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

BI 121 Lecture 14

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

II. ***Nervous System Connections*** LS 7

A. How does the signal cross the nerve-muscle gap? ch 7 p 185-92 fig 7-5 p 190

B. 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 pp194-6

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

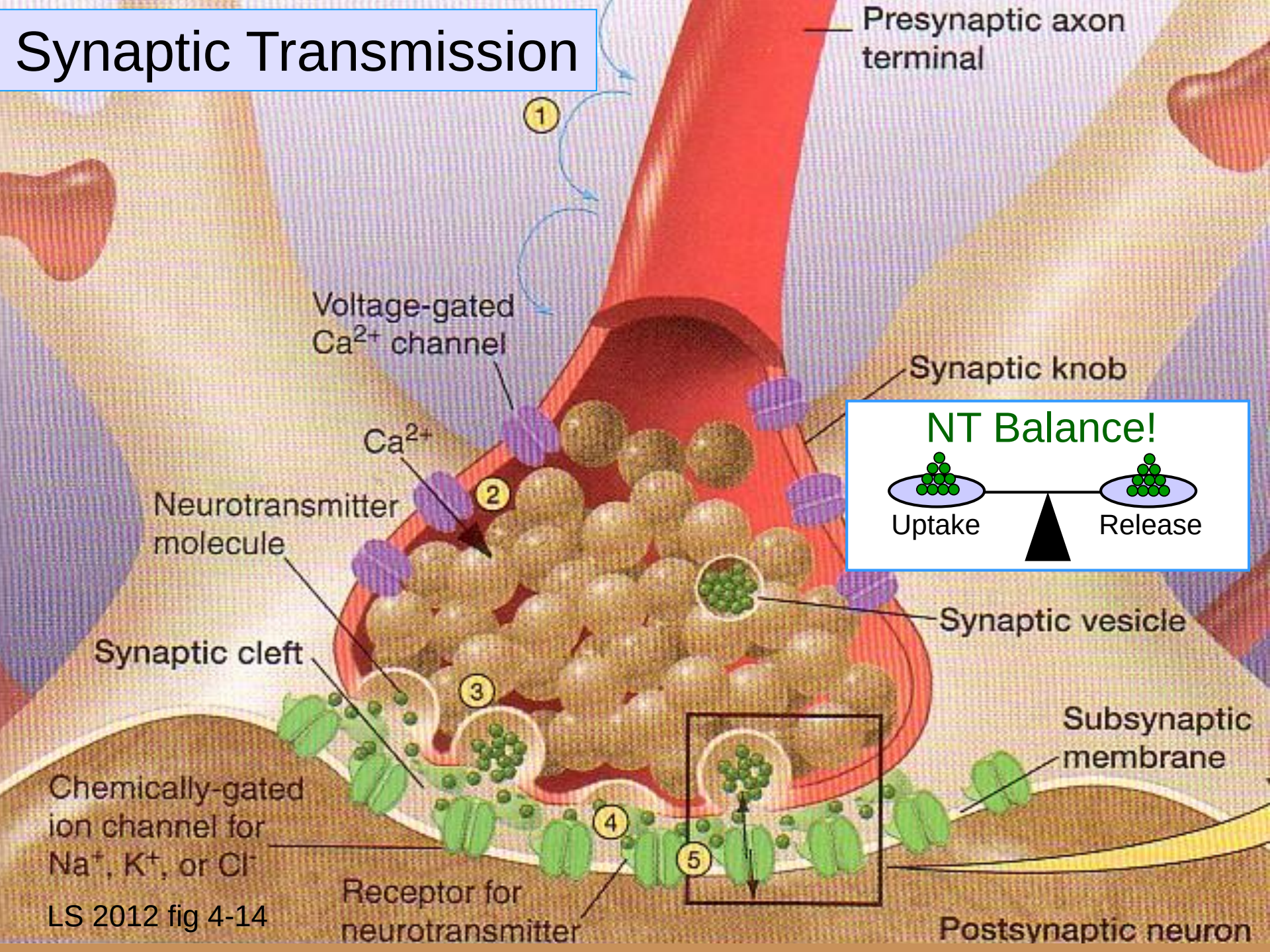
E. How do muscles contract? LS fig 8-6, 8-10

F. What's a cross-bridge cycle? LS fig 8-11 +…

G. Summary of skeletal muscle contraction, videos courtesy David Bolinsky, *XVIVO* & Malcolm Campbell, *Davidson C.*

H. Exercise adaptation variables, strength *vs.* endurance tr.

Synaptic Transmission



LS 2012 fig 4-14

Links That May Be Helpful!

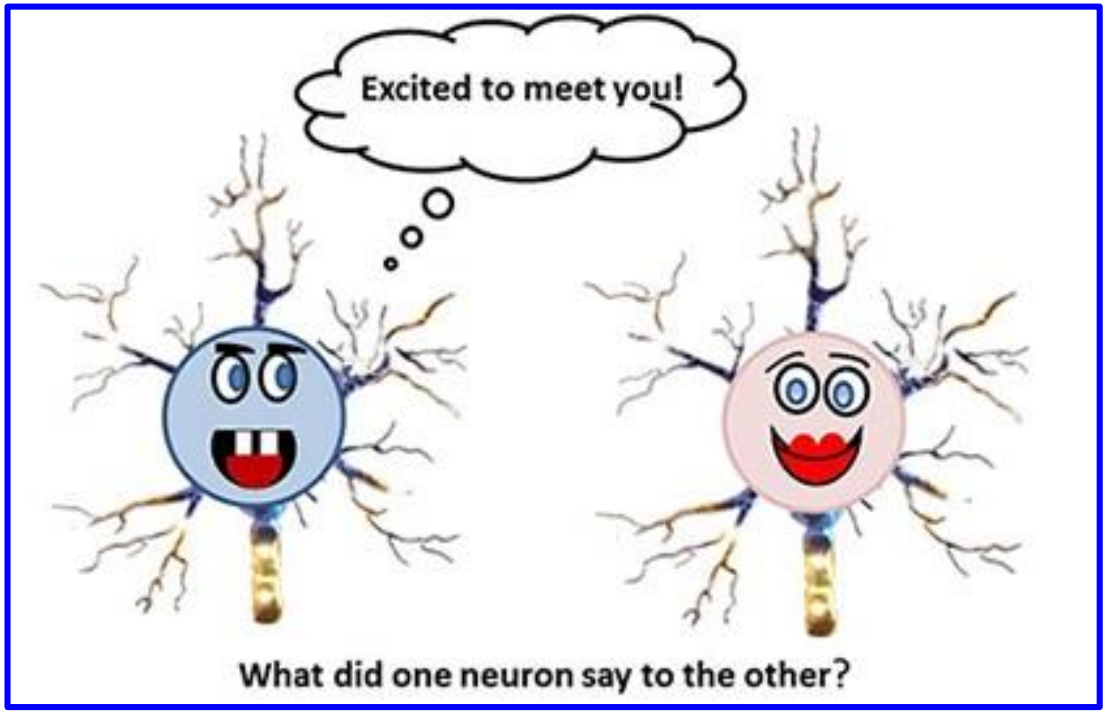
https://www.youtube.com/watch?v=6RbPIOq0O3w

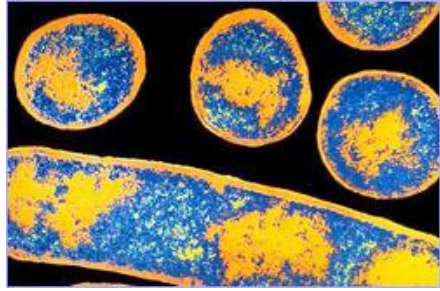
https://www.youtube.com/watch?v=mItV4rC57kM

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

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

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

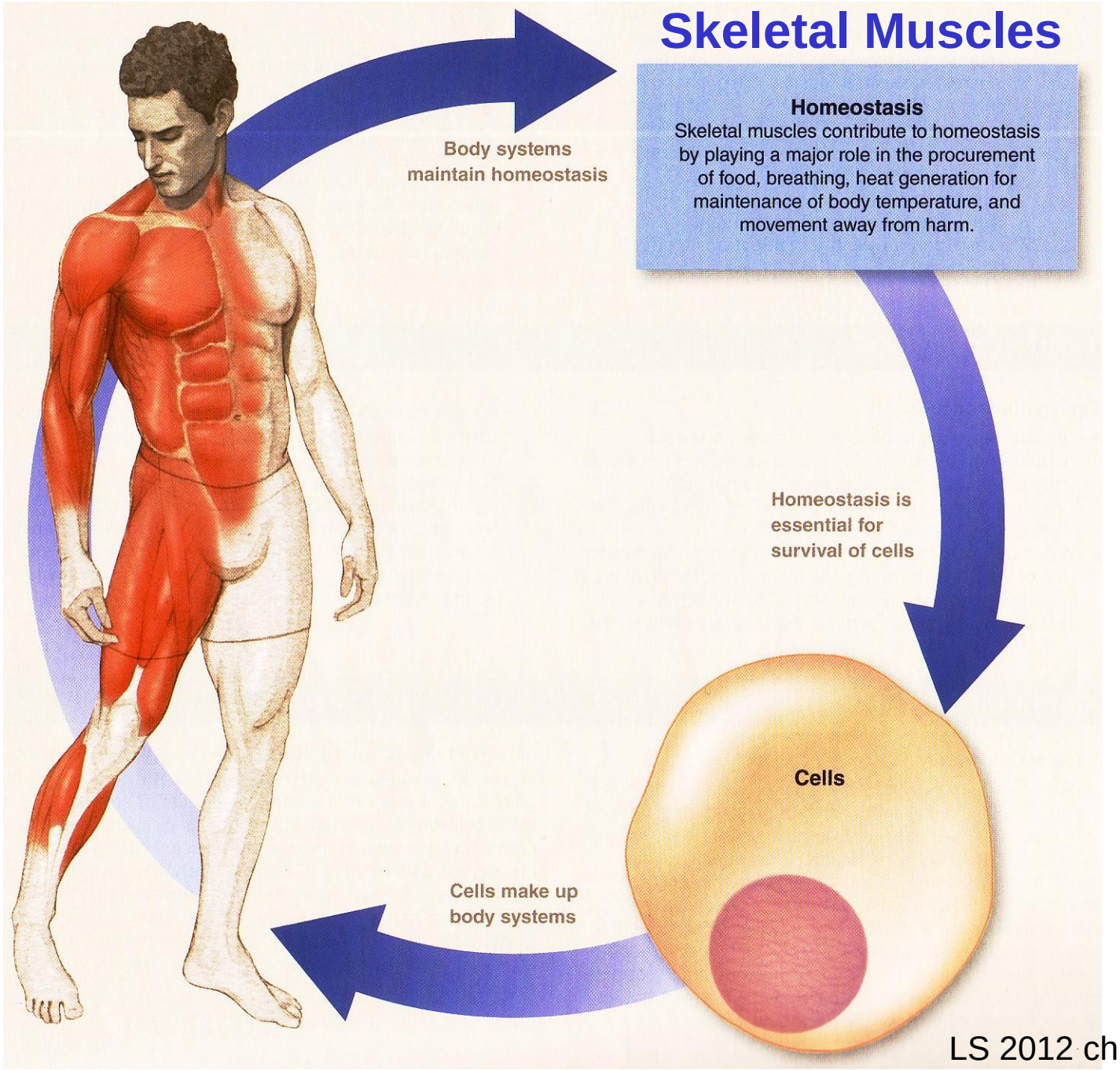




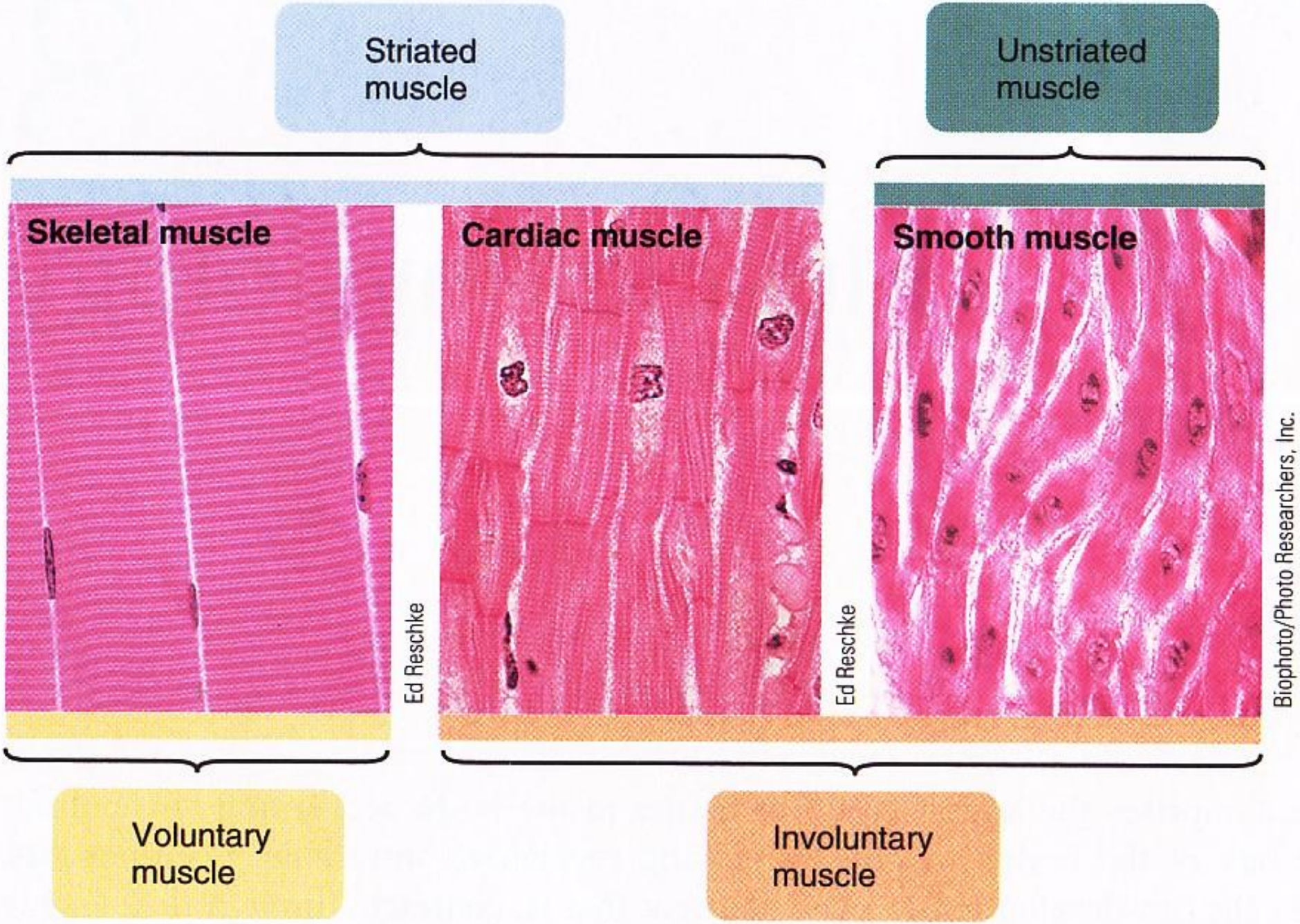

Campbell's
CLASSICS
BEAN
BACON

Axon of motor neuron
Myelin sheath
Action potential propagation in motor neuron
1
Axon terminal
Terminal button
Ca2+
Calcium channel
Vesicle of acetylcholine
2
Action potential propagation in muscle fiber
6
3
Muscle fiber
Plasma membrane of muscle fiber
4
K+
Acetylcholine receptor site
5
Na+
Cation channel
7
Local current flow between depolarized end plate and adjacent membrane
Acetylcholinesterase
Motor end plate
Contractile elements within muscle fiber

Skeletal Muscles

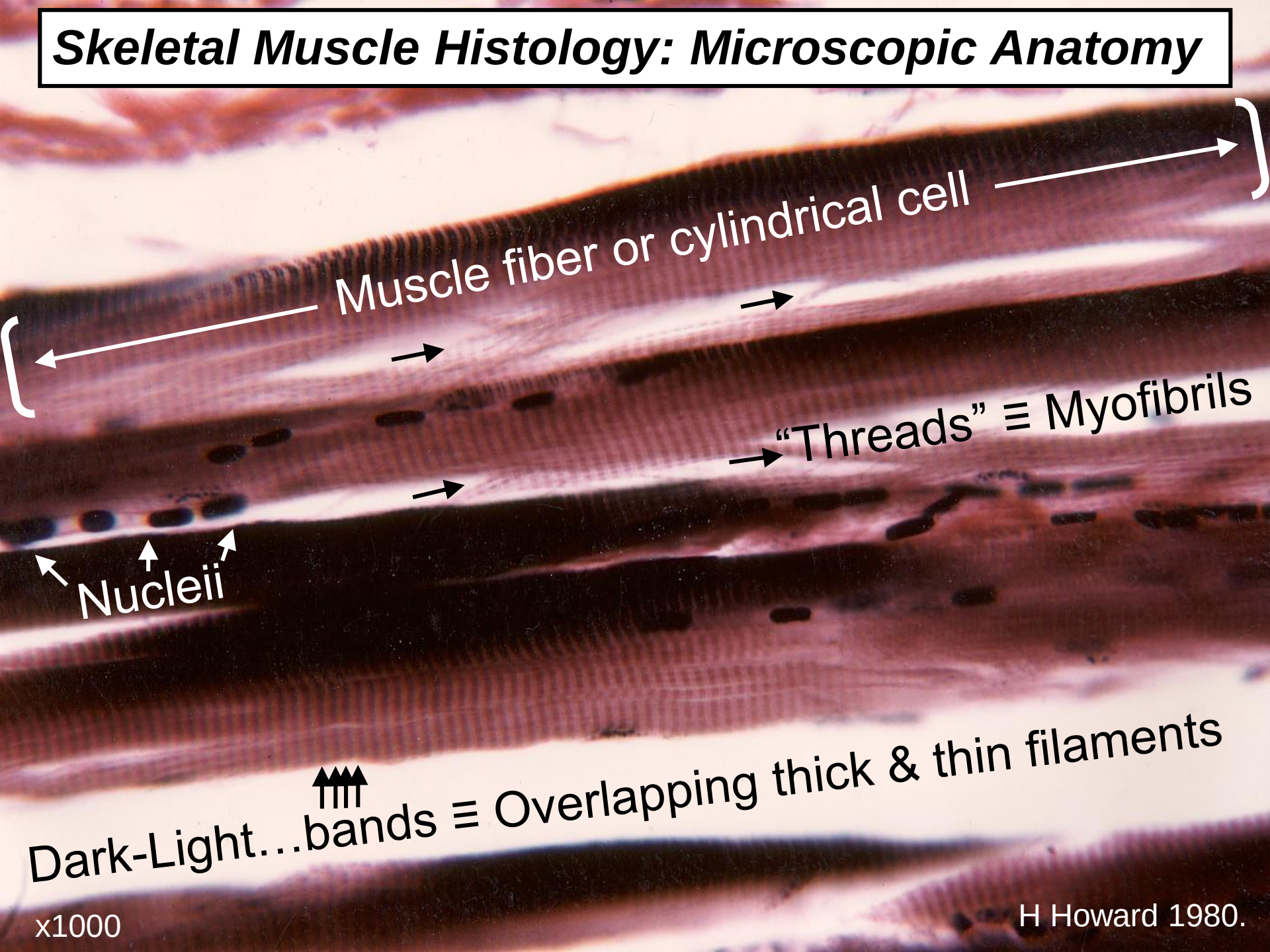


LS 2012 ch 8 vignette

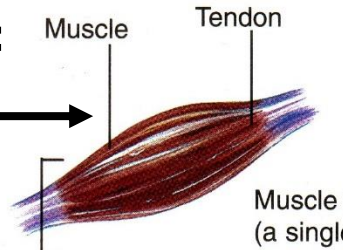


LS 2012 fig 8-1

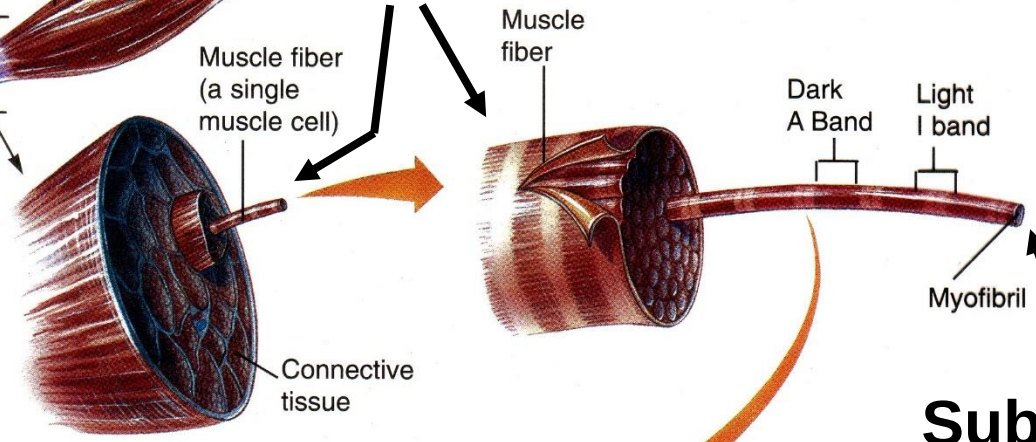
Skeletal Muscle Histology: Microscopic Anatomy



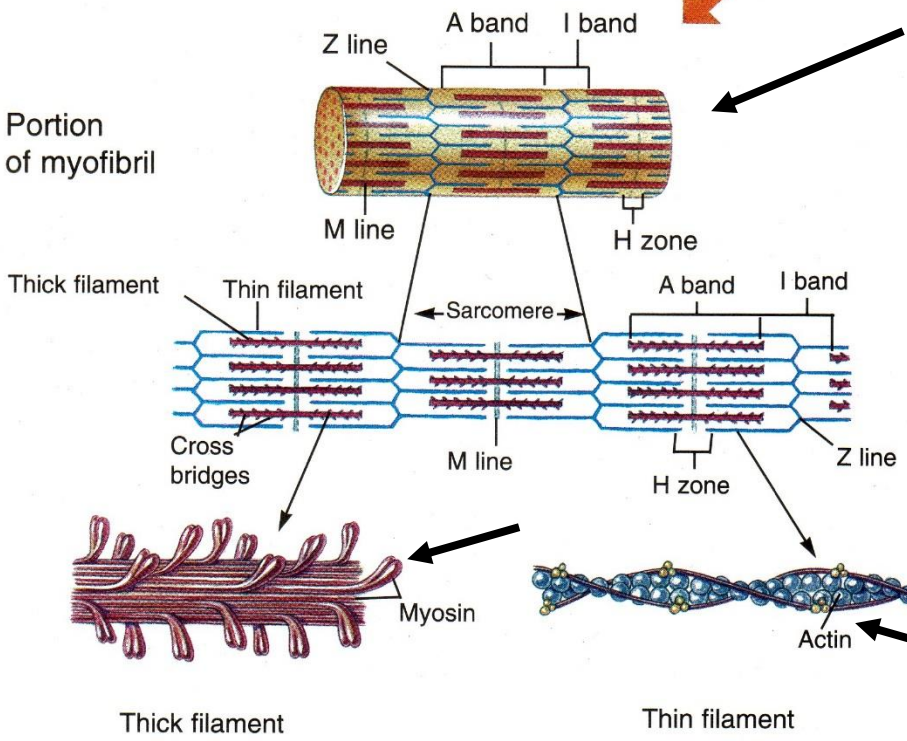
Organ = Muscle



Cell = Myocyte = Fiber



Subcellular = Cytoskeleton



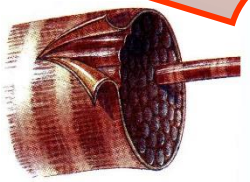
Molecules = Actin & Myosin

LS 2006, cf:
LS 2012 fig 8-2
DC 2013 fig 12-3

Whole Muscle

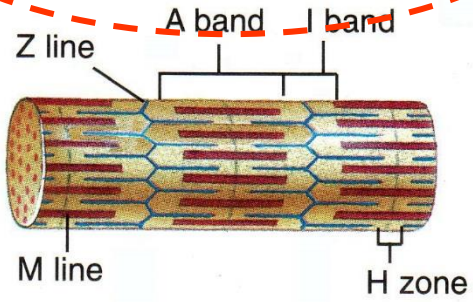
Organ

Myocyte or Muscle Fiber



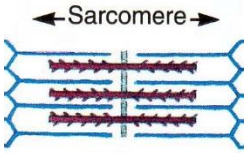
Cell

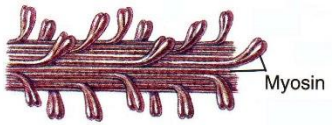
Myofibril



Cytoskeleton

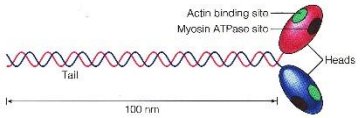
Thick & Thin Filaments

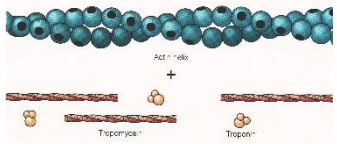


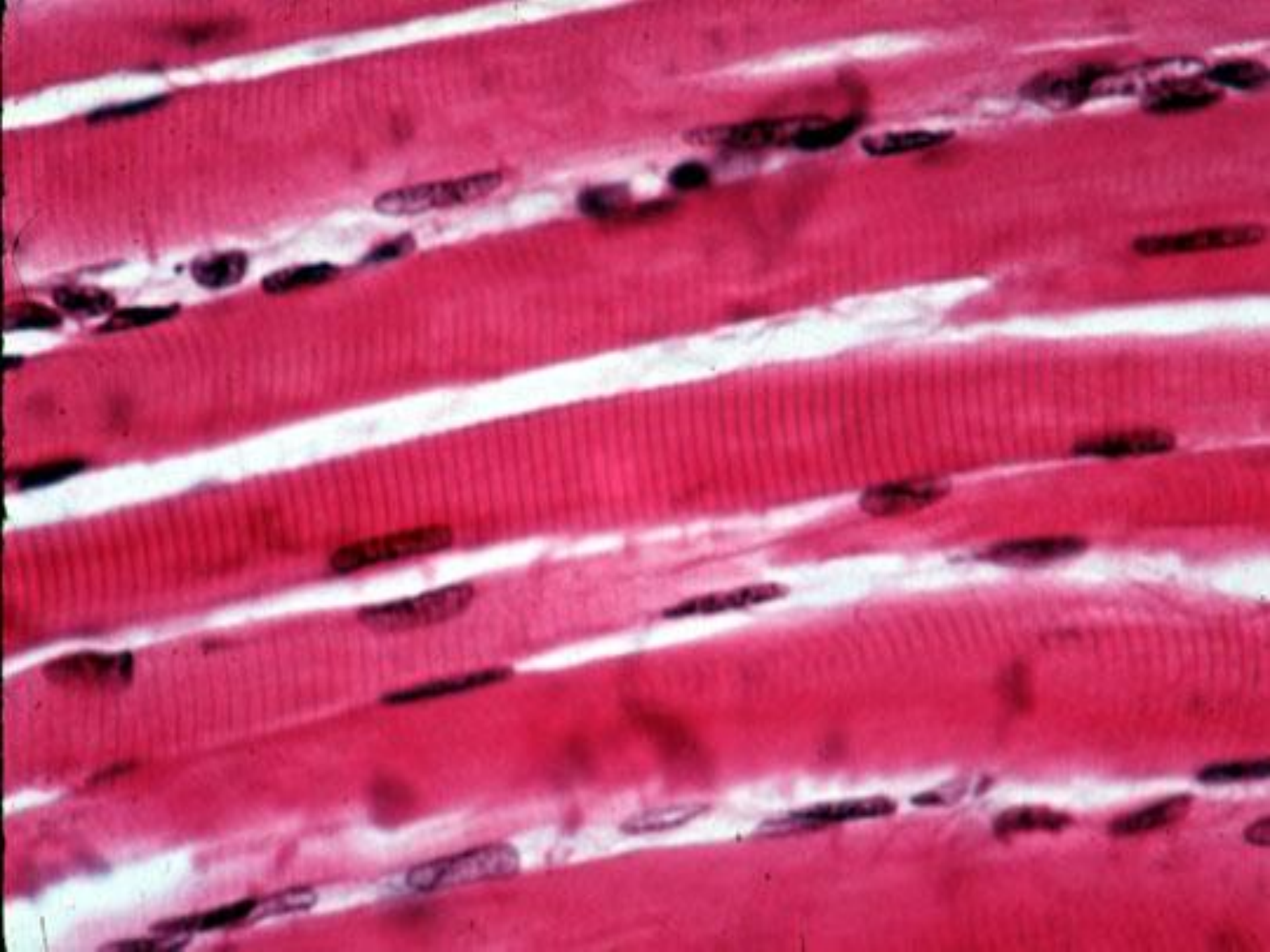


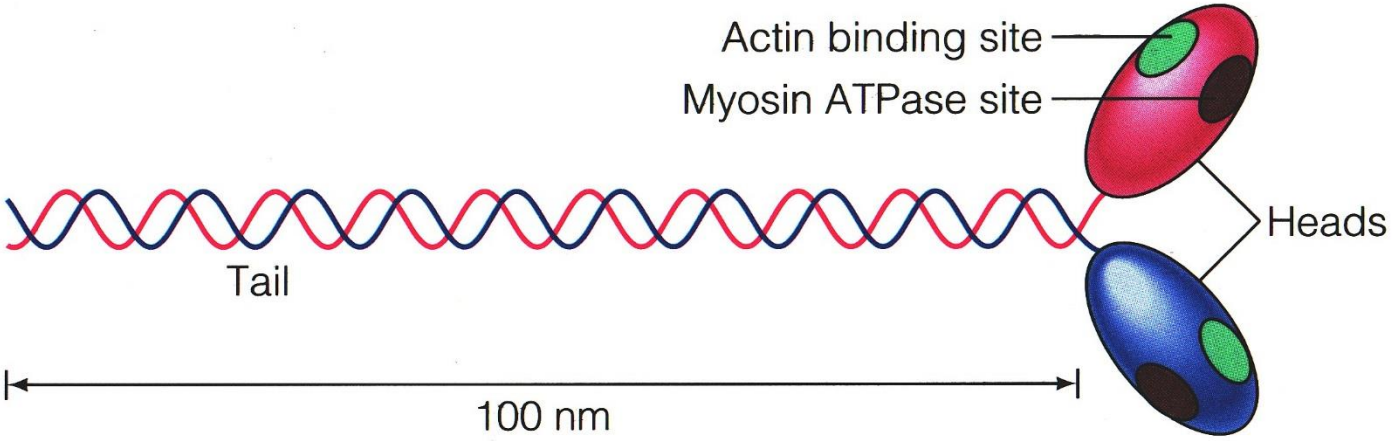
Myosin & Actin

Molecules



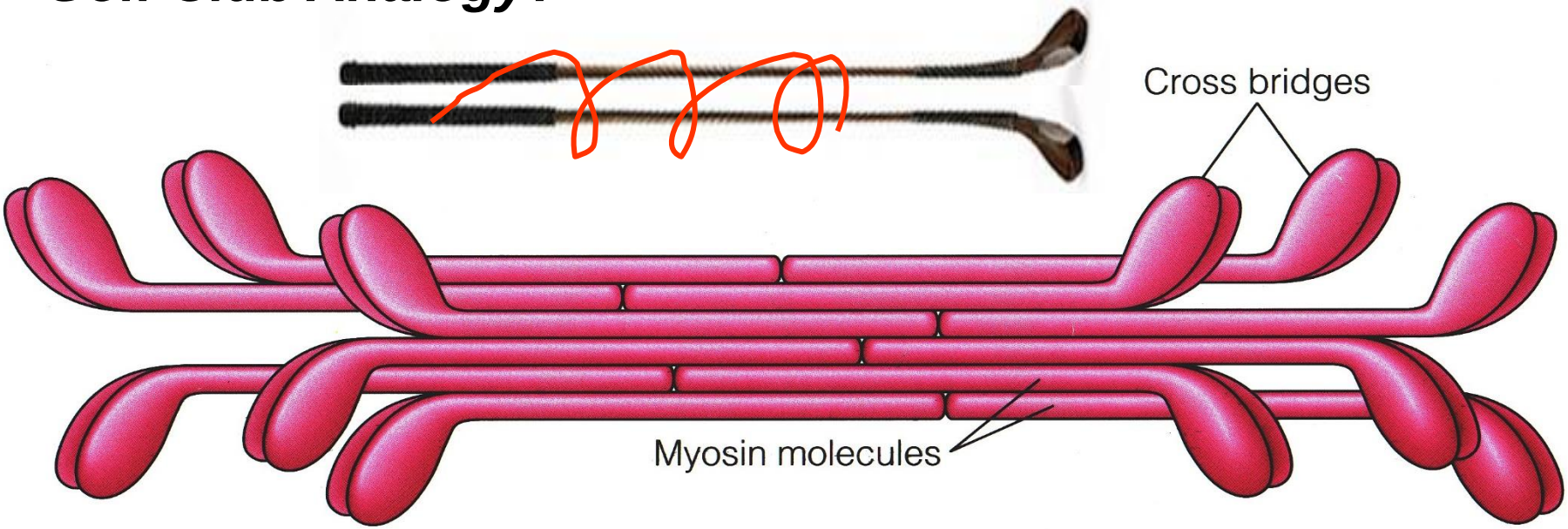






(a)

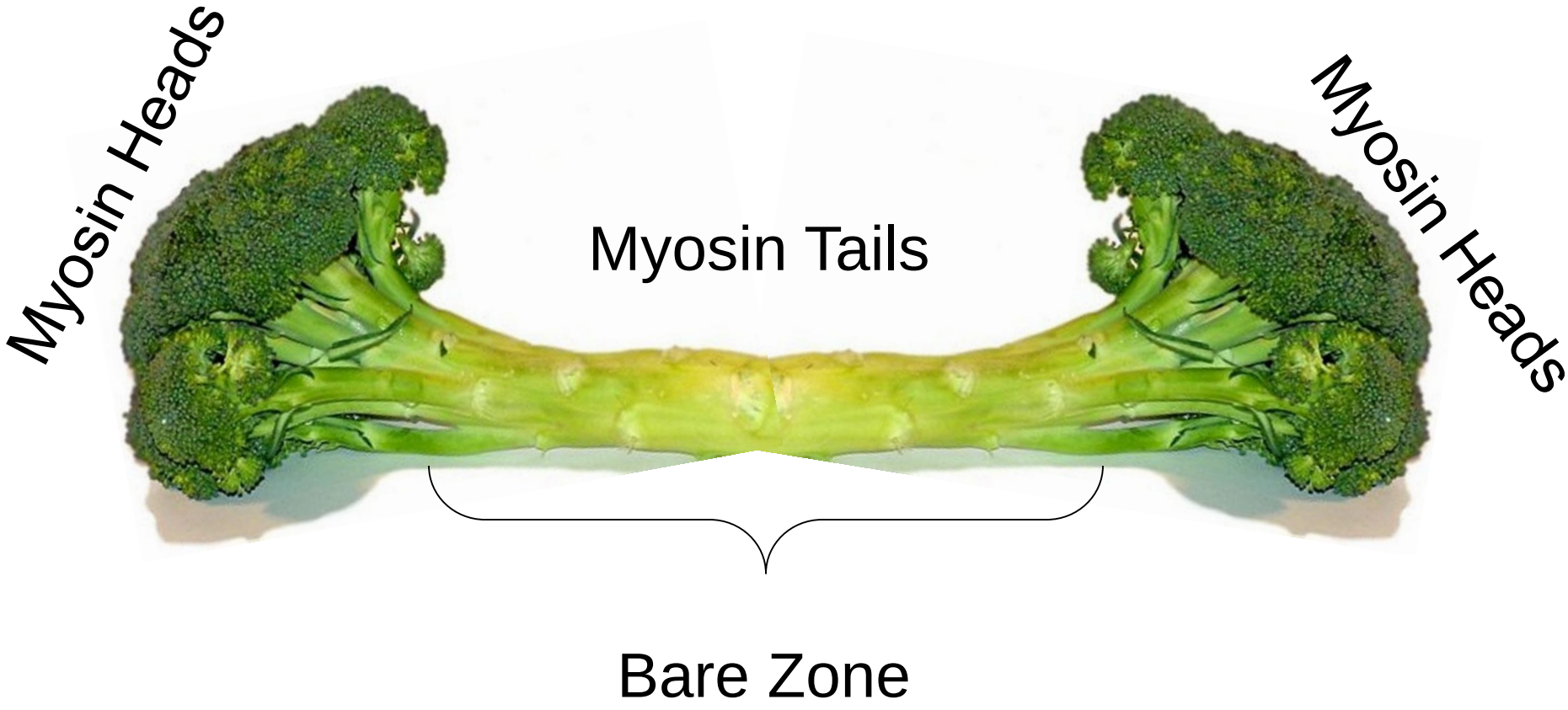
Golf Club Analogy?

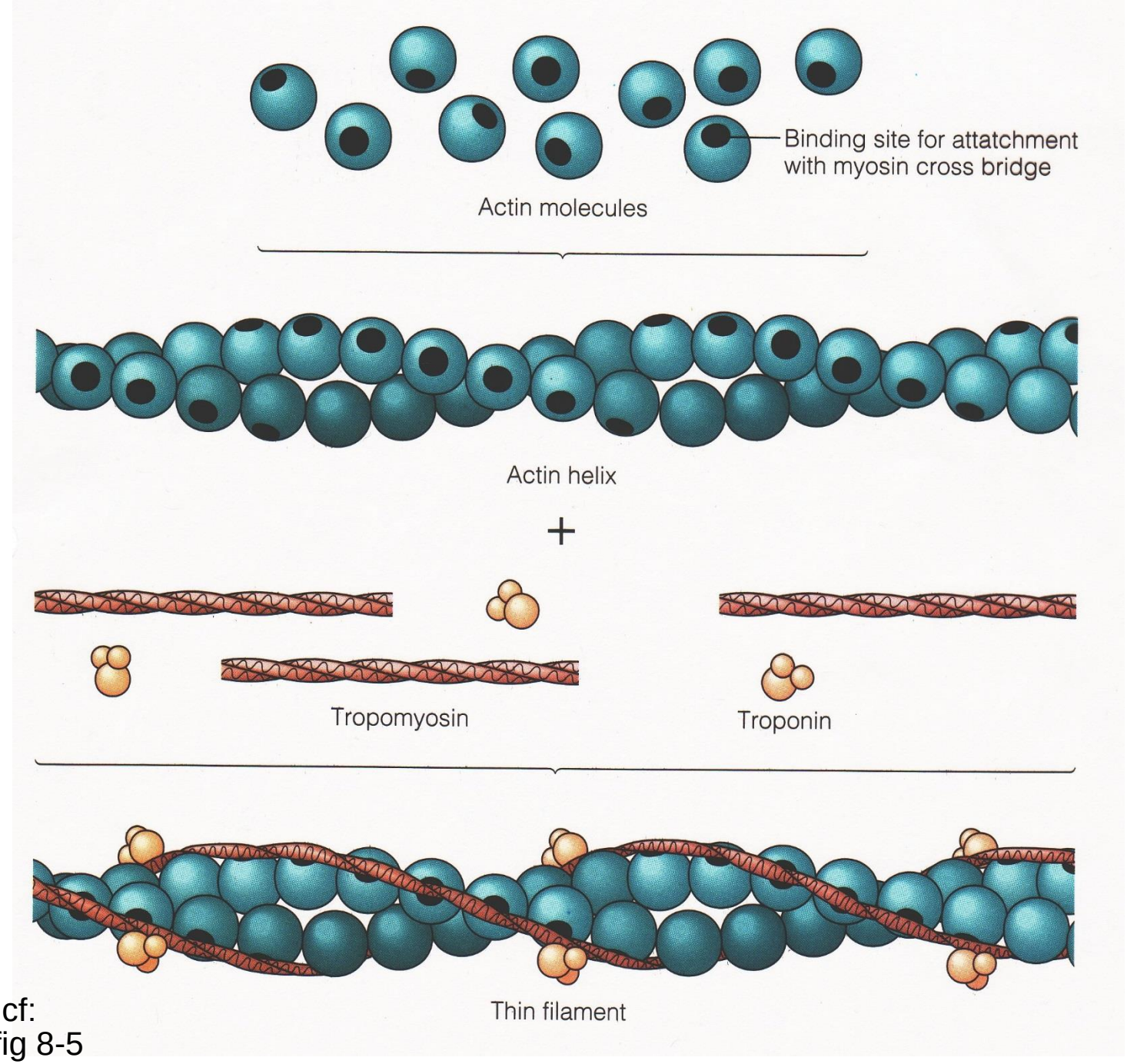


(b)

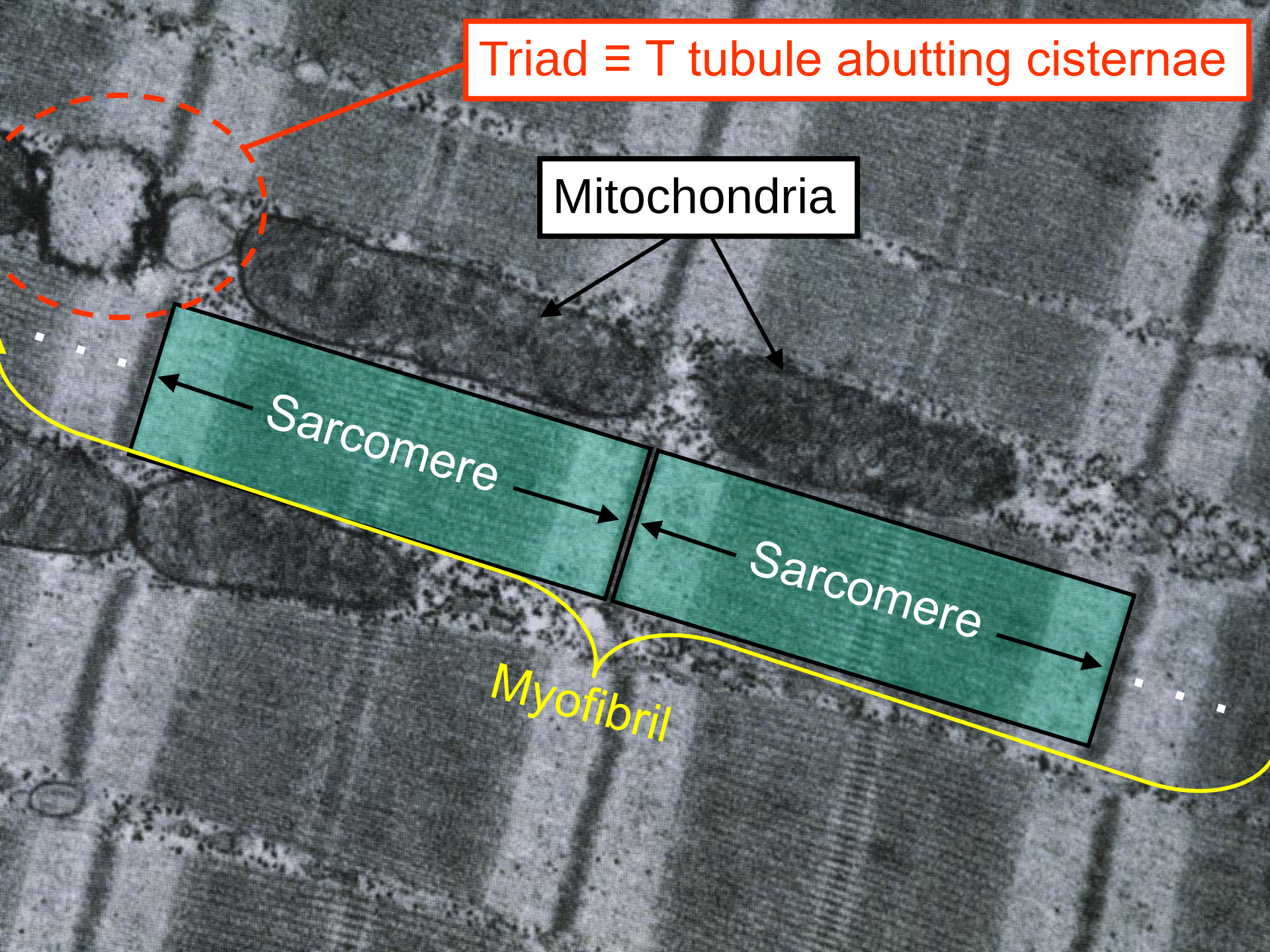
LS 2006, cf:
LS 2012 fig 8-4

Broccoli Analogy?



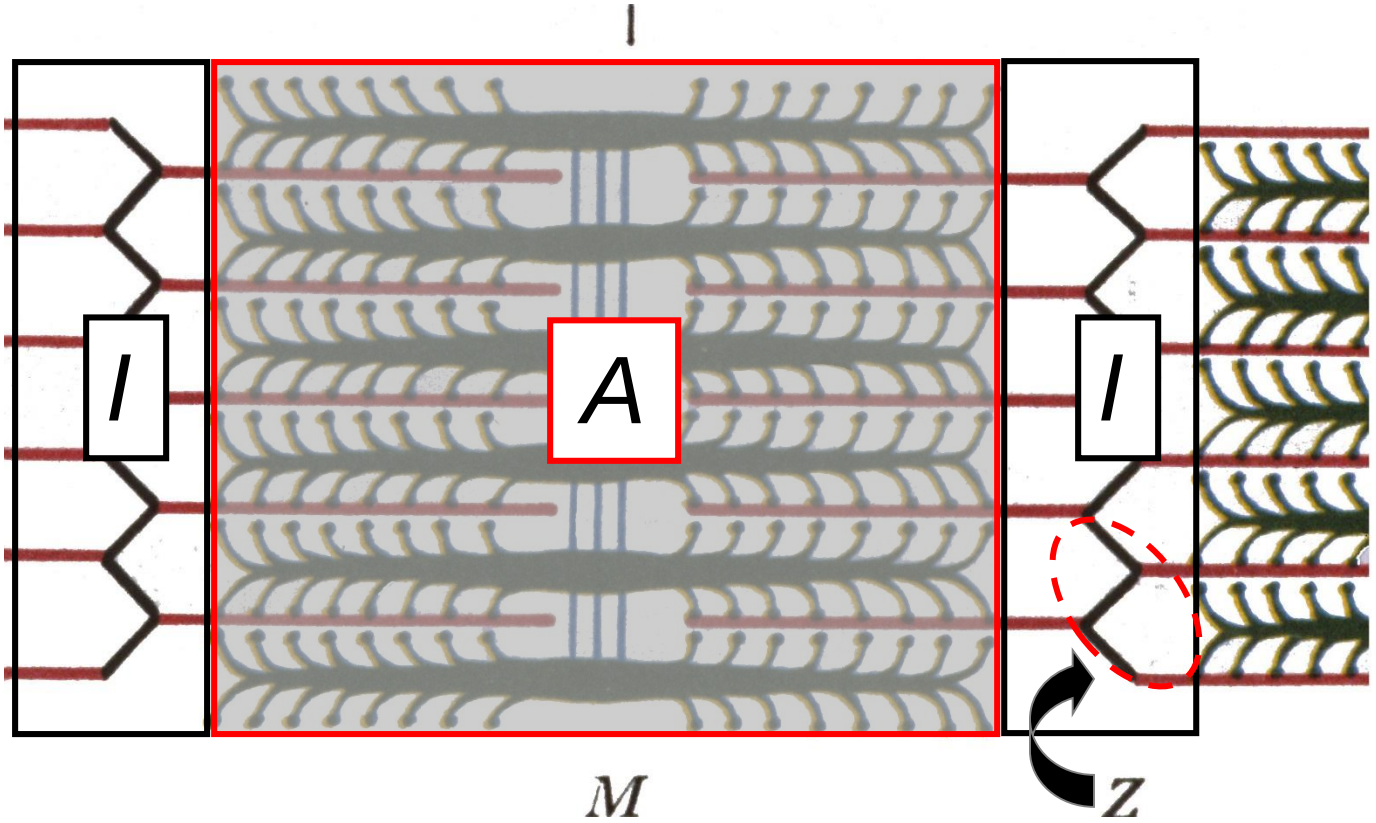


LS 2006, cf:
LS 2012 fig 8-5


Triad ≡ T tubule abutting cisternae
Mitochondria
Sarcomere
Sarcomere
Myofibril

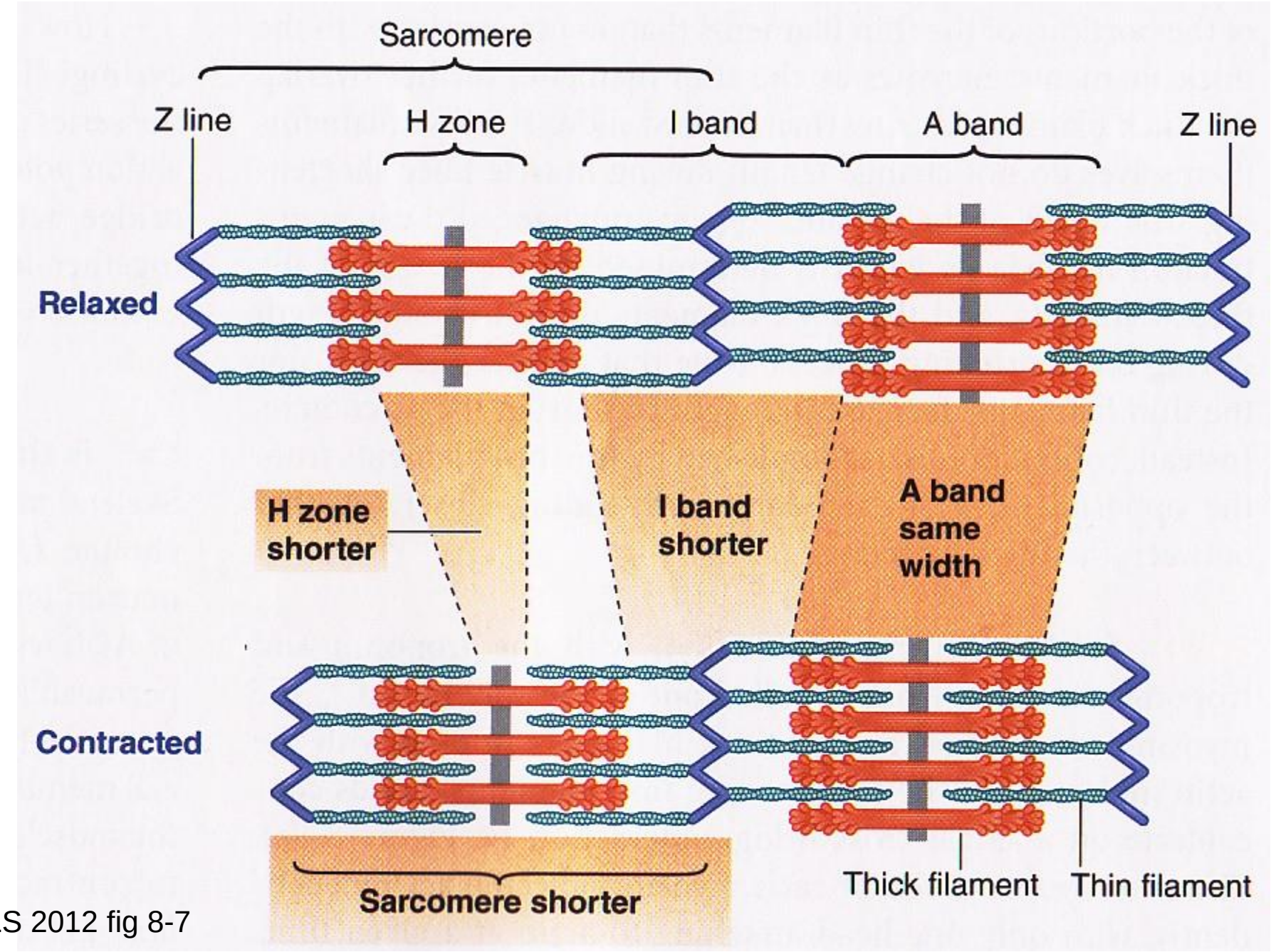
A Band = Dark Band

*A*nisotropic = Light Can't Shine Through



I Band = Light Band

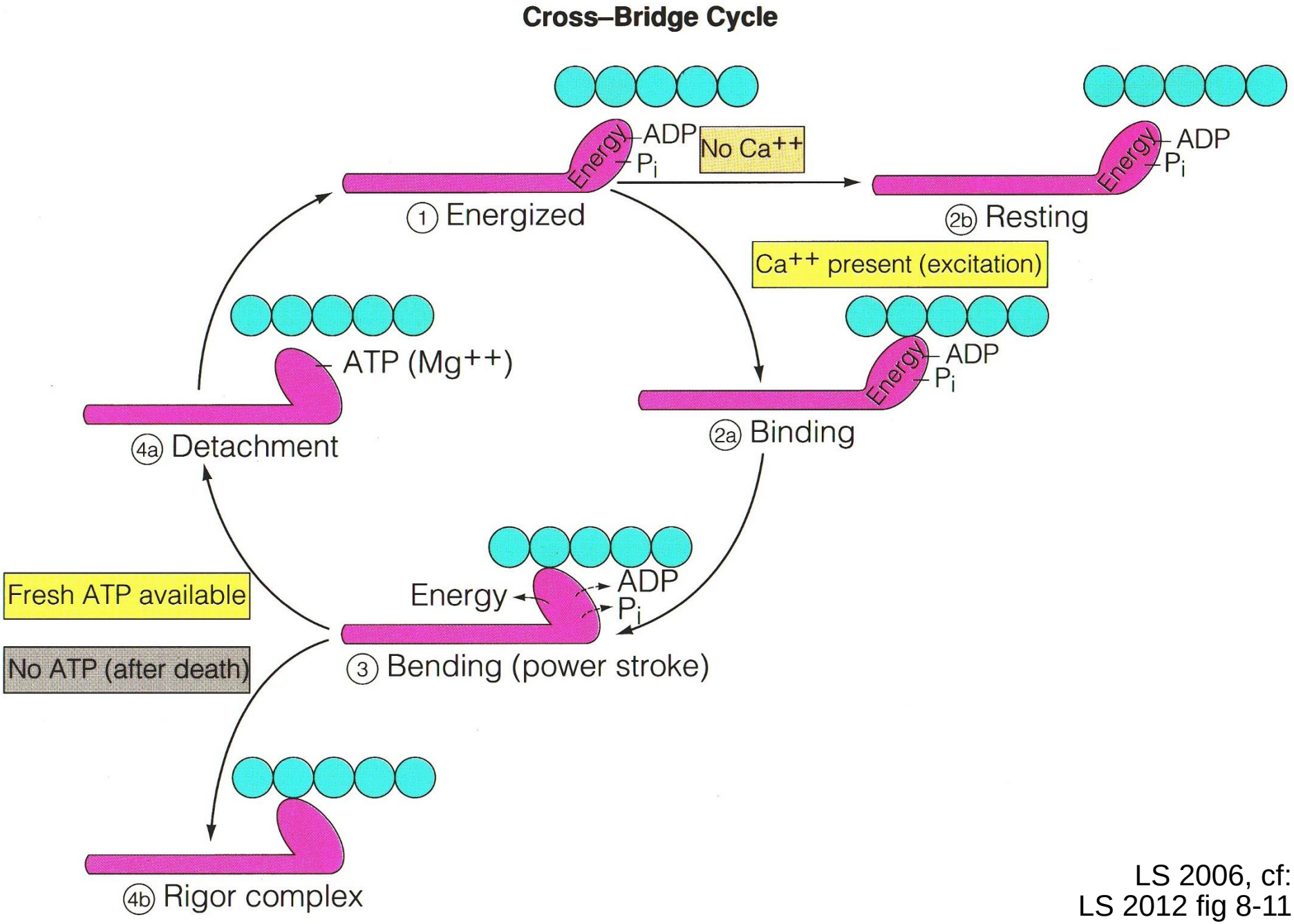
*I*sotropic = Light Can Shine Through



LS 2012 fig 8-7

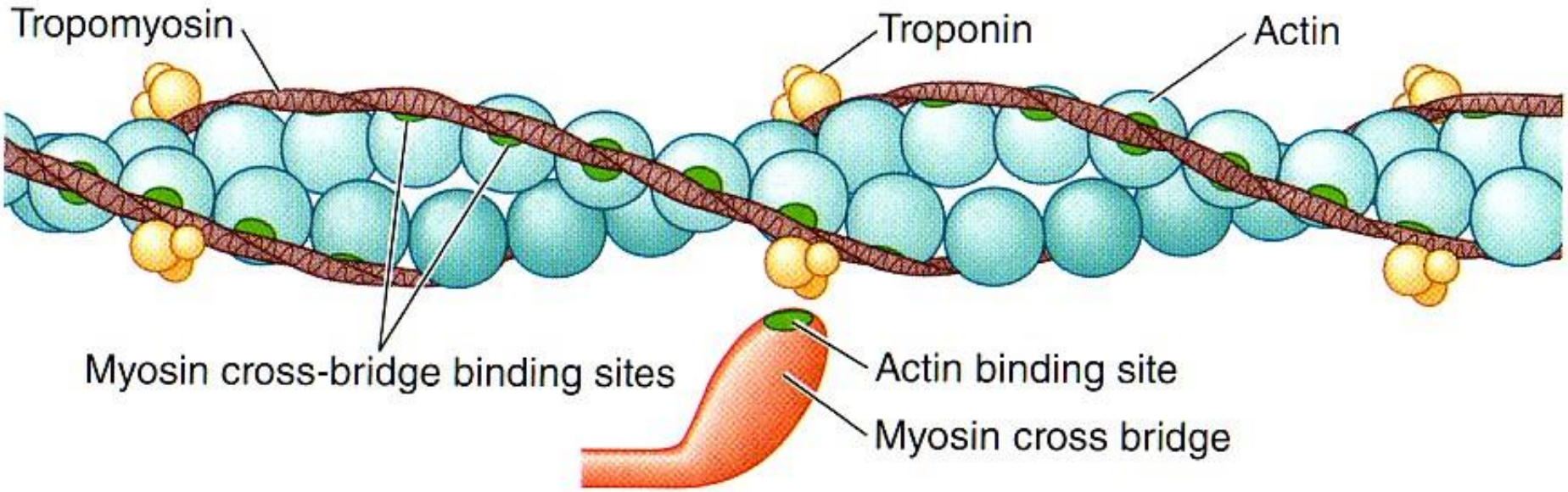
Discussion + Time for Questions!

What do we guess happens at the molecular level?



LS 2006, cf:
LS 2012 fig 8-11

Relaxed: No Cross-Bridge Binding



(a) Relaxed

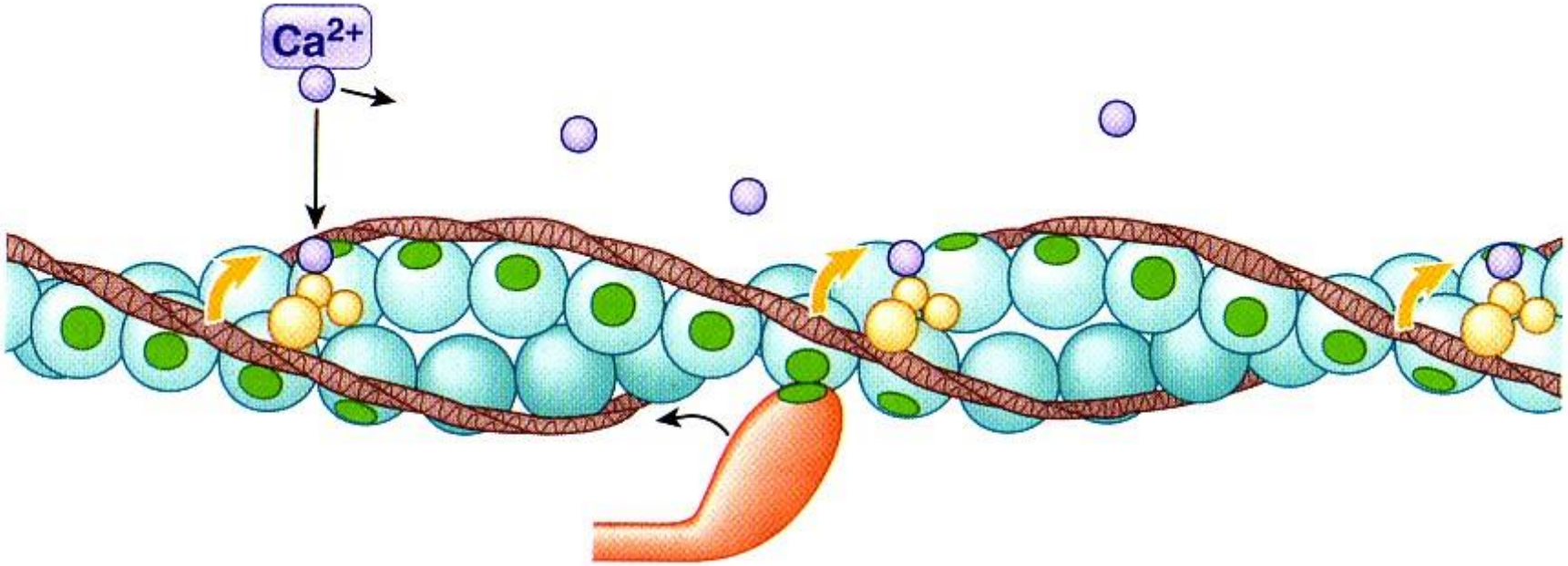
1. No excitation.

2. No cross-bridge binding because cross-bridge binding site on actin is physically covered by troponin–tropomyosin complex.

3. Muscle fiber is relaxed.

LS 2012 fig 8-6a

Excited: Calcium Triggers Cross-Bridge Binding



(b) Excited

1. Muscle fiber is excited and Ca^{2+} is released.

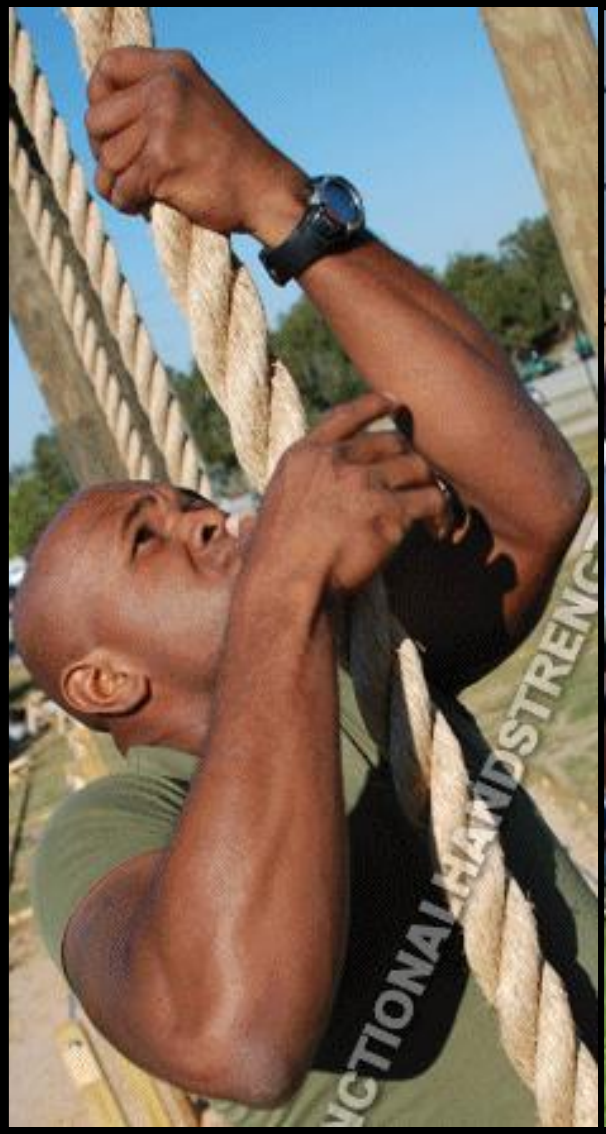
2. Released Ca^{2+} binds with troponin, pulling troponin–tropomyosin complex aside to expose cross-bridge binding site.

3. Cross-bridge binding occurs.

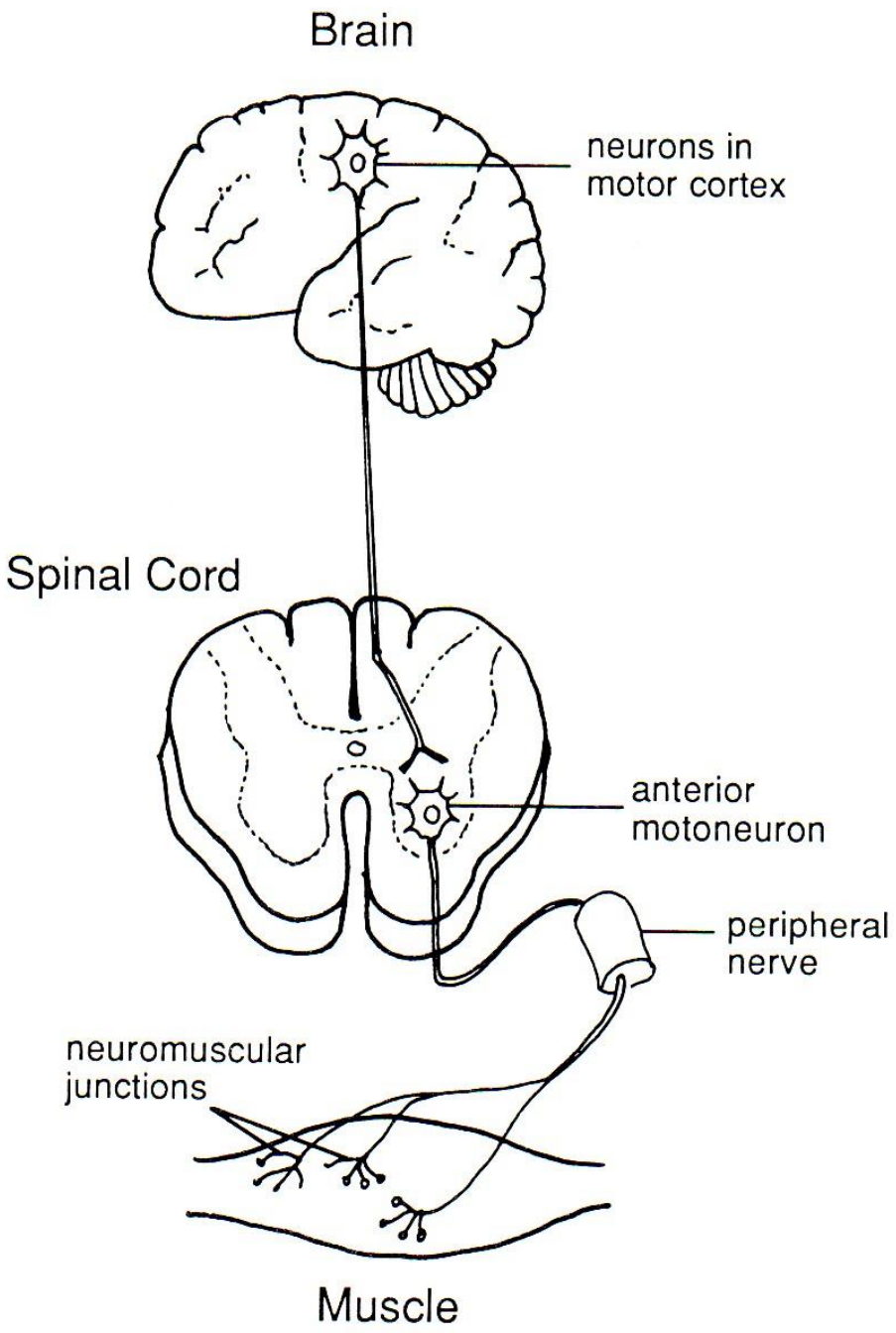
4. Binding of actin and myosin cross bridge triggers power stroke that pulls thin filament inward during contraction.

LS 2012 fig 8-6b

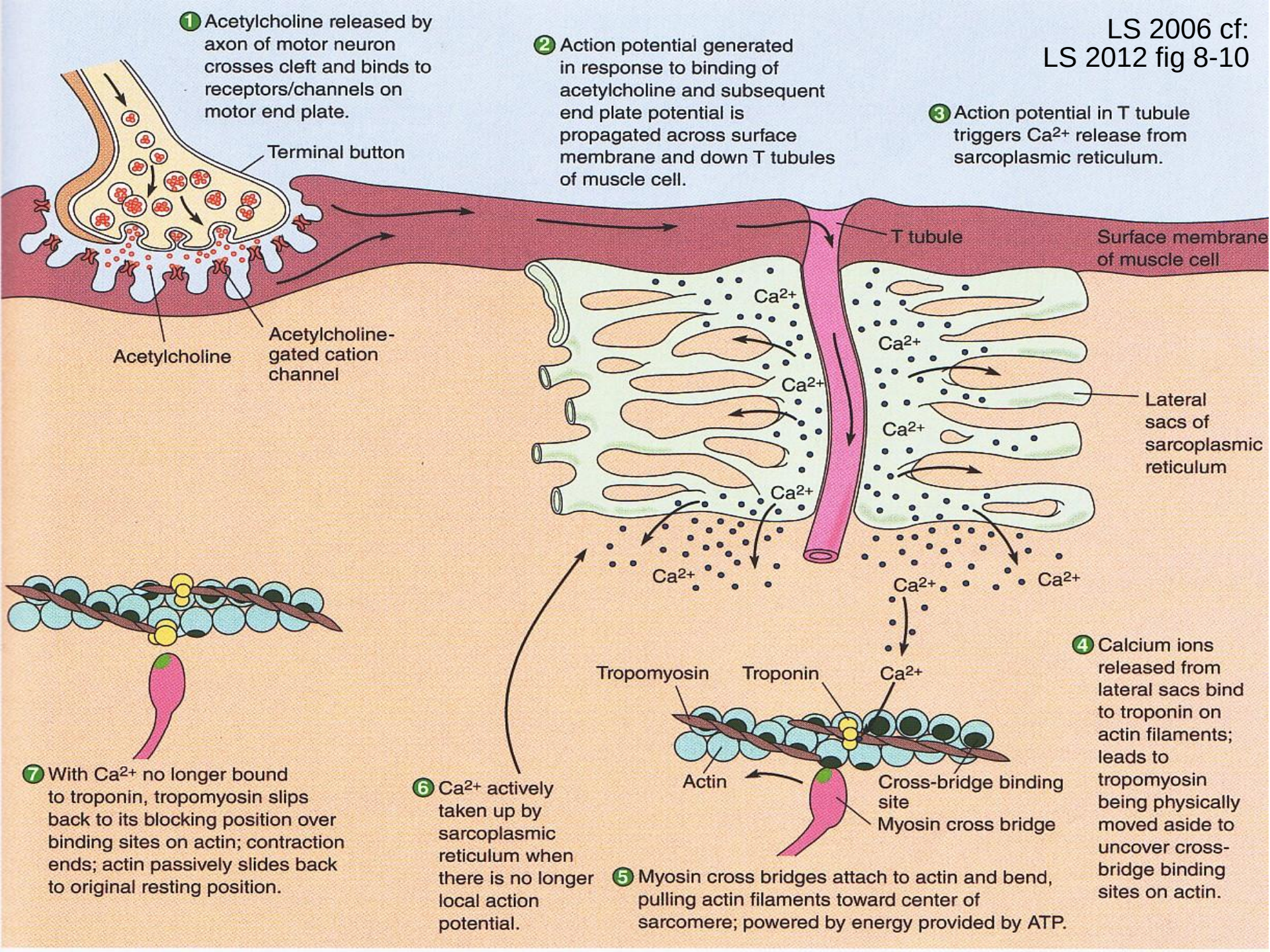
Rope Climb or Tug of War
Grasp, then Regrasp!



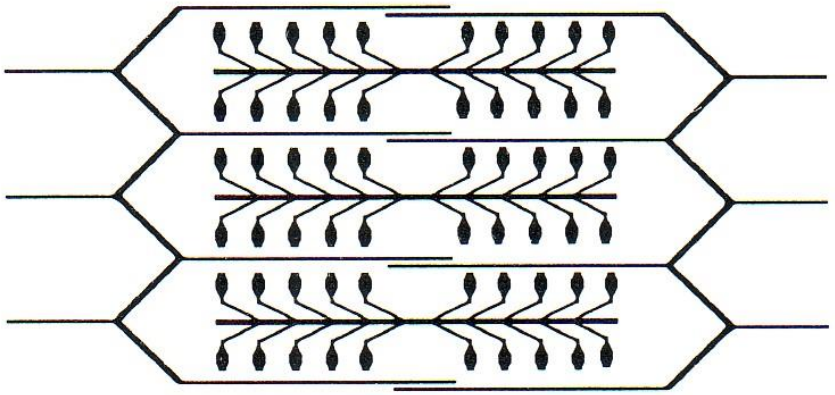

Summary
We are almost there!


Brain
neurons in
motor cortex
Spinal Cord
anterior
motoneuron
peripheral
nerve
neuromuscular
junctions
Muscle

LS 2006 cf:
LS 2012 fig 8-10

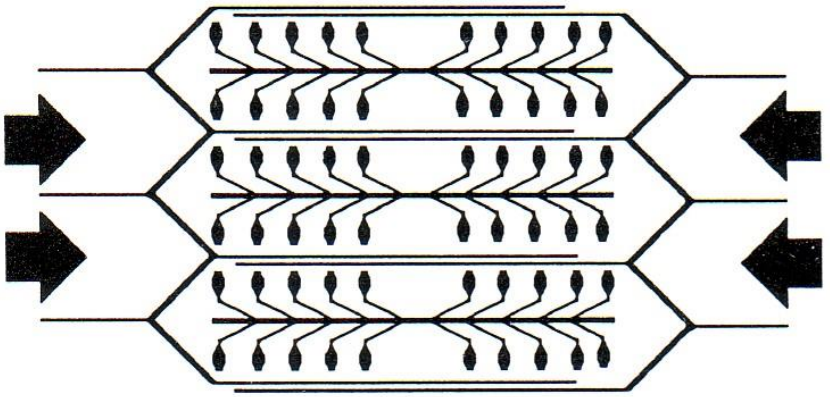


Relaxation Phase

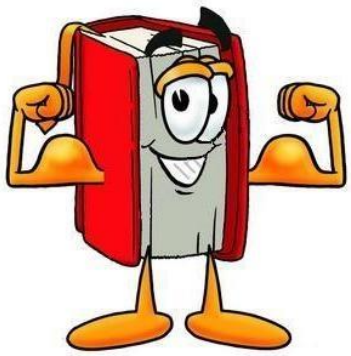


1. Excitation by nerve fiber
2. Conduction by T-tubules
3. Ca^{2+} release by SR

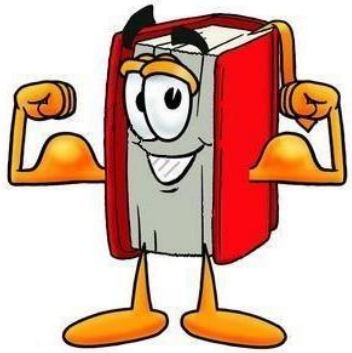
Contractile Phase



D Liang & VP Lombardi 1989



Muscle Contraction Resources



https://www.ncbi.nlm.nih.gov/books/NBK9961/

https://www.youtube.com/watch?v=jUBBW2Yb5KI

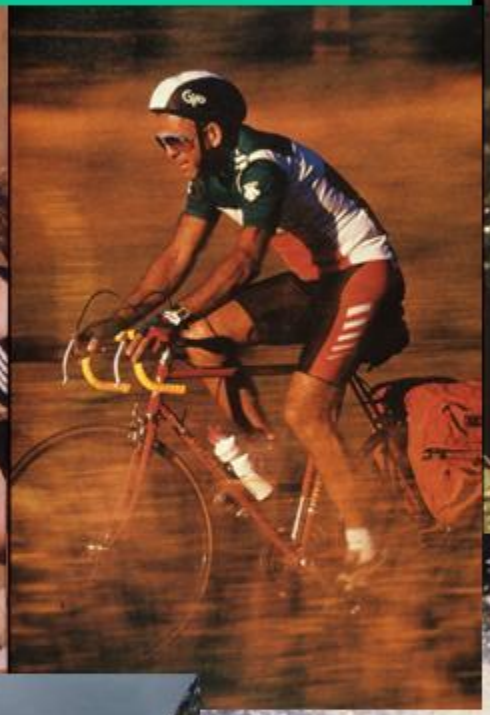
https://www.youtube.com/watch?v=sJZm2YsBwMY

A. Malcolm Campbell
Davidson College, Davidson, NC
www.bio.davidson.edu/courses/movies.html

David Bolinsky, XVIVO
Rocky Hill, CT
http://www.xvivo.net/

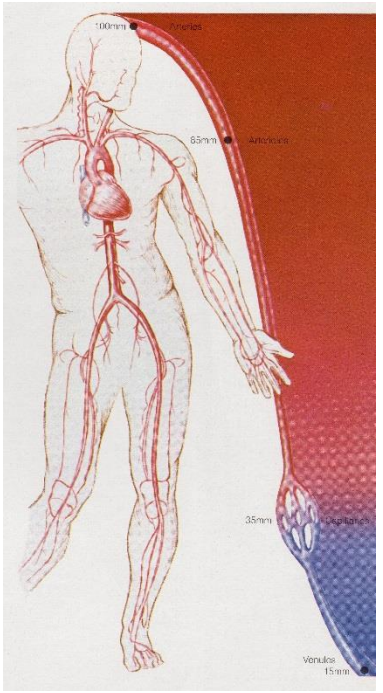
Adaptations to Exercise?

Mode, Intensity, Duration, Frequency,
Distribution of Training Sessions?
Conditions of Environment? Individual?

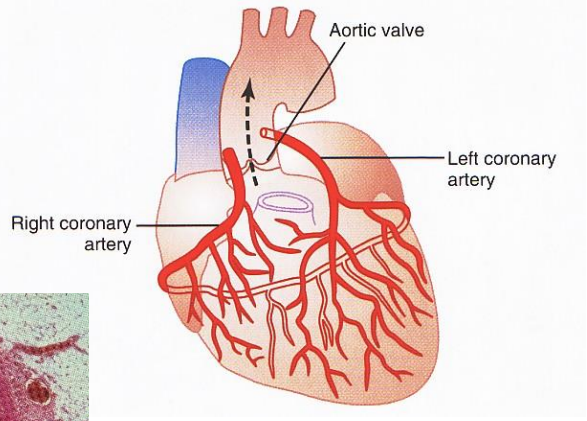


Adaptations to Exercise?

Body Levels of Organization?
Which Body System?

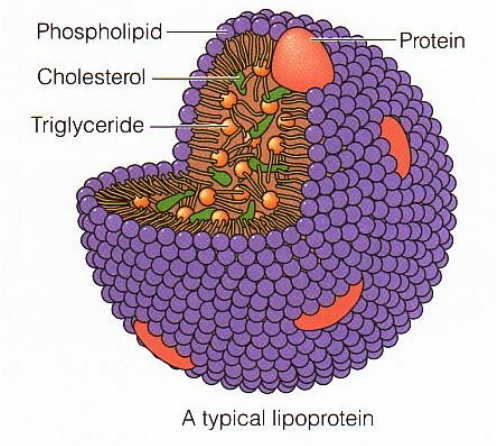


Body System



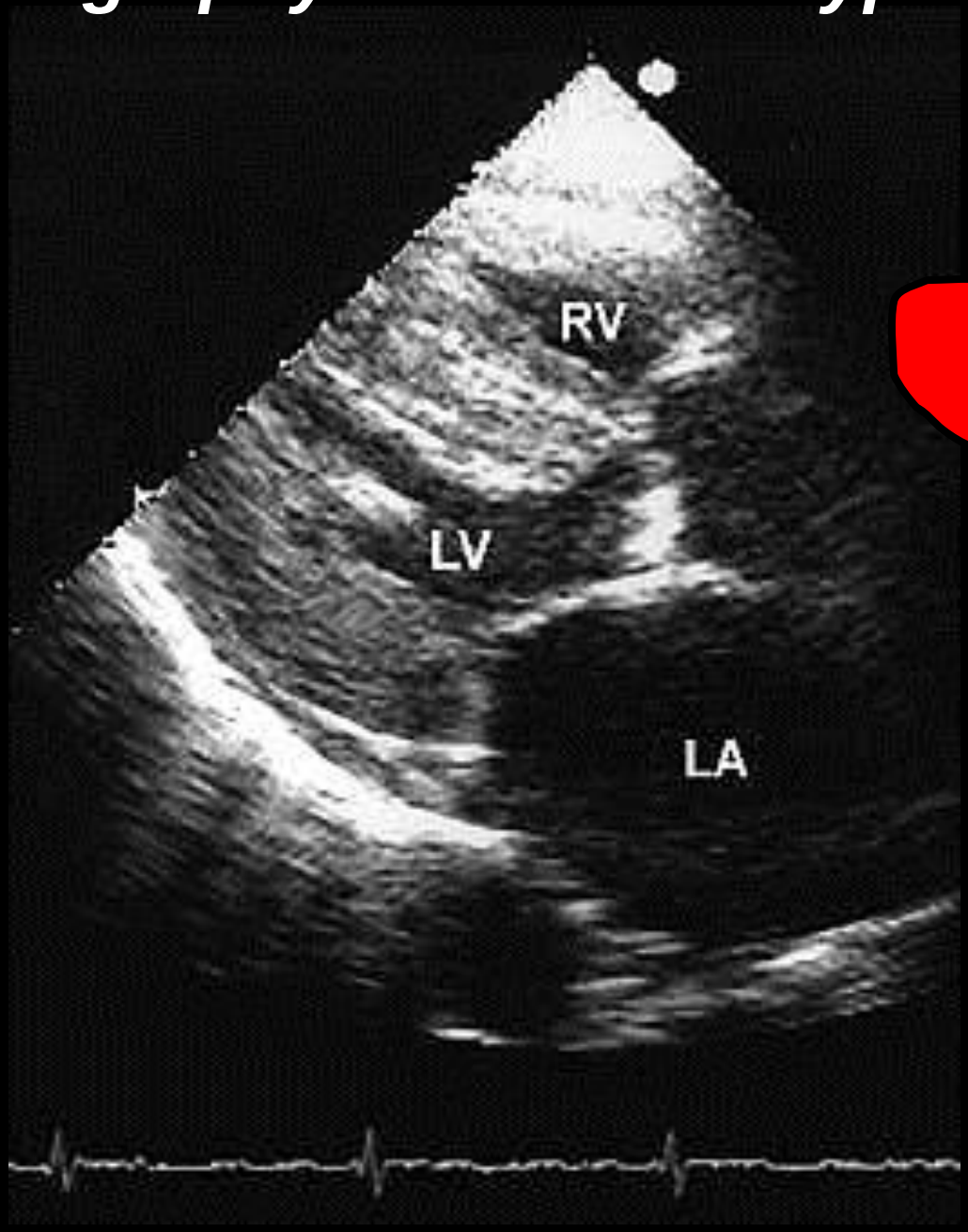
Organ

Cell/Tissue

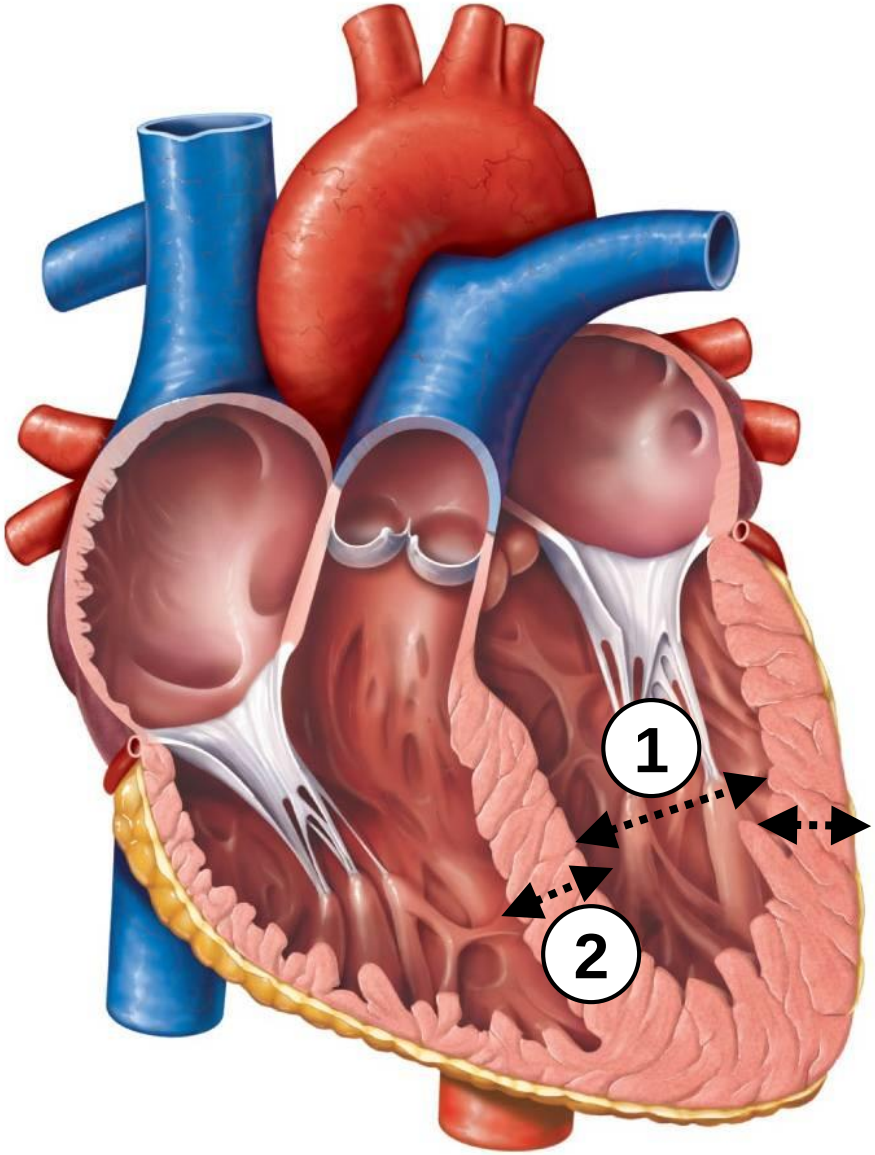


Molecular

Echocardiography documents hypertrophy...



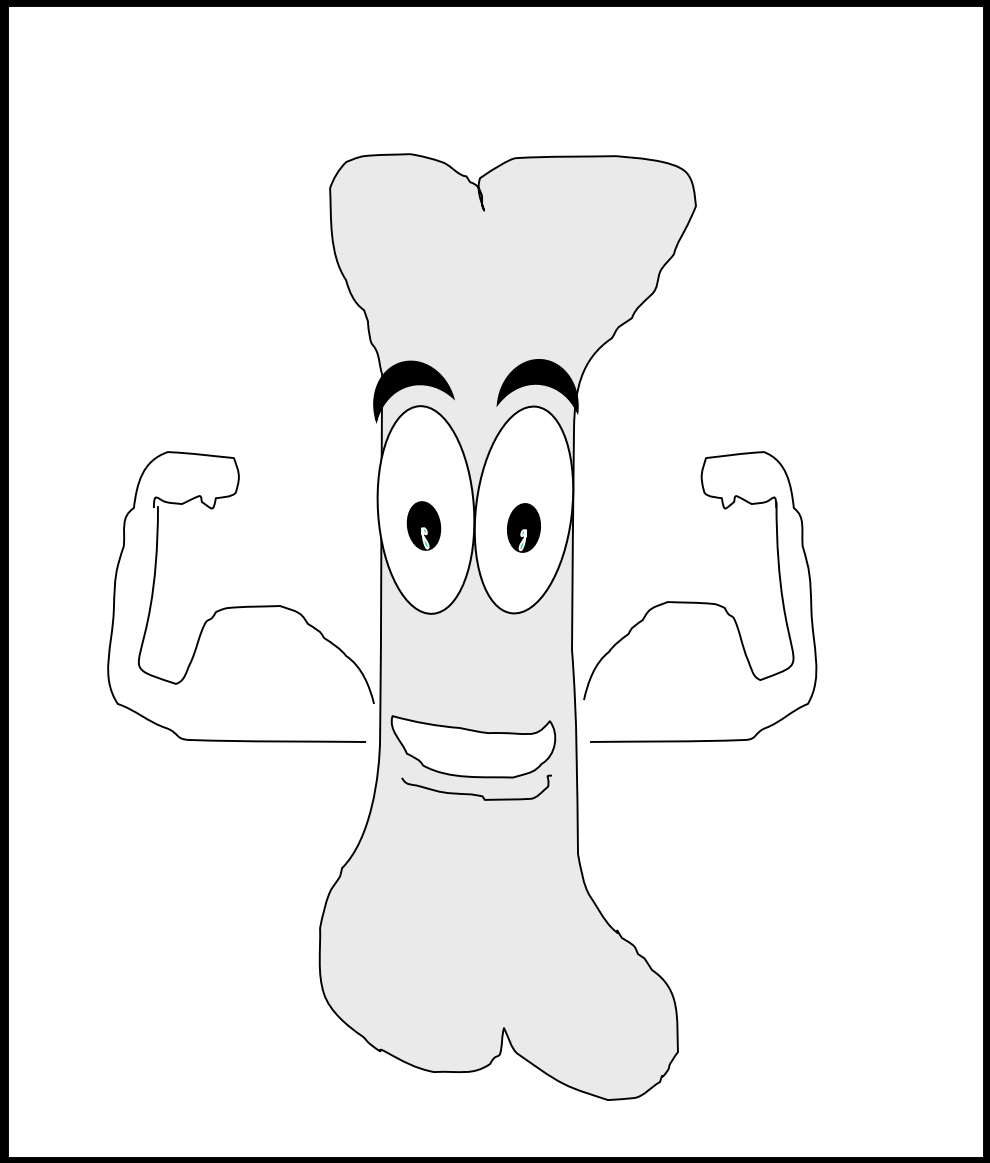
Cardiac Adaptations to Exercise: ① Endurance vs. ② StrengthTraining



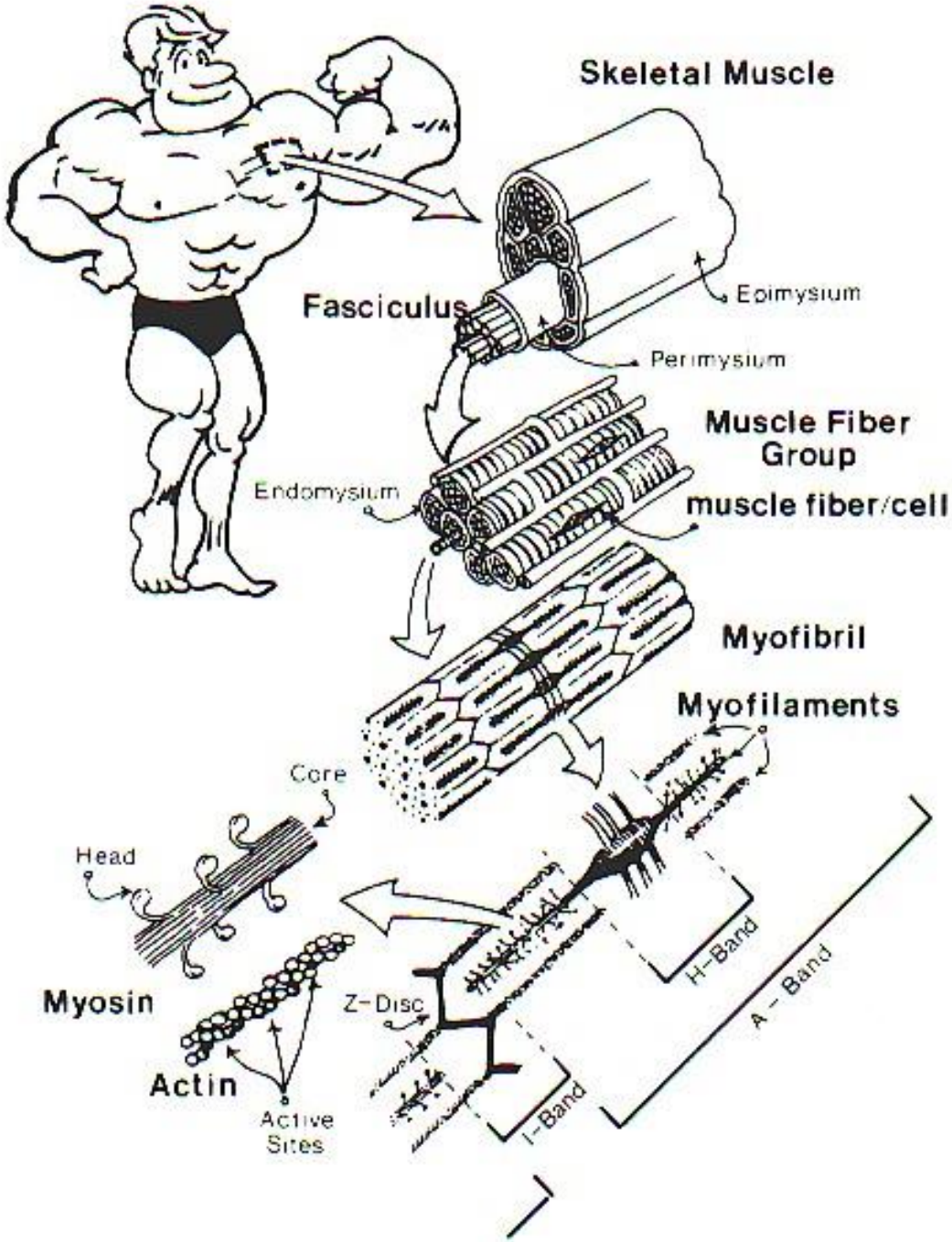
NB: ① > ↑ LBM

1 + 2

As muscles tug on bones, bones get stronger, too!...many systems adapt!!



Muscle Adaptations to Exercise



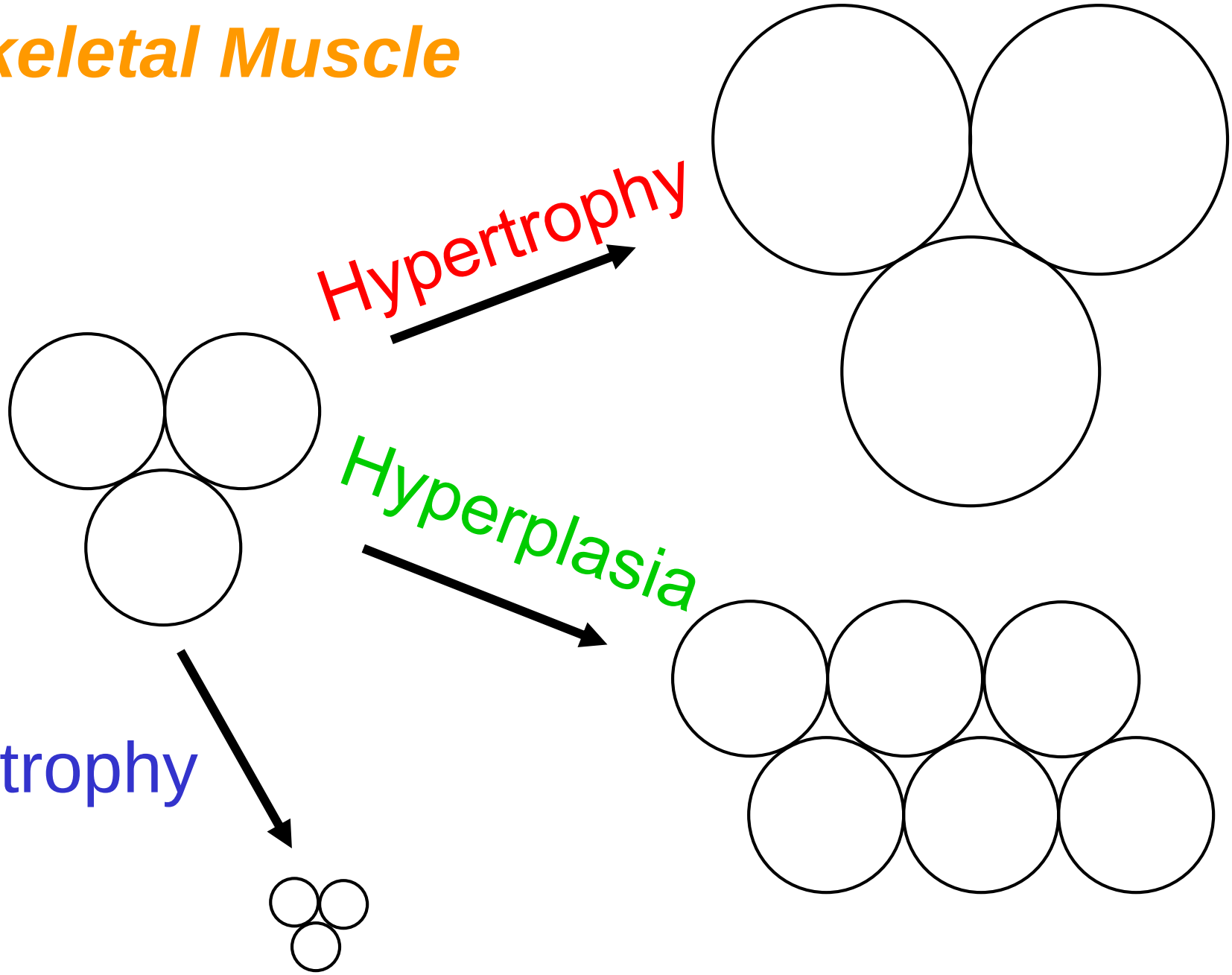
Atrophy

decrease in size & strength

Hypertrophy

increase in size & strength

Skeletal Muscle



Women & Hypertrophy?

What happens in muscles at cellular & subcellular levels?

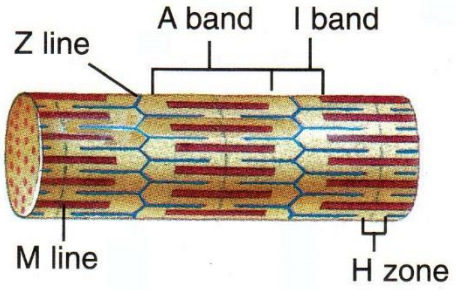
Myofibril

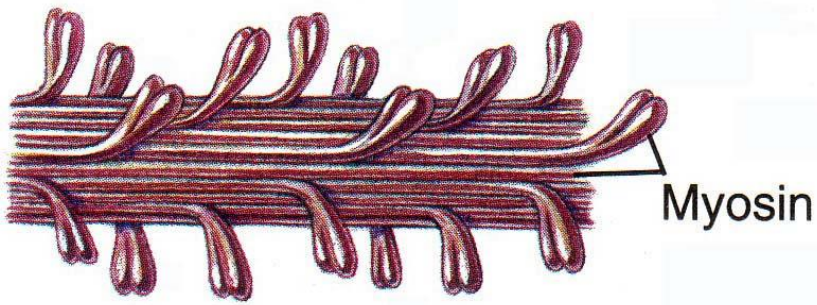
Hypertrophy: *Increased*

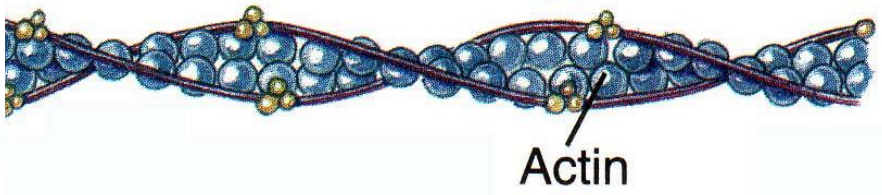
Number of Myofibrils

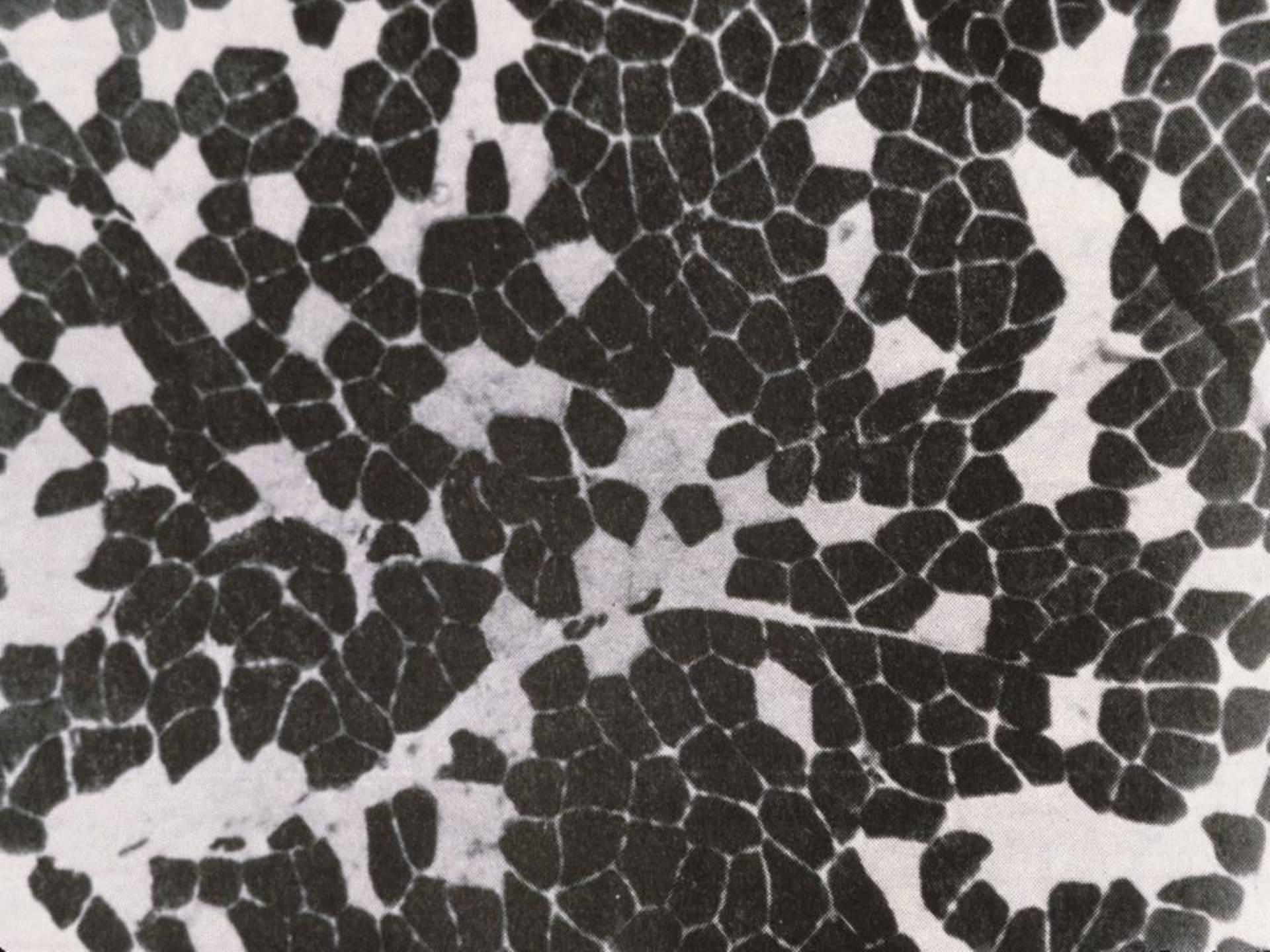
Thick & Thin Filaments

Myosin & Actin Molecules







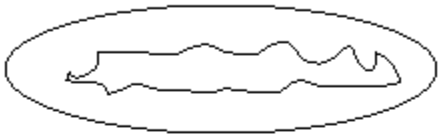


Characteristics of Skeletal Muscle Fibers

Characteristic	TYPE OF FIBER		
	Slow Oxidative (Type I)	Fast Oxidative (Type IIa)	Fast Glycolytic (Type IIb)
Myosin-ATPase Activity	Low	High	High
Speed of Contraction	Slow	Fast	Fast
Resistance to Fatigue	High	Intermediate	Low
Aerobic Capacity	High	High	Low
Anaerobic Capacity	Low	Intermediate	High
Mitochondria	Many	Many	Few
Capillaries	Many	Many	Few
Myoglobin Content	High	High	Low
Color of Fibers	Red	Red	White
Glycogen Content	Low	Intermediate	High

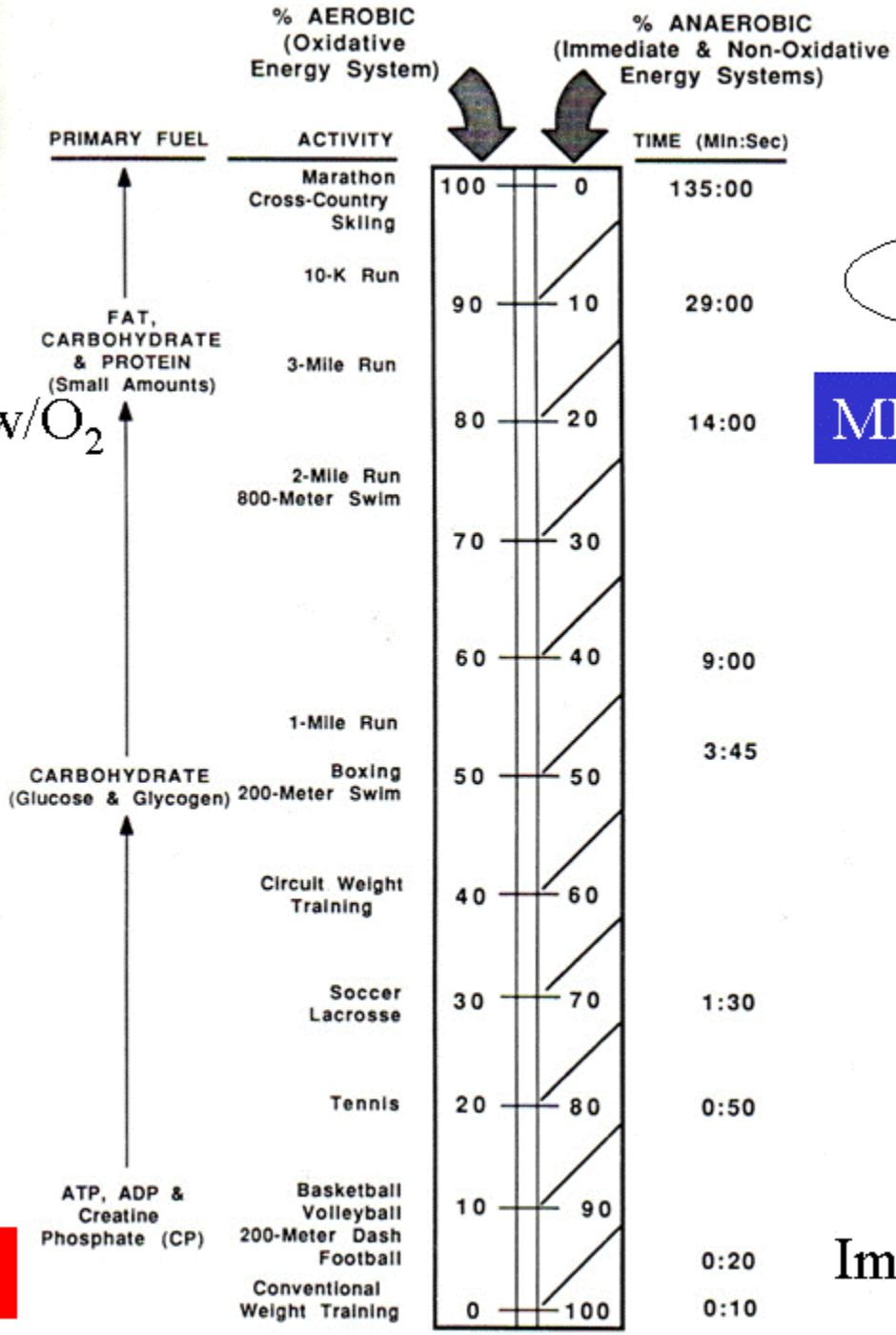
LS 2012 tab 8-1 modified
> VP Lombardi 1989

AEROBIC w/O_2



MITOCHONDRIA

ANAEROBIC



CYTOSOL

Glycolysis

Immediate/ATP-PC

Changes in Muscle Due to Strength Training

- ↑ Size of larger fast vs smaller slow fibers
- ↑ CP as well as creatine phosphokinase (CPK) which enhances short-term power output
- ↑ Key enzymes which help store and dissolve sugar including glycogen phosphorylase (GPP) & phosphofructokinase (PFK)
- ↓ Mitochondrial # relative to muscle tissue
- ↓ Vascularization relative to muscle tissue
- ↑ Splitting of fast fibers? Hyperplasia? With growth hormone (GH), androgenic-anabolic steroids (AAS)?

Changes in Muscle Due to Endurance Training

- ↑ Mitochondria, # & size
- ↑ Mitochondrial (aerobic) enzymes including those specific for fat burning
- ↑ Vascularization of muscles (better blood flow)
- ↑ Stores of fat in muscles accompanied by
- ↓ Triglycerides/fats in bloodstream
- ↑ Enzymes: activation, transport, breakdown (β-oxidation) of fatty acids
- ↑ Myoglobin (enhances O_2 transport)
- ↑ Resting energy levels which inhibit sugar breakdown
- ↑ Aerobic capacity of all three fiber types.

Which end of continuum?

+

Which energy nutrient/s?

+ Which specific muscles?

cf:


45

Dancing can be super aerobic exercise, too, & you don't have to be a star!

Extremes of the energy continuum!