

BI 121 Lecture 13



I'm gonna smash Exam II because
— I'm dedicated & I ❤️ physiology!



I. Announcements **No lab today – Study for Exam II!!**

Optional Lab notebook check after last Lab 6, Mac pulmonary function testing (PFT) next Thursday. Q?

II. Peripheral Nervous System Connections

LS sections of ch 3, 4, & 7

A. How do excitable cells signal? ch 3 pp 62-7; ch 4 pp 74-83

B. How does the signal cross the nerve-muscle gap?

ch 7 p 185-92 fig 7-5 p 190

1. Ca^{2+} bones!...but what else? p 190

2. What do black widow spider venom, botulism, curare & nerve gas have in common? Botox pp 189-92

III. Muscle Structure + Function LS ch 8 + DC Module 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

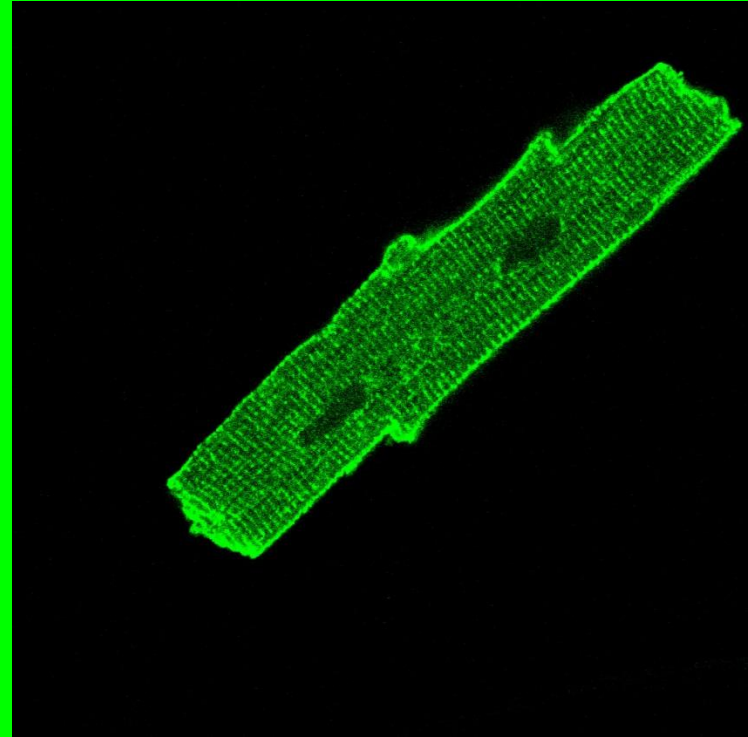
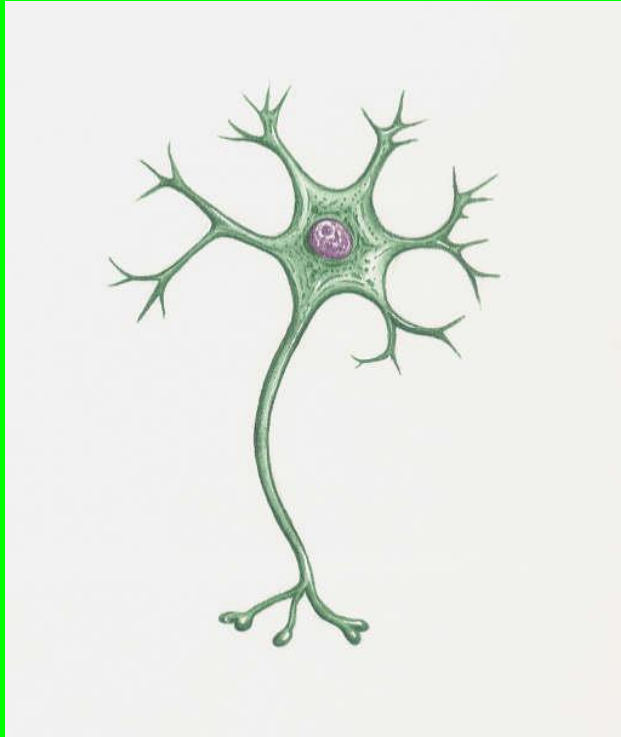
C. What do thick filaments look like? LS fig 8-4, DC fig 12-4

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 +...

Why are nerve & muscle unique?



They are excitable!!

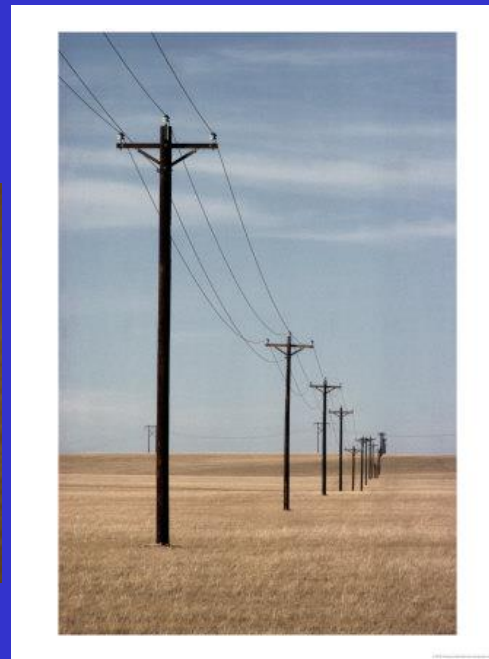
Action Potentials \equiv Spikes \equiv Impulses

Ultra-short reversal of membrane potential

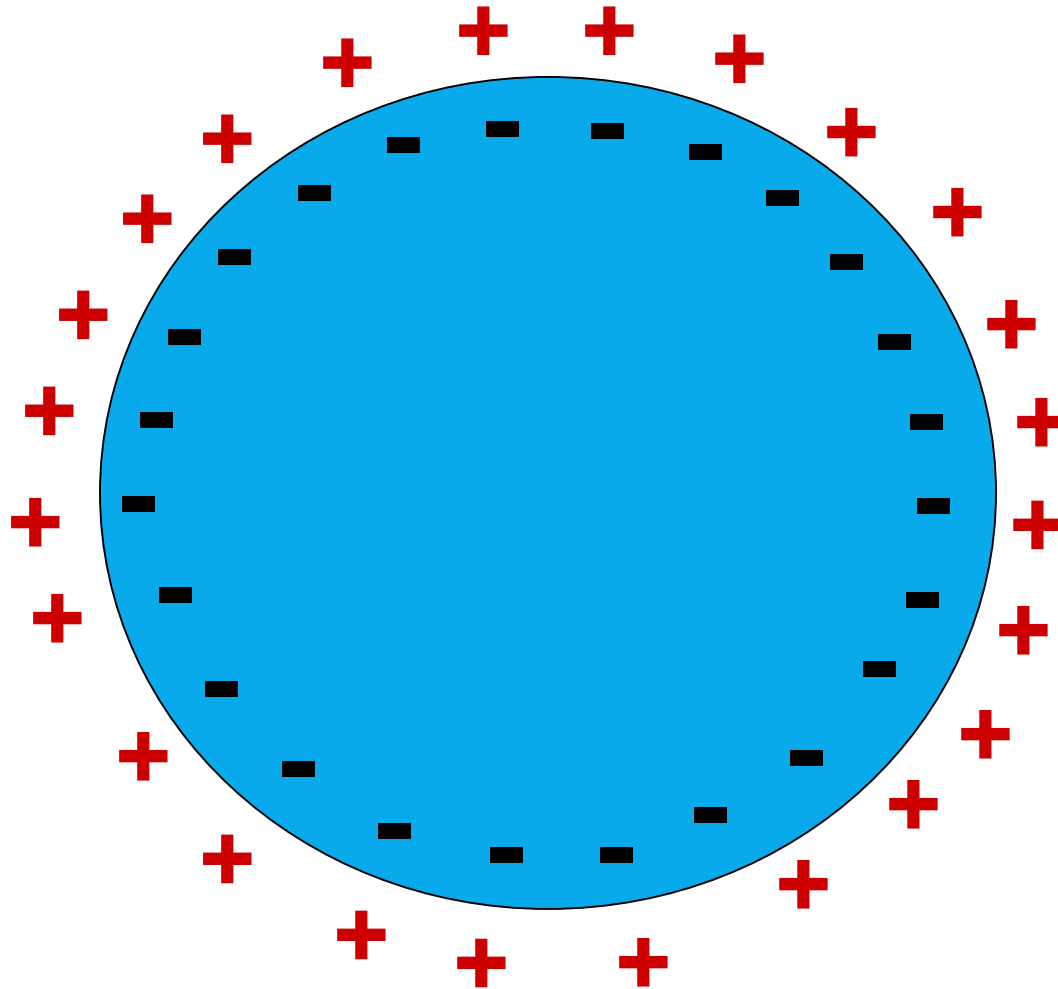
Only in nerve and muscle cells

Maintains strength over distance

Primary way nerves & muscles communicate!



"Resting"/Membrane Potential?



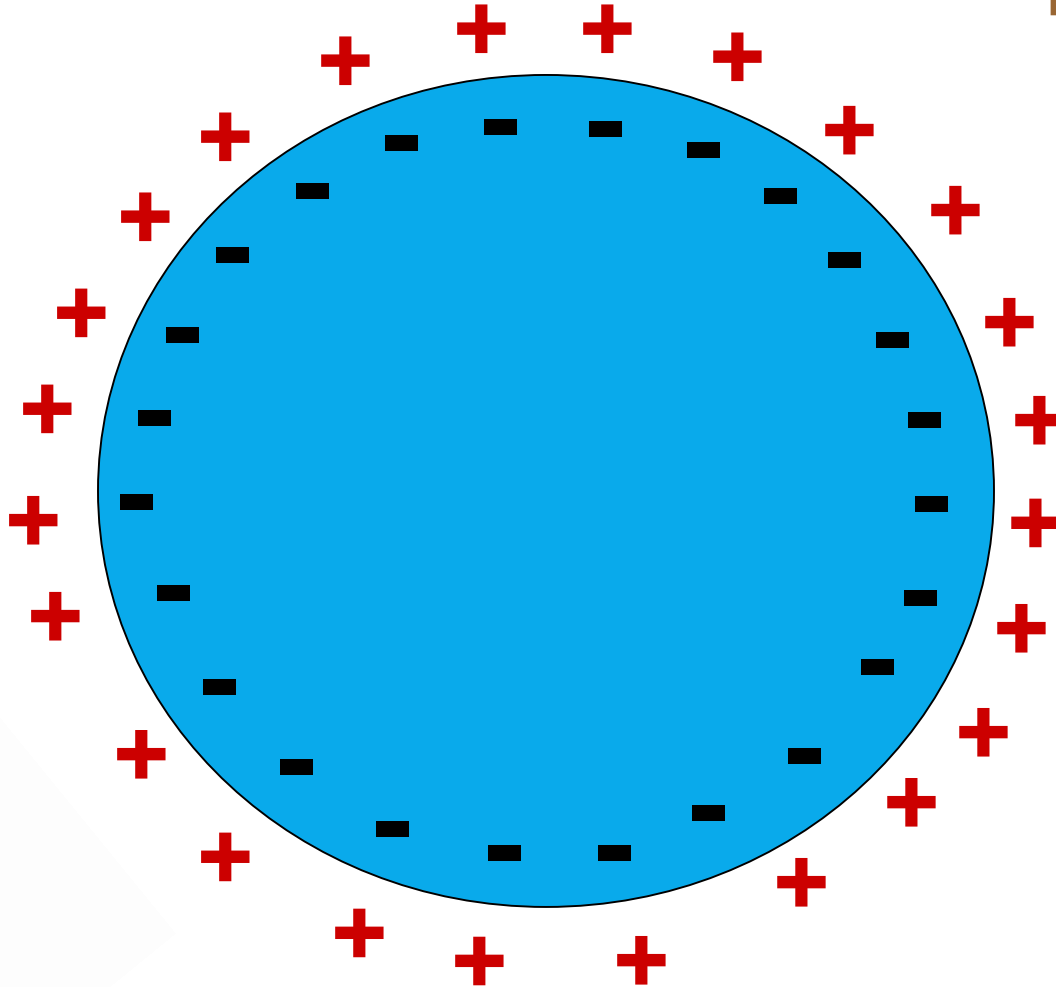
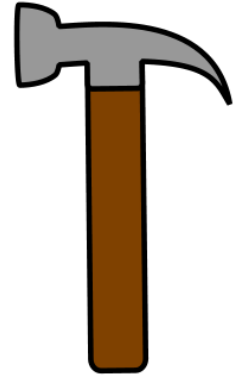
Cells are slightly negative inside!

Stimulate Cell @ Rest

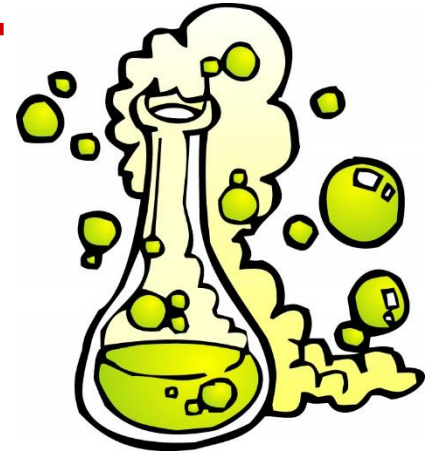
Thermal



Mechanical



1

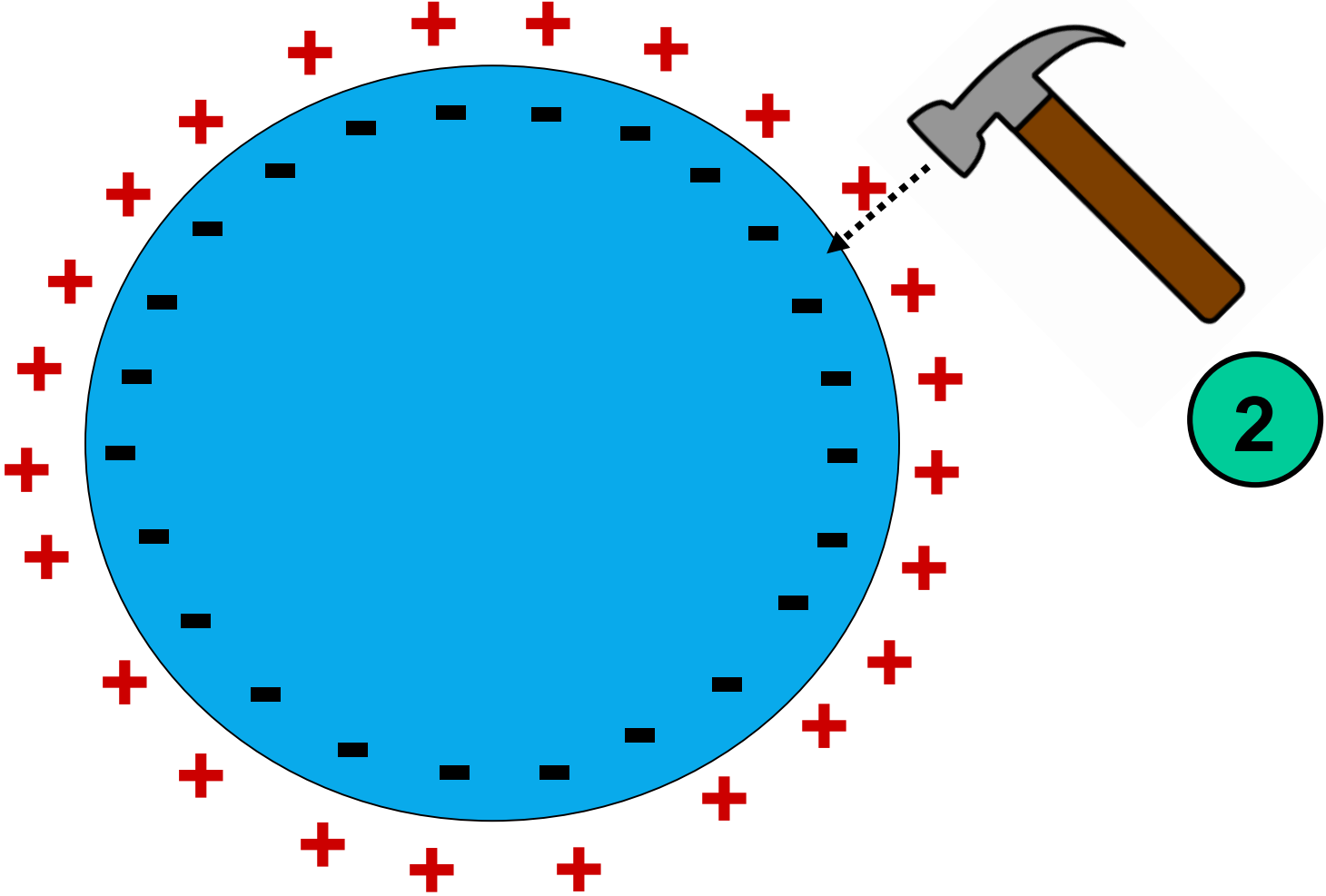


Electrical

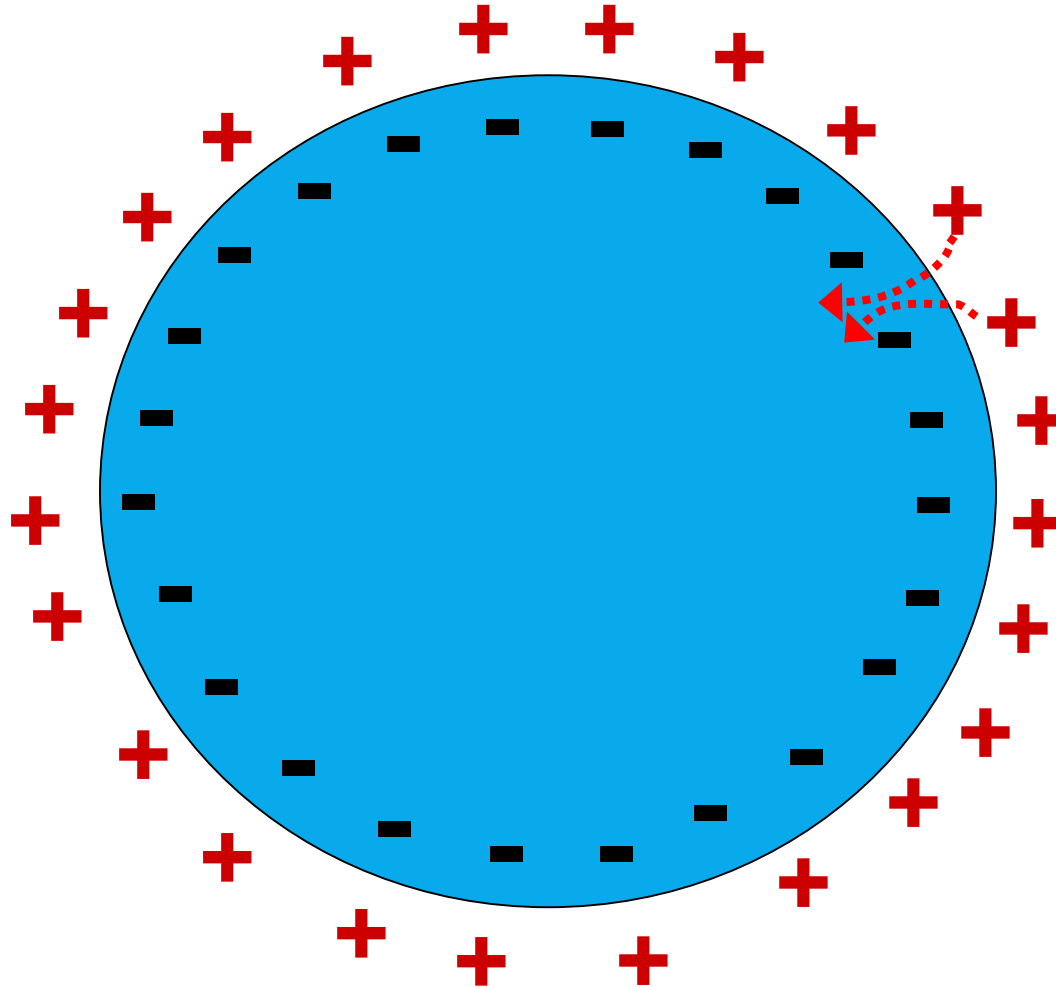
Chemical



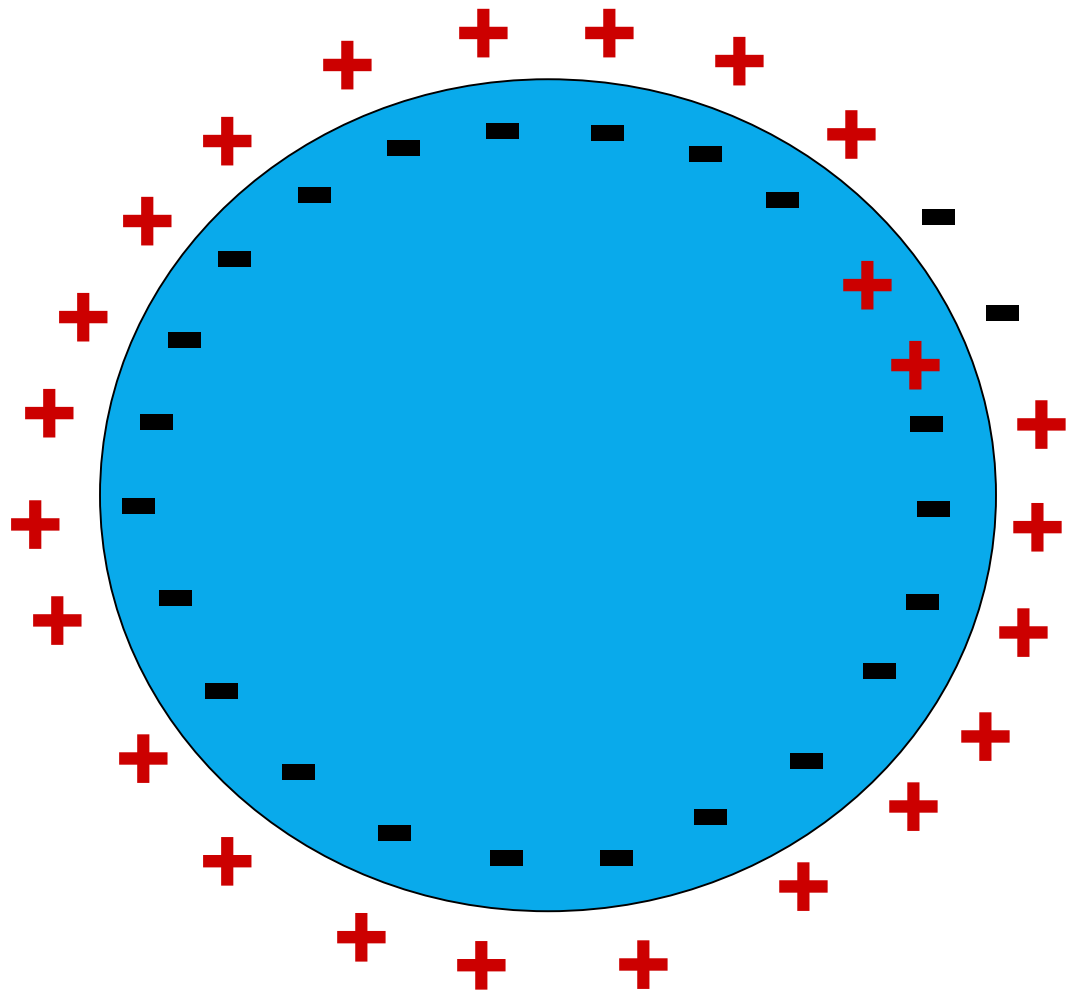
Tap! Tap!..



Changes Cell Membrane Permeability to Sodium/Na+!

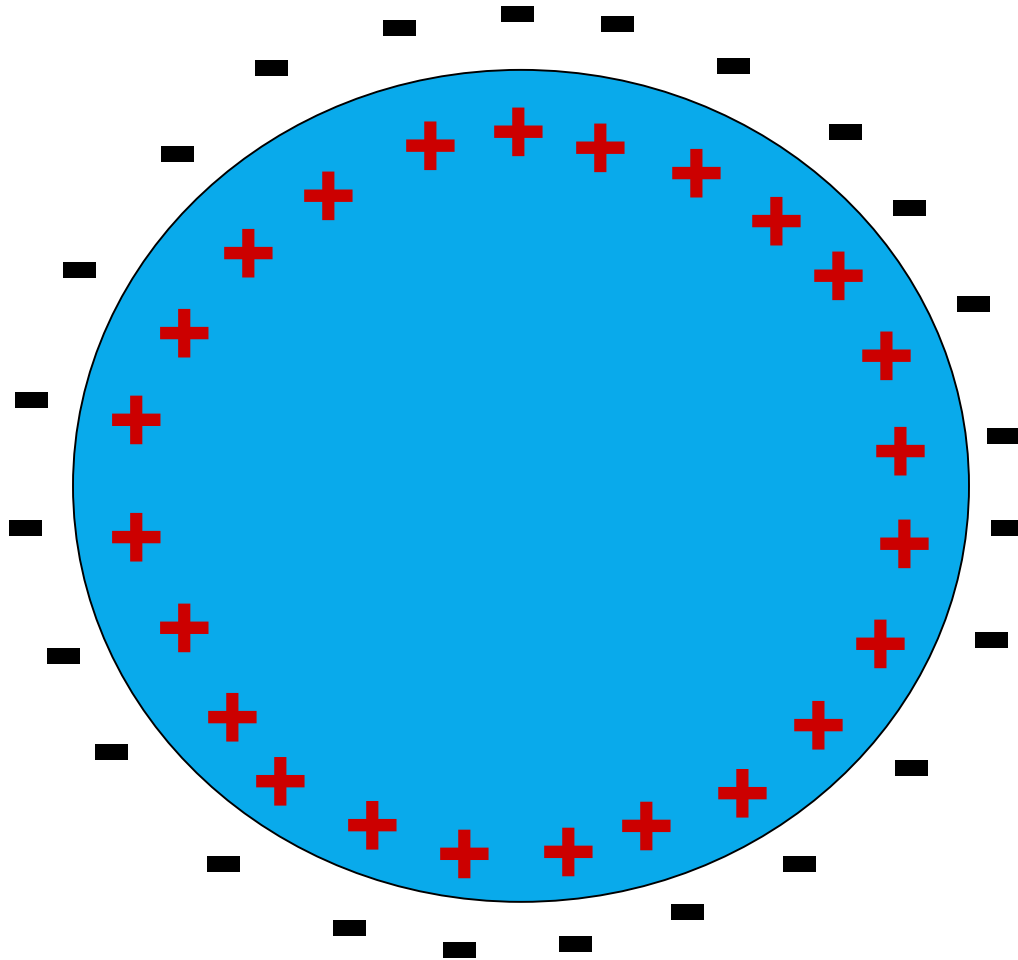


+ Charges/Na+ Rushes In!



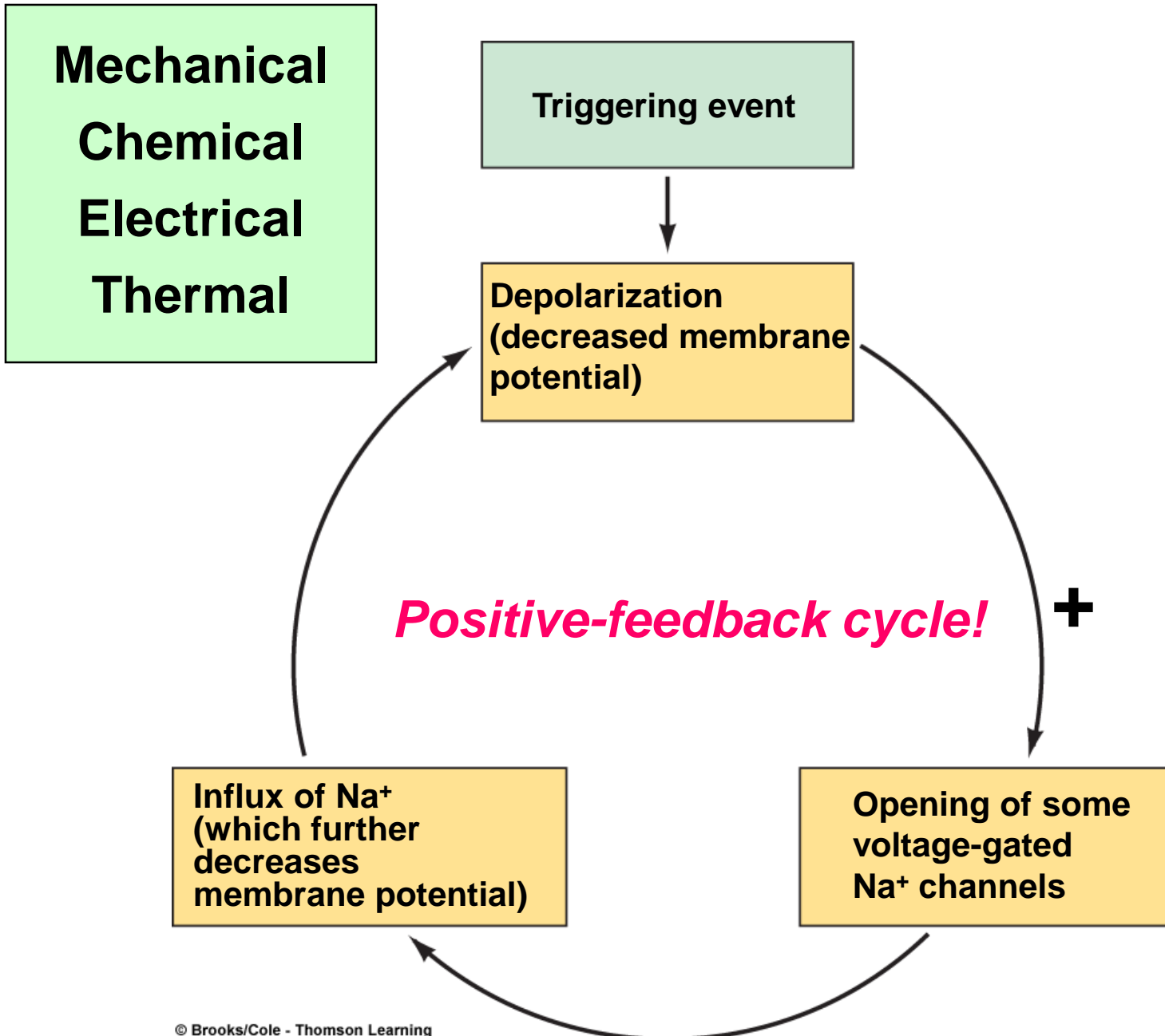
4

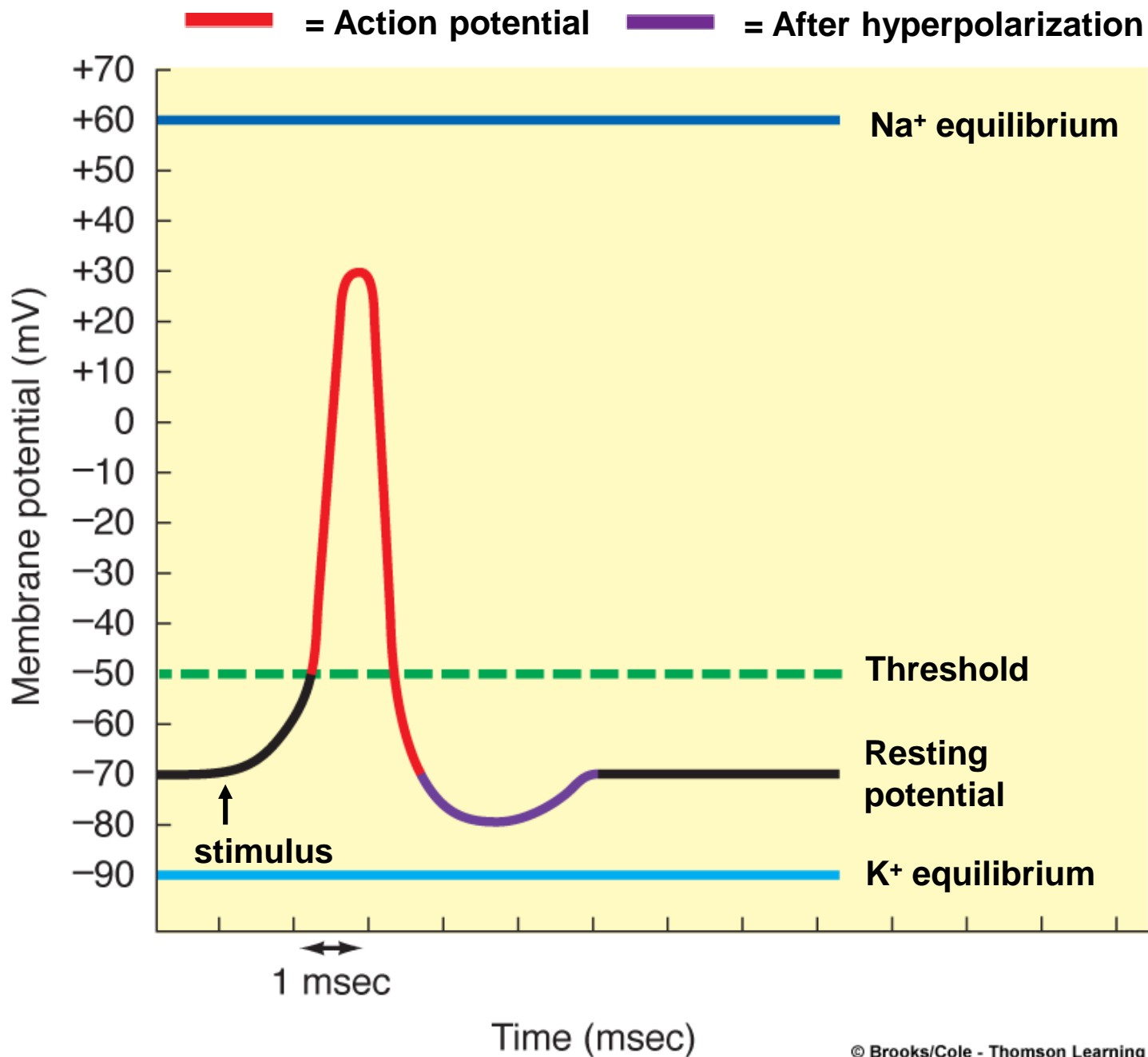
Action Potential has occurred!

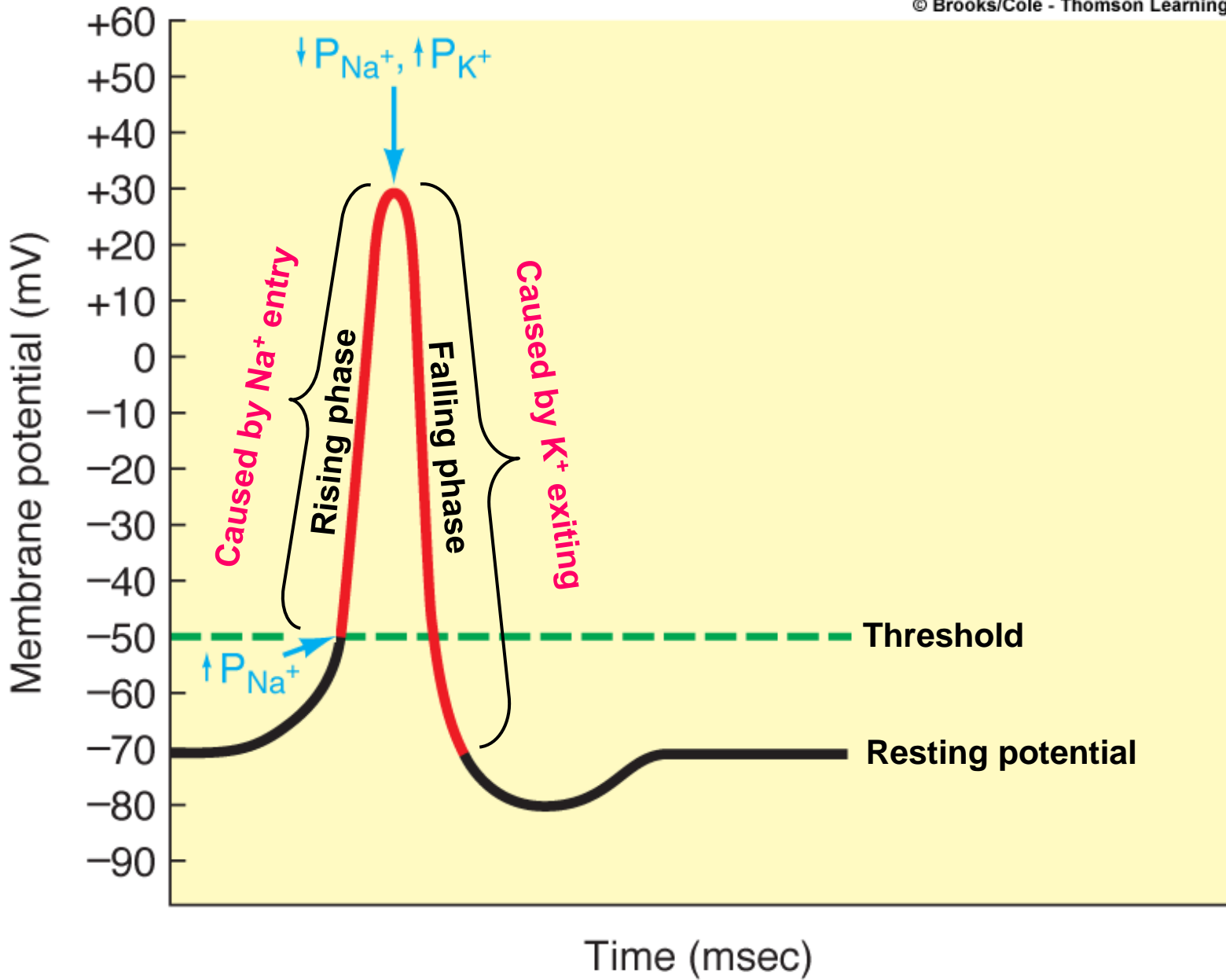


5

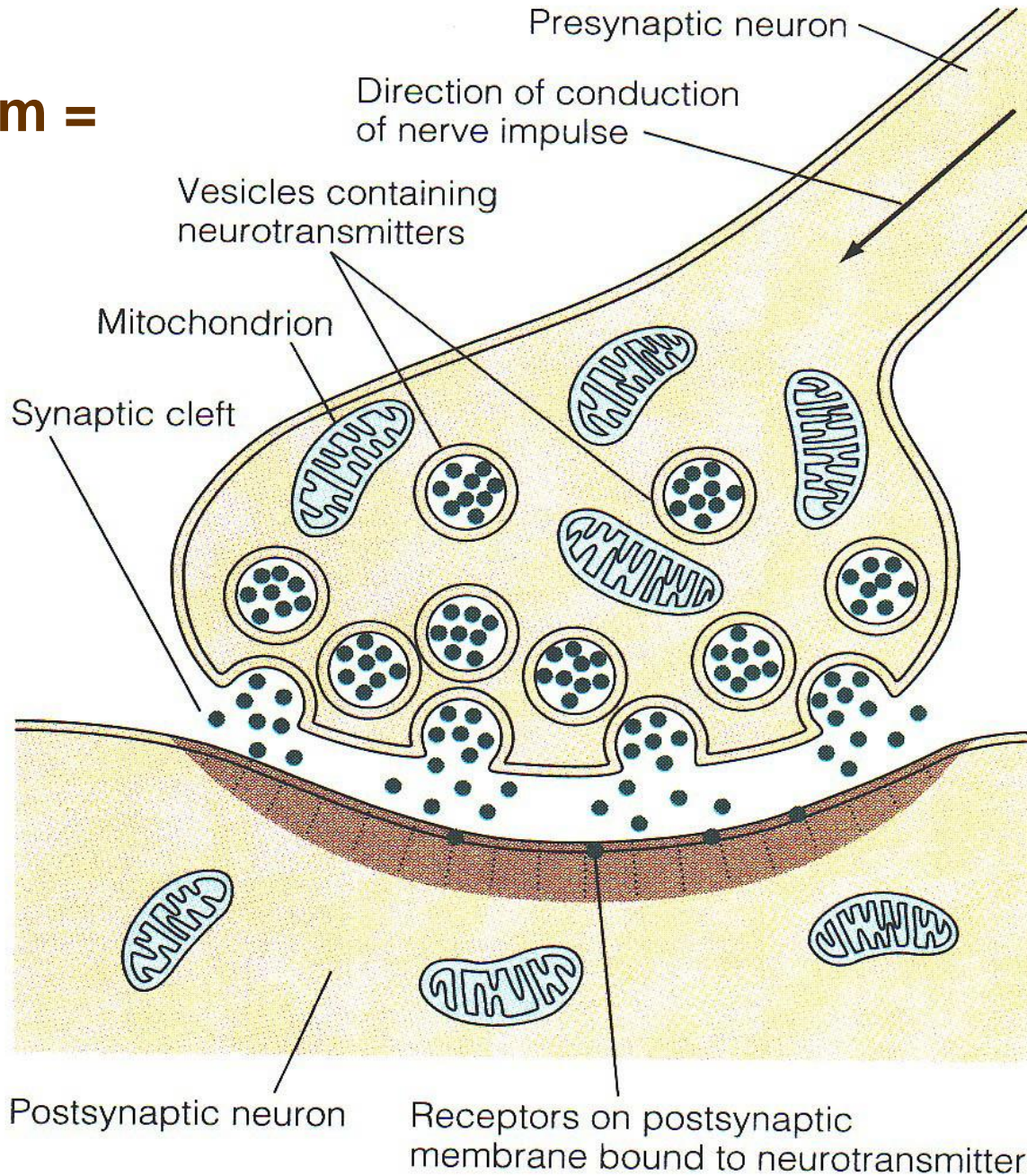
Brief (1-2 ms) reversal to + inside cell!

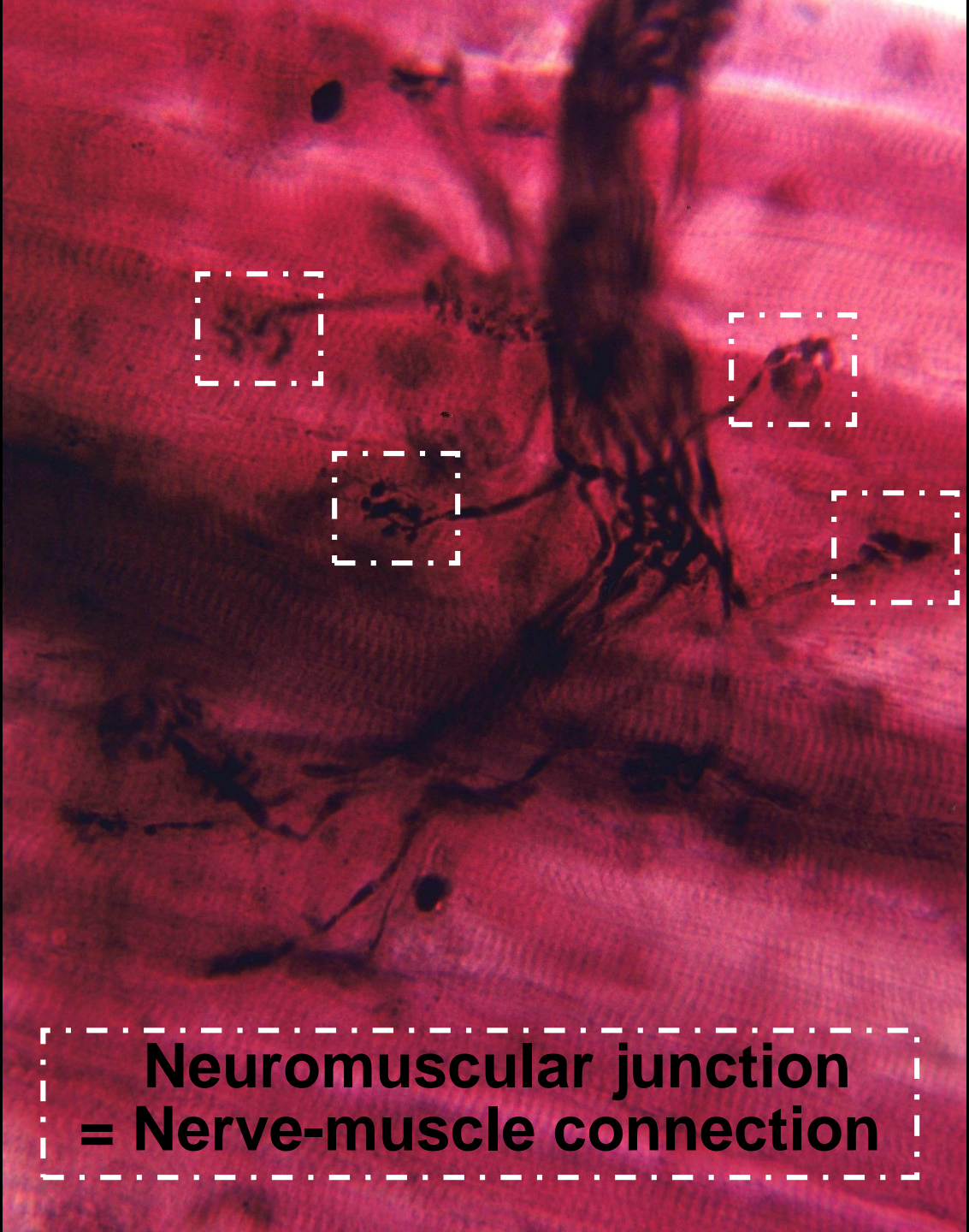




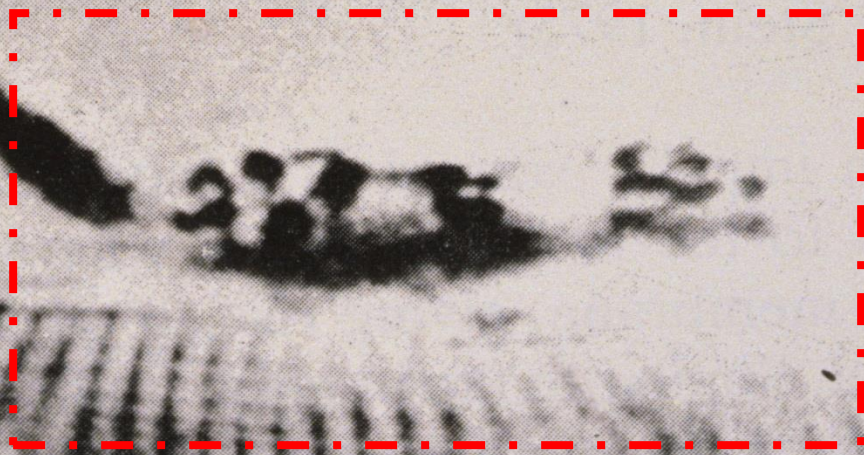
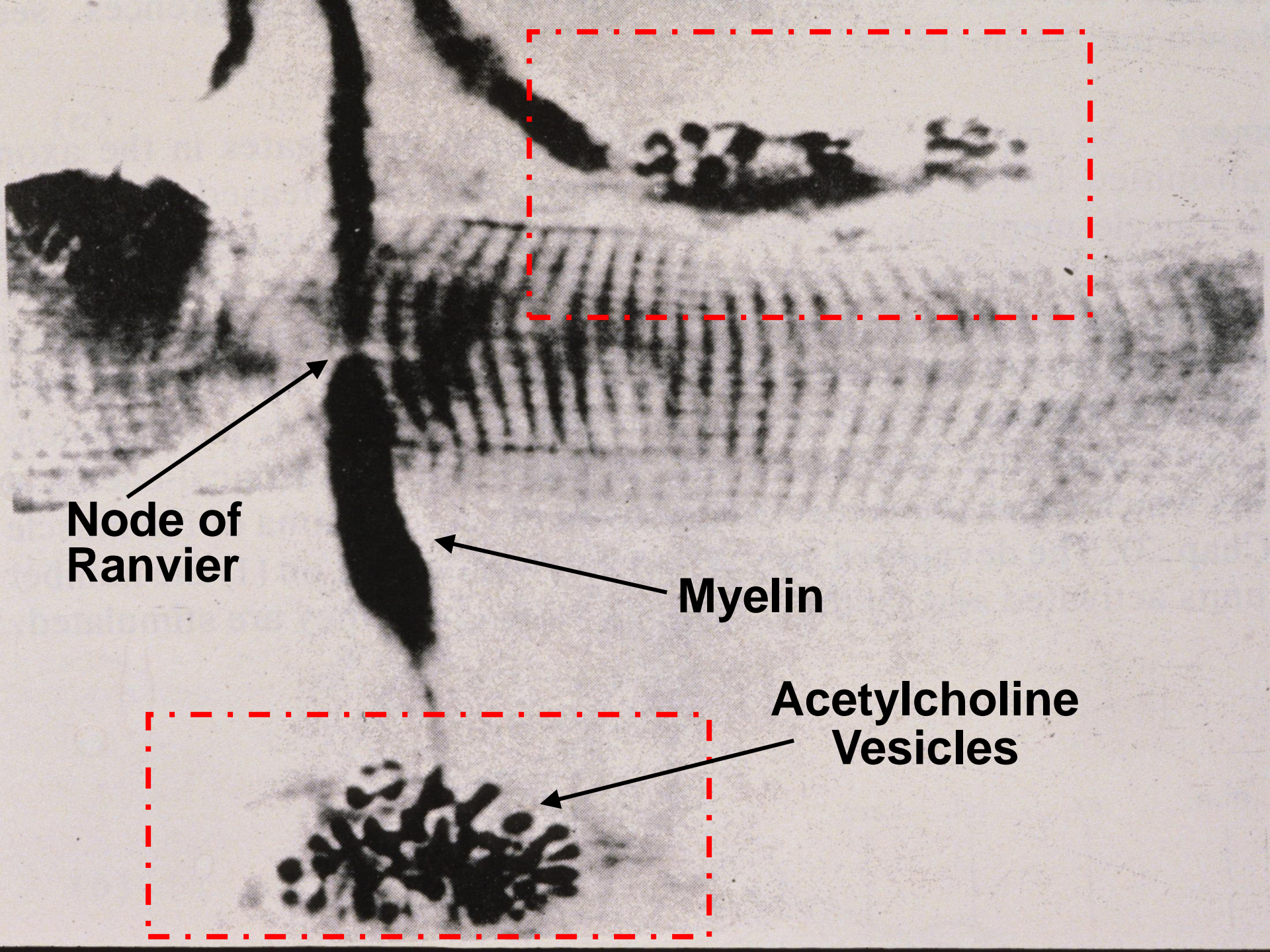


**Synapse =
Generic term =
connection
between
excitable
cells!**





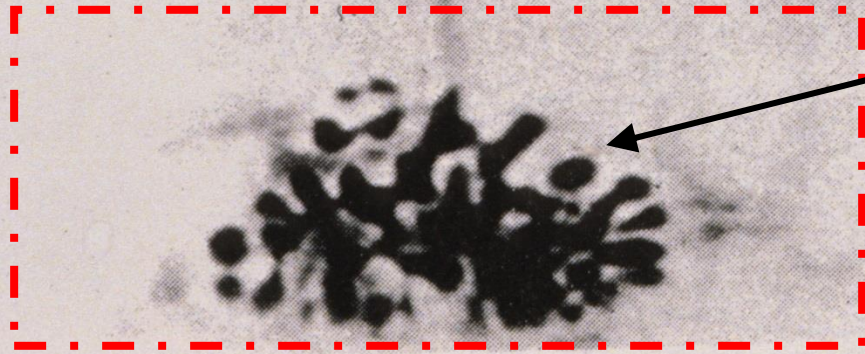
**Neuromuscular junction
= Nerve-muscle connection**



**Node of
Ranvier**

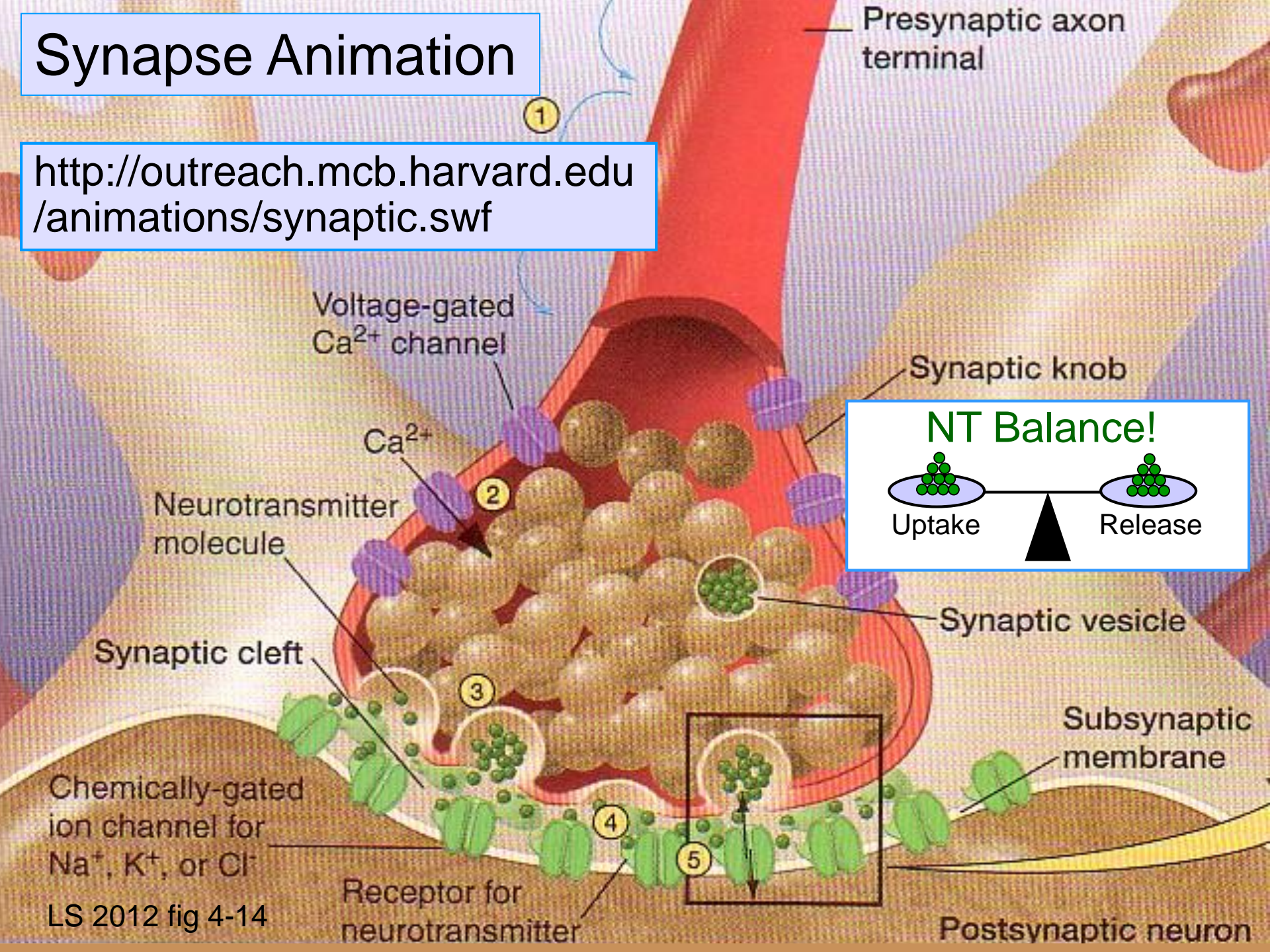
Myelin

**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

Receptor for neurotransmitter

Postsynaptic neuron

Other Links That May Be Helpful!

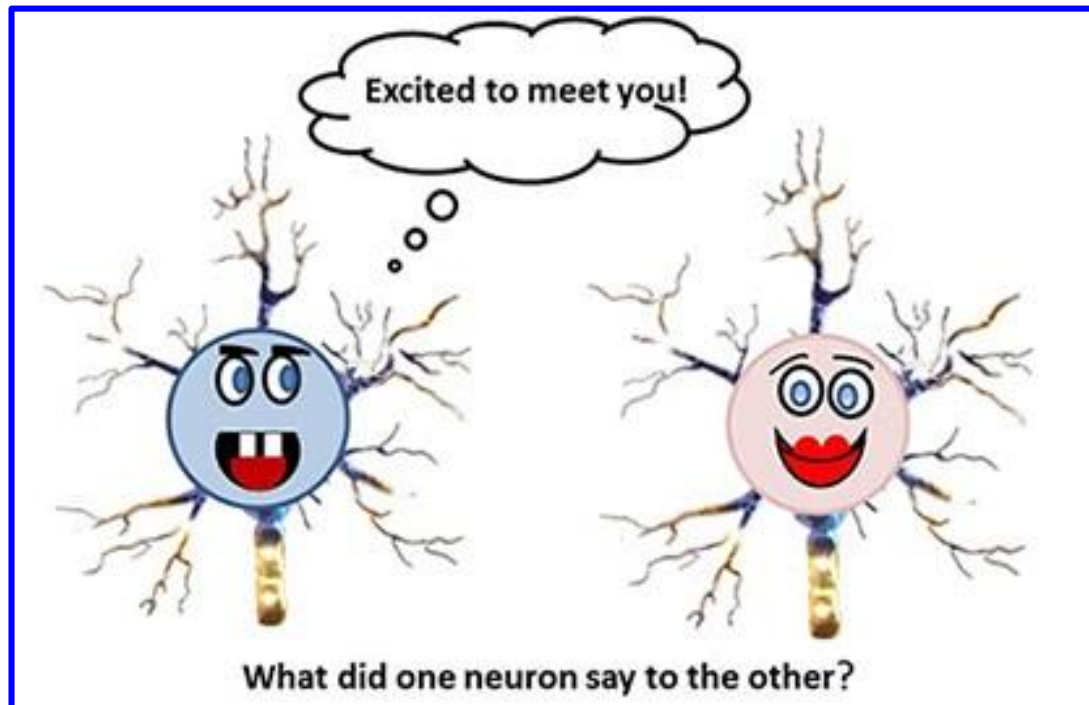
<https://www.youtube.com/watch?v=6RbPIOq0O3w>

<https://www.youtube.com/watch?v=mltV4rC57kM>

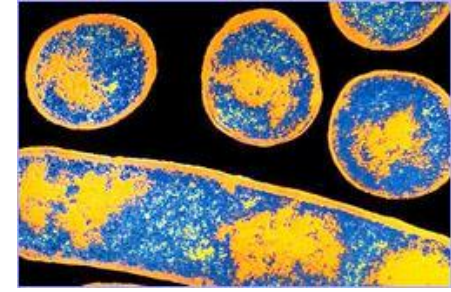
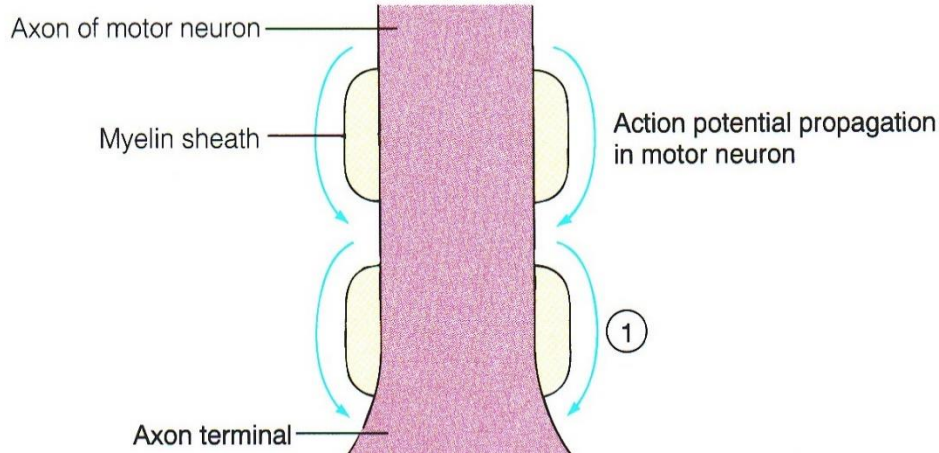
<https://www.youtube.com/watch?v=WhowH0kb7n0>

<http://sites.sinauer.com/psychopharm2e/animation03.01.html>

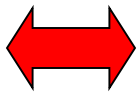
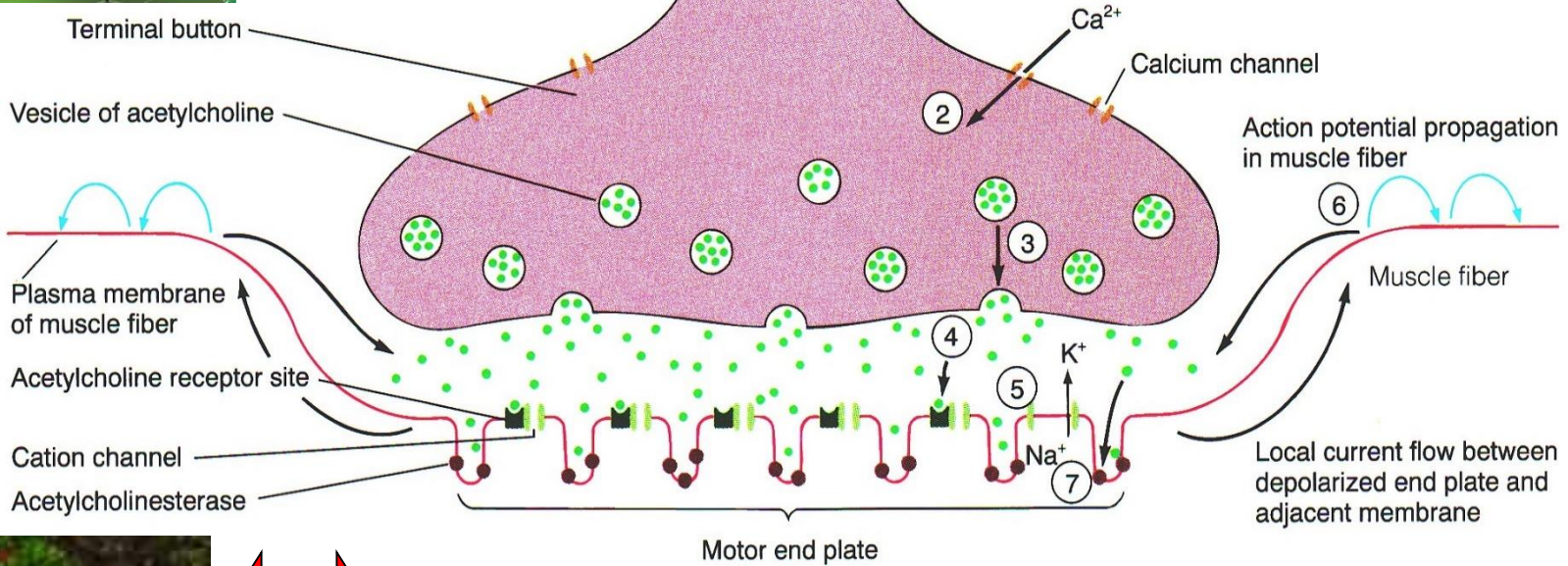
<https://www.youtube.com/watch?v=VitFvNvRIIY>



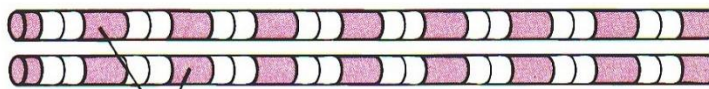
↑ 3



~~3~~



4

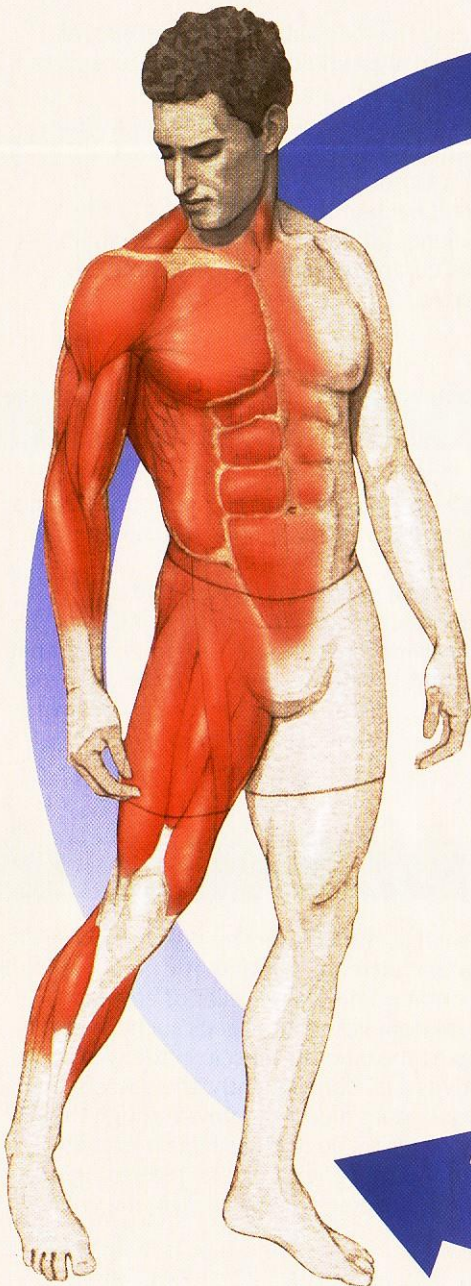


~~7~~

Time for a break! 😊



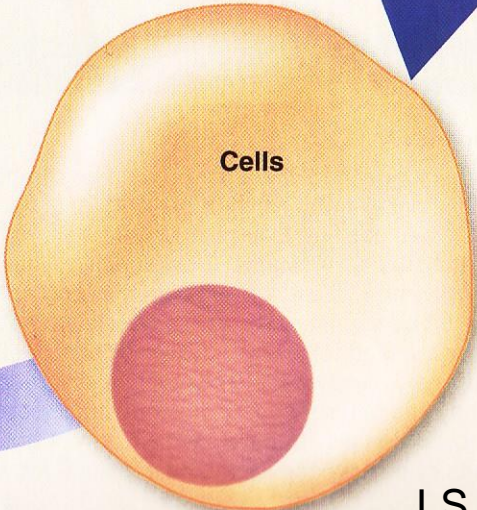
Skeletal Muscles



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

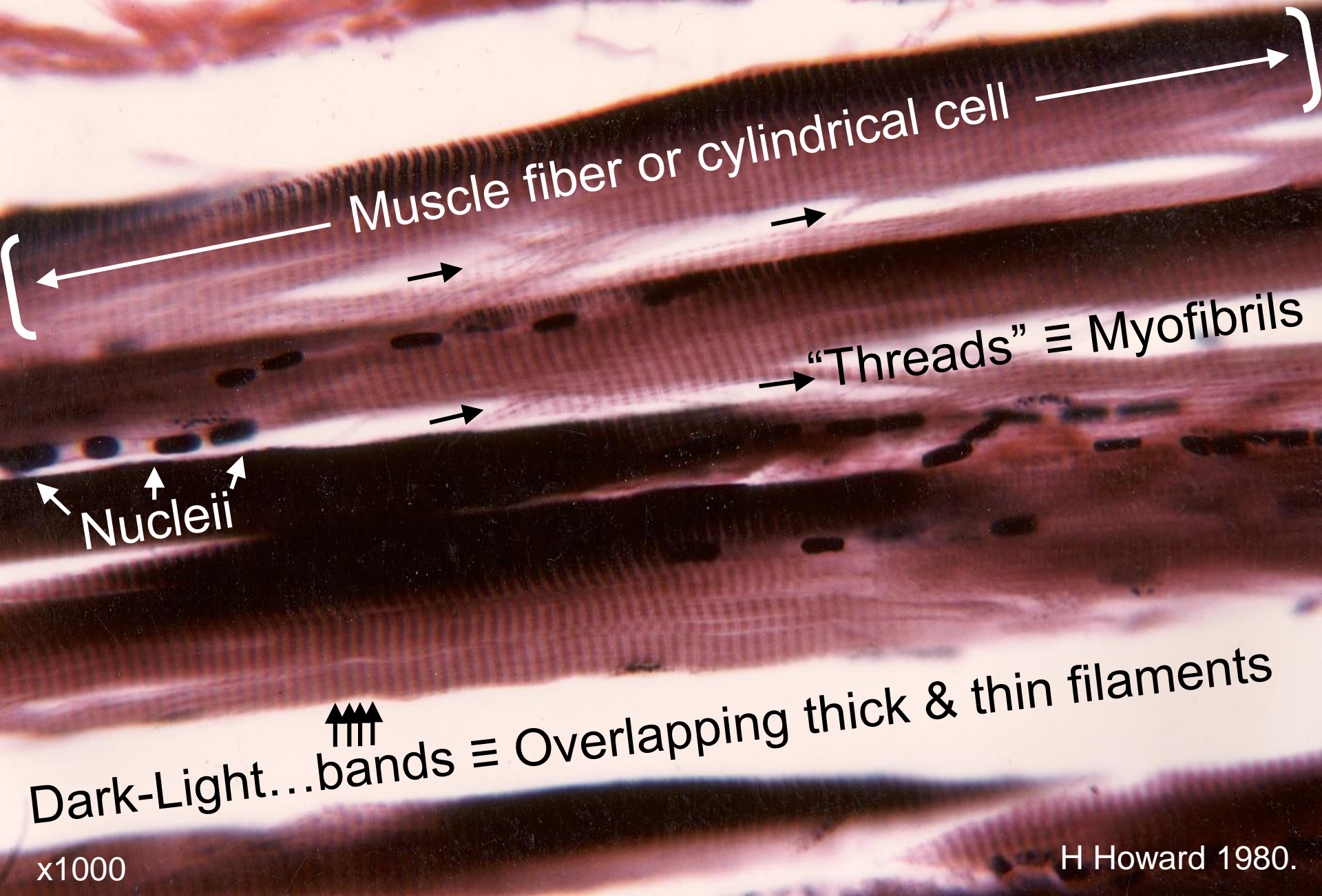
Ed Reschke

Voluntary muscle

Involuntary muscle

Biophoto/Photo Researchers, Inc.

Skeletal Muscle Histology: Microscopic Anatomy



Muscle fiber or cylindrical cell

Nucleii

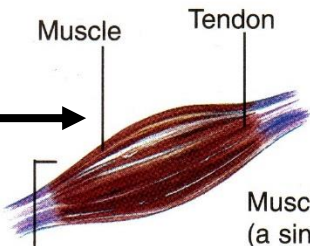
"Threads" \equiv Myofibrils

Dark-Light...bands \equiv Overlapping thick & thin filaments

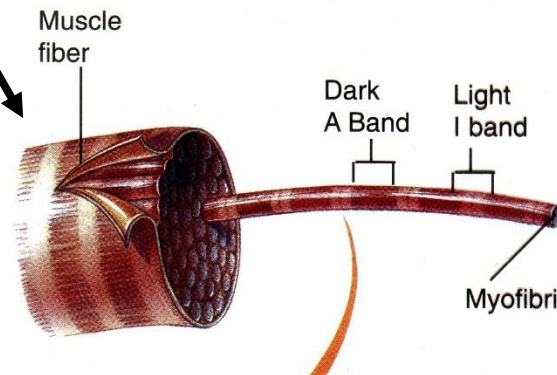
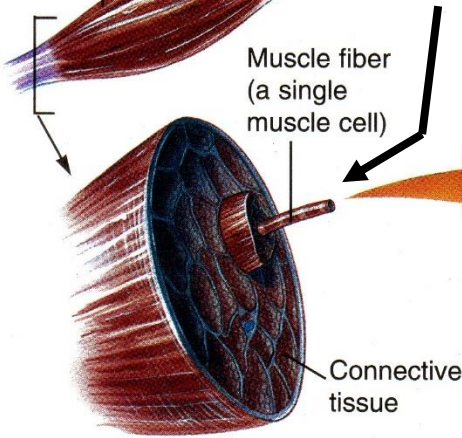
x1000

H Howard 1980.

**Organ =
Muscle**

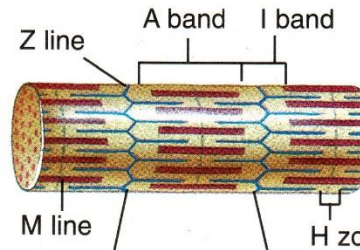


Cell = Myocyte = Fiber

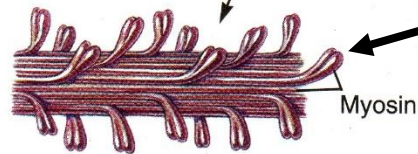
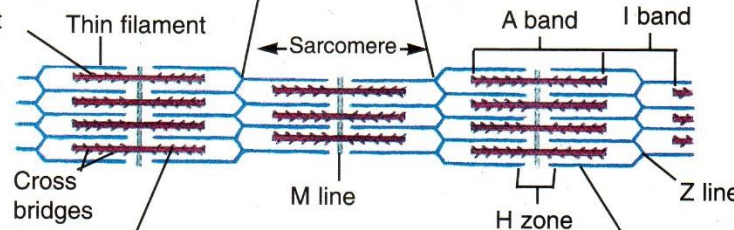


**Subcellular =
Cytoskeleton**

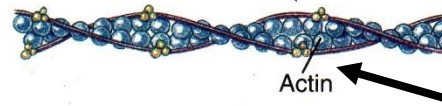
Portion
of myofibril



Thick filament

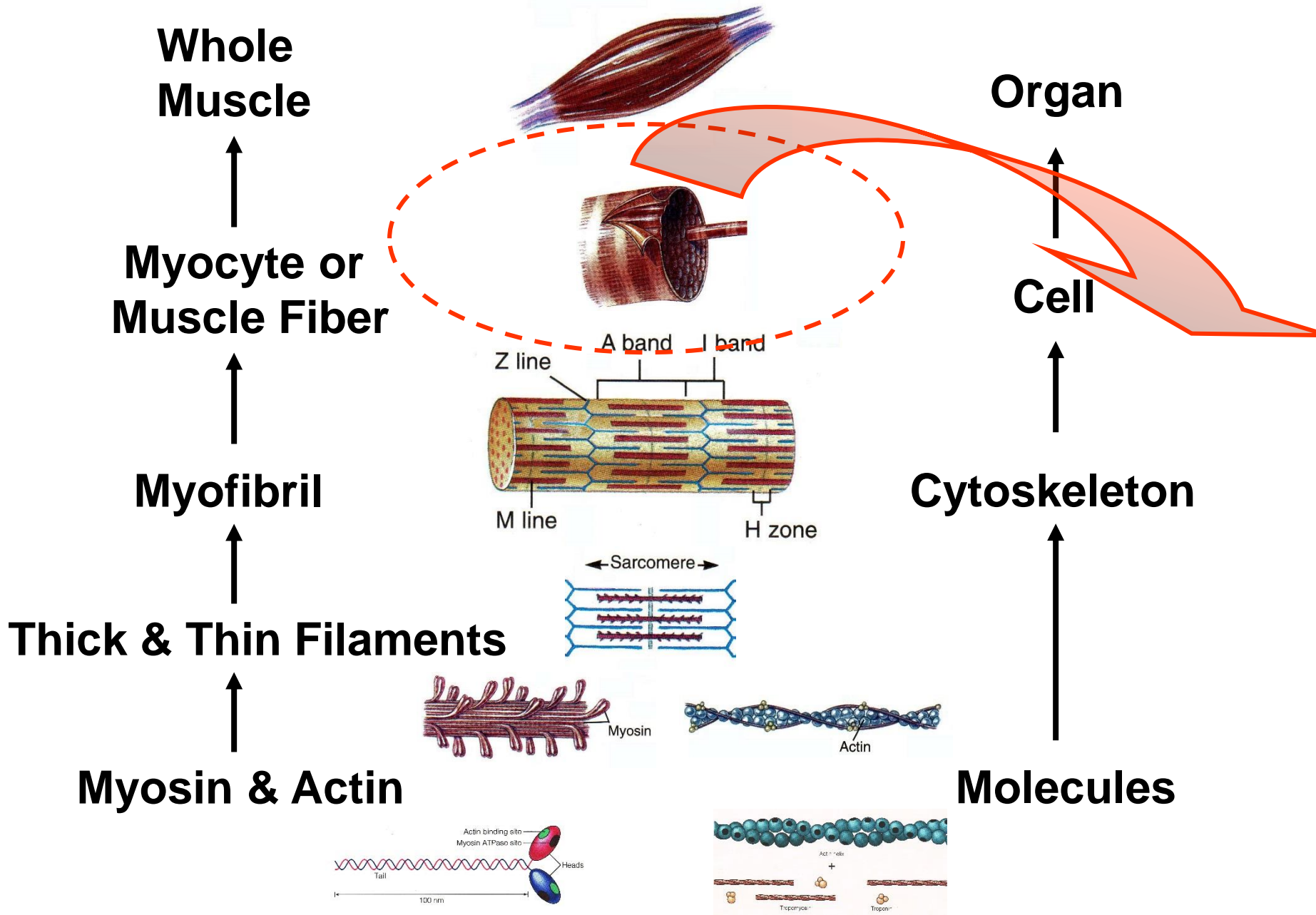


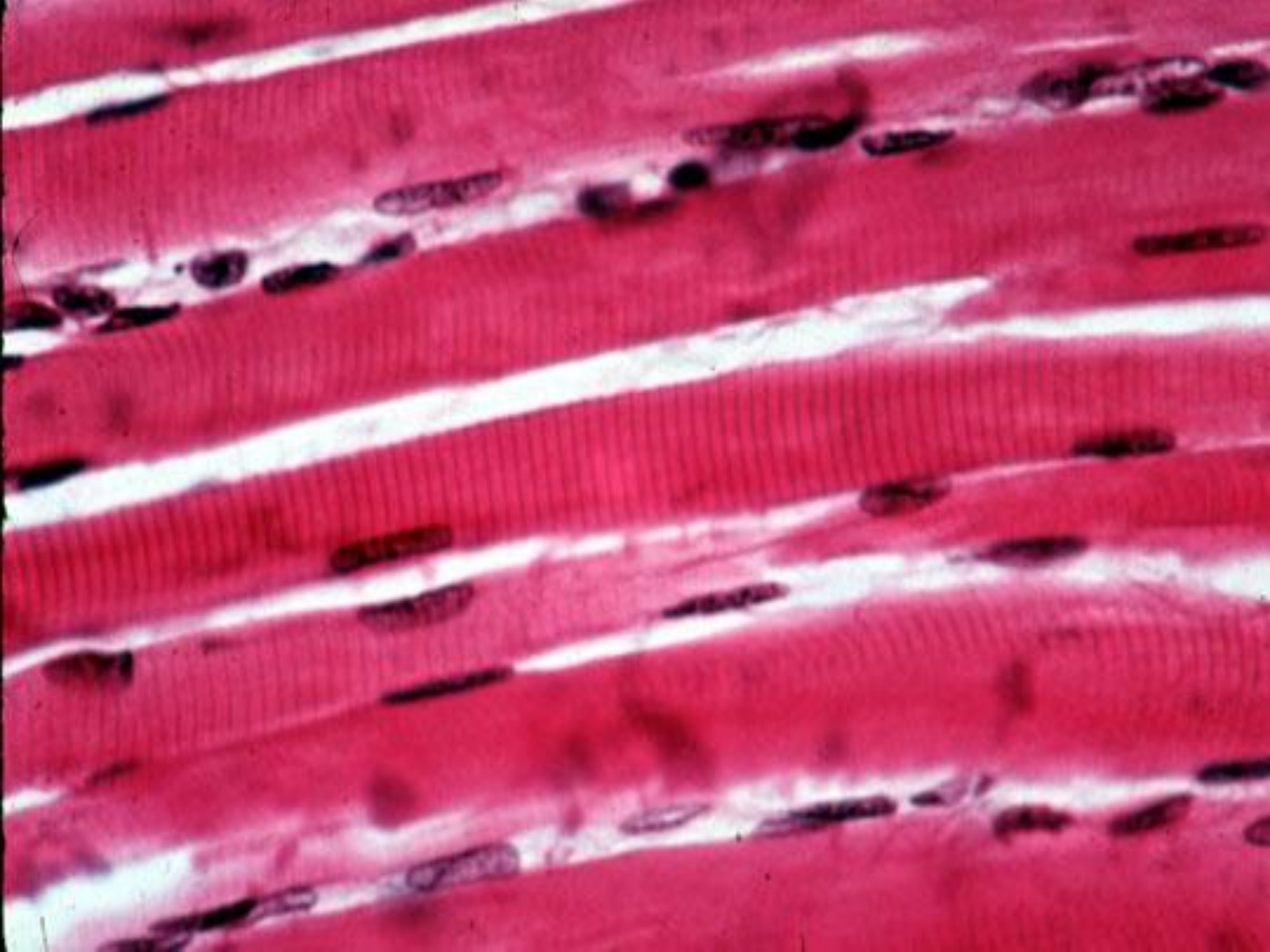
Thick filament

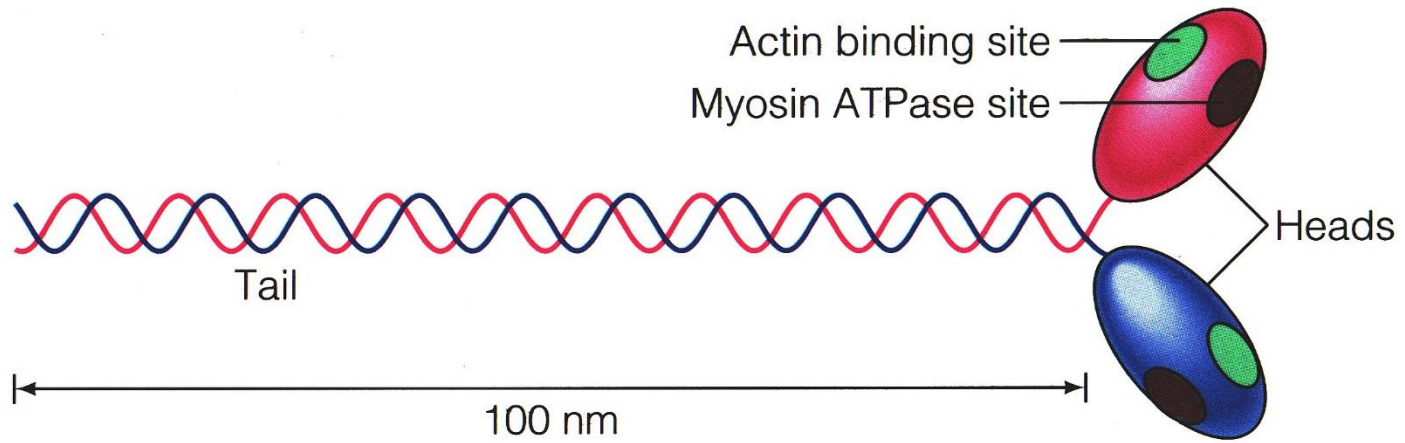


Thin filament

**Molecules =
Actin & Myosin**

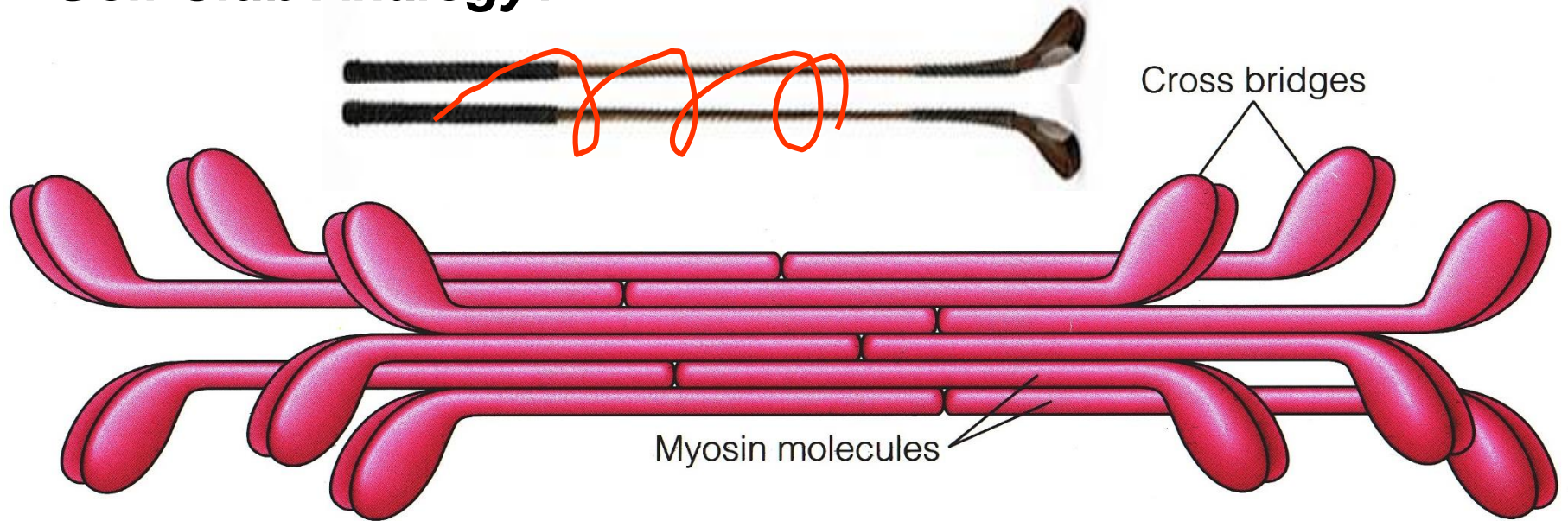






(a)

Golf Club Analogy?



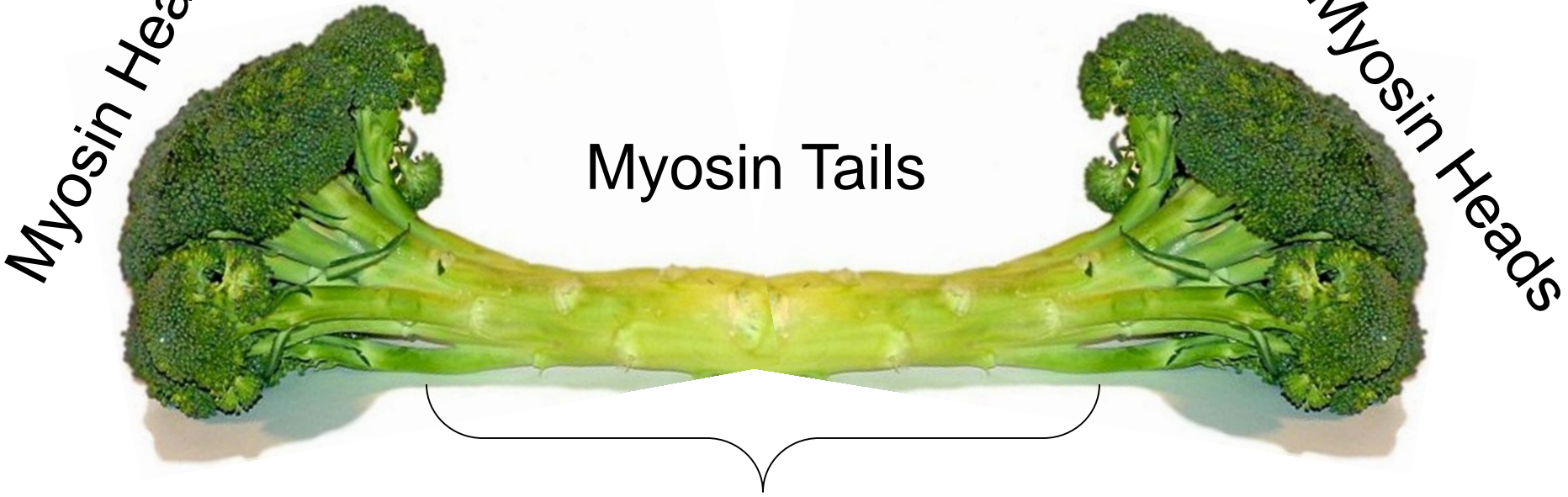
(b)

Broccoli Analogy?

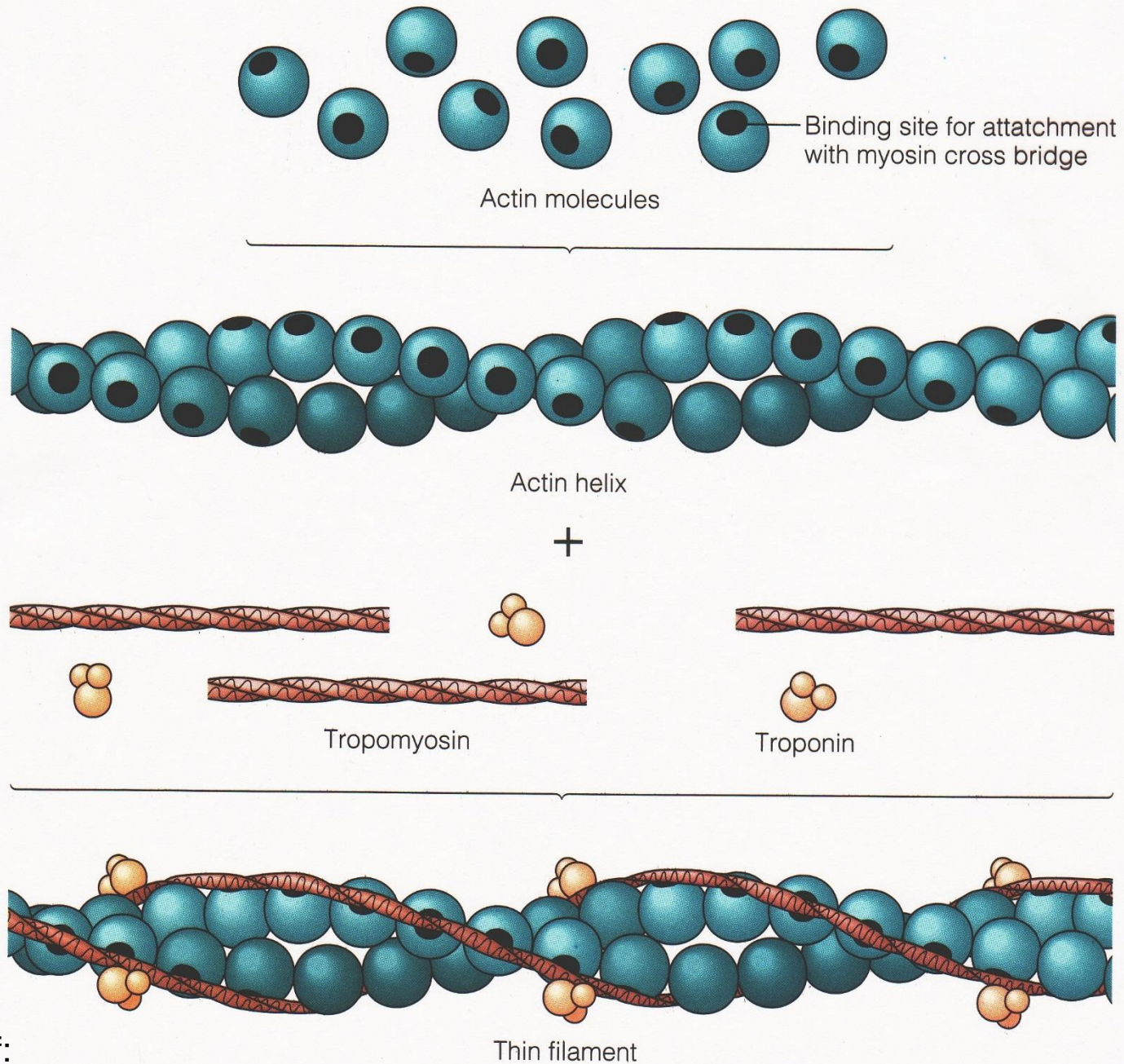
Myosin Heads

Myosin Heads

Myosin Tails

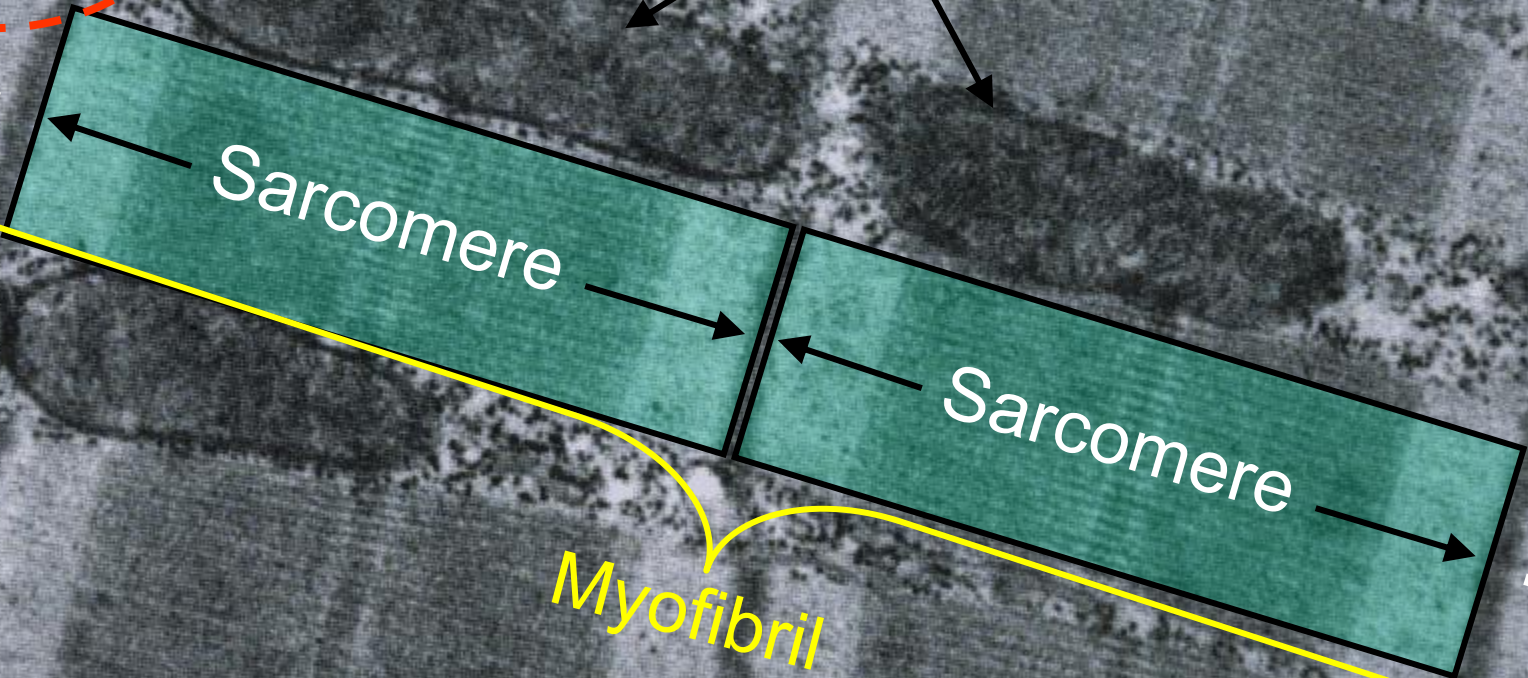


Bare Zone



Triad \equiv T tubule abutting cisternae

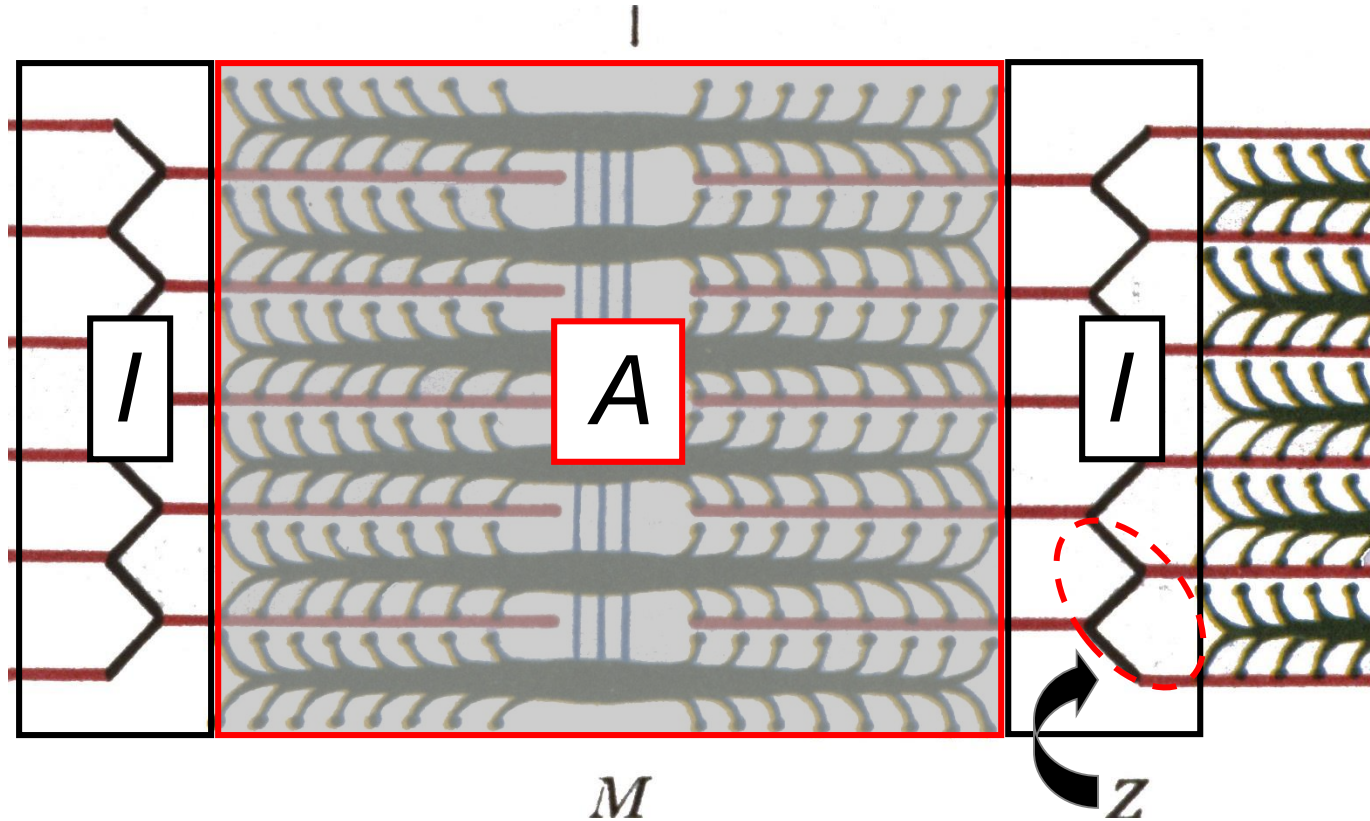
Mitochondria



Myofibril

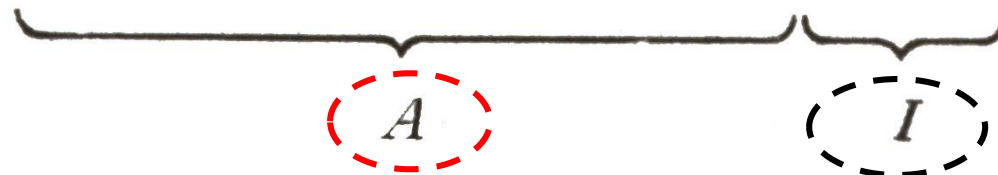
A Band = Dark Band

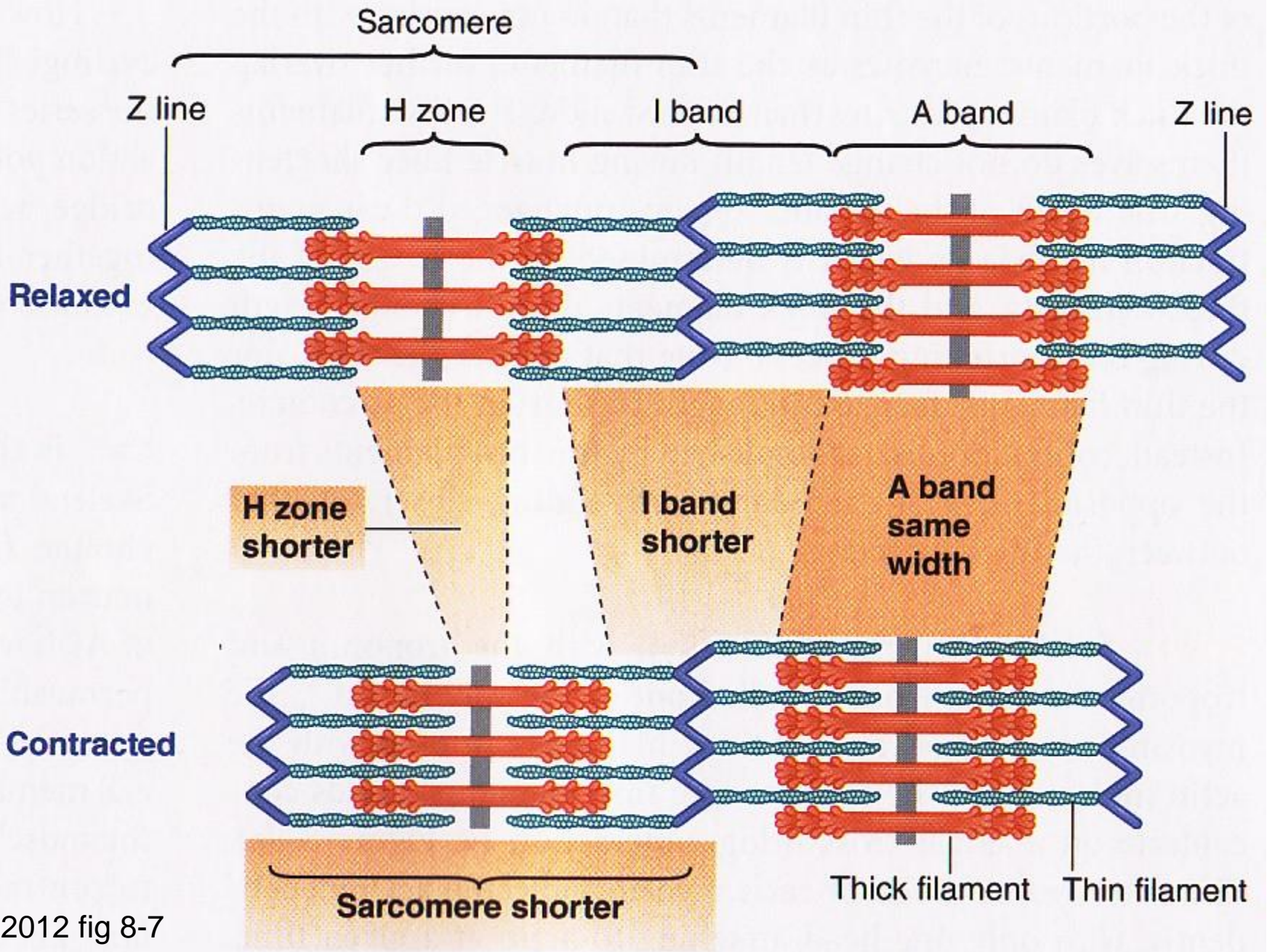
Anisotropic = Light Can't Shine Through



I Band = Light Band

Isootropic = Light Can Shine Through





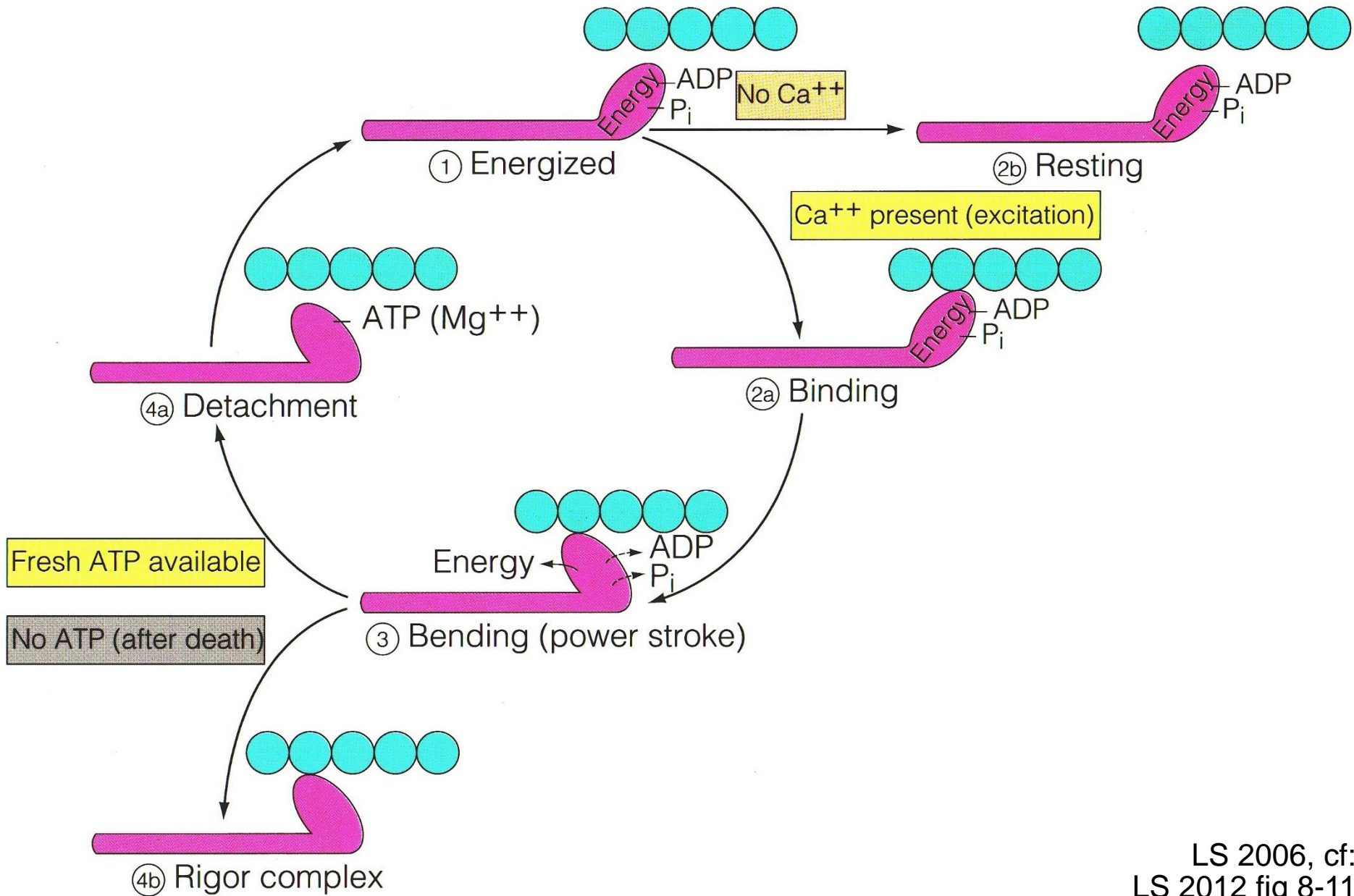
LS 2012 fig 8-7

Discussion + Time for Questions!

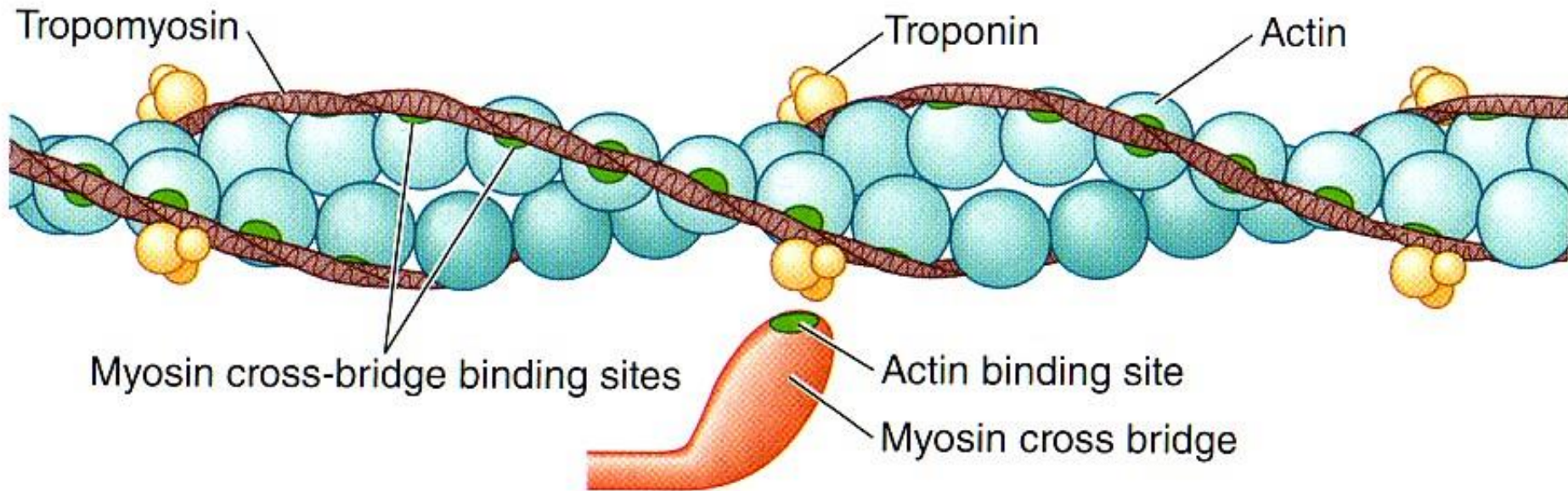


***What do we guess
happens at the
molecular level?***

Cross-Bridge Cycle



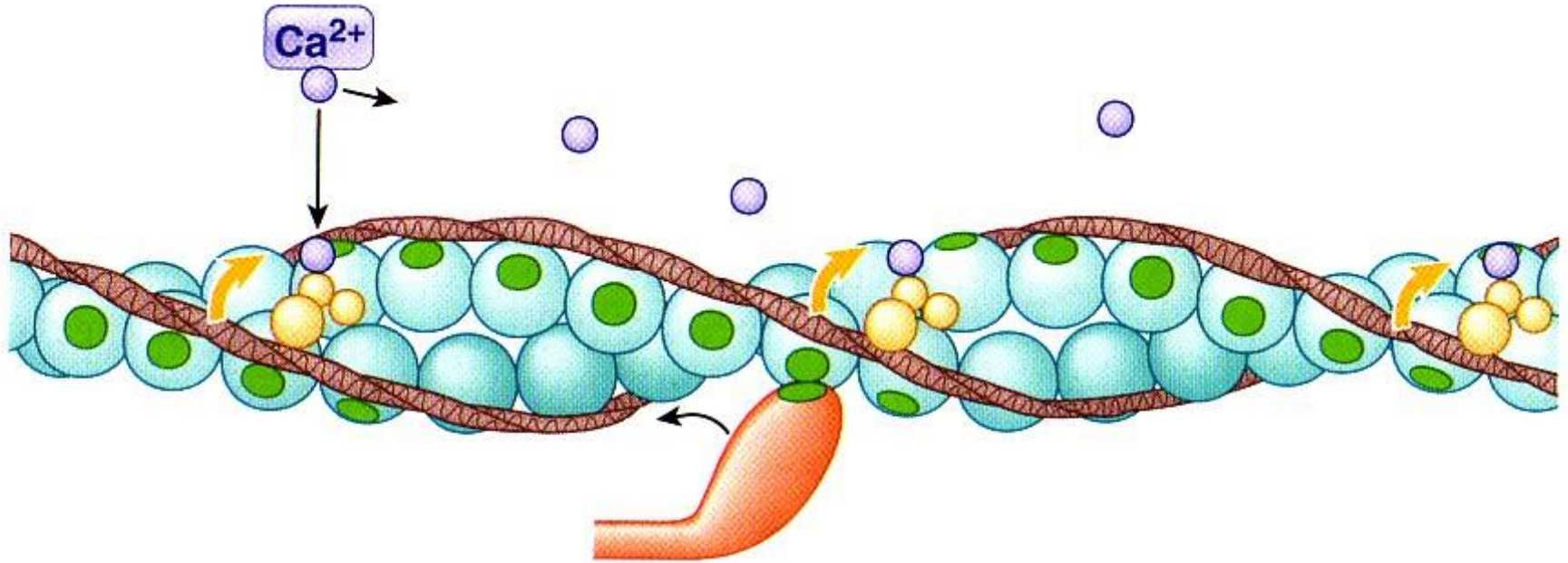
Relaxed: No Cross-Bridge Binding



(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.

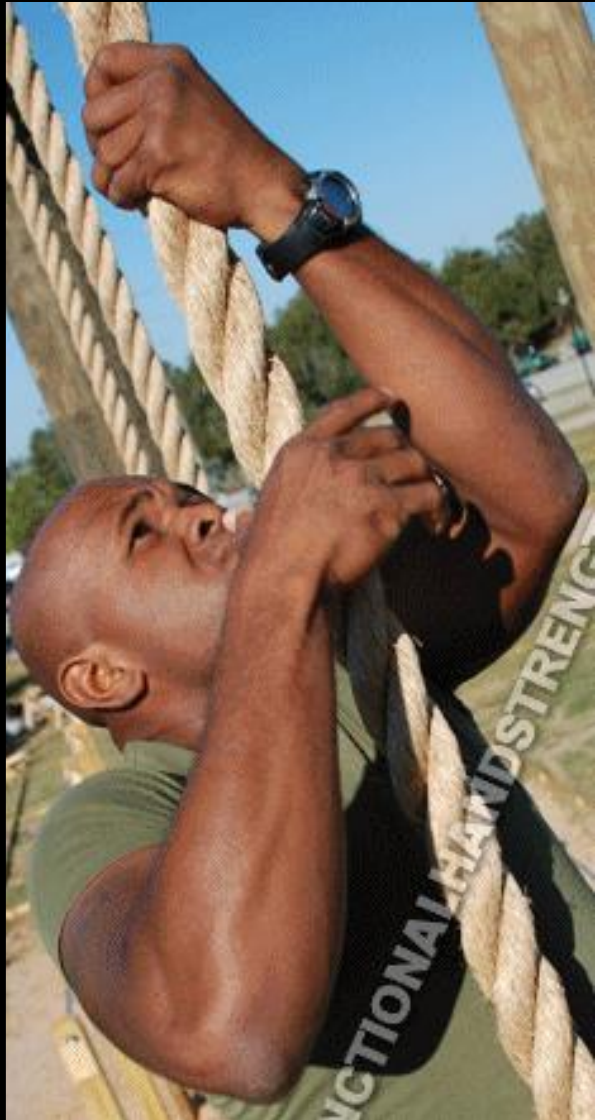
Excited: Calcium Triggers Cross-Bridge Binding



(b) Excited

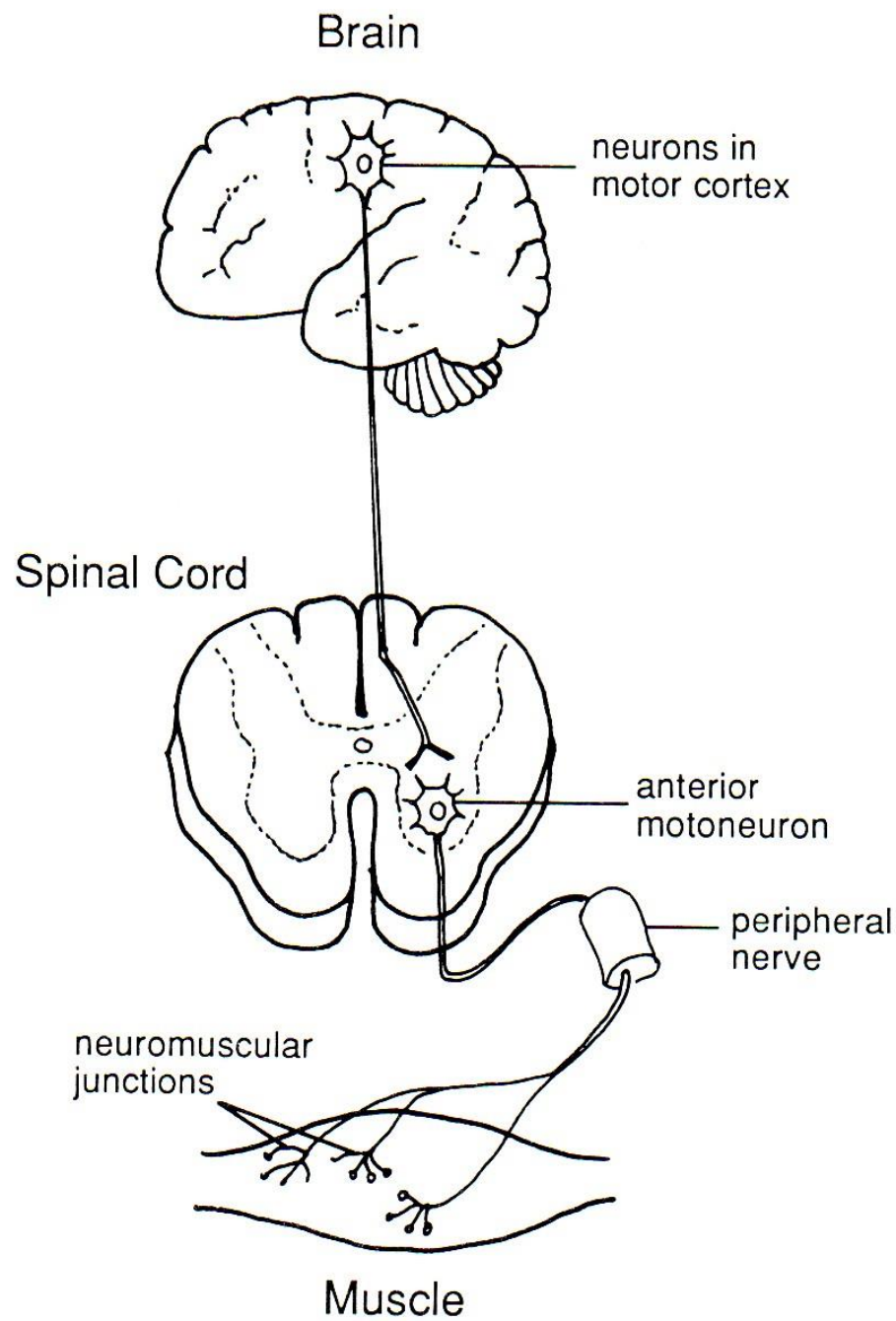
- 1** Muscle fiber is excited and Ca^{2+} is released.
- 2** Released Ca^{2+} binds with troponin, pulling troponin–tropomyosin complex aside to expose cross-bridge binding site.
- 3** Cross-bridge binding occurs.
- 4** Binding of actin and myosin cross bridge triggers power stroke that pulls thin filament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

Rope Climb or Tug of War Grasp, then Regrasp!



Summary
We are
almost
there!

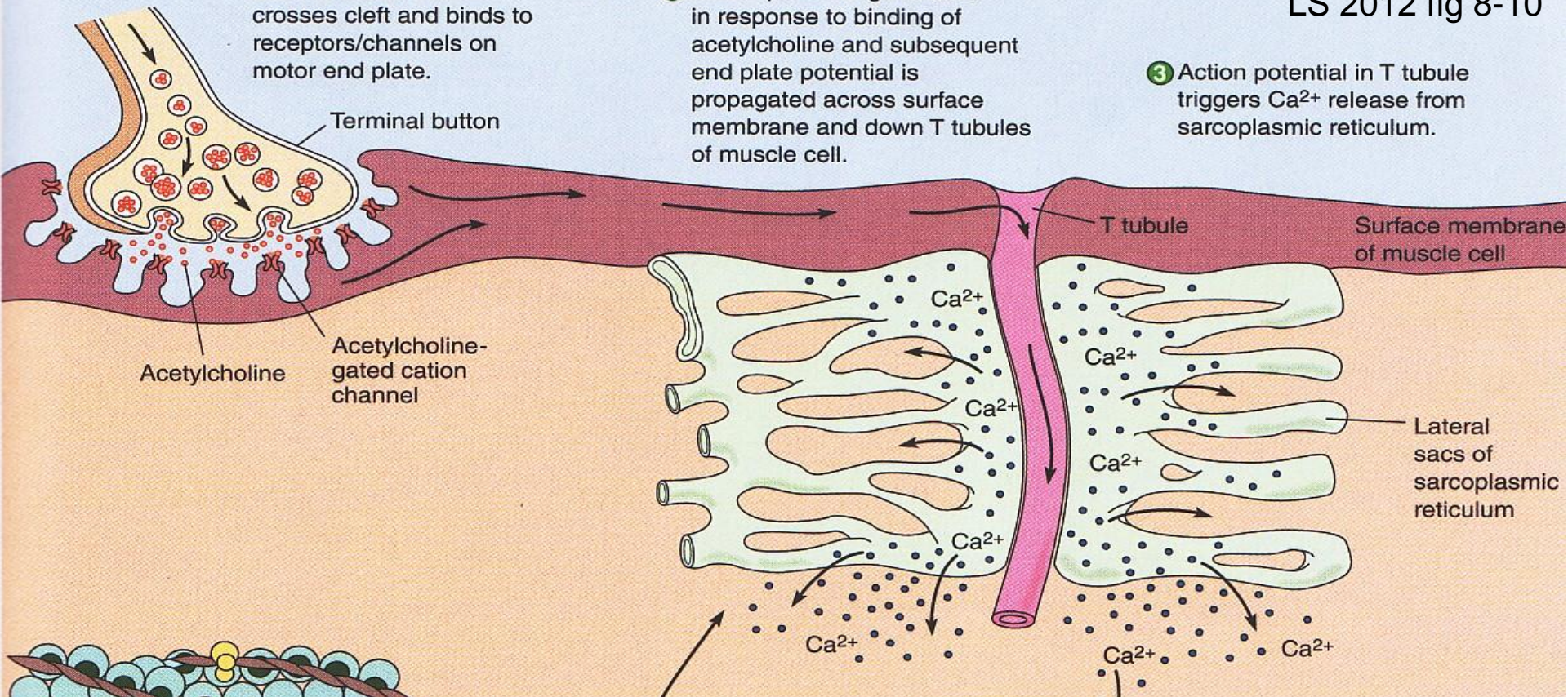




1 Acetylcholine released by axon of motor neuron crosses cleft and binds to receptors/channels on motor end plate.

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

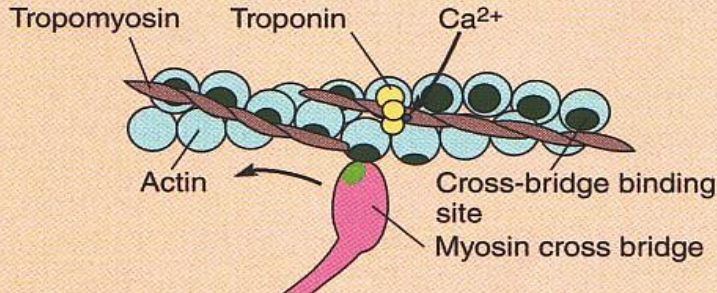
Ca^{2+}

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.

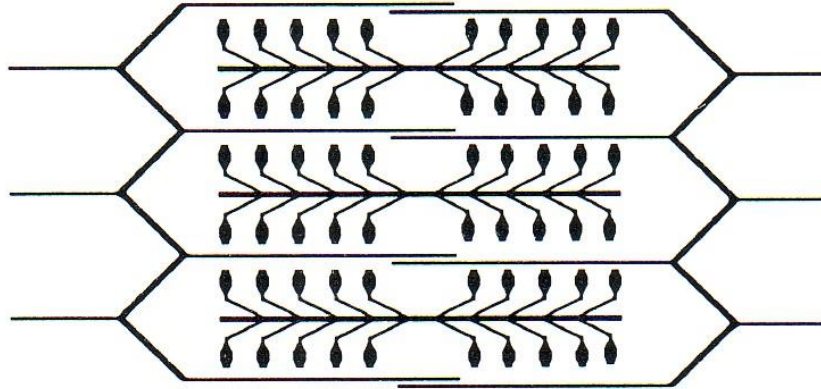


Tropomyosin Troponin

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

