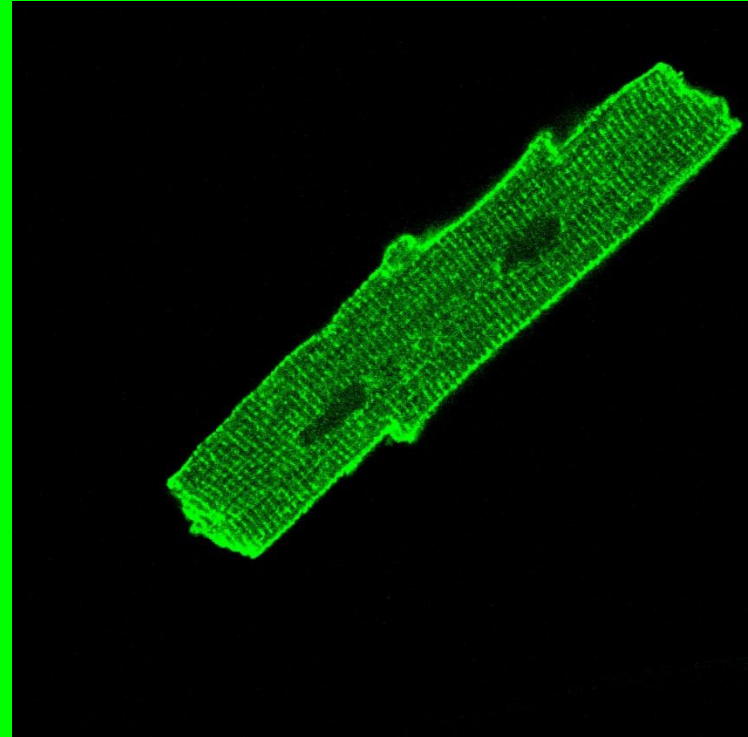
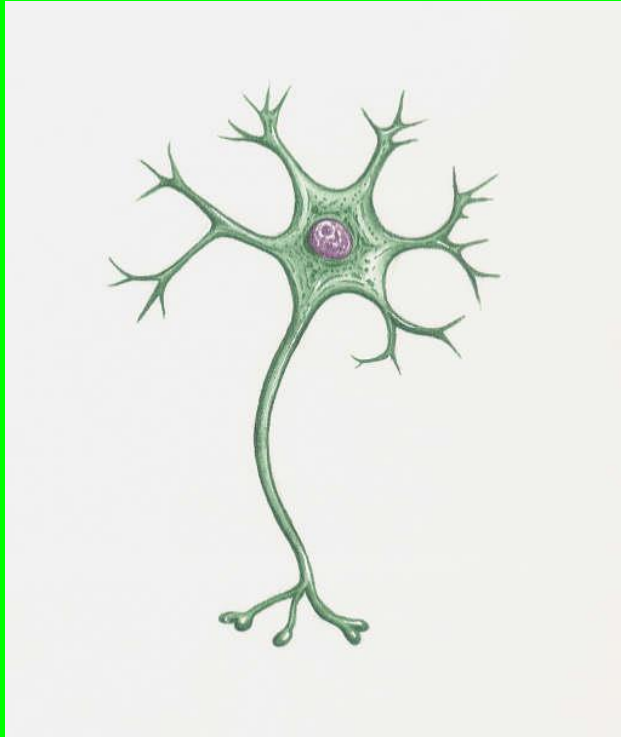
...choose this!!



Time for a break! 😊



Why are nerve & muscle unique?



They are excitable!!

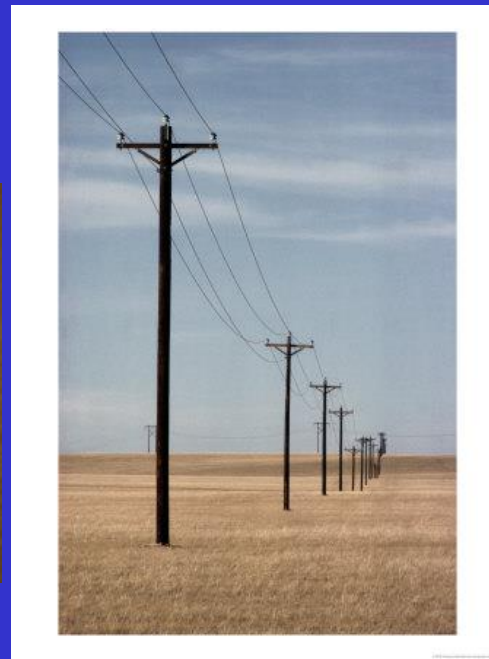
Action Potentials \equiv Spikes \equiv Impulses

Ultra-short reversal of membrane potential

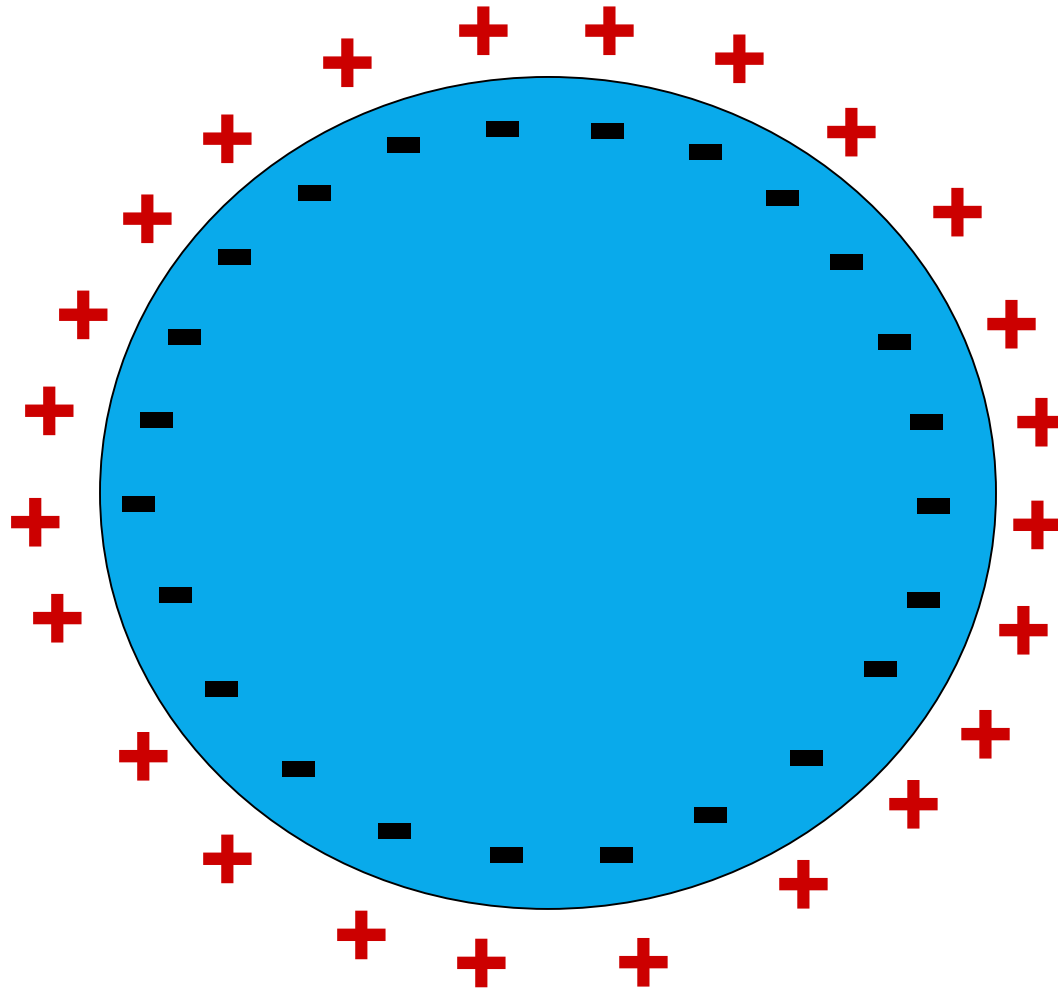
Only in nerve and muscle cells

Maintains strength over distance

Primary way nerves & muscles communicate!



"Resting"/Membrane Potential?



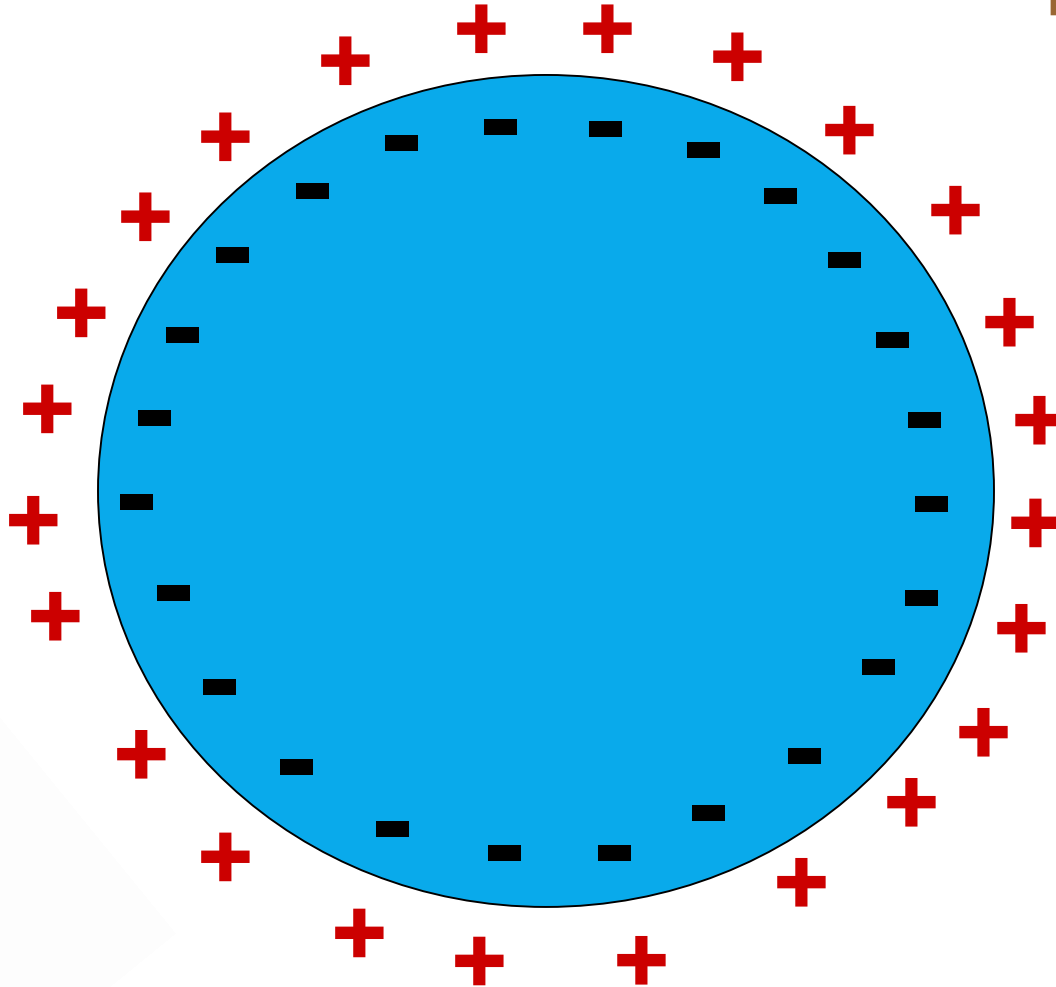
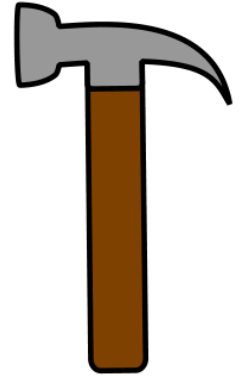
Cells are slightly negative inside!

Stimulate Cell @ Rest

Thermal



Mechanical



1

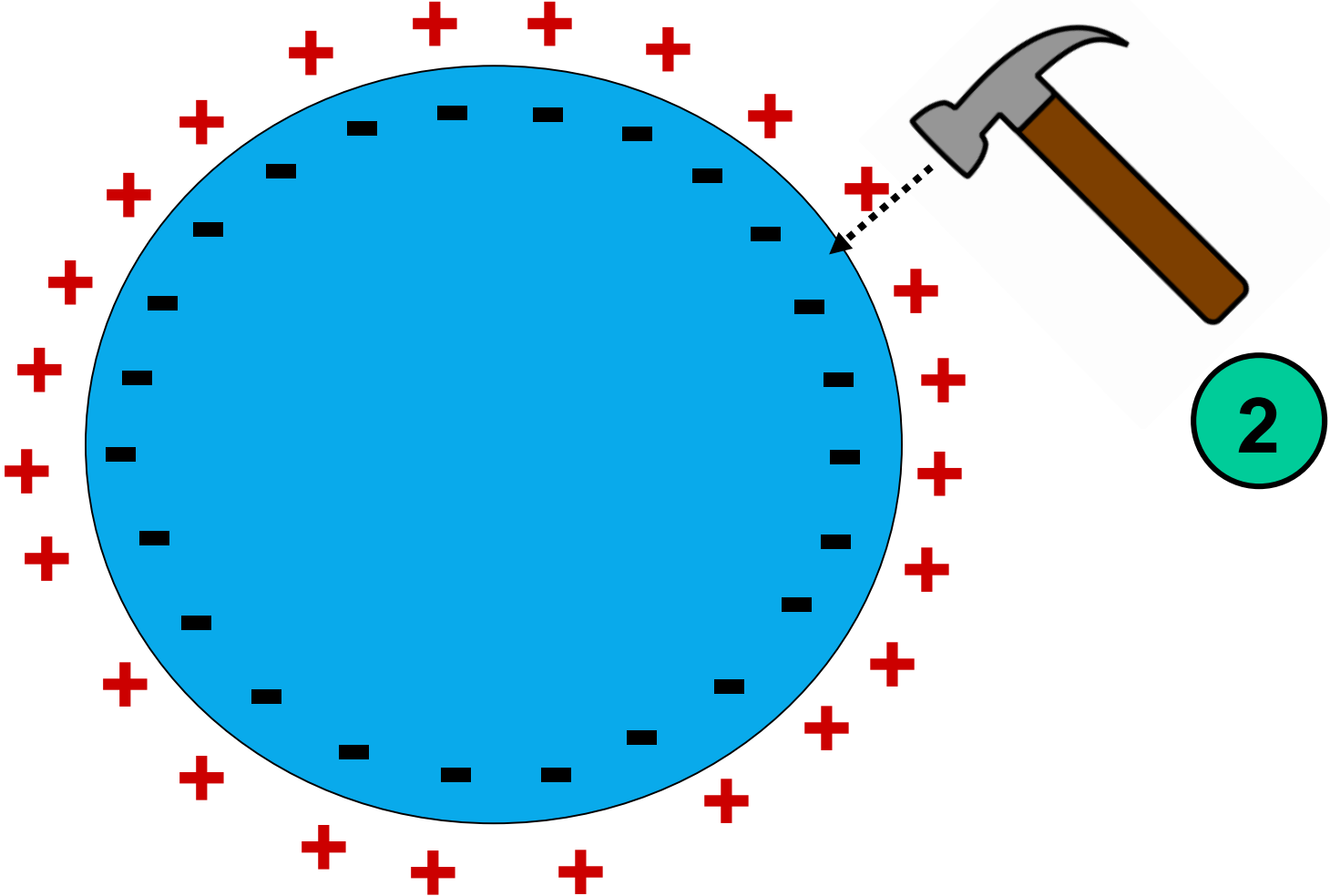


Electrical

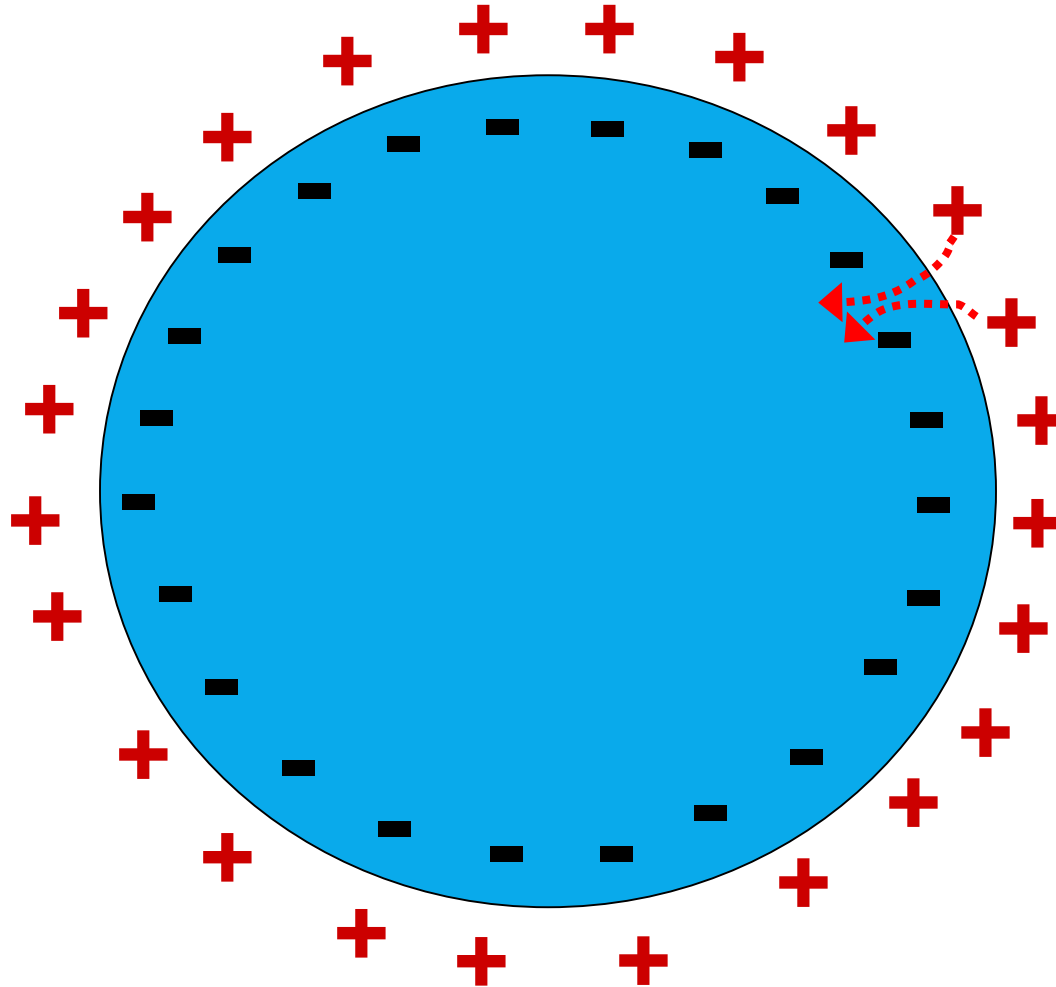
Chemical



Tap! Tap!..

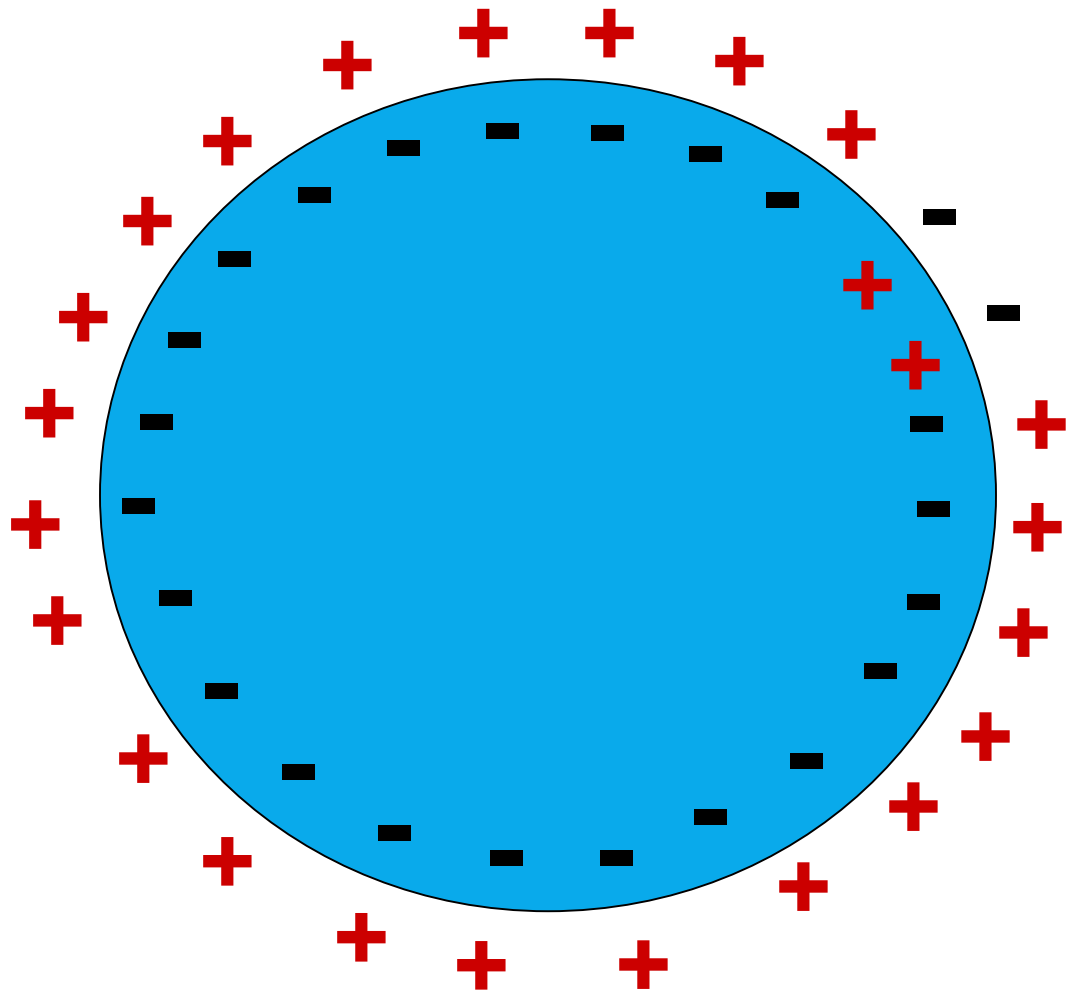


Changes Cell Membrane Permeability to Sodium/Na+!



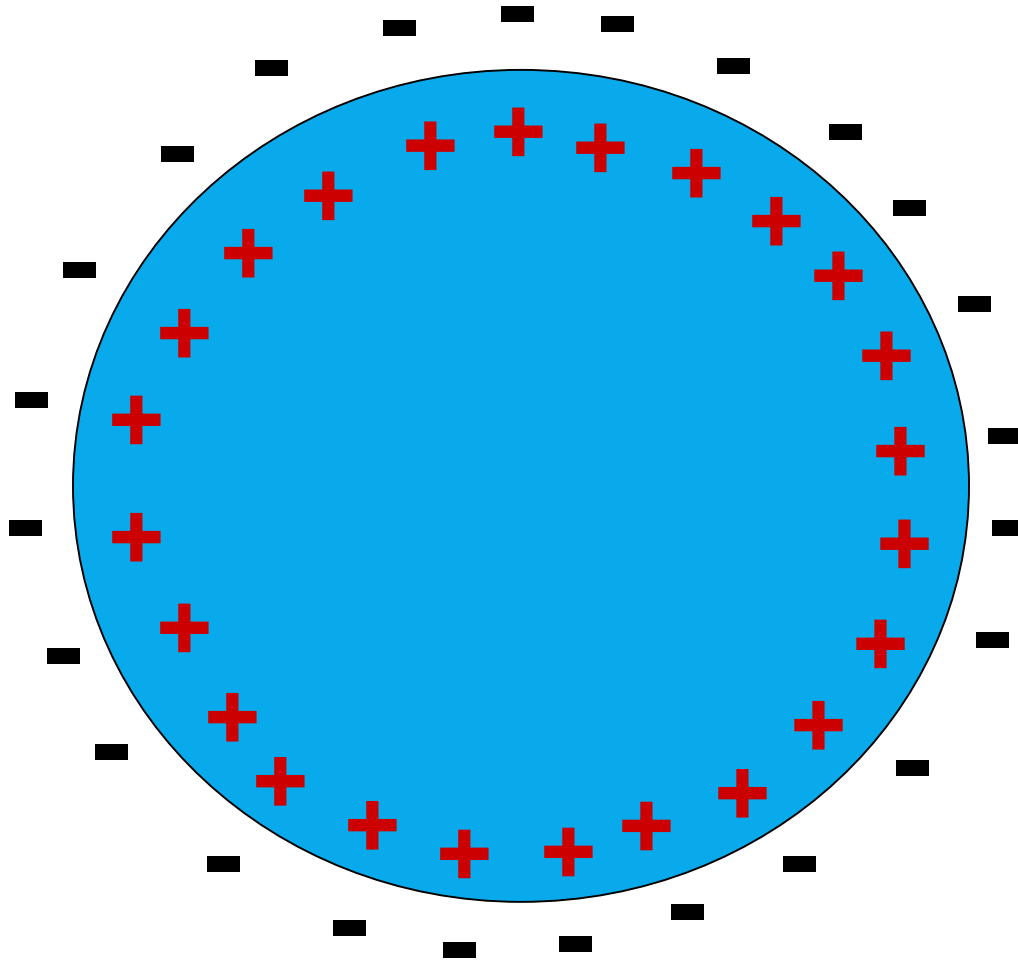
3

+ Charges/Na+ Rushes In!



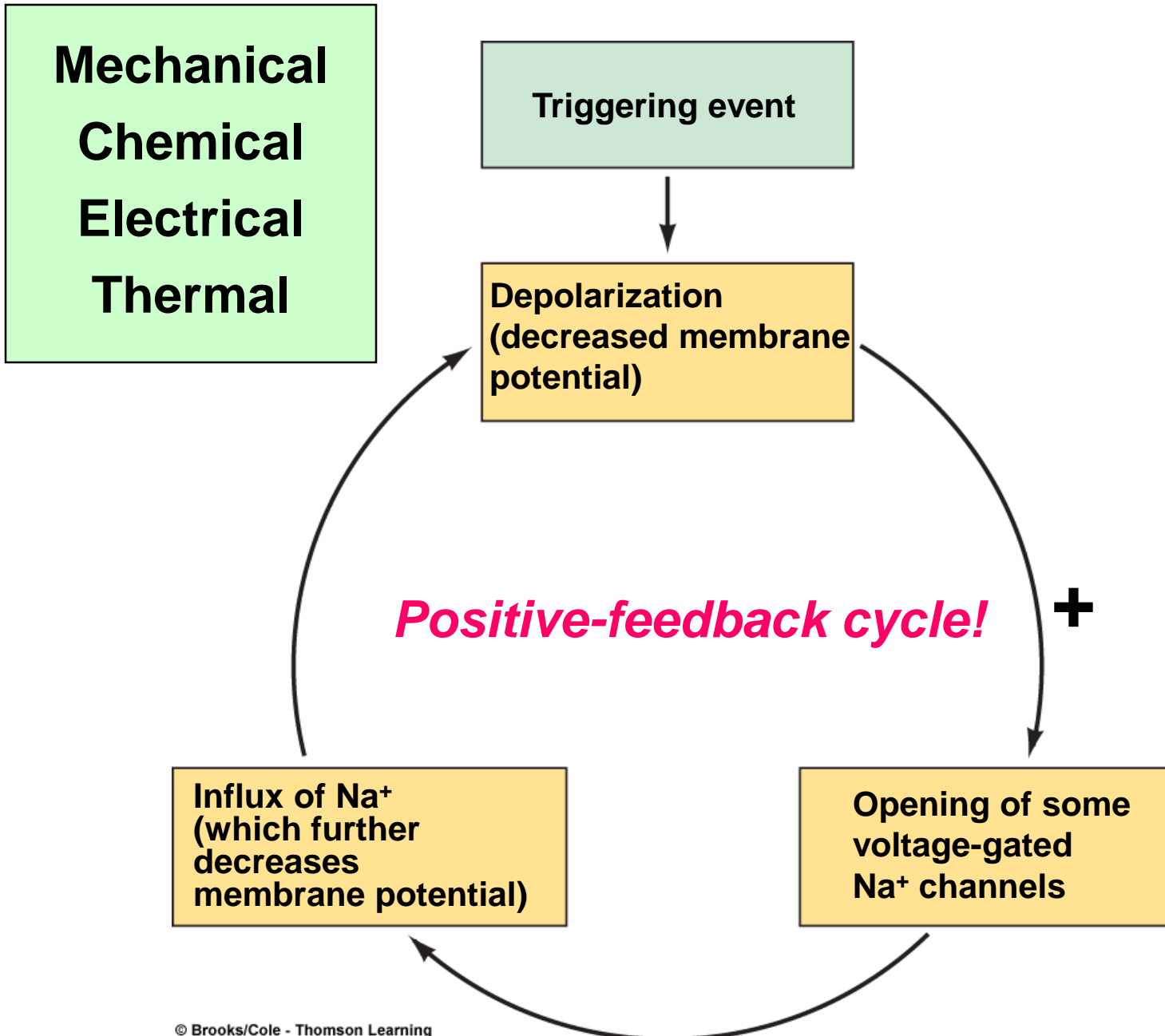
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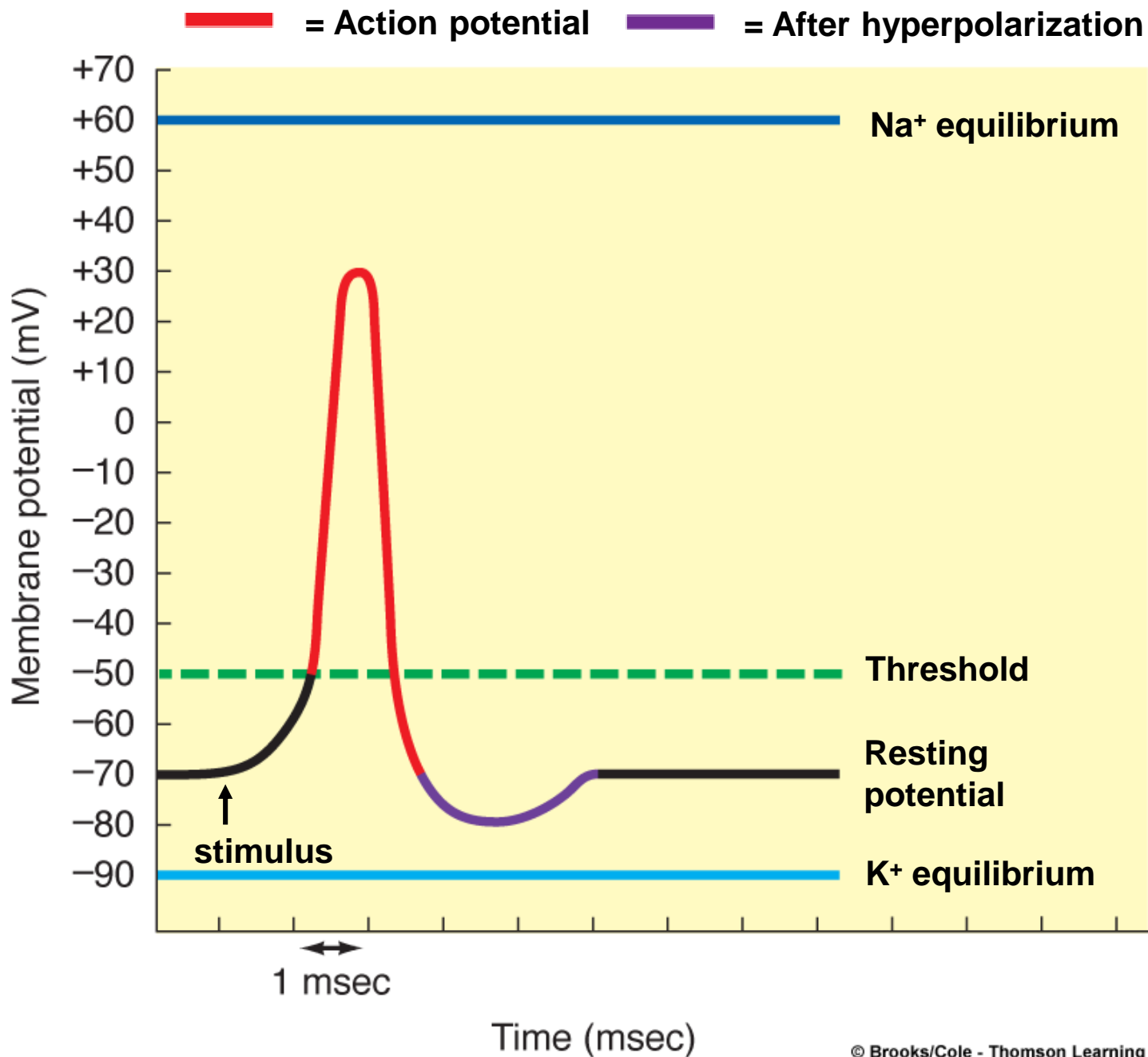
Action Potential has occurred!

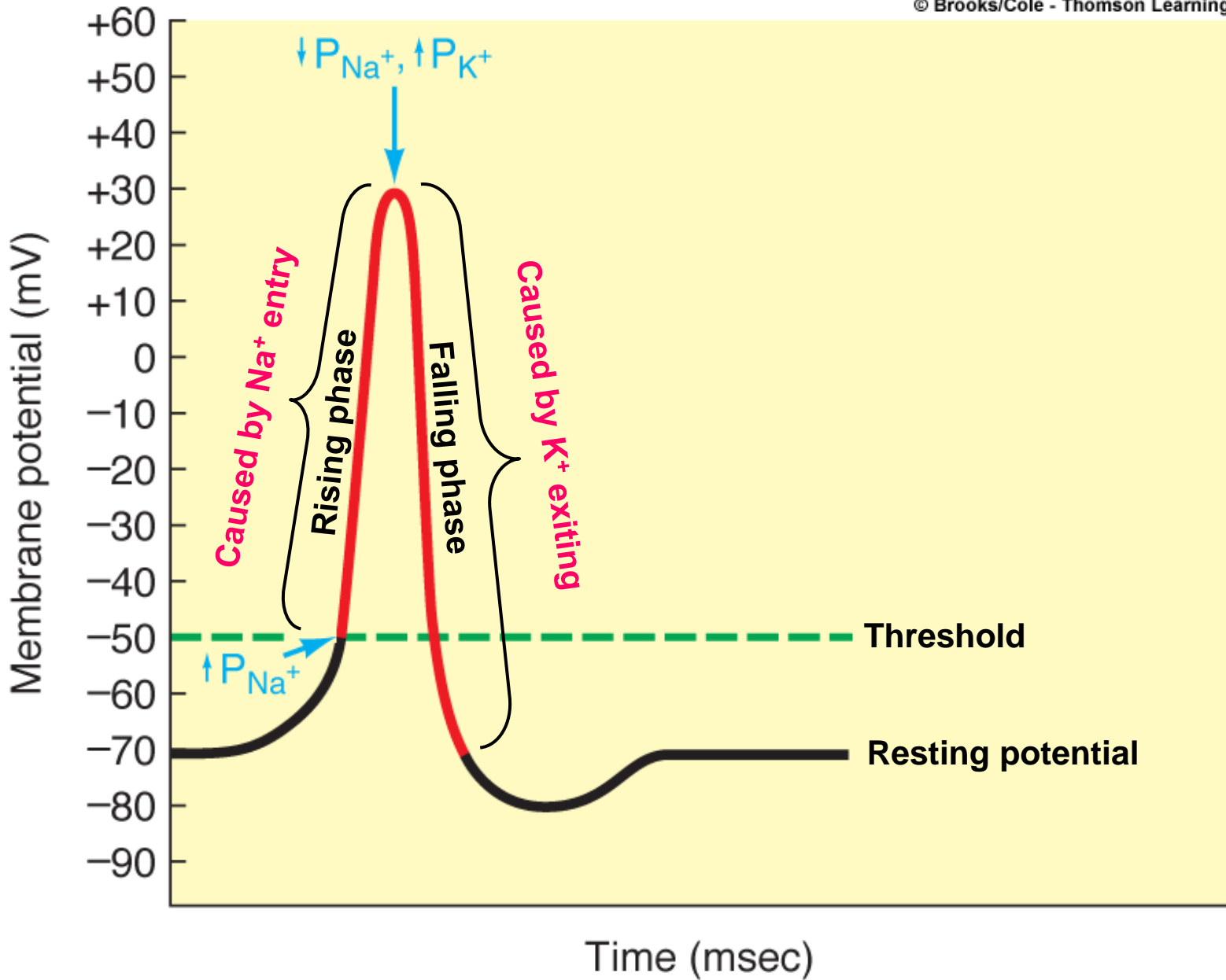


5

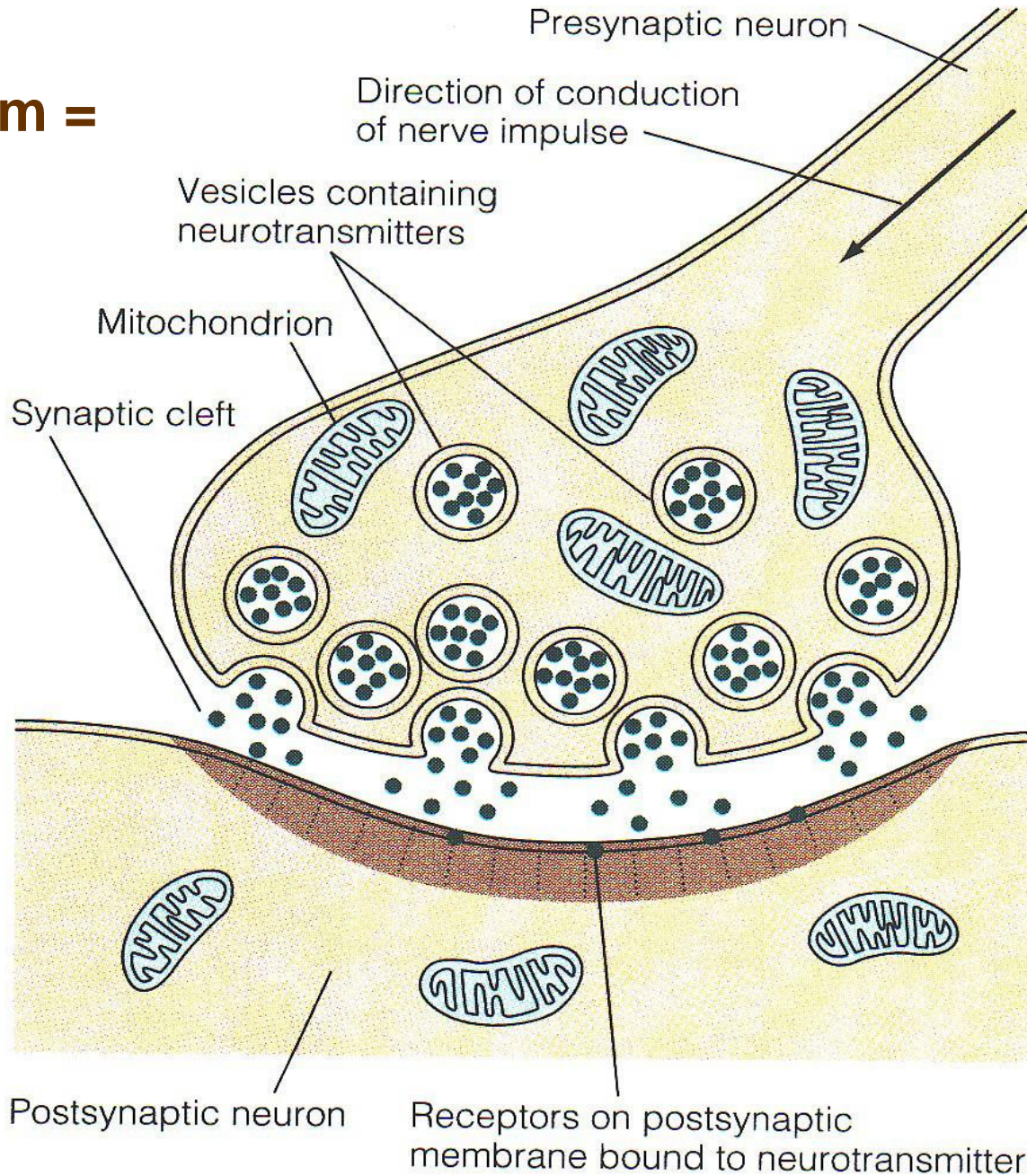
Brief (1-2 ms) reversal to + inside cell!

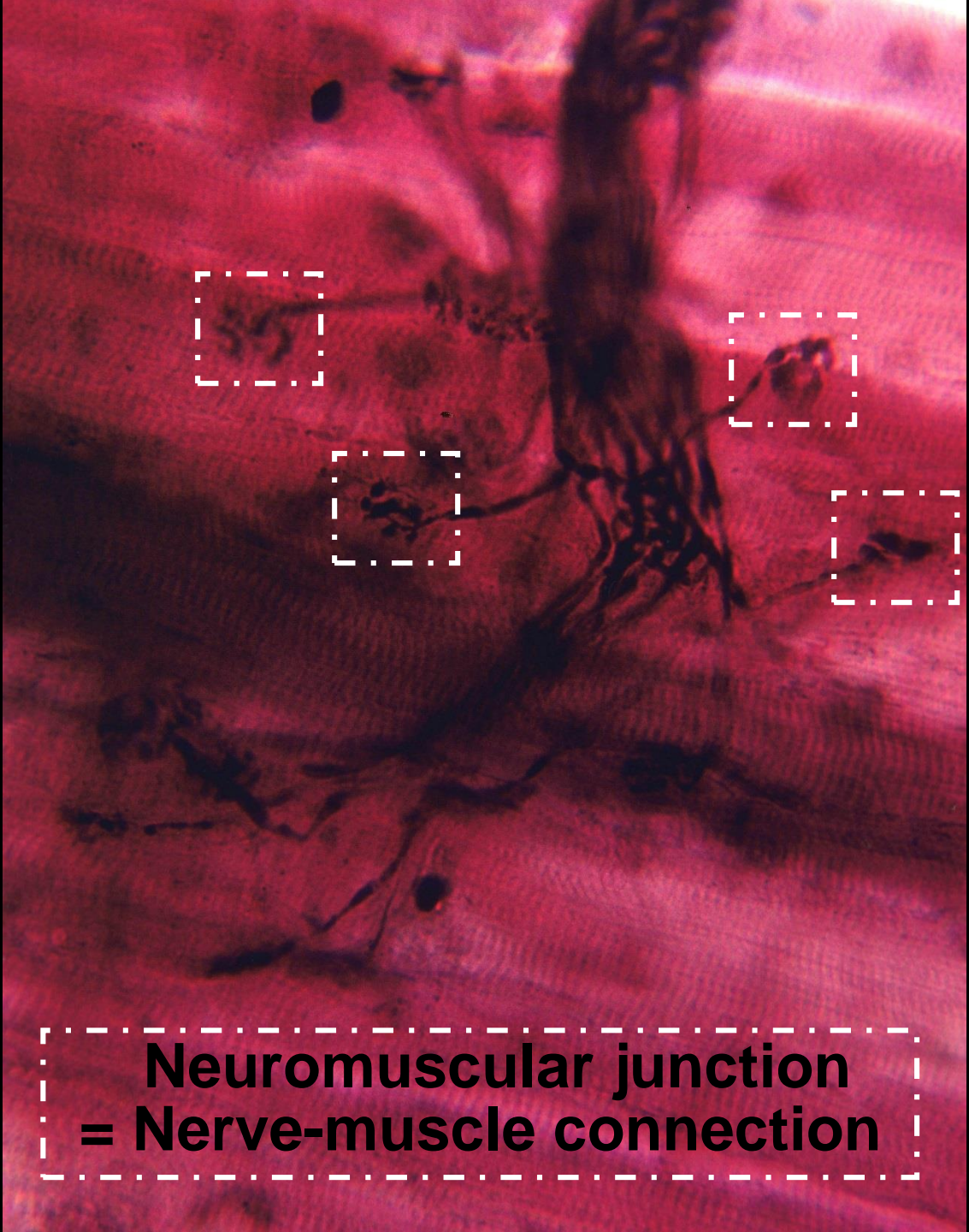




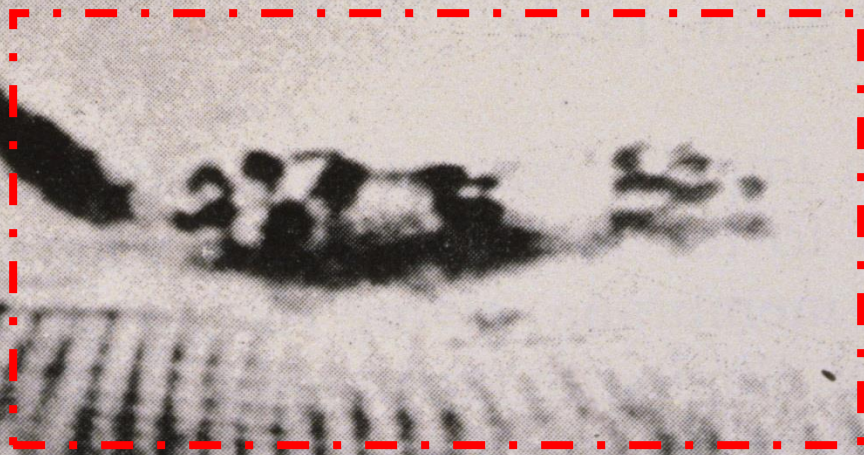
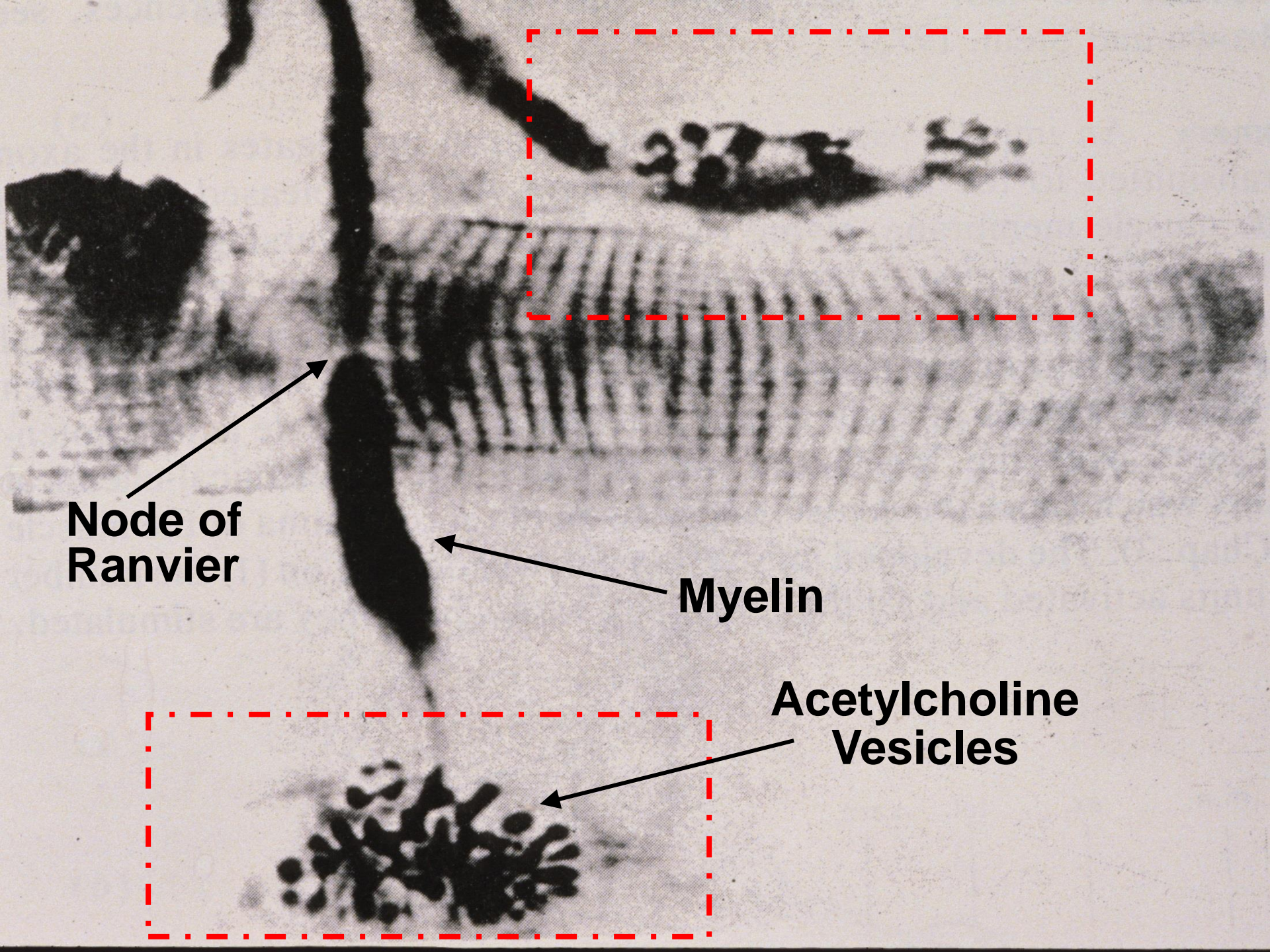


**Synapse =
Generic term =
connection
between
excitable
cells!**





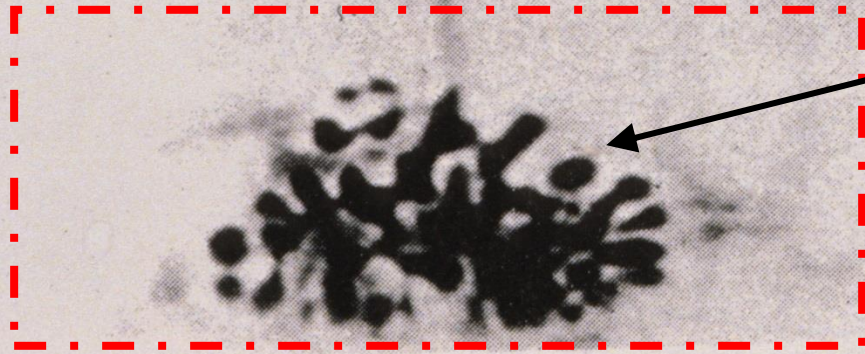
**Neuromuscular junction
= Nerve-muscle connection**



**Node of
Ranvier**

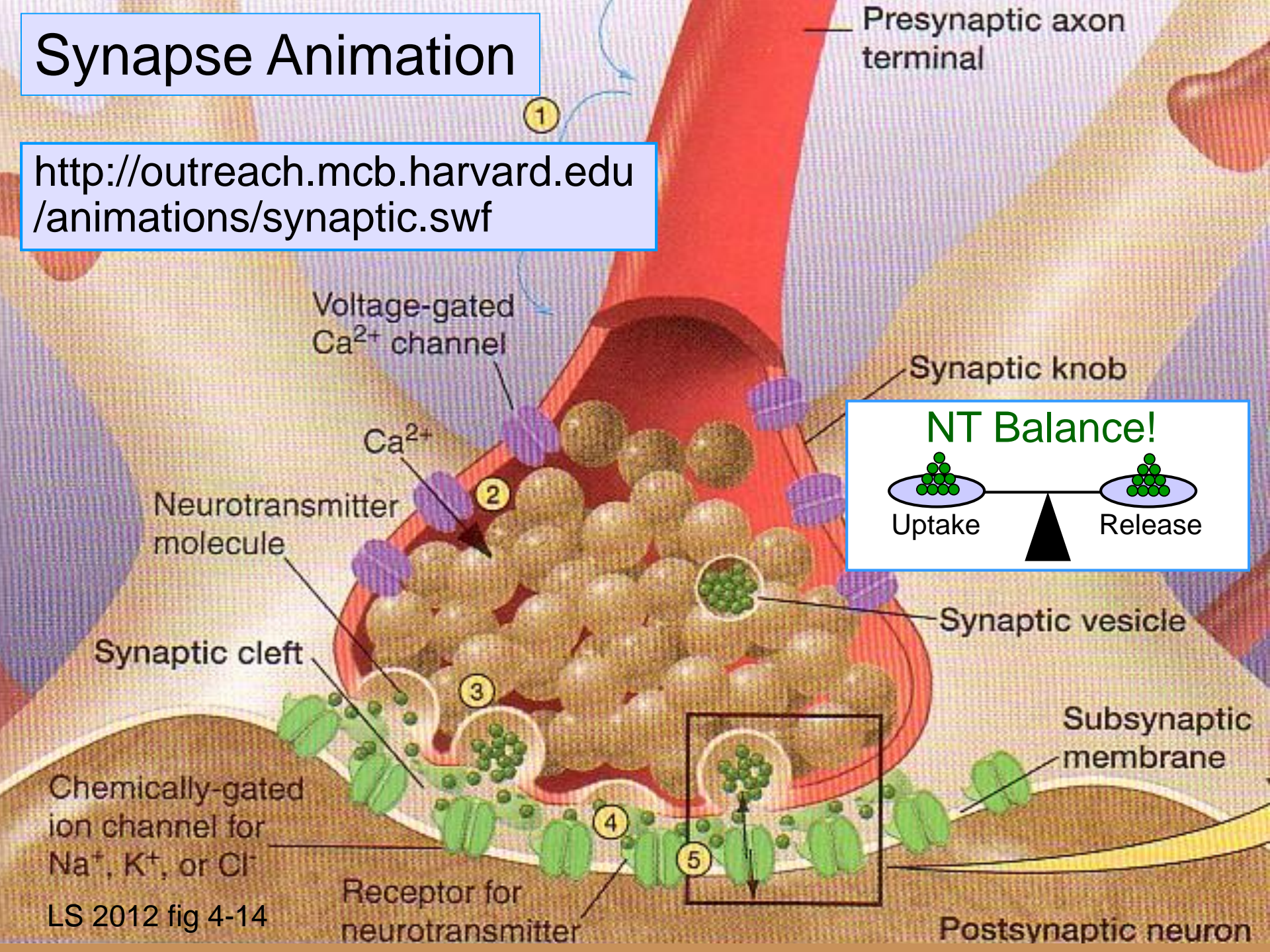
Myelin

**Acetylcholine
Vesicles**



Synapse Animation

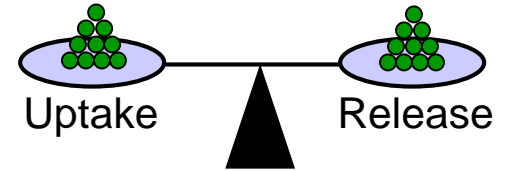
<http://outreach.mcb.harvard.edu/animations/synaptic.swf>



Chemically-gated ion channel for Na^+ , K^+ , or Cl^-

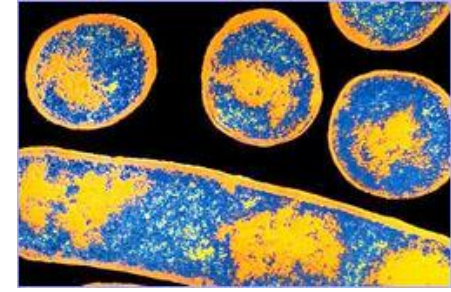
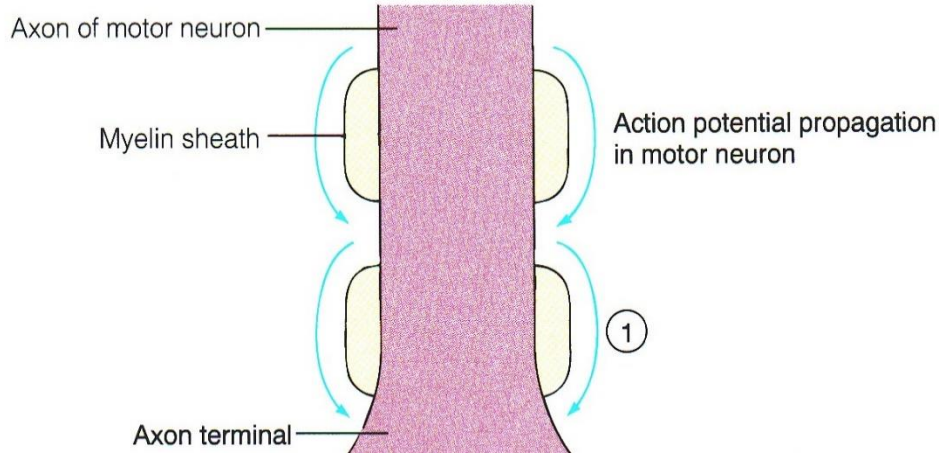
LS 2012 fig 4-14

NT Balance!

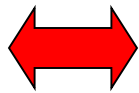
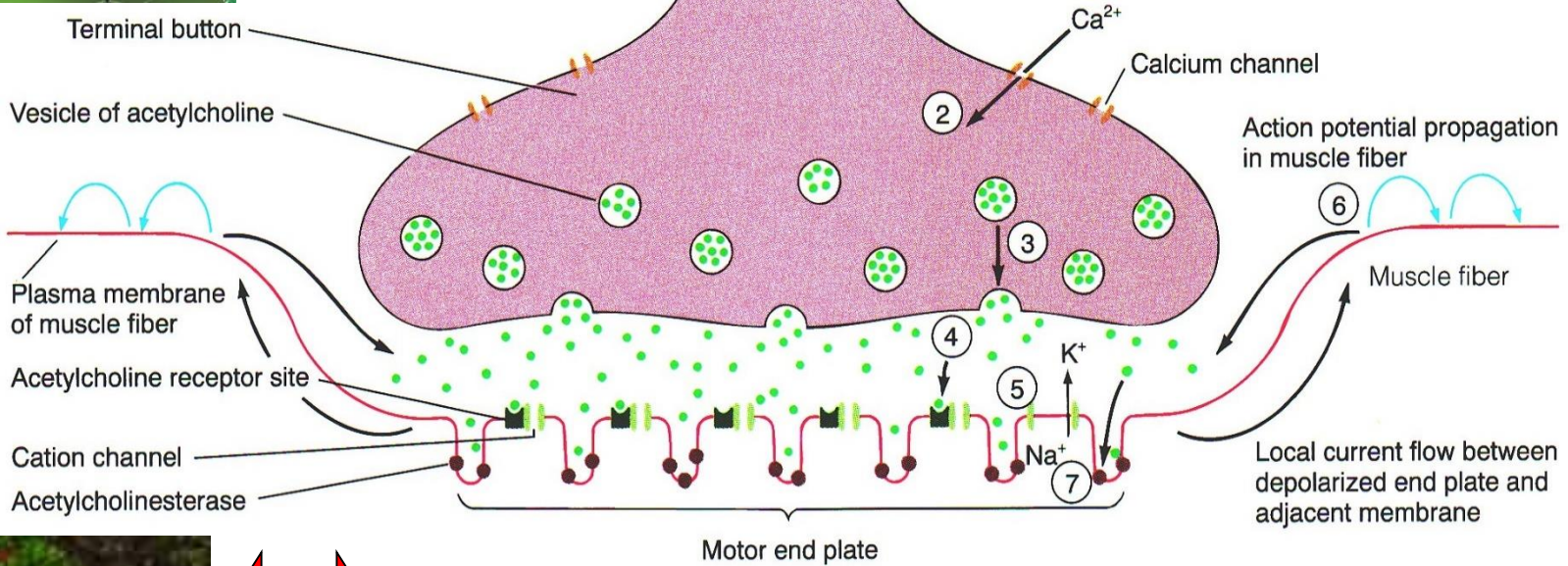


Postsynaptic neuron

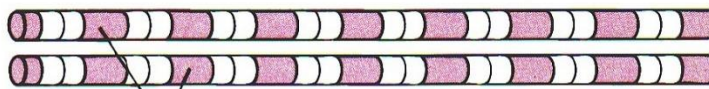
↑ 3



~~3~~



4

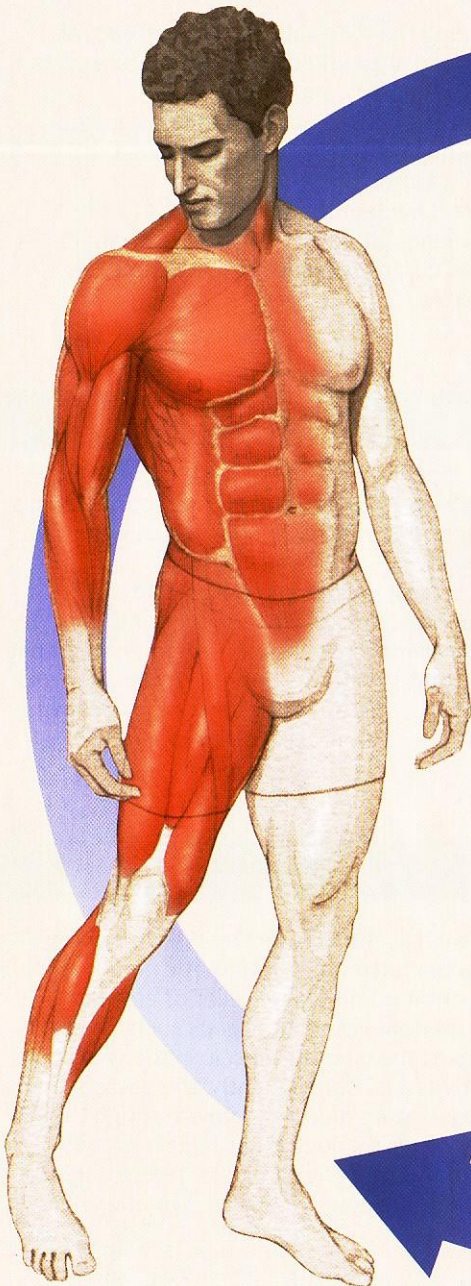


Contractile elements within muscle fiber

~~7~~



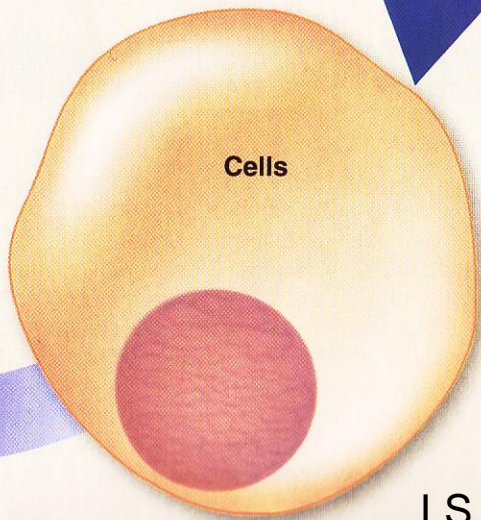
Skeletal Muscles



Body systems
maintain homeostasis

Homeostasis
Skeletal muscles contribute to homeostasis by playing a major role in the procurement of food, breathing, heat generation for maintenance of body temperature, and movement away from harm.

Homeostasis is
essential for
survival of cells



Cells make up
body systems

Striated muscle

Unstriated muscle

Skeletal muscle

Cardiac muscle

Smooth muscle

Ed Reschke

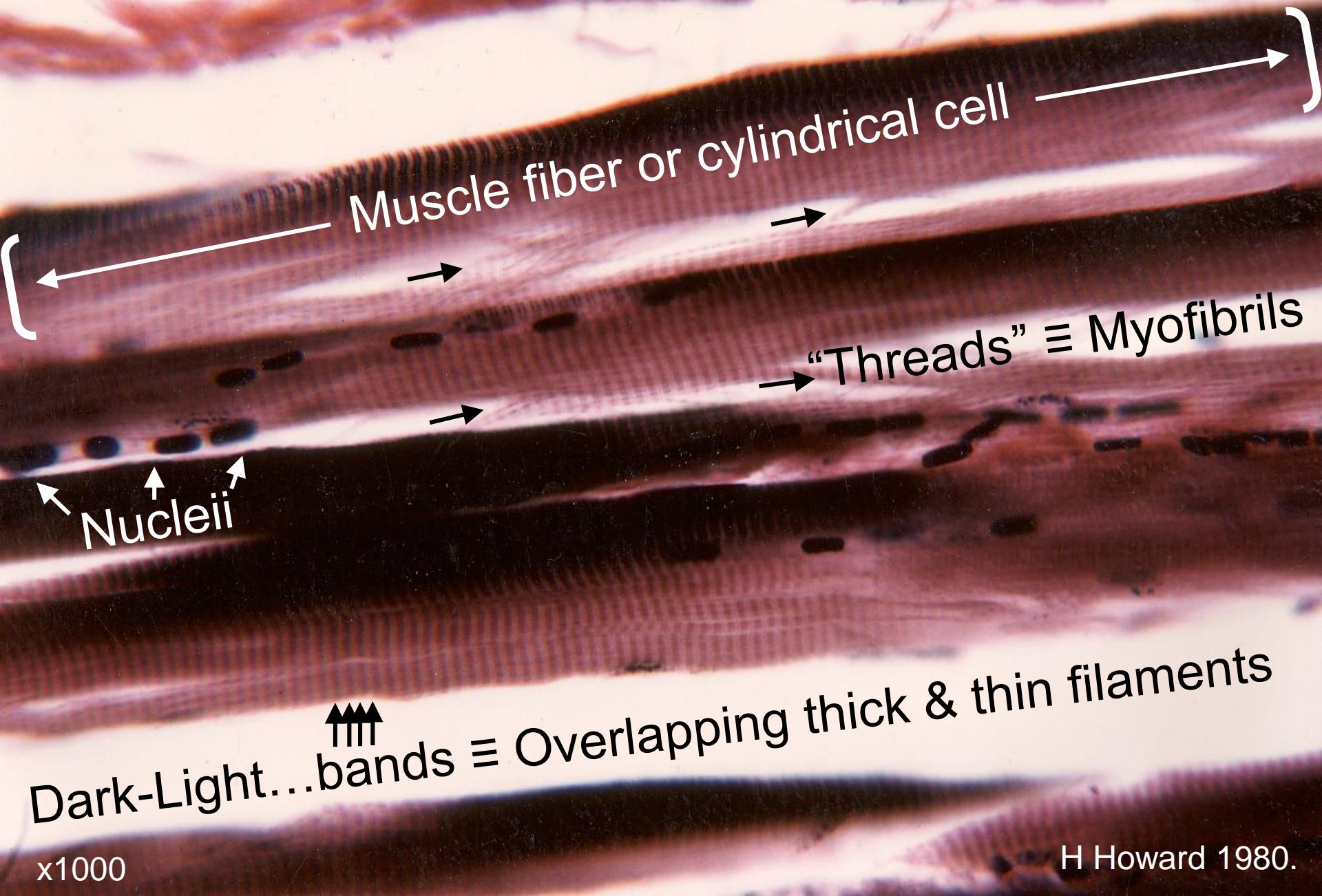
Ed Reschke

Biophoto/Photo Researchers, Inc.

Voluntary muscle

Involuntary muscle

Skeletal Muscle Histology: Microscopic Anatomy



Muscle fiber or cylindrical cell

Nucleii

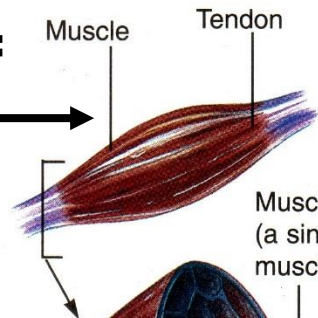
"Threads" ≡ Myofibrils

Dark-Light...bands ≡ Overlapping thick & thin filaments

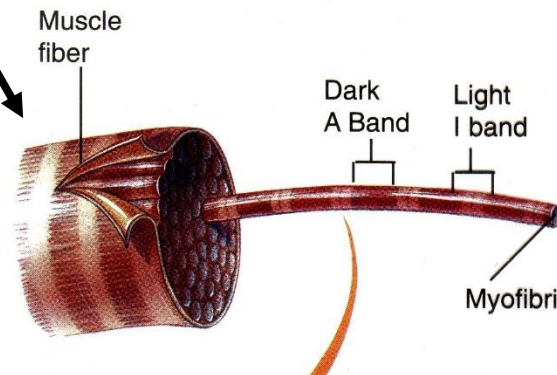
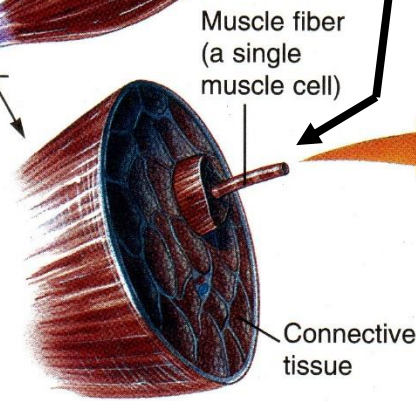
x1000

H Howard 1980.

**Organ =
Muscle**

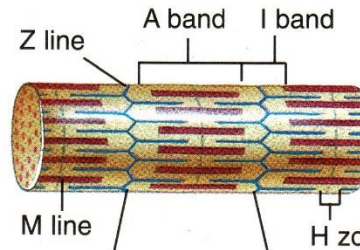


Cell = Myocyte = Fiber

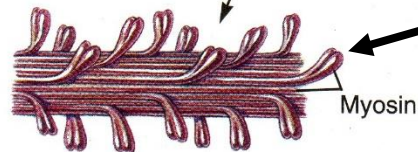
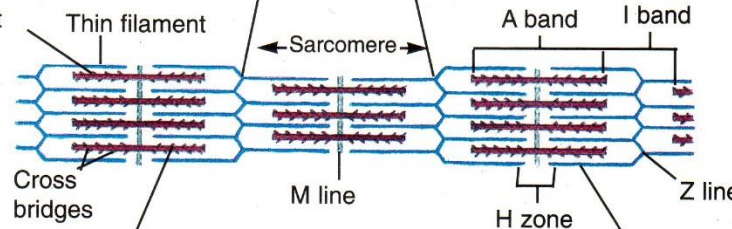


**Subcellular =
Cytoskeleton**

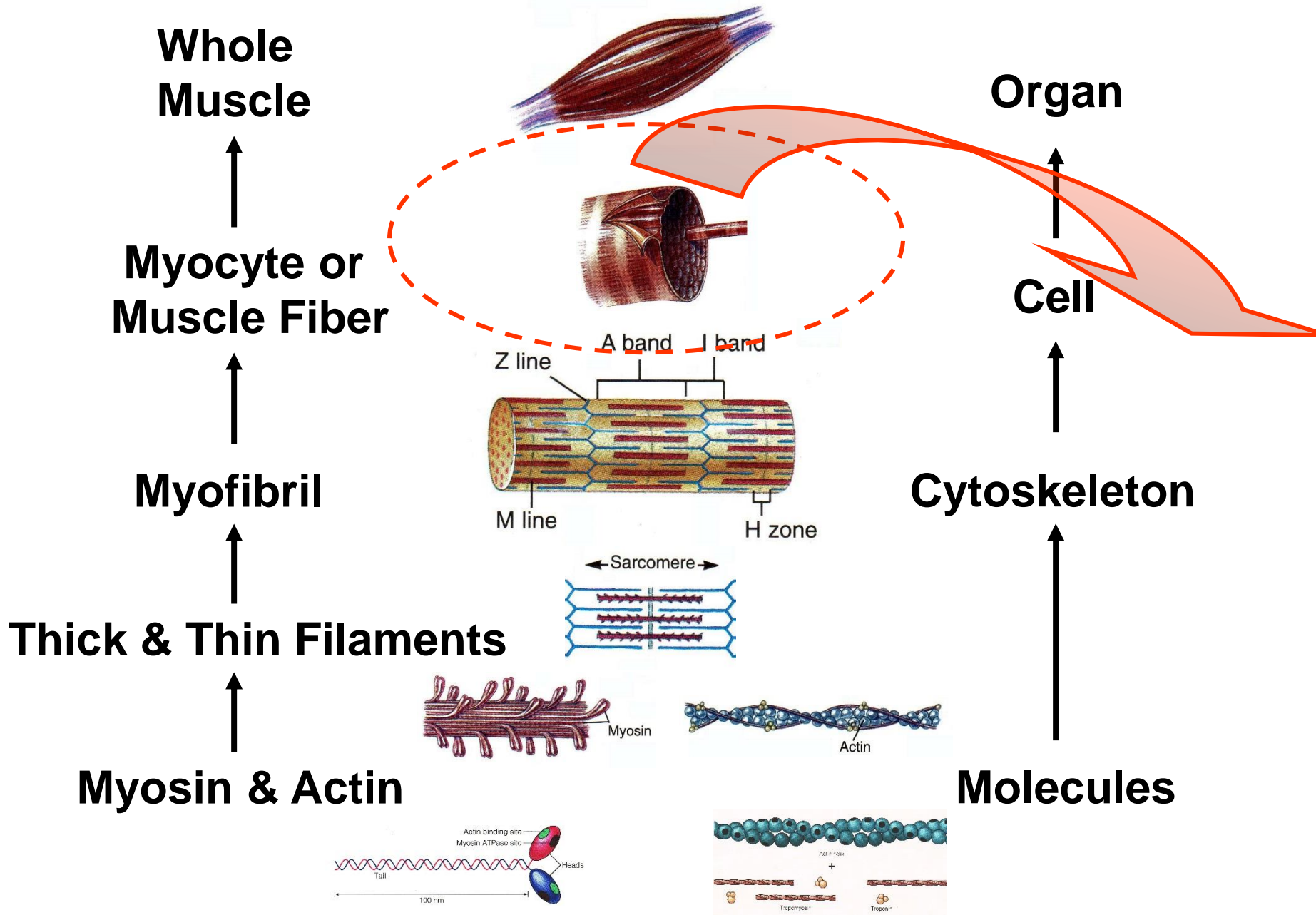
Portion
of myofibril

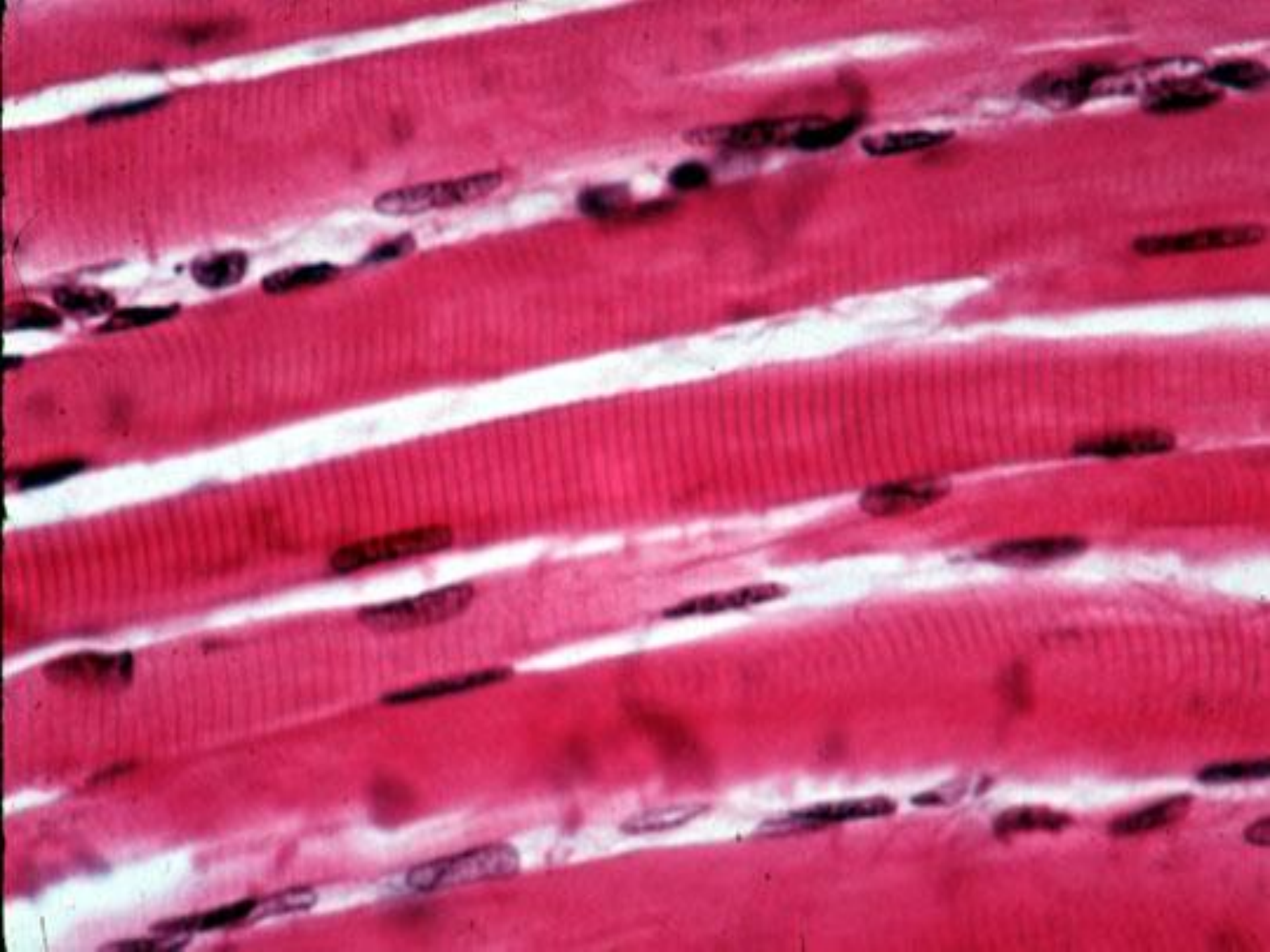


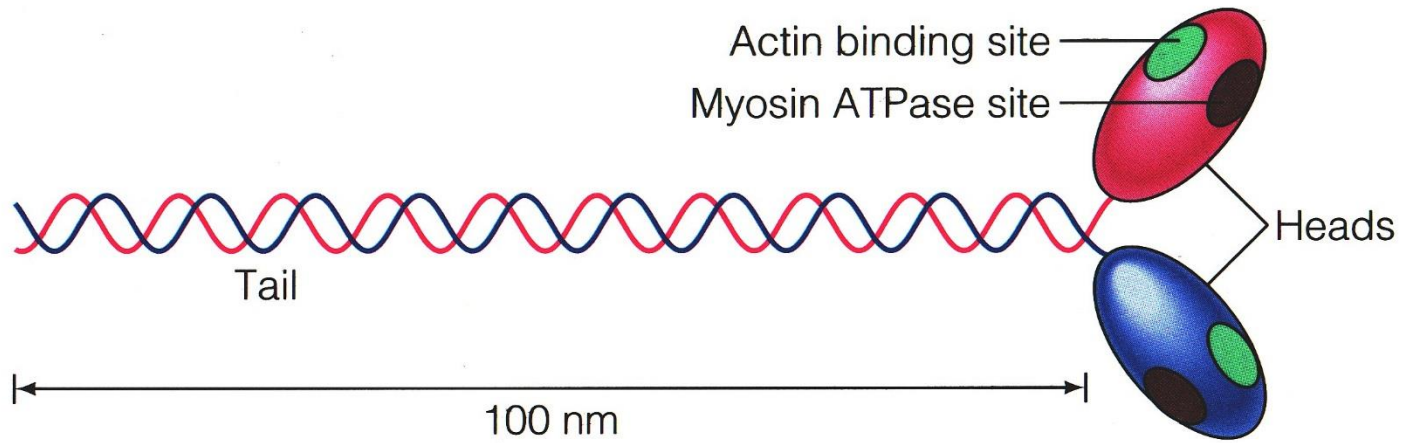
Thick filament



**Molecules =
Actin & Myosin**

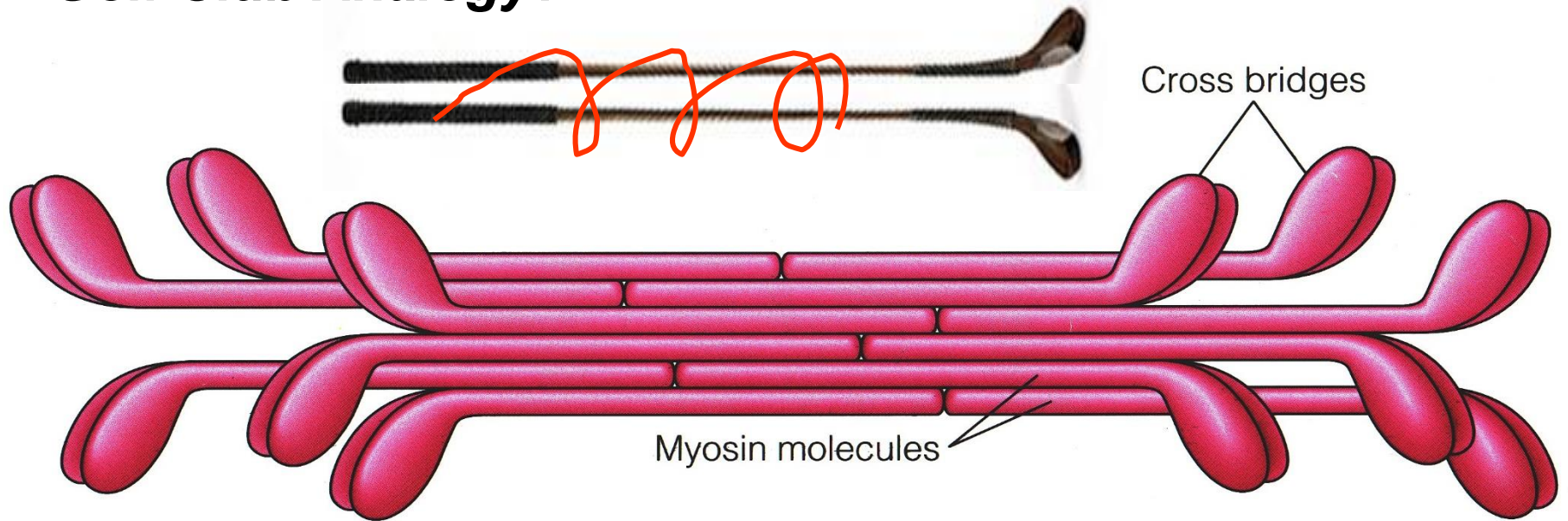






(a)

Golf Club Analogy?



(b)

Broccoli Analogy?

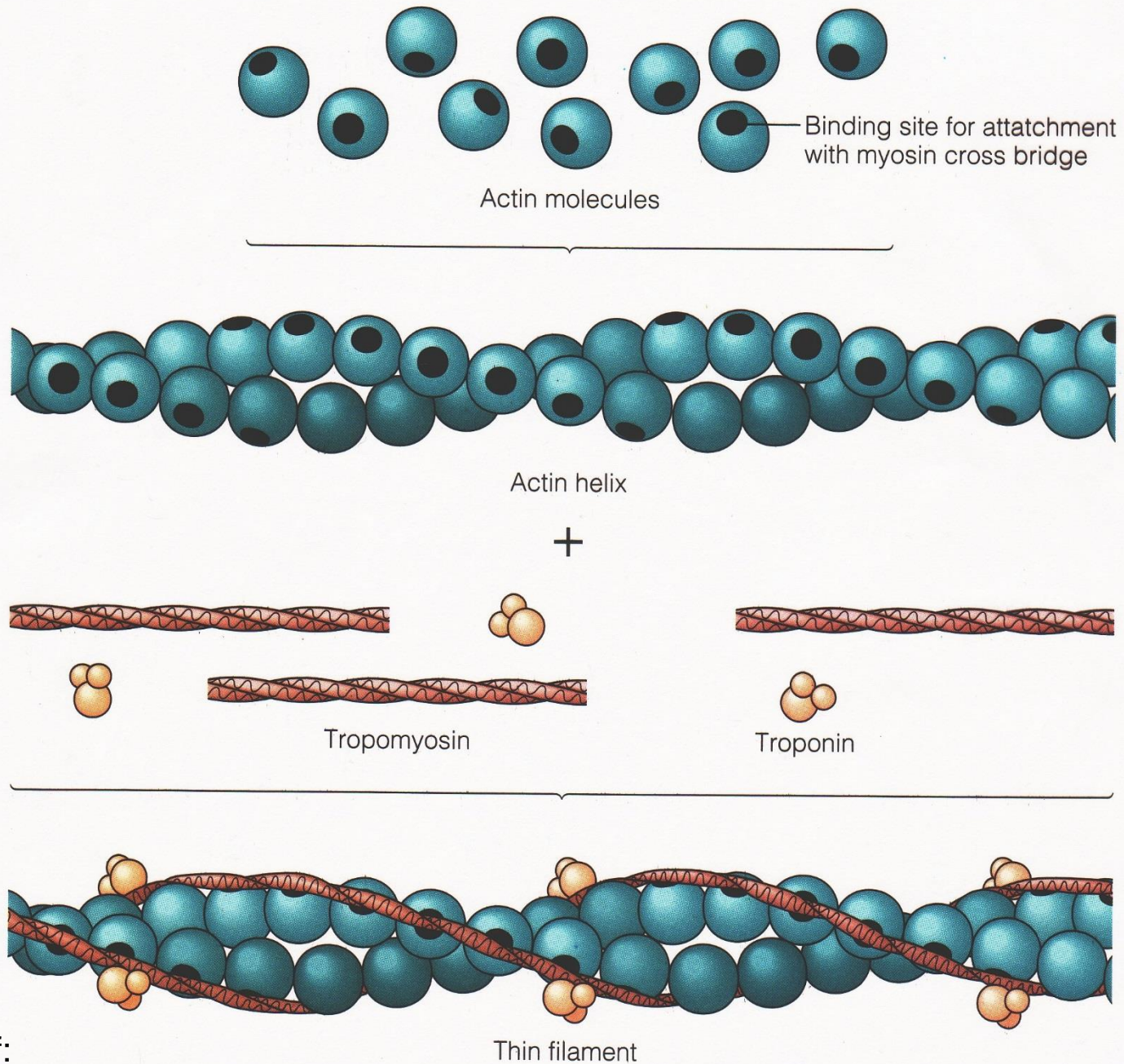
Myosin Heads

Myosin Heads

Myosin Tails

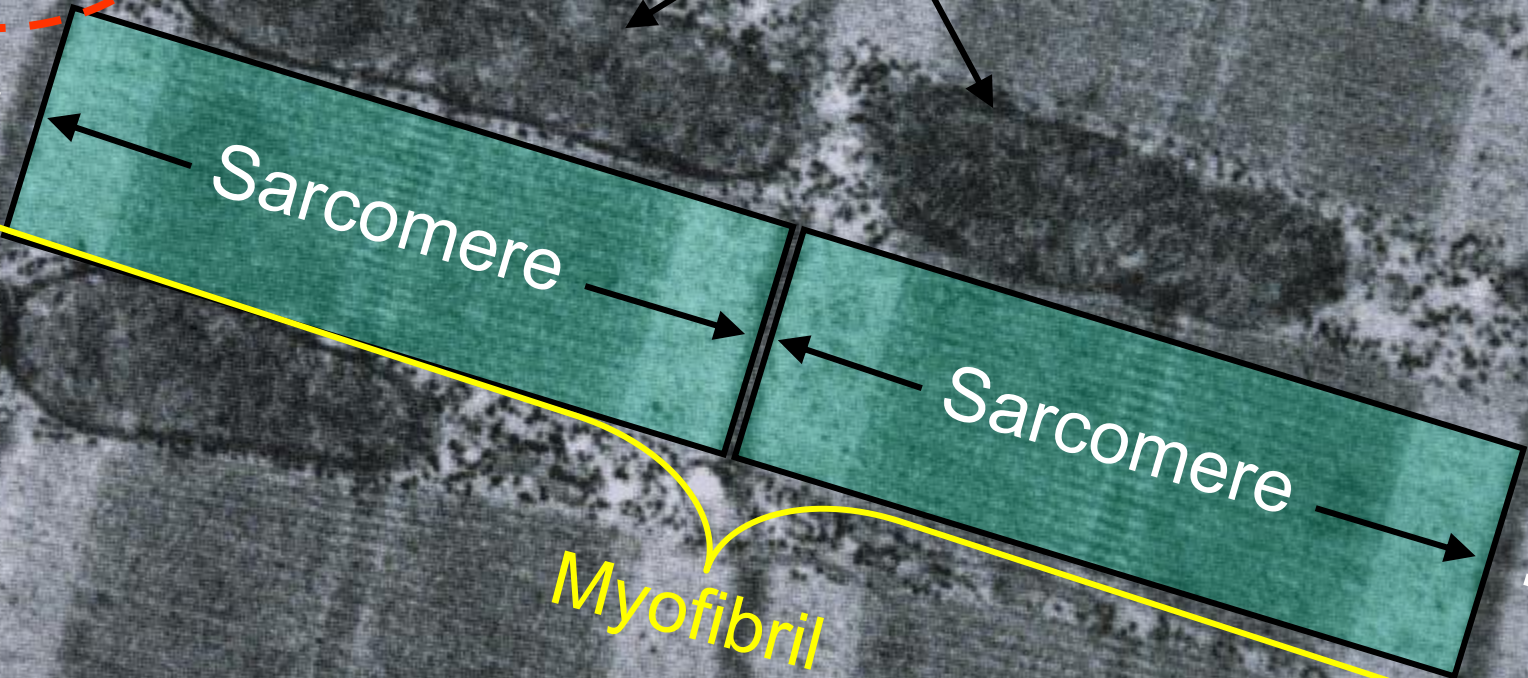


Bare Zone



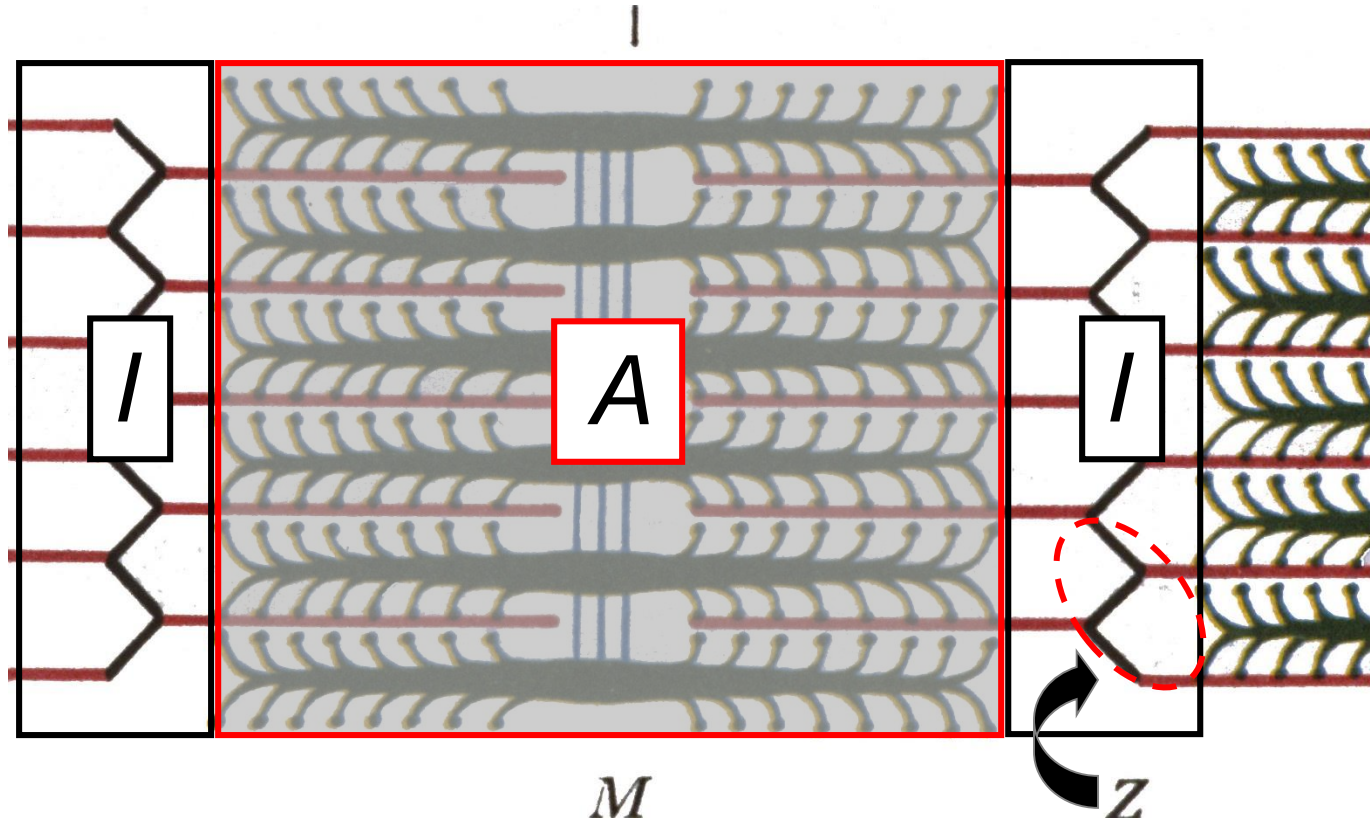
Triad \equiv T tubule abutting cisternae

Mitochondria

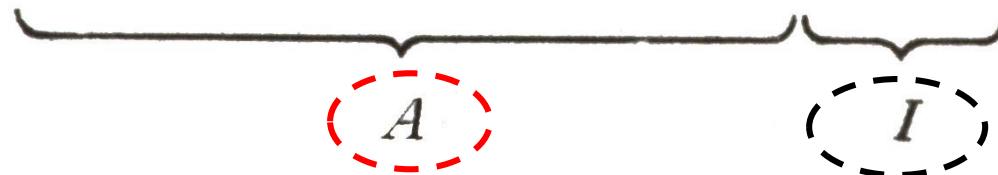


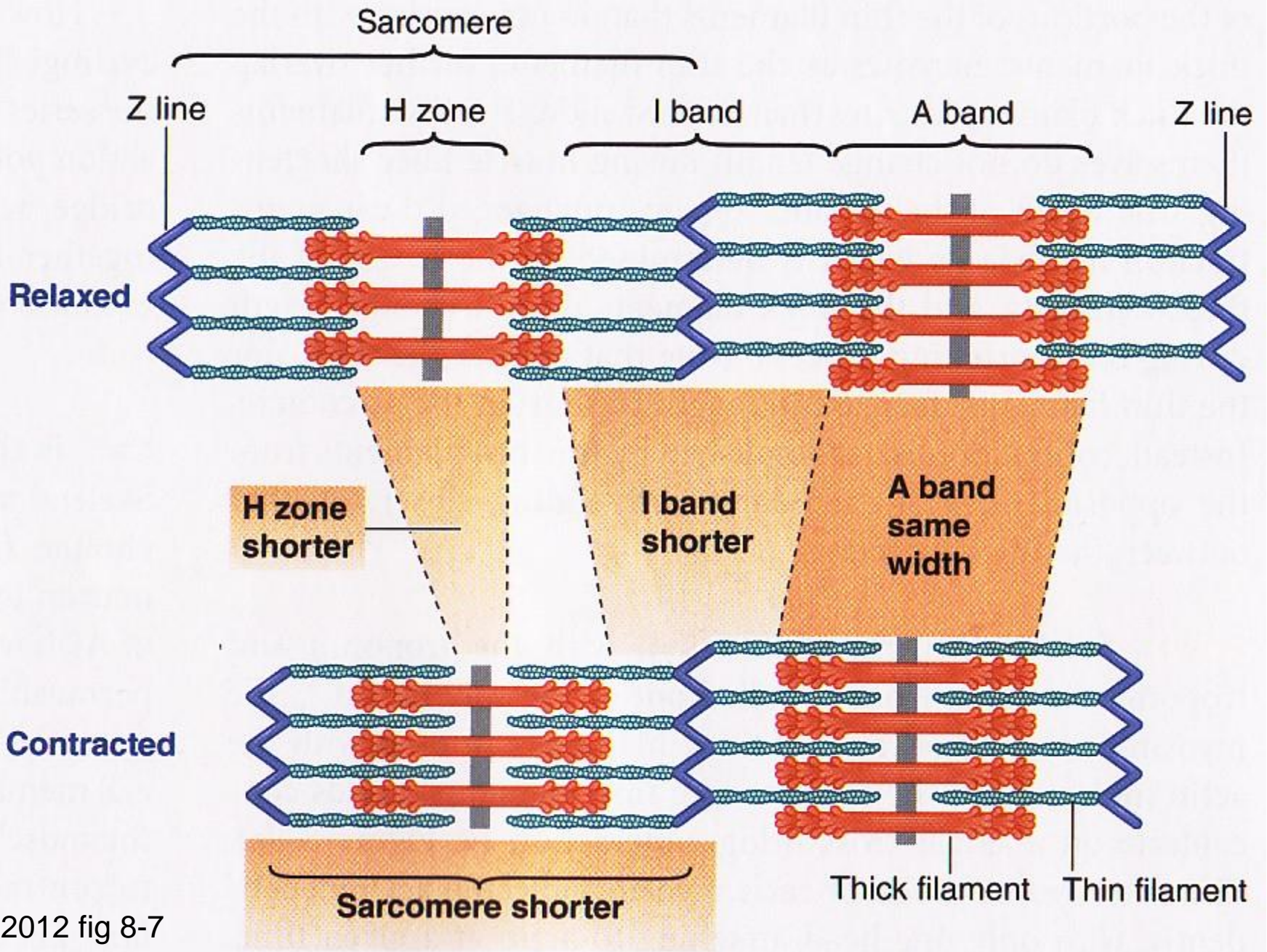
Myofibril

A Band = Dark Band
Anisotropic = Light Can't Shine Through



I Band = Light Band
Isotropic = Light Can Shine Through





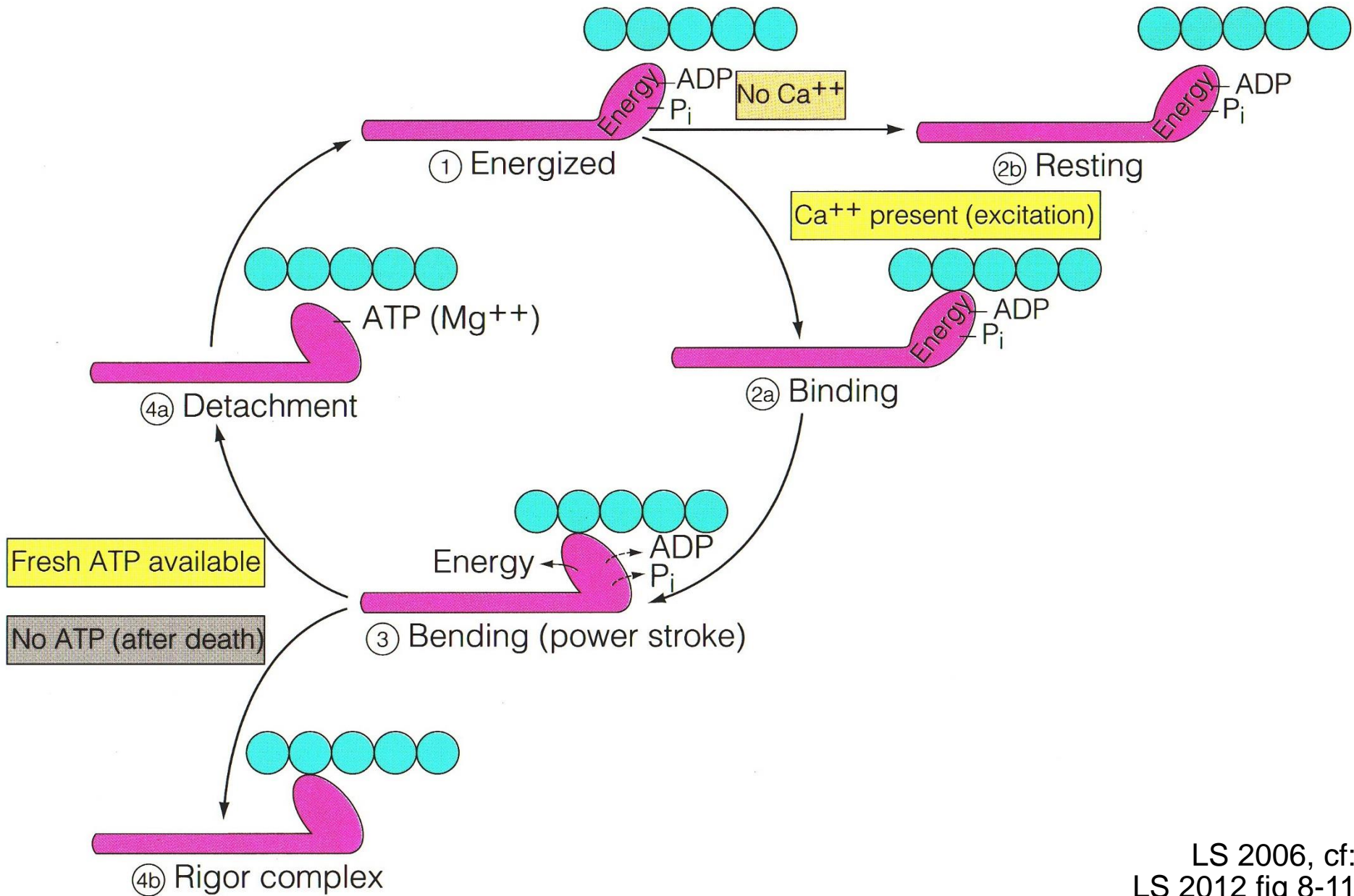
LS 2012 fig 8-7

Discussion + Time for Questions!

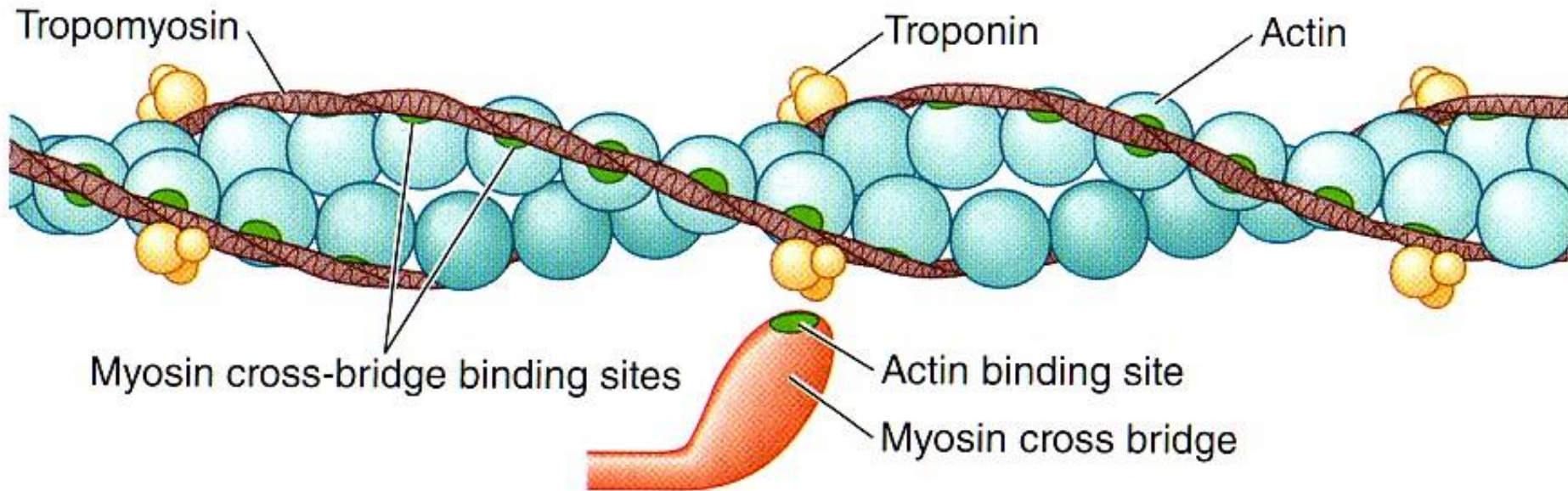


***What do we guess
happens at the
molecular level?***

Cross-Bridge Cycle



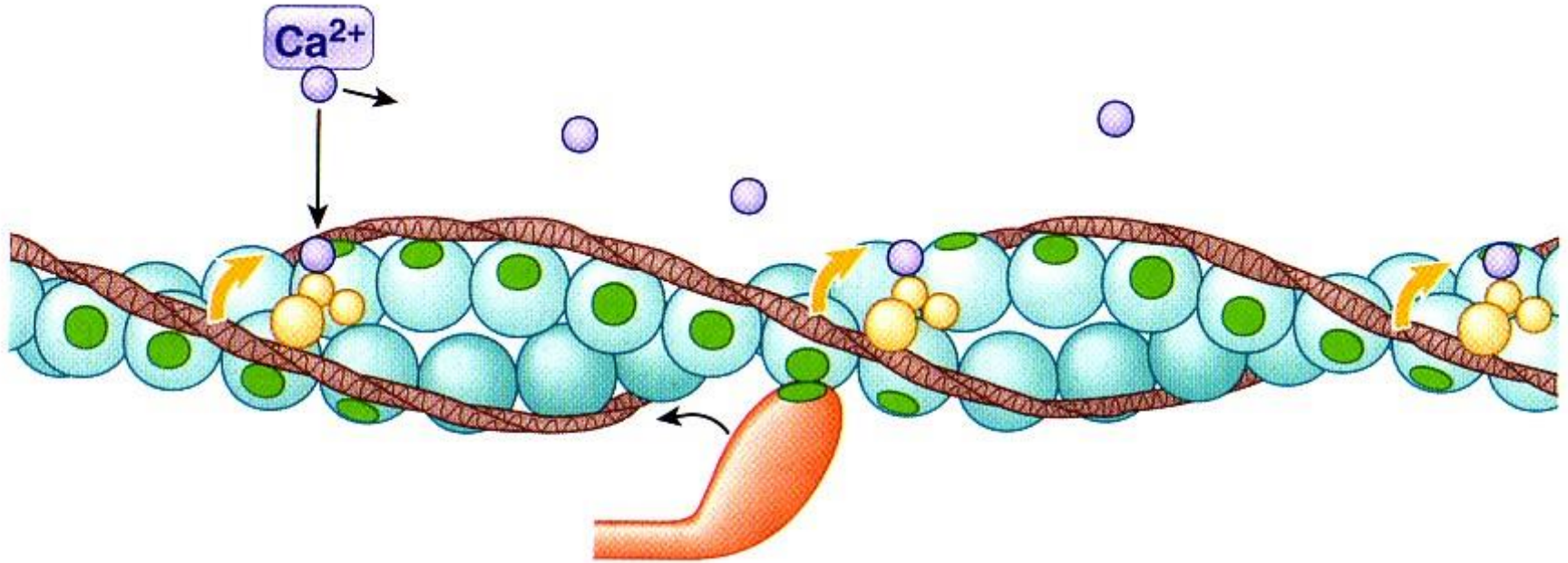
Relaxed: No Cross-Bridge Binding



(a) Relaxed

- 1** No excitation.
- 2** No cross-bridge binding because cross-bridge binding site on actin is physically covered by troponin–tropomyosin complex.
- 3** Muscle fiber is relaxed.

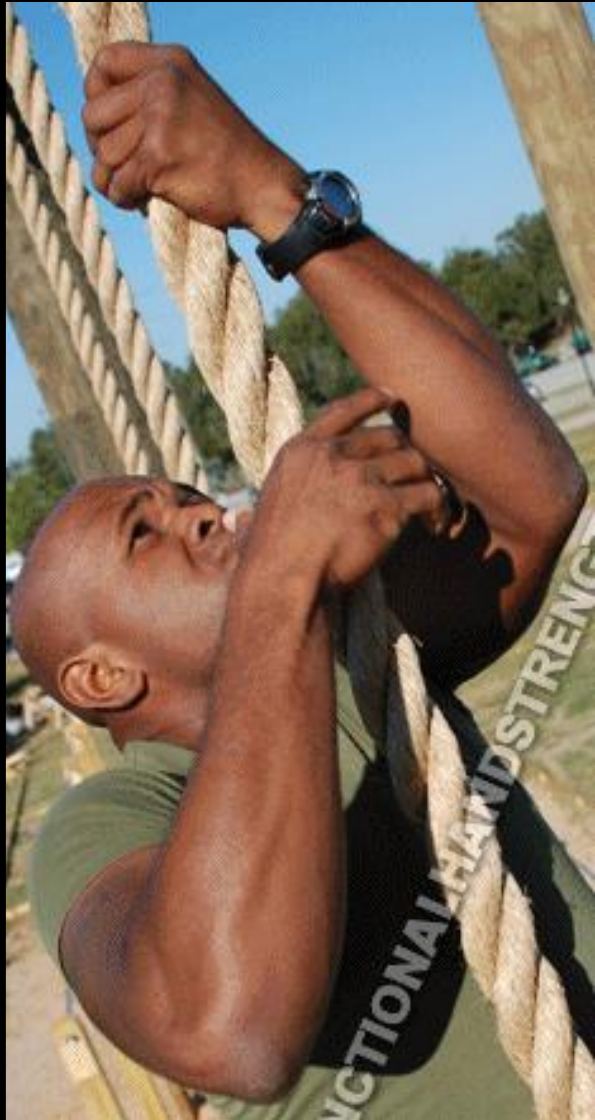
Excited: Calcium Triggers Cross-Bridge Binding



(b) Excited

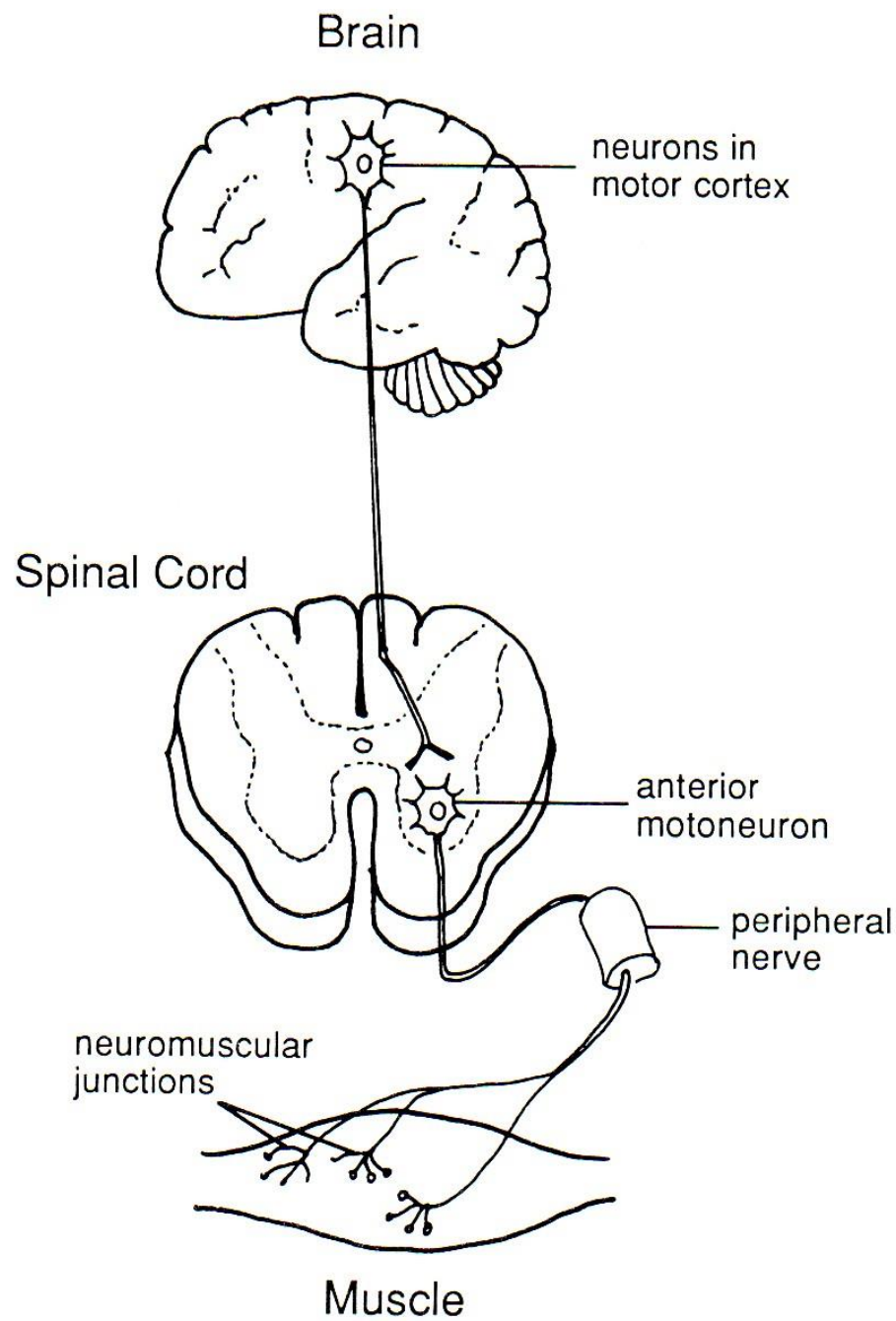
- 1** Muscle fiber is excited and Ca^{2+} is released.
- 2** Released Ca^{2+} binds with troponin, pulling troponin–tropomyosin complex aside to expose cross-bridge binding site.
- 3** Cross-bridge binding occurs.
- 4** Binding of actin and myosin cross bridge triggers power stroke that pulls thin filament inward during contraction.

Rope Climb or Tug of War Grasp, then Regrasp!



Summary
We are almost
there!

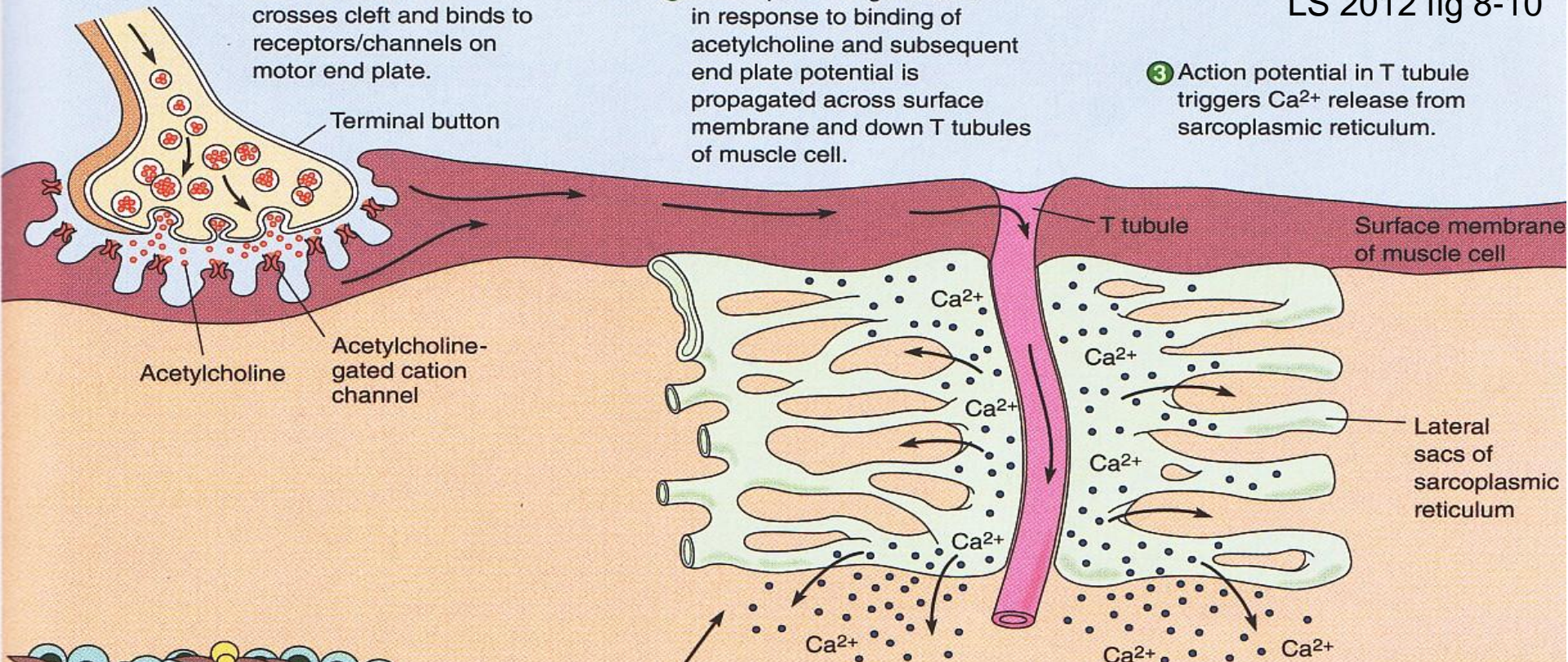




1 Acetylcholine released by axon of motor neuron crosses cleft and binds to receptors/channels on motor end plate.

2 Action potential generated in response to binding of acetylcholine and subsequent end plate potential is propagated across surface membrane and down T tubules of muscle cell.

3 Action potential in T tubule triggers Ca^{2+} release from sarcoplasmic reticulum.



Acetylcholine
Acetylcholine-gated cation channel

T tubule
Surface membrane of muscle cell

Lateral sacs of sarcoplasmic reticulum

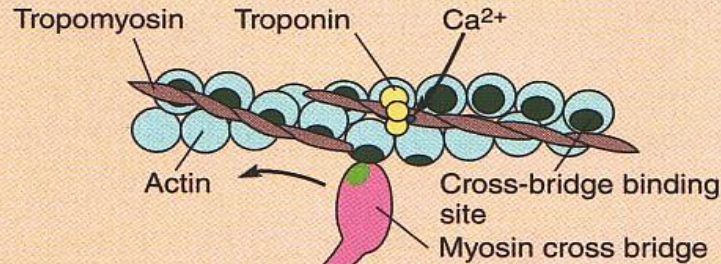
Ca^{2+}

7 With Ca^{2+} no longer bound to troponin, tropomyosin slips back to its blocking position over binding sites on actin; contraction ends; actin passively slides back to original resting position.

6 Ca^{2+} actively taken up by sarcoplasmic reticulum when there is no longer local action potential.

5 Myosin cross bridges attach to actin and bend, pulling actin filaments toward center of sarcomere; powered by energy provided by ATP.

4 Calcium ions released from lateral sacs bind to troponin on actin filaments; leads to tropomyosin being physically moved aside to uncover cross-bridge binding sites on actin.

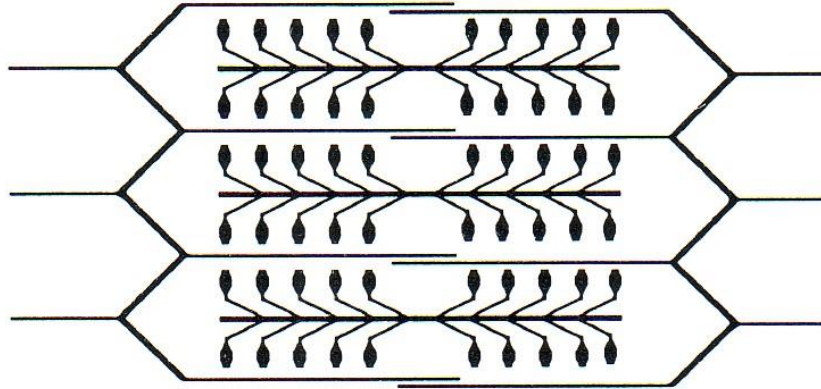


Tropomyosin Troponin

Actin
Cross-bridge binding site
Myosin cross bridge

Ca^{2+}

Relaxation Phase



1. Excitation by nerve fiber
2. Conduction by T-tubules
3. Ca^{2+} release by SR

Contractile Phase

