Bl 121 Lecture 12 Thanks for your help with the blood chemistry lab!...

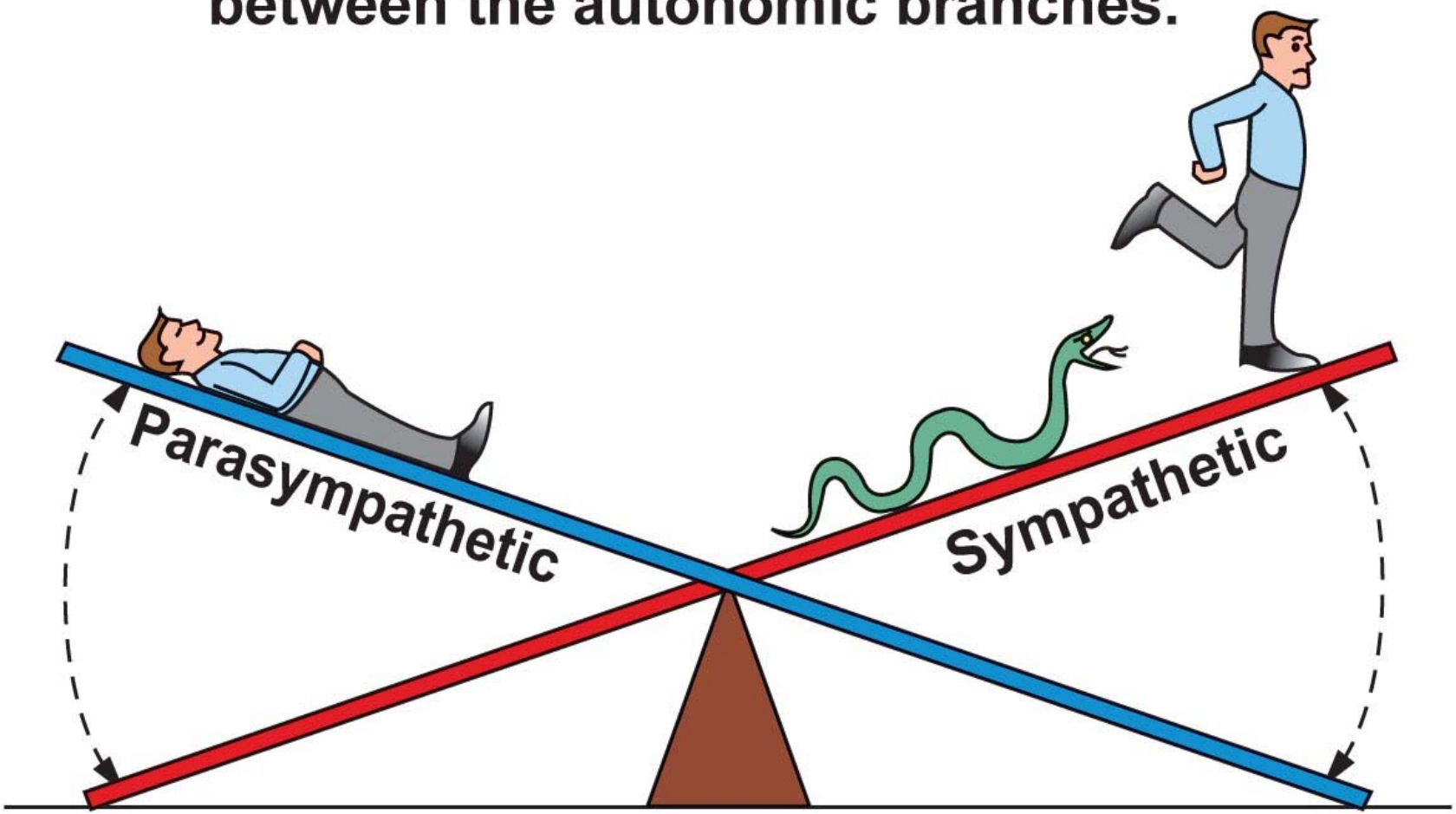
I. ***Announcements*** **Optional notebook check + Lab 6 tomorrow. Pulmonary Function Testing. Final exam > your Q on Wed. Q?**

II. ***Autonomic Nervous System Overview*** **LS pp 178 – 85**
LS Table 7-1 p 183 + stories to remember *fight-or-flight!*

III. ***Neuromuscular Connections*** **LS ch 7 pp 186-92, DC pp 69-71**
How does the signal cross the nerve-muscle gap? LS fig 7-5
- **A. Normal function? Ca2+ for bones!…but what else? LS p 190**
- **B. What do black widow spider venom, botulism, curare & nerve gas have in common? Botox? LS p 189-91**

IV. ***Muscle Structure, Function & Adaptation*** **LS ch 8, DC Module 12**
- **A. Muscle types: cardiac, smooth, skeletal LS fig 8-1 p 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. How about thin filaments? LS fig 8-5**
- **E. Banding pattern? LS fig 8-3, fig 8-7**
- **F. How do muscles contract? LS fig 8-6, 8-10**
- **G. What's a cross-bridge cycle? LS fig 8-11 +…**
- **H. Summary of skeletal muscle contraction**
- **I. Exercise adaptation variables: *mode*, *intensity*, *duration*, *frequency*, *distribution*, *individual* & environmental char...?**
- **J. Endurance *vs.* strength training continuum? fiber types...**

Homeostasis is a dynamic balance between the autonomic branches.



Rest-and-digest: Parasympathetic activity dominates.

Fight-or-flight: Sympathetic activity dominates.

D Silverthorn 2010


PARASYMPATHETIC = RESTING, DIGESTIVE, HOUSEKEEPING FUNCTIONS

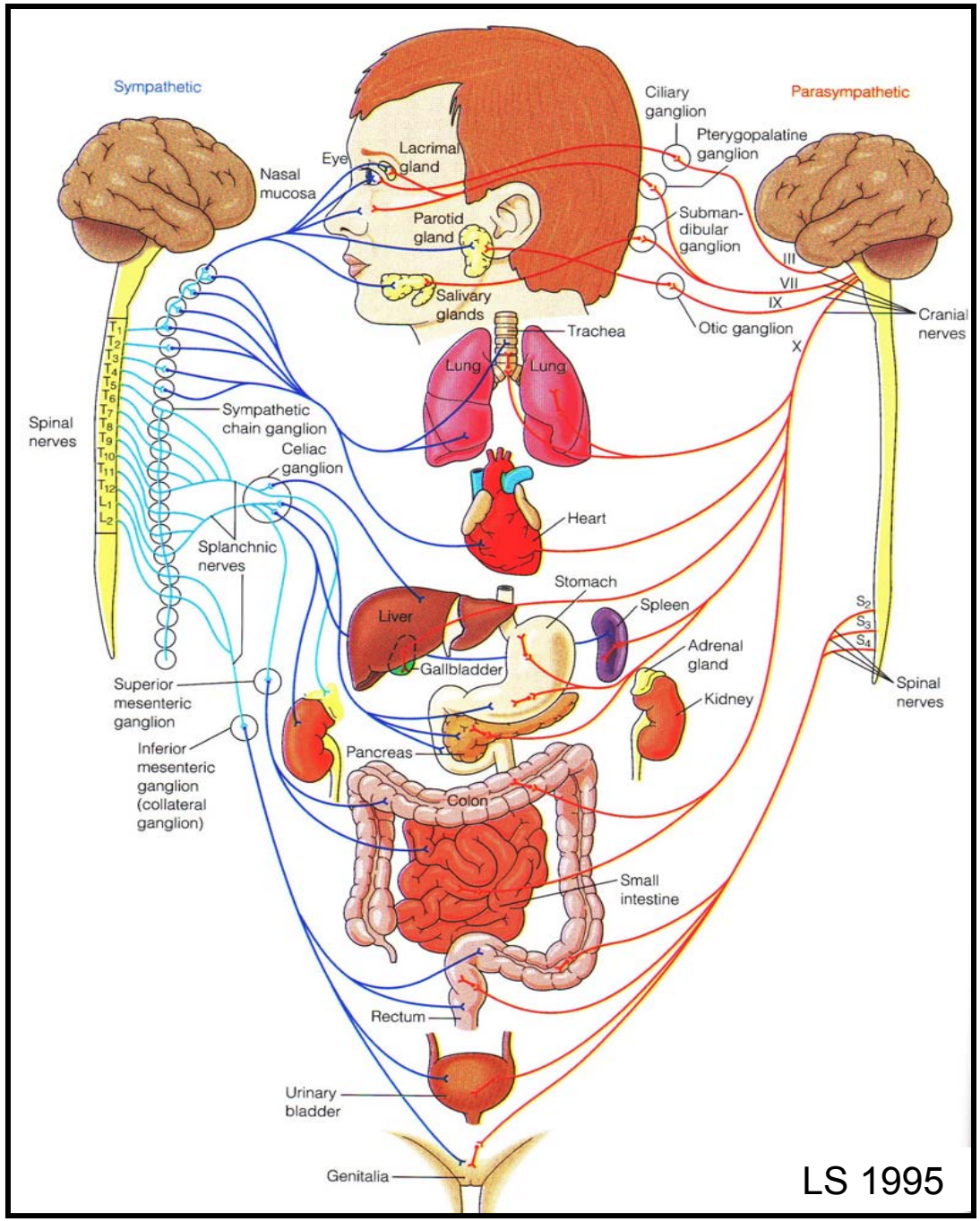
FIGHT/FLIGHT/ALARM REACTION!!

Autonomic Nervous System

Why overlap or dual innervation?

Fine-tune control & safety!

cf: LS 2012 fig 7-3



Why adrenal activation & response important?

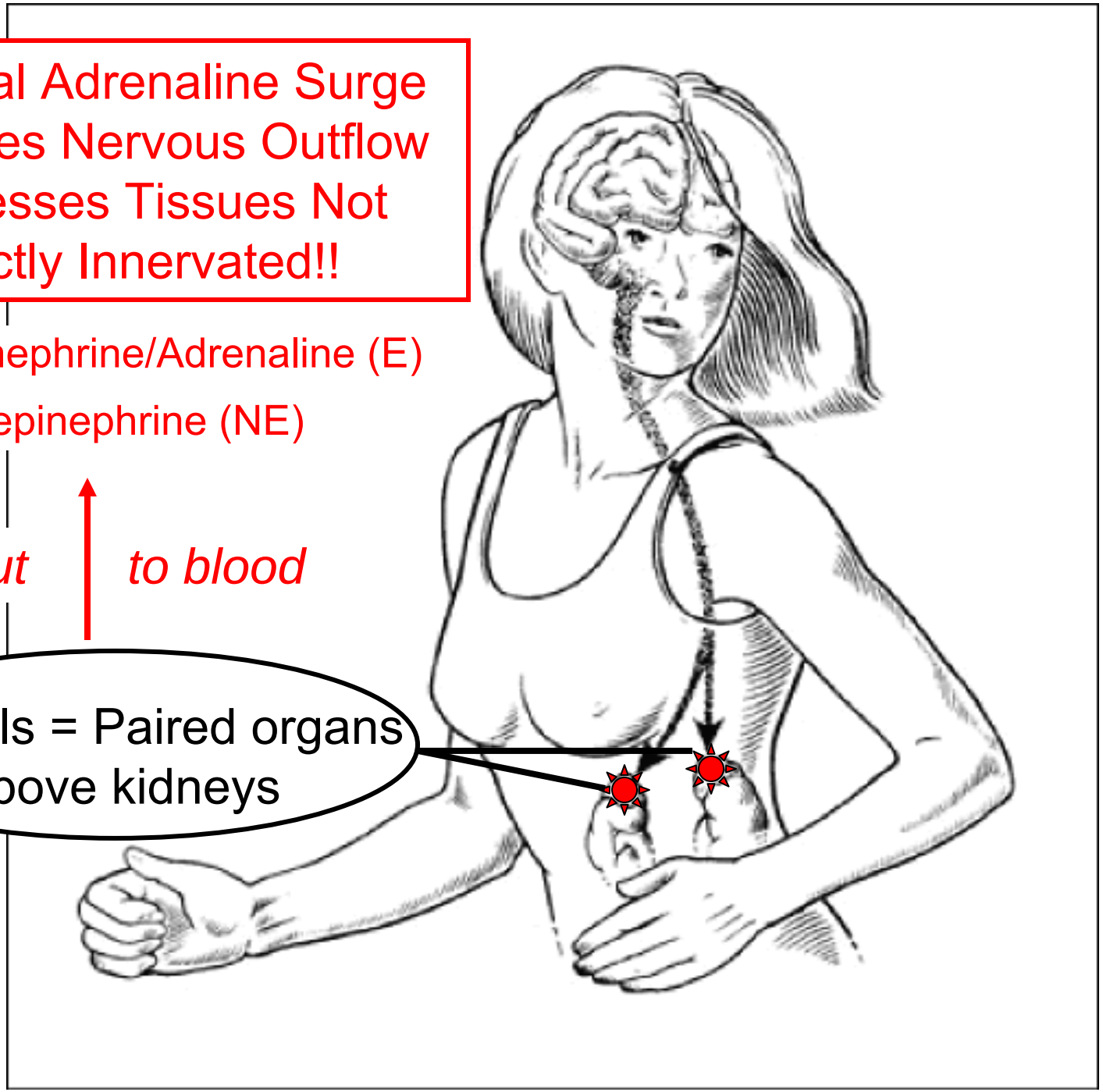
Hormonal Adrenaline Surge Reinforces Nervous Outflow & Accesses Tissues Not Directly Innervated!!

80% Epinephrine/Adrenaline (E)

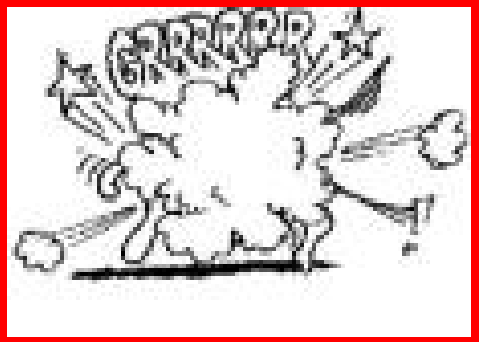
20% Norepinephrine (NE)

Output *to blood*

Adrenals = Paired organs above kidneys



Fight-or-Flight Stories!



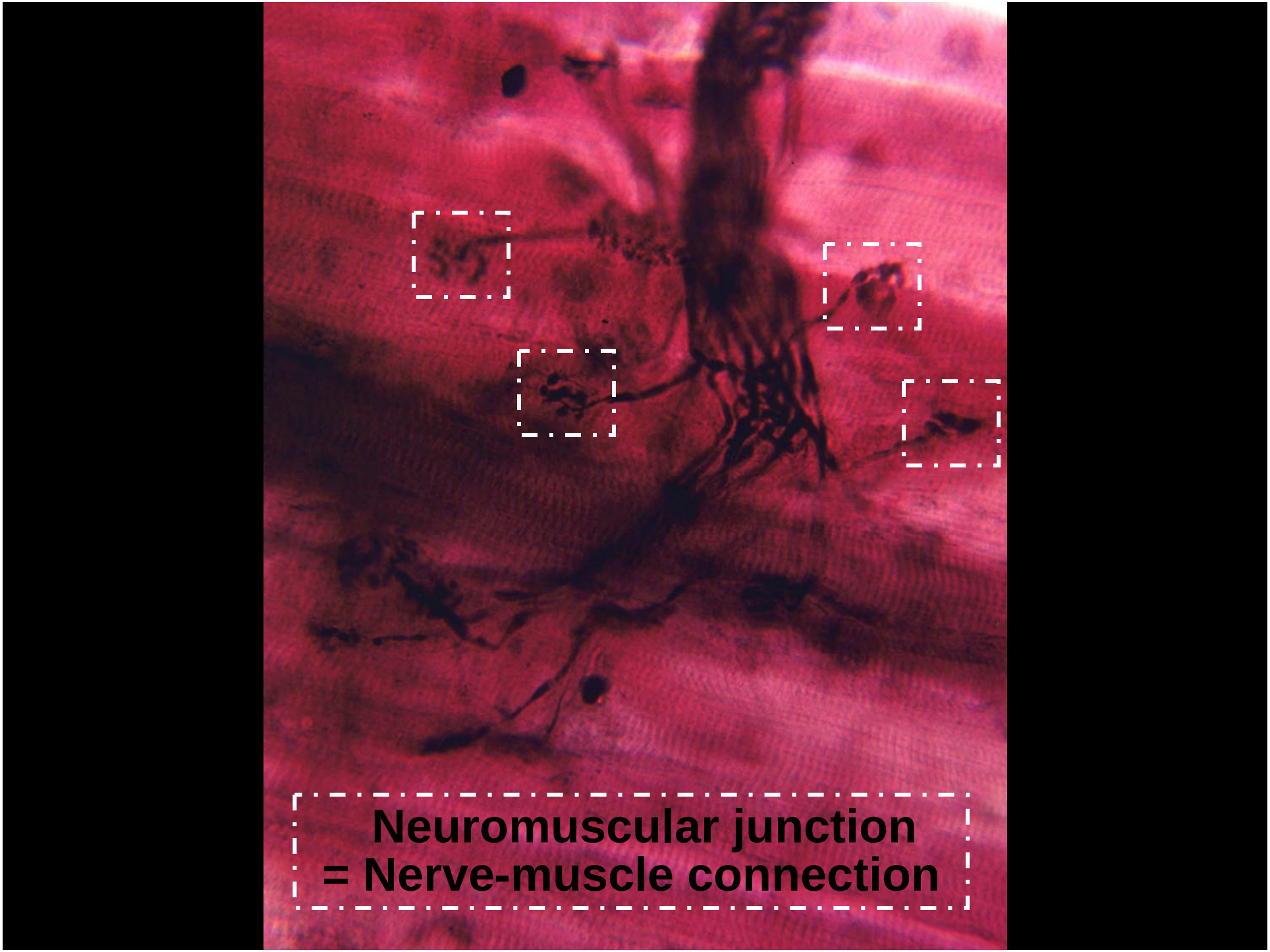
or

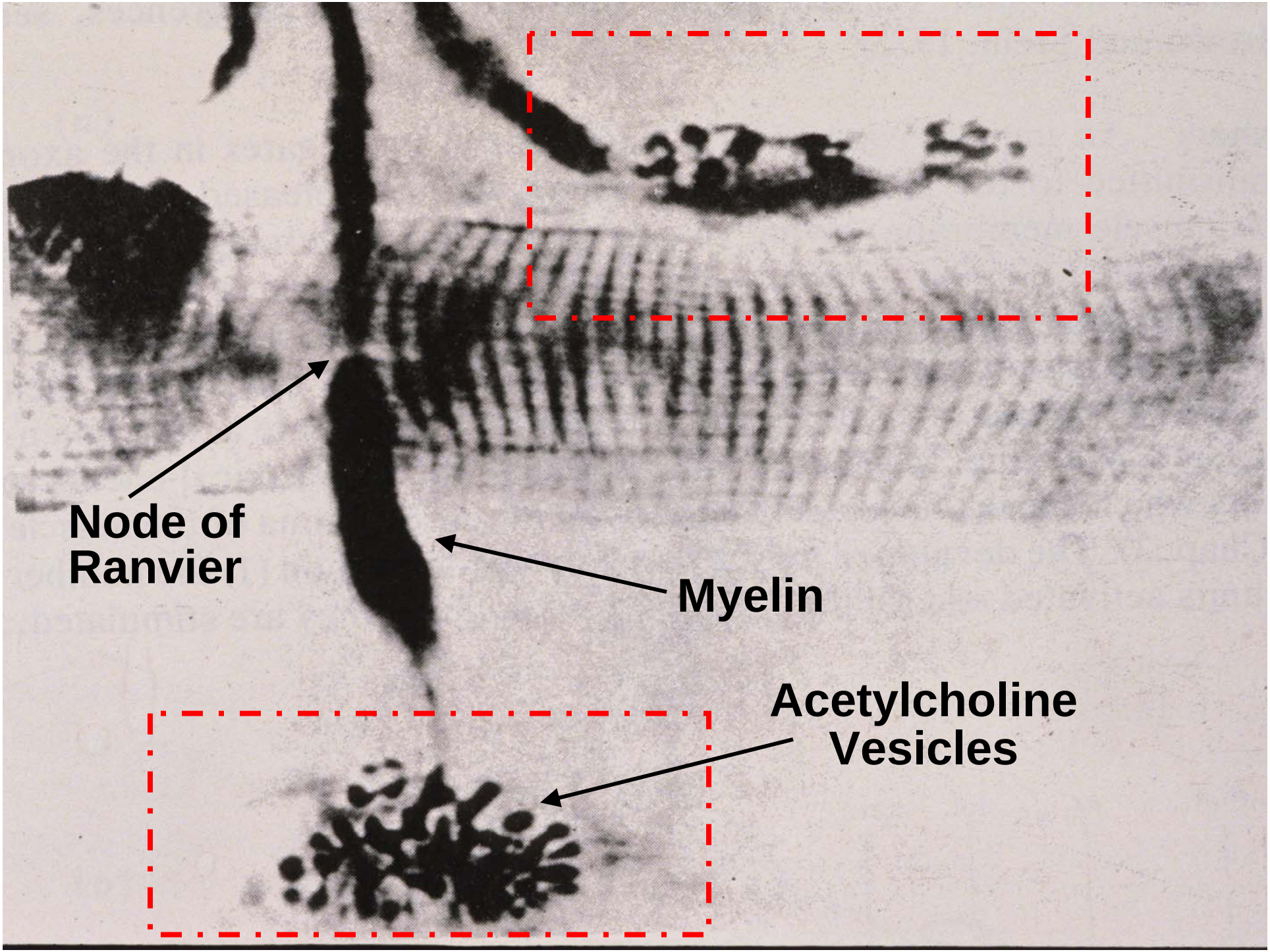
…choose this!!

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)	Increases motility
	Contracts sphincters (to prevent forward movement of tract contents)	Relaxes sphincters (to permit forward movement of tract contents)
	Inhibits digestive secretions	Stimulates digestive secretions
Urinary Bladder	Relaxes	Contracts (emptying)
Eye	Dilates the pupil	Constricts the pupil
	Adjusts the eye for far vision	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		
Exocrine pancreas	Inhibits pancreatic exocrine secretion	Stimulates pancreatic exocrine secretion (important for digestion)
Sweat glands	Stimulates secretion by sweat glands important in cooling the body	Stimulates secretion by specialized sweat glands in the armpits and genital area
Salivary glands	Stimulates a small volume of thick saliva rich in mucus	Stimulates a large volume of watery saliva rich in enzymes
Endocrine Glands		
Adrenal medulla	Stimulates epinephrine and norepinephrine secretion	None
Endocrine pancreas	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

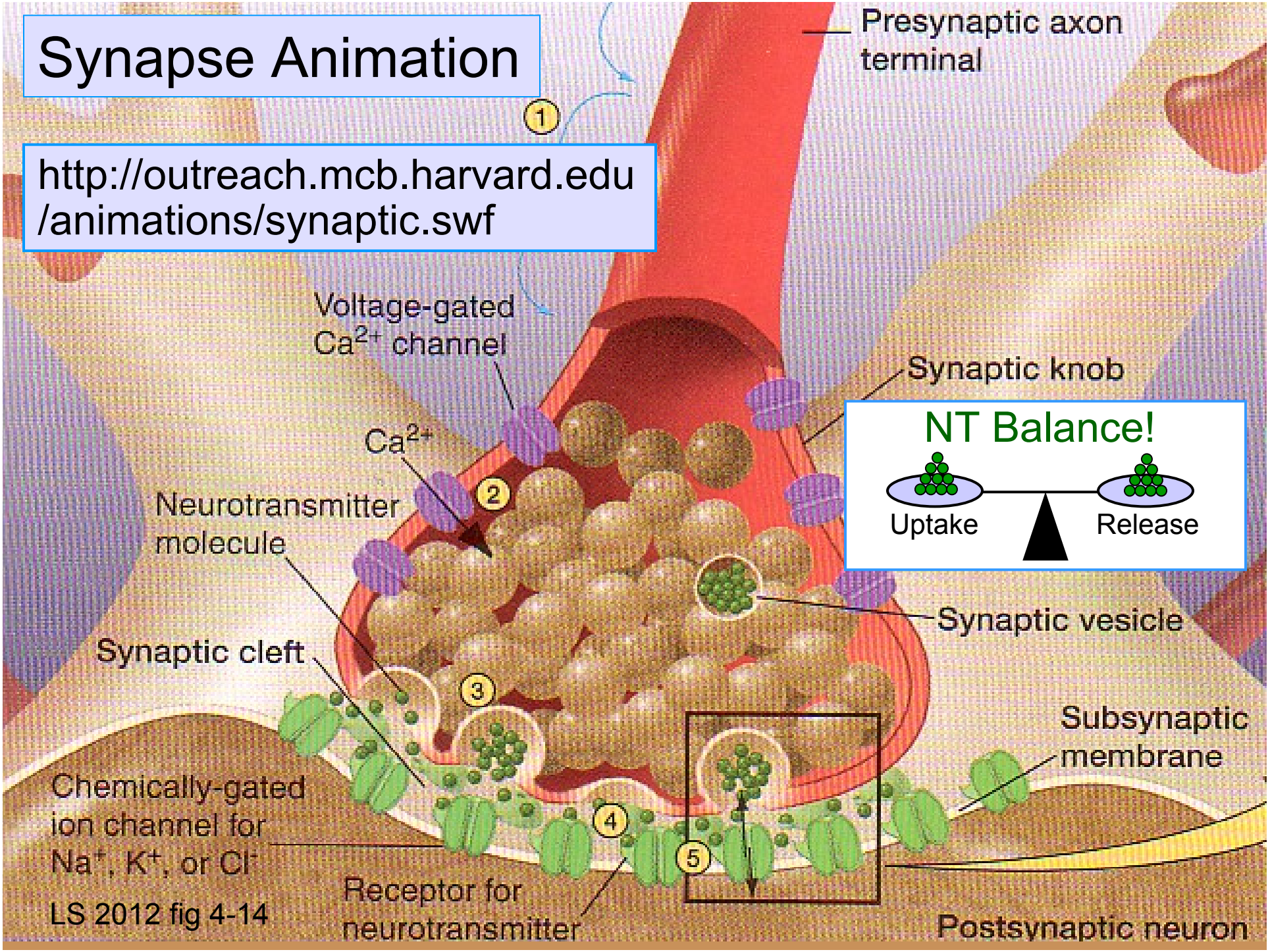
LS 2012


Neuromuscular junction
= Nerve-muscle connection

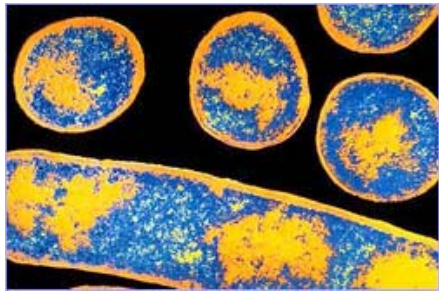

Node of
Ranvier
Myelin
Acetylcholine
Vesicles

Synapse Animation

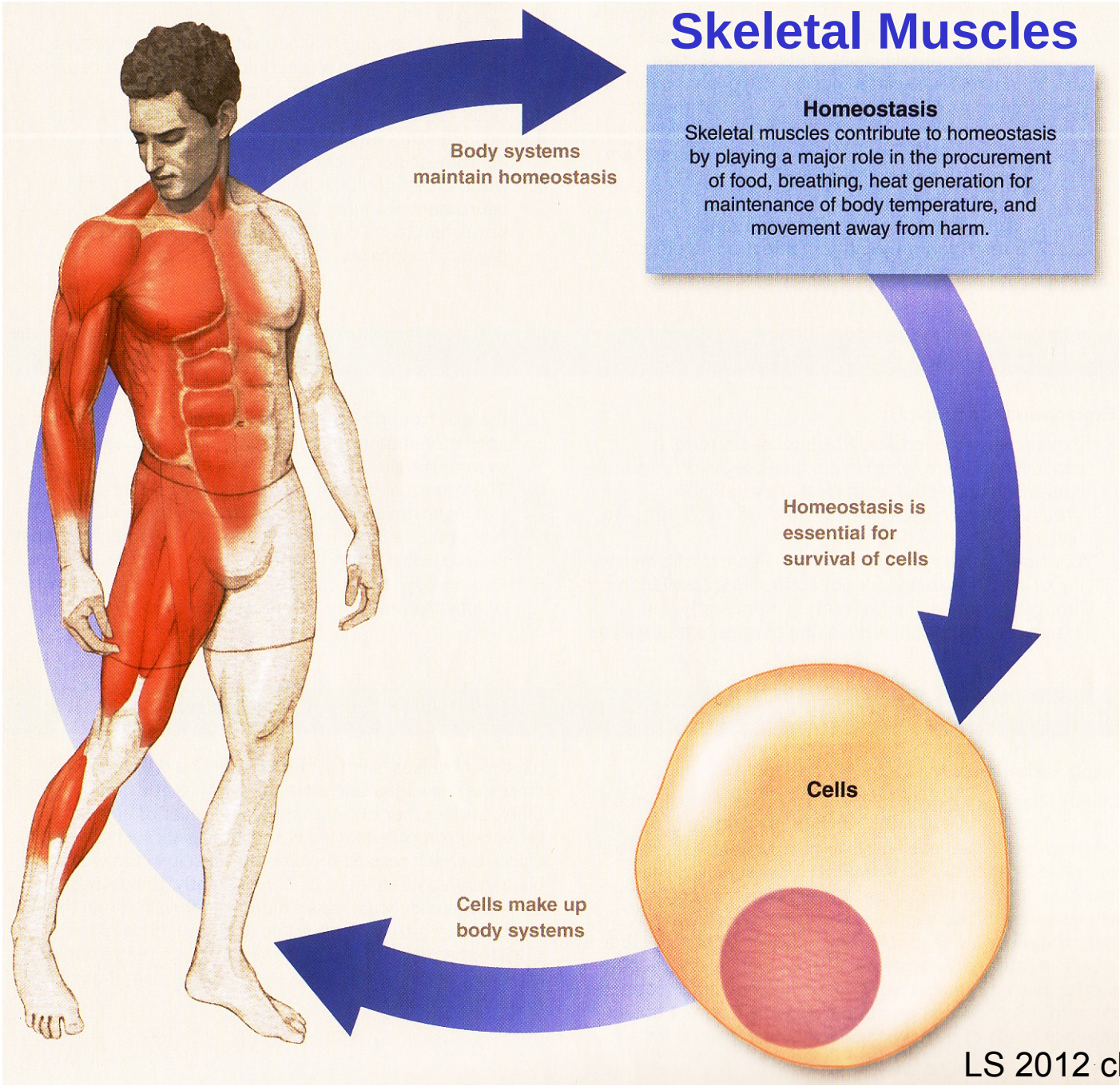
http://outreach.mcb.harvard.edu/animations/synaptic.swf



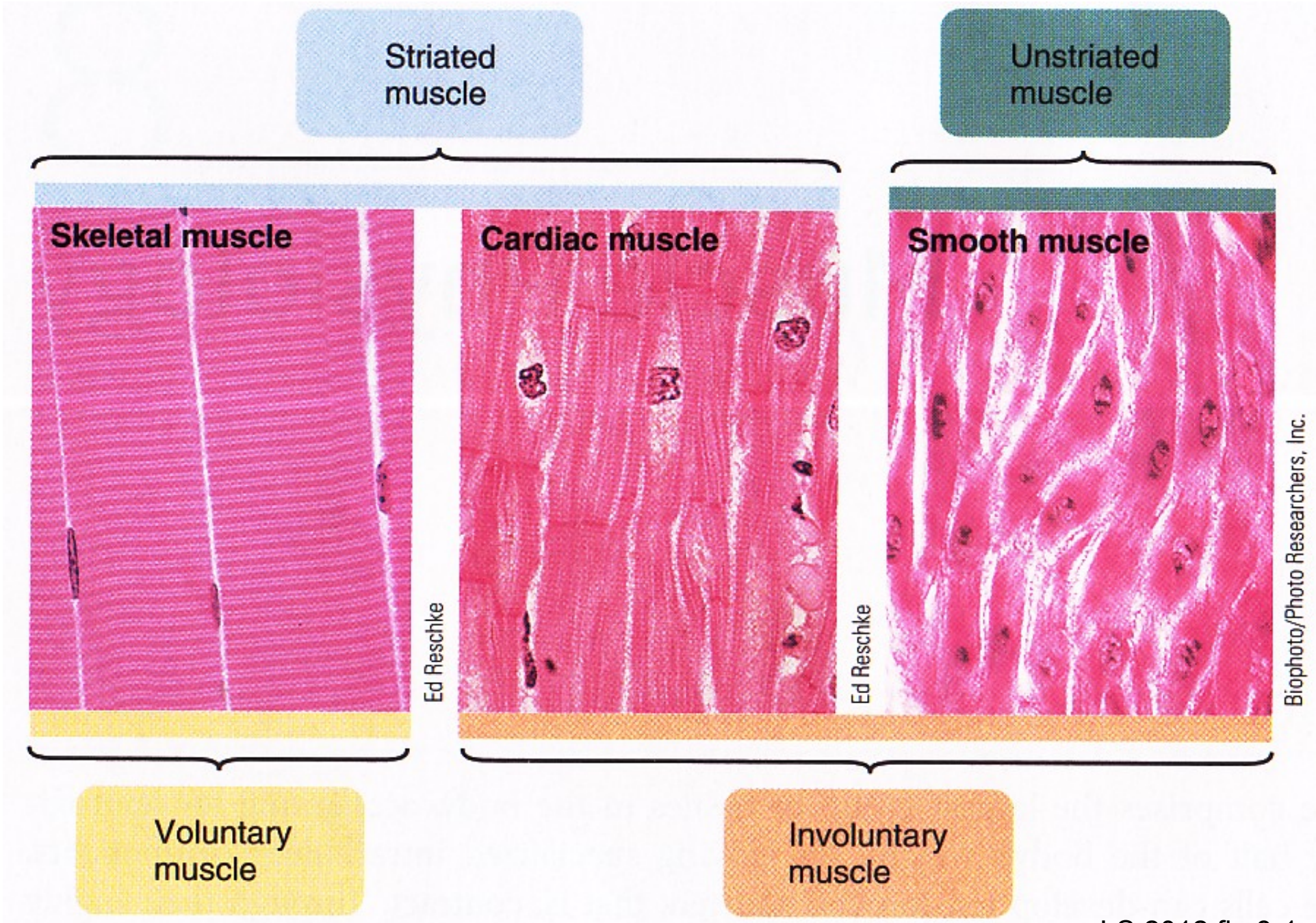
LS 2012 fig 4-14



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

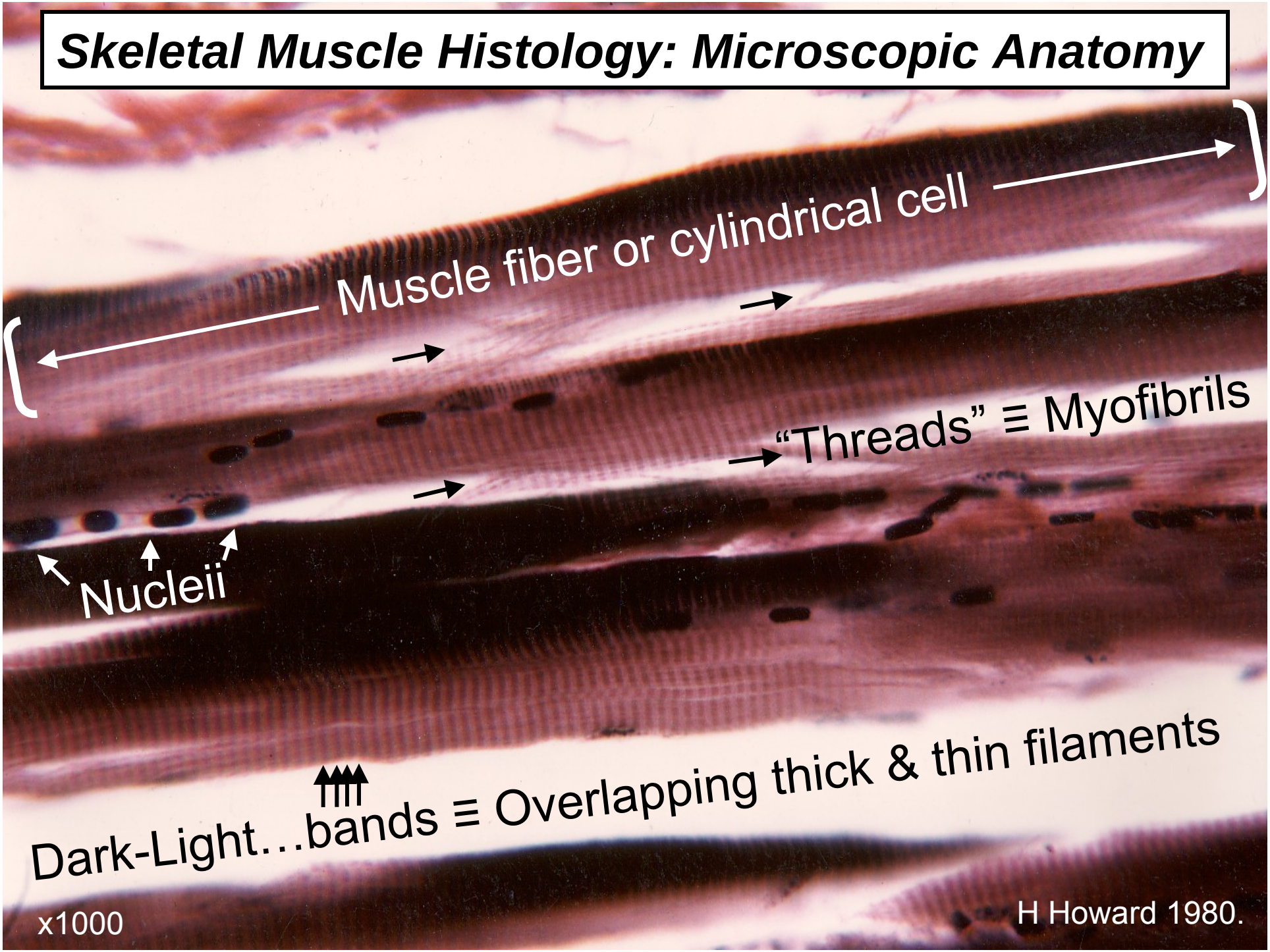


LS 2012 ch 8 vignette

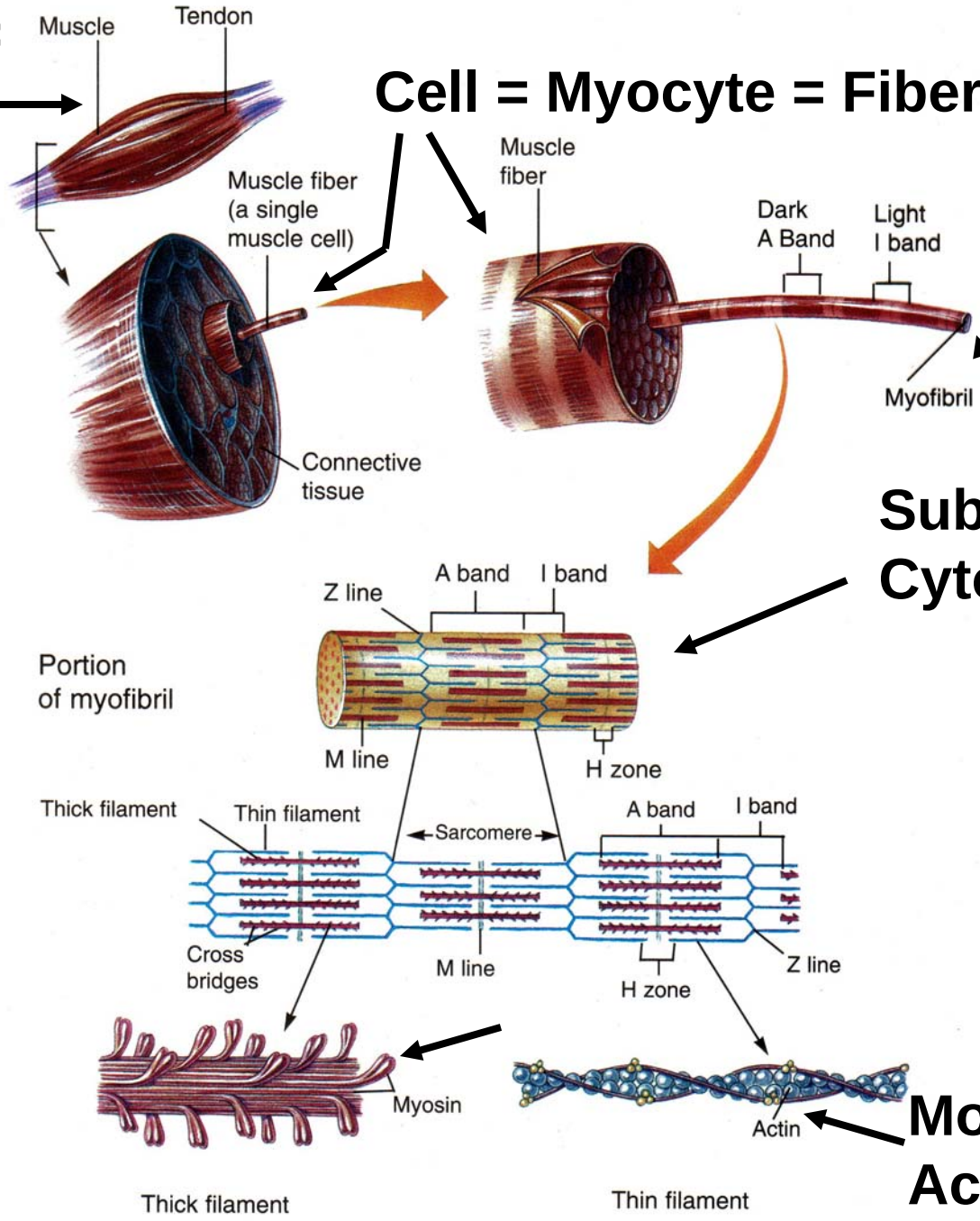


LS 2012 fig 8-1

Skeletal Muscle Histology: Microscopic Anatomy



Organ = Muscle



Cell = Myocyte = Fiber

Subcellular = Cytoskeleton

Molecules = Actin & Myosin

LS 2006, cf:
LS 2012 fig 8-2

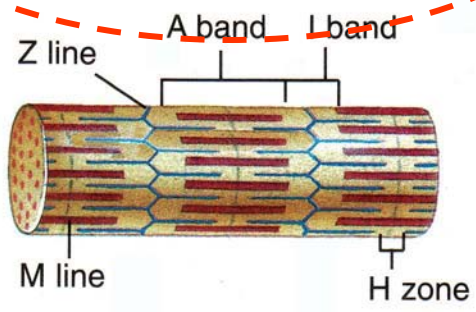
Whole Muscle

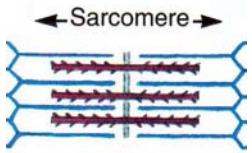
Myocyte or Muscle Fiber

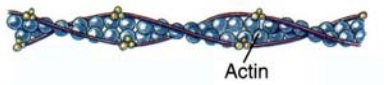
Myofibril

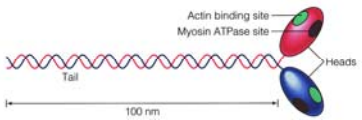
Thick & Thin Filaments

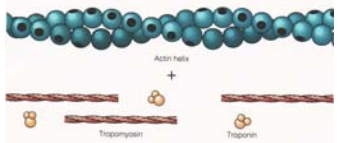
Myosin & Actin









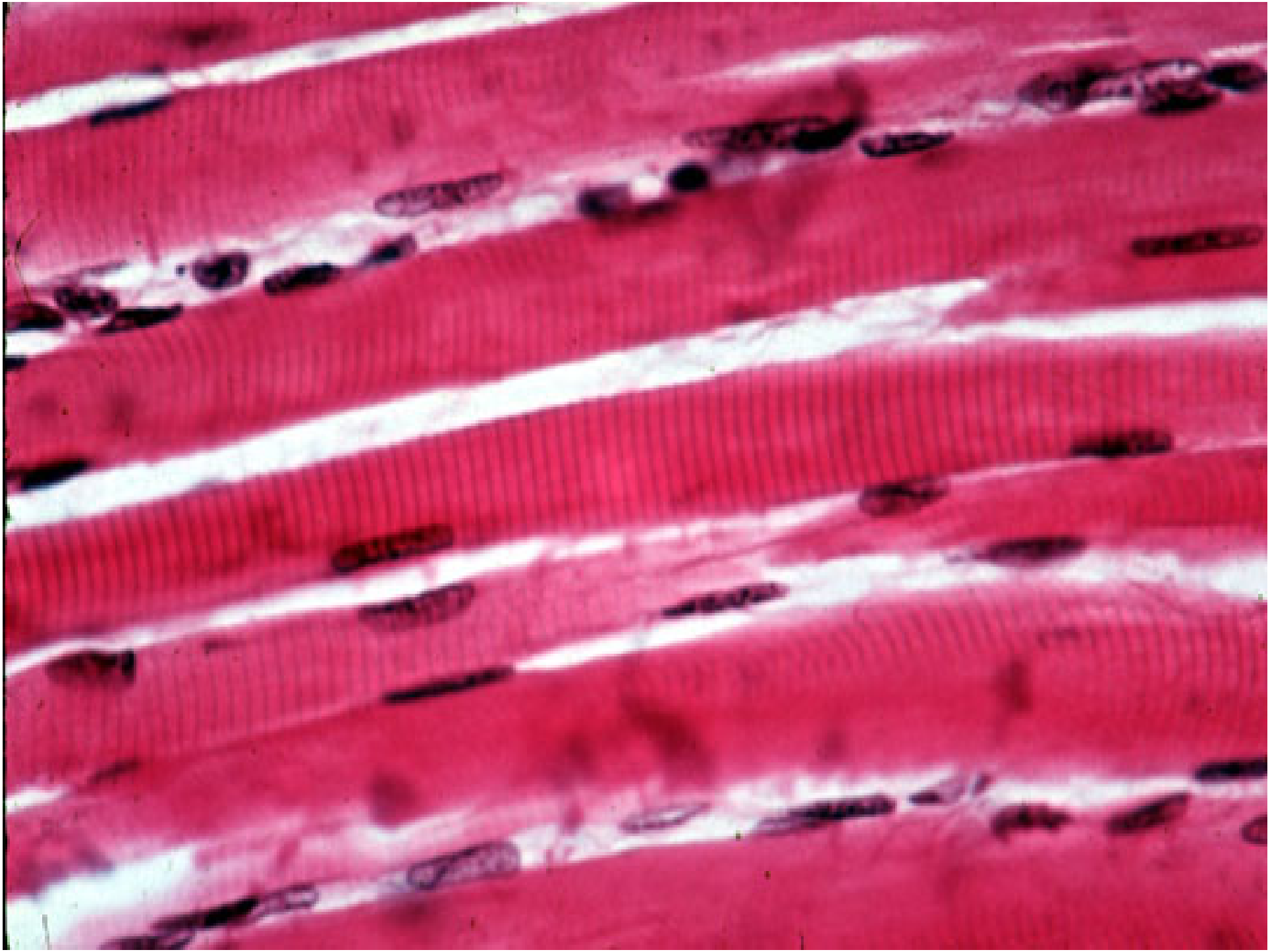


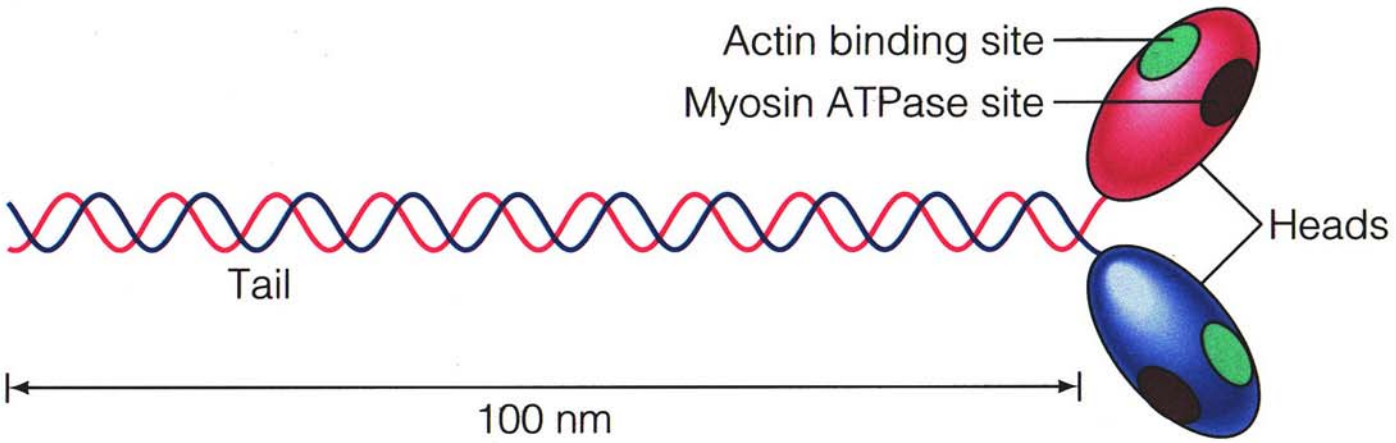
Organ

Cell

Cytoskeleton

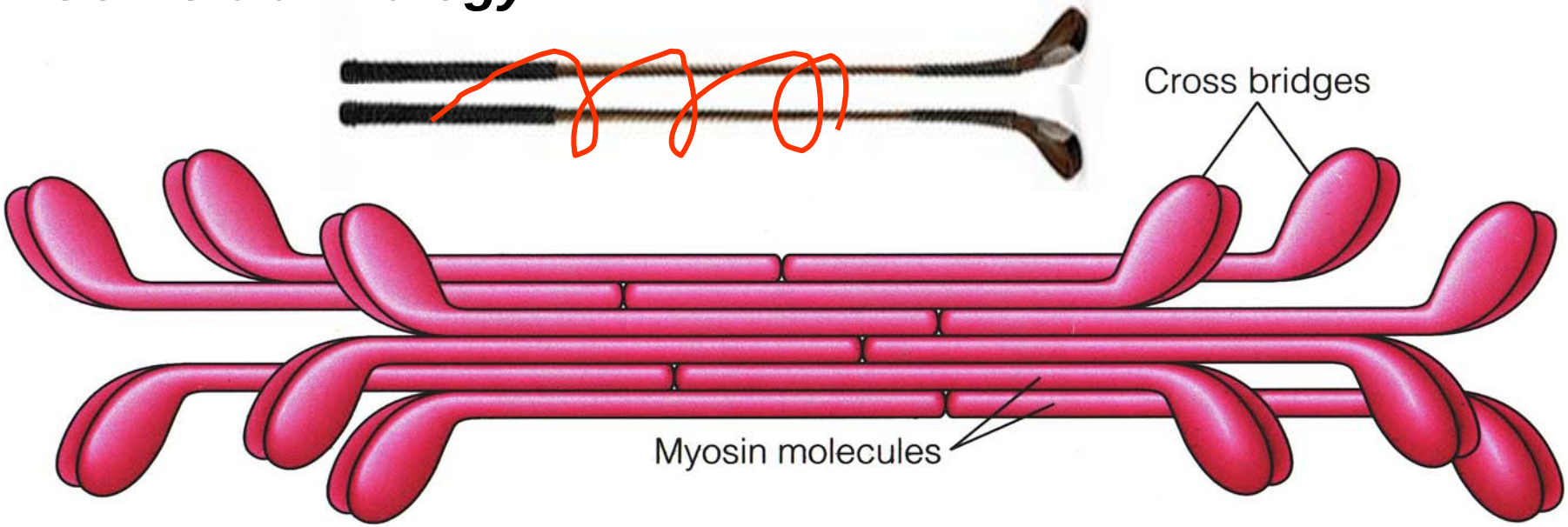
Molecules





(a)

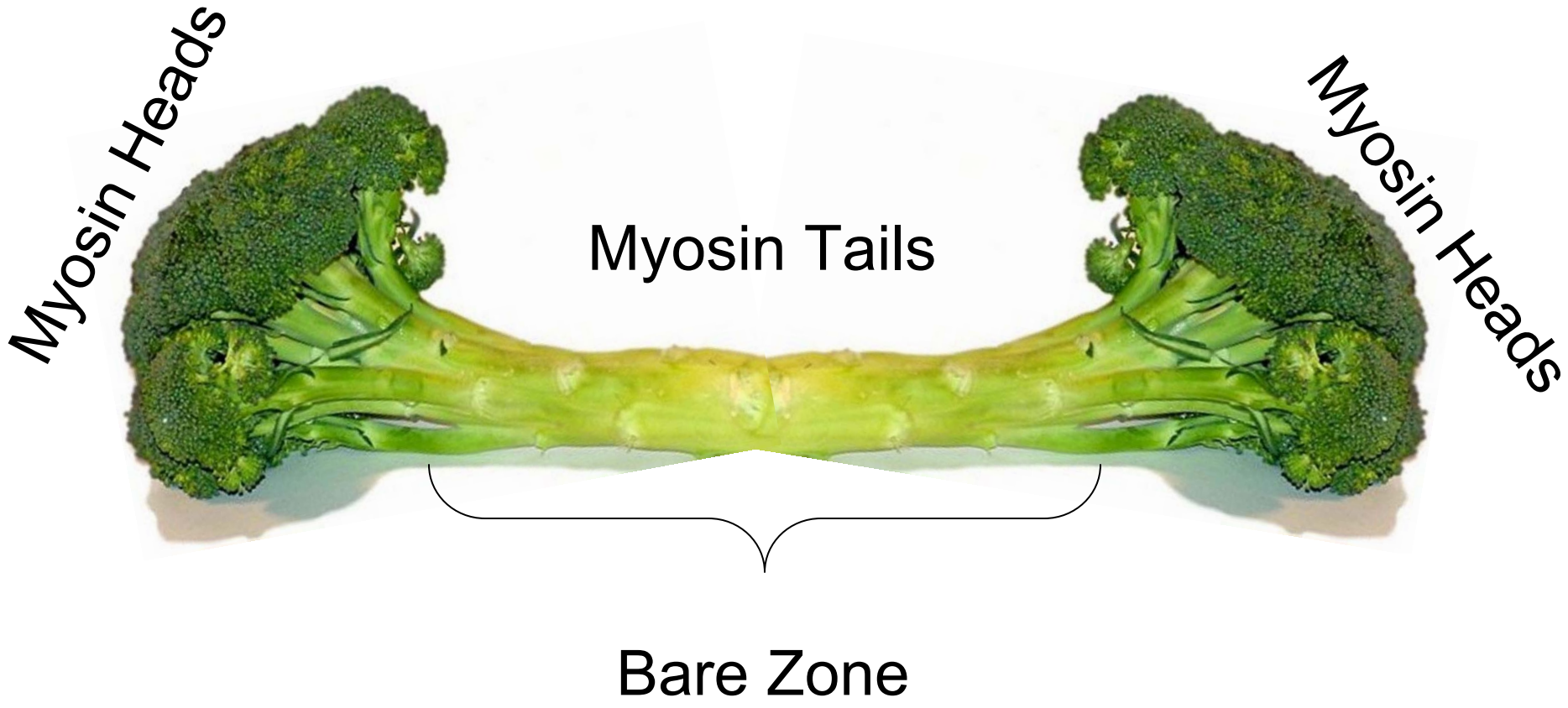
Golf Club Analogy?

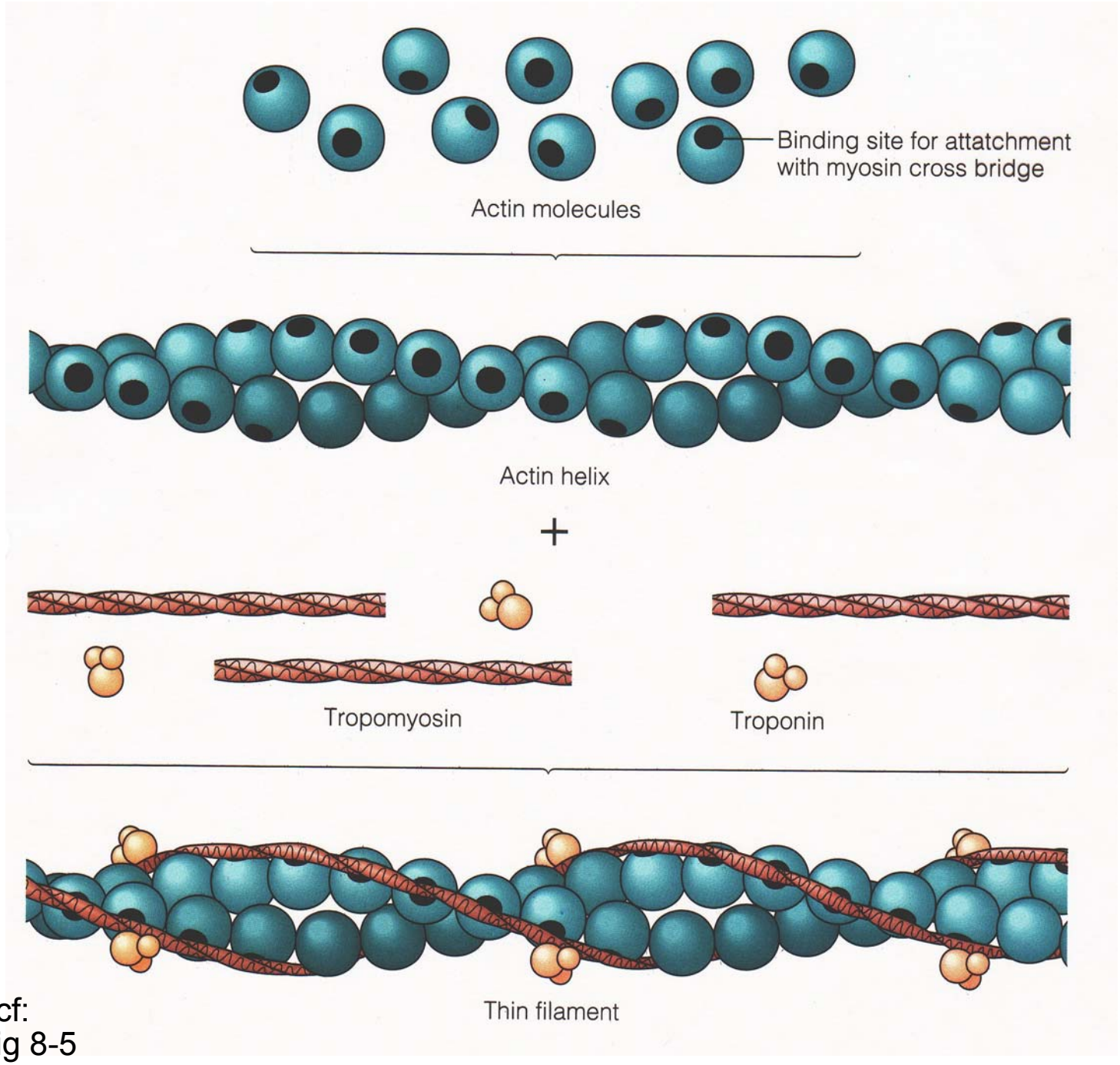


(b)

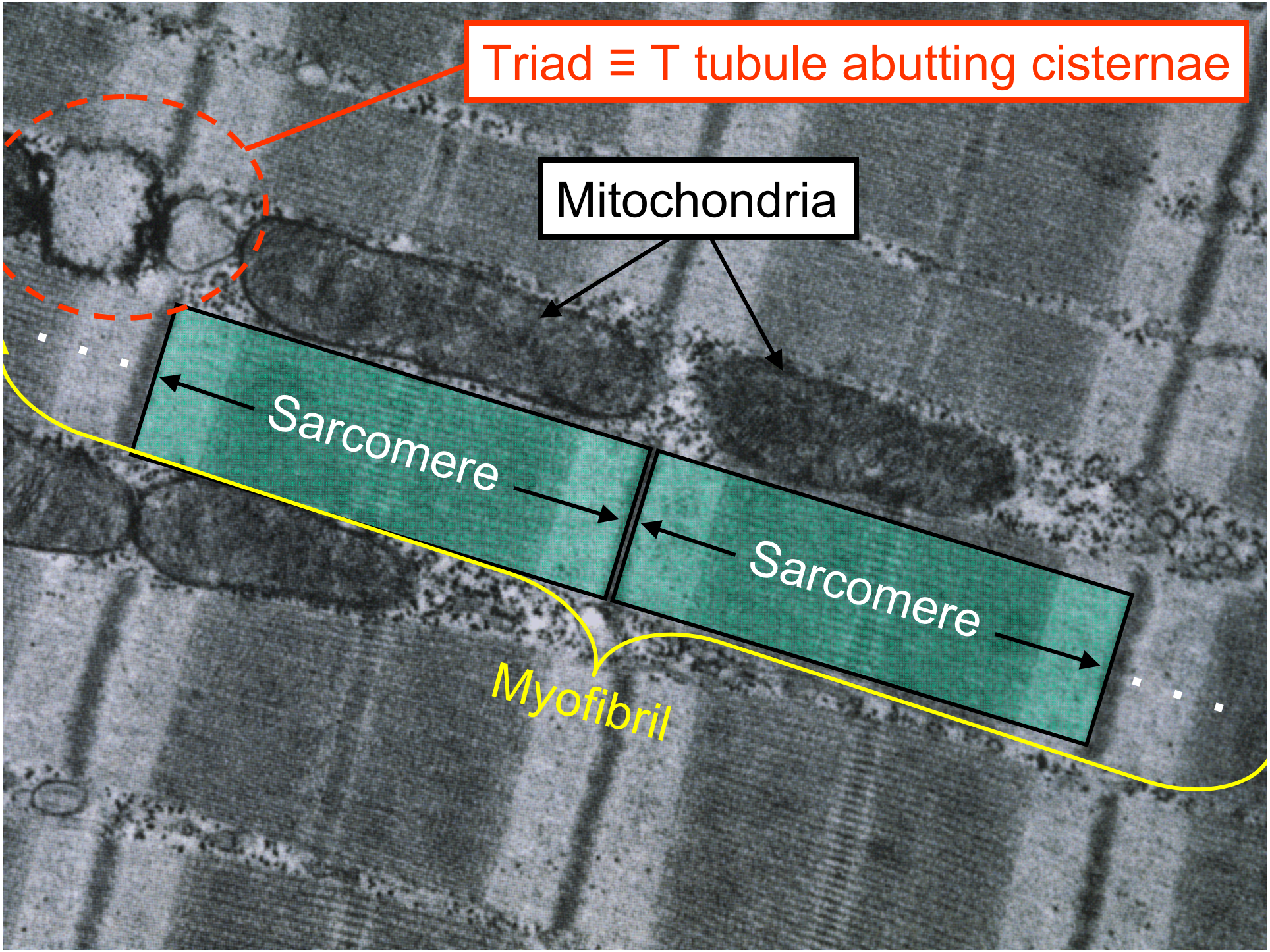
LS 2006, cf:
LS 2012 fig 8-4

Broccoli Analogy?



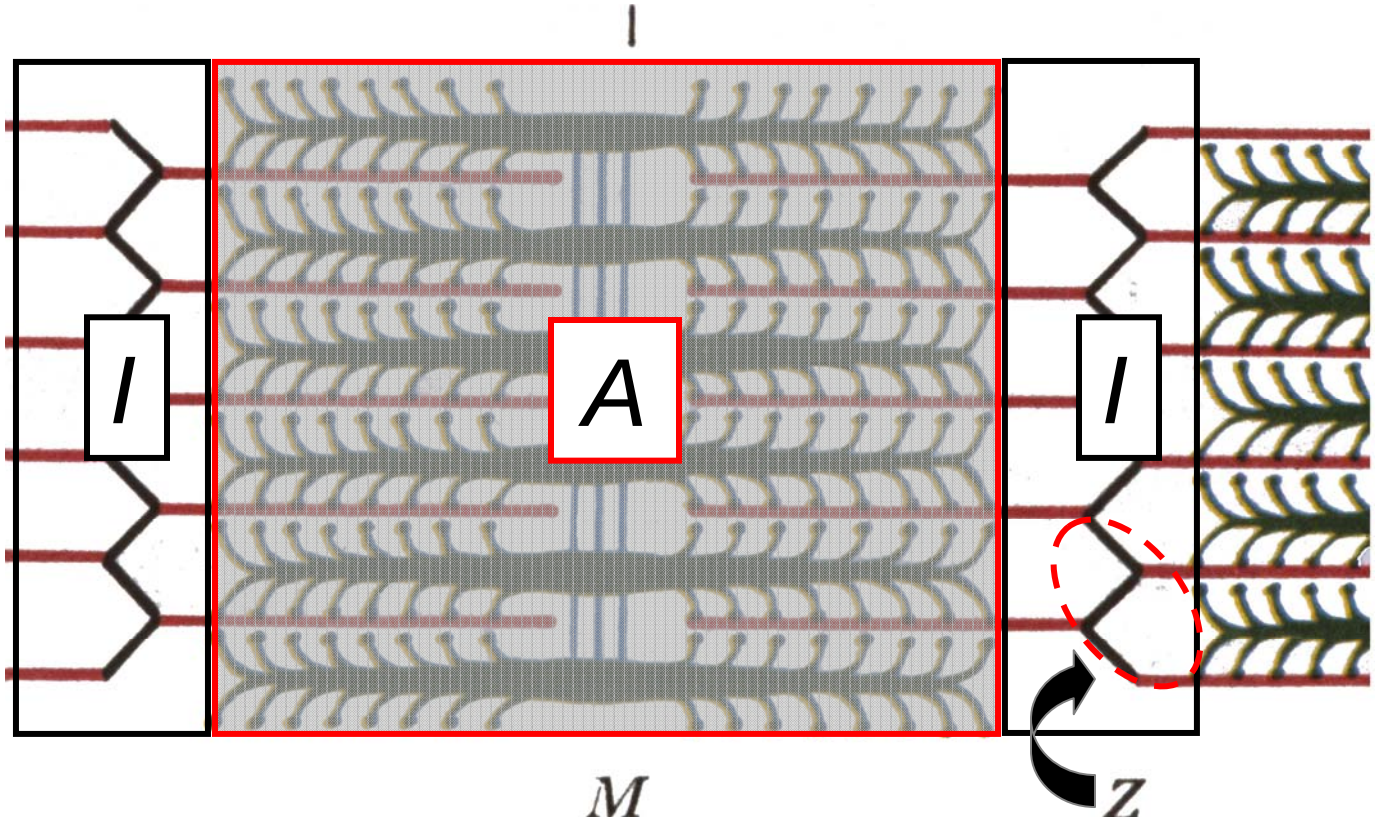


LS 2006, cf:
LS 2012 fig 8-5


Triad ≡ T tubule abutting cisternae
Mitochondria
Sarcomere
Sarcomere
Myofibril

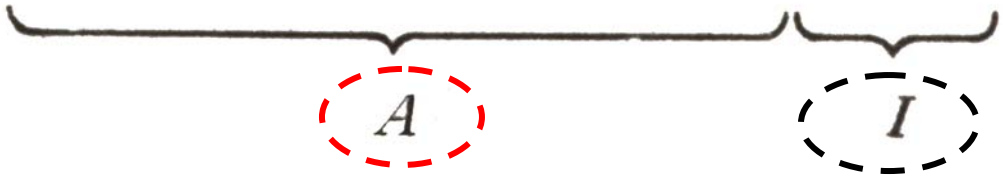
A Band = Dark Band

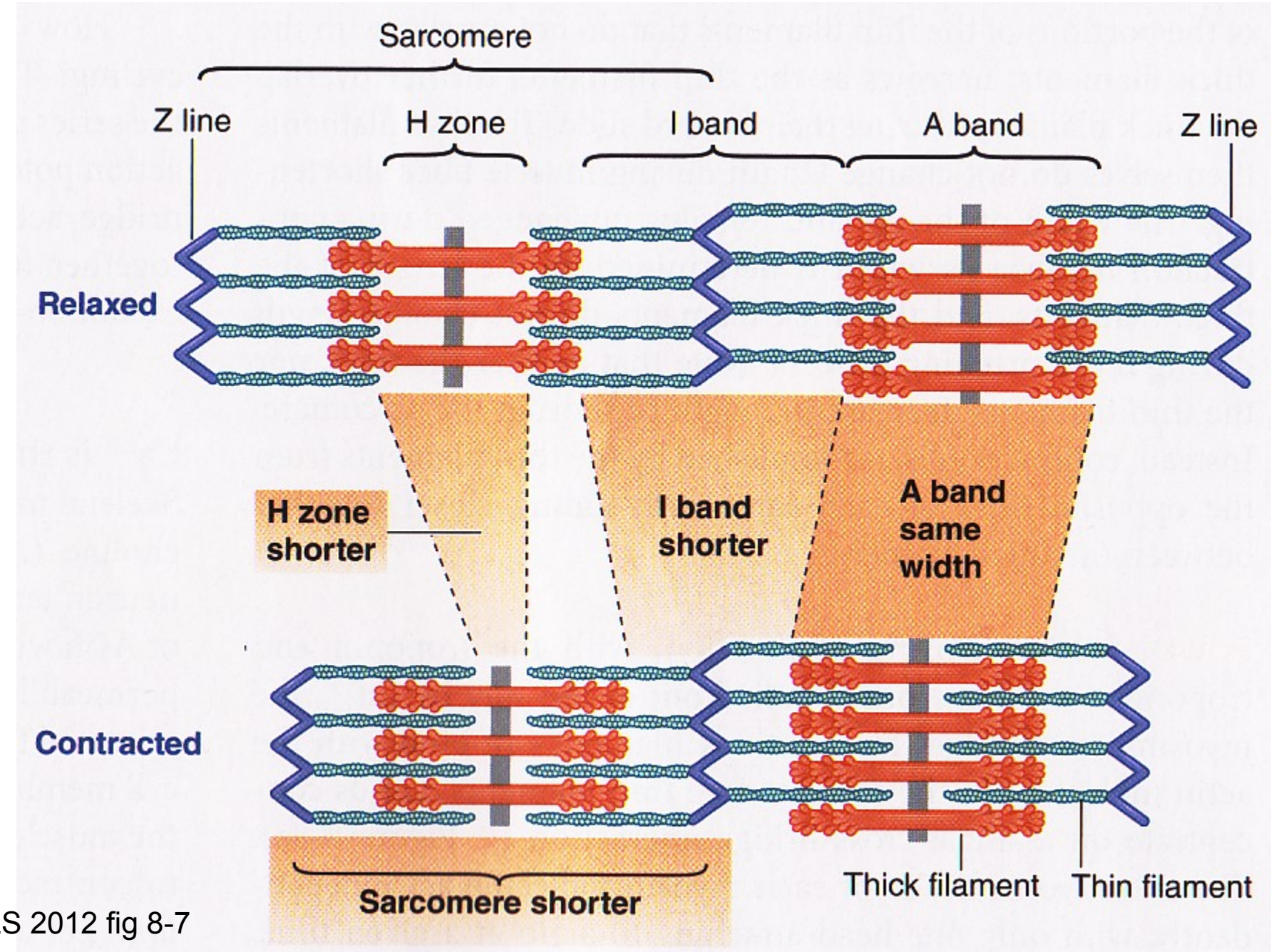
*A*nisotropic = Light Can't Shine Through



I Band = Light Band

*I*sotropic = Light Can Shine Through





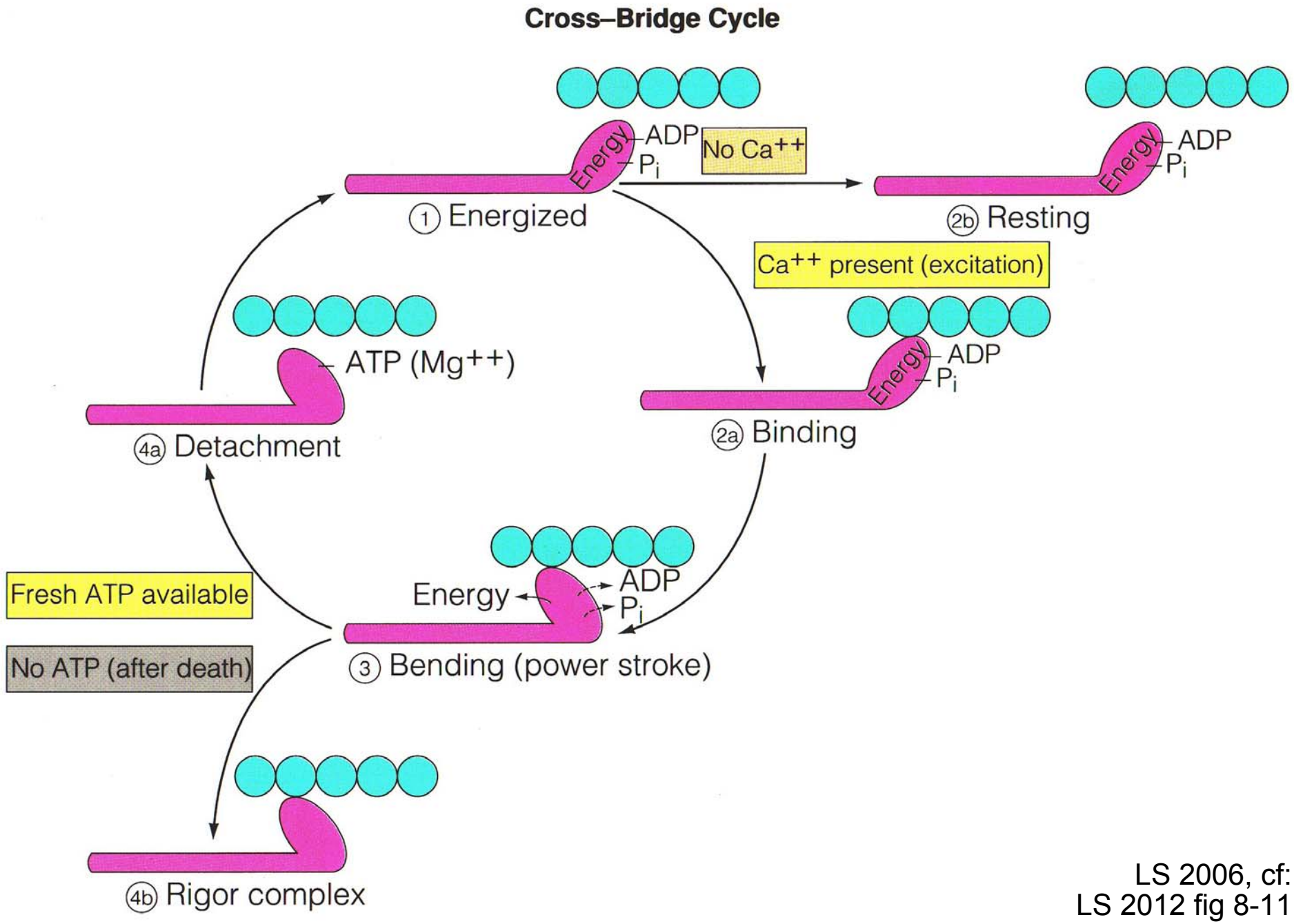
LS 2012 fig 8-7

Discussion

+

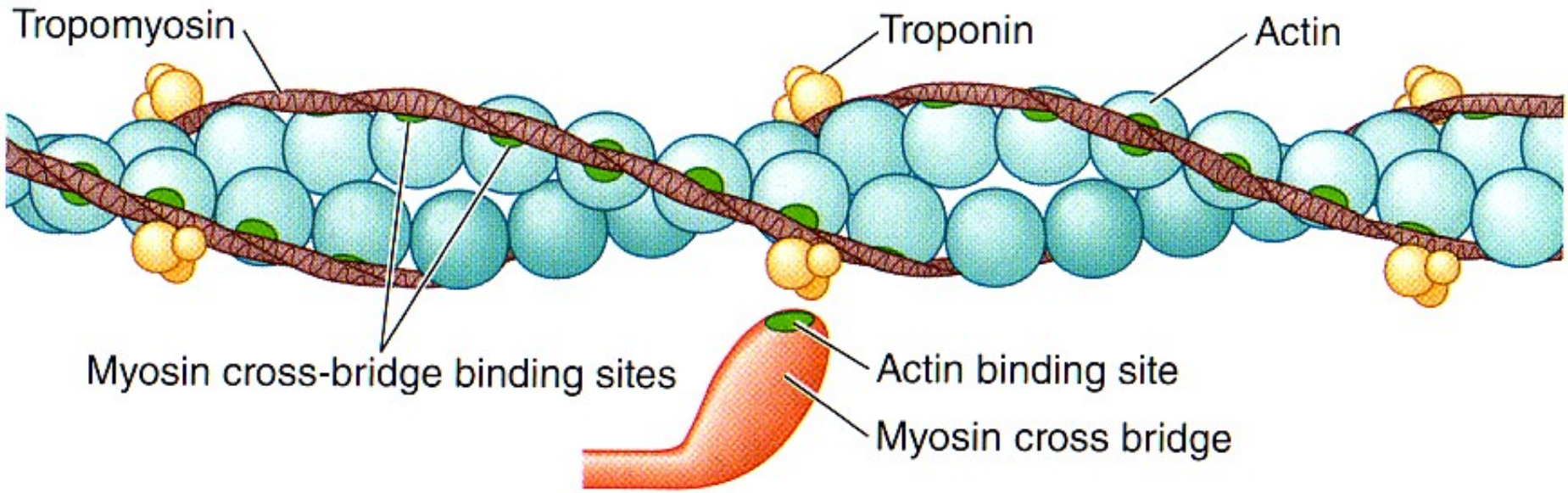
for Q?

What do we guess happens at the molecular level?



LS 2006, cf:
LS 2012 fig 8-11

Relaxed: No Cross-Bridge Binding



(a) Relaxed

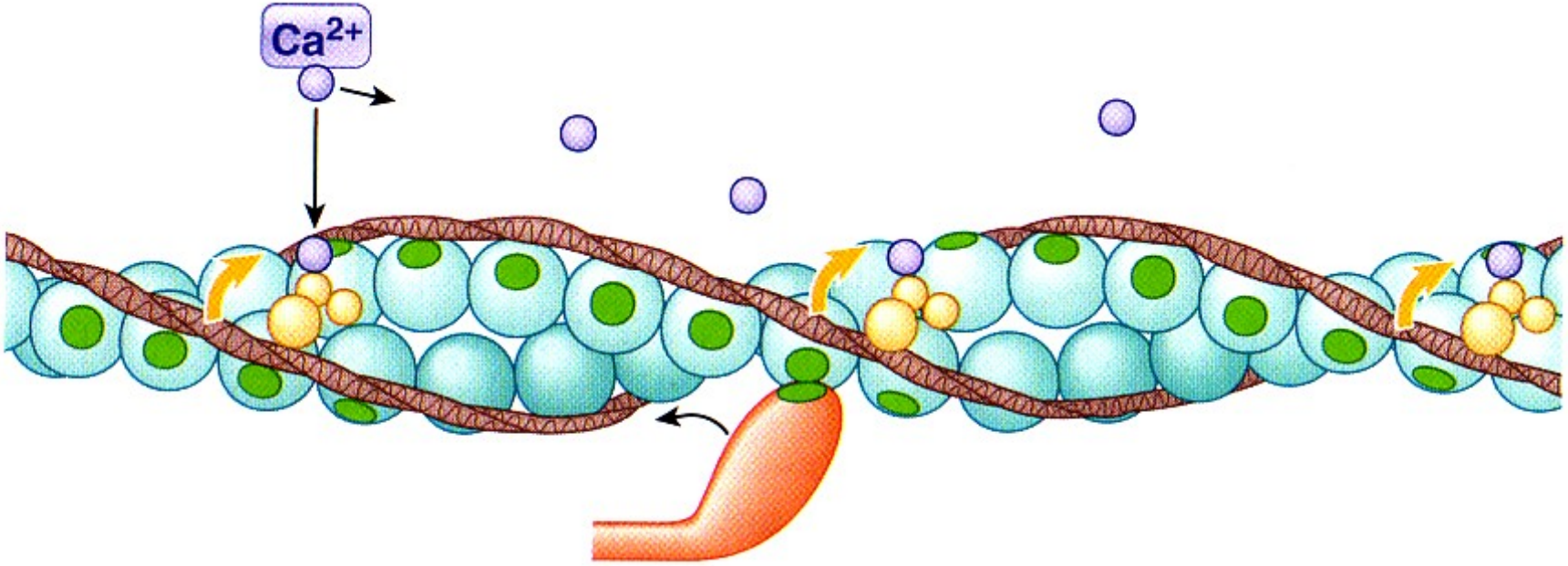
1 No excitation.

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.

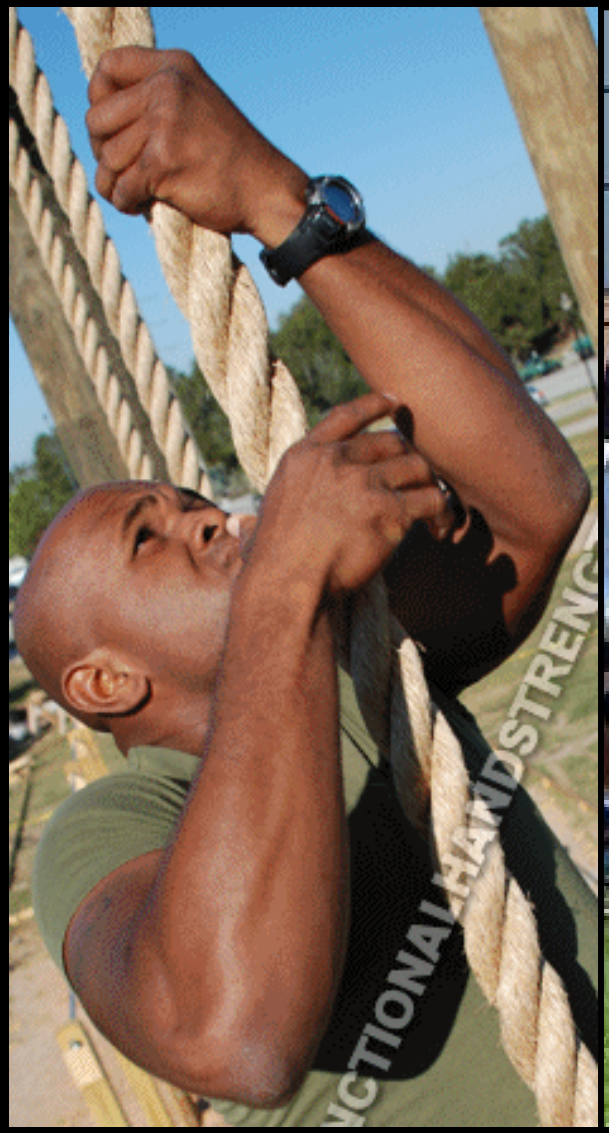
2. Released Ca^{2+} binds with troponin, pulling troponin–tropomyosin complex aside to expose cross-bridge binding site.

3. Cross-bridge binding occurs.

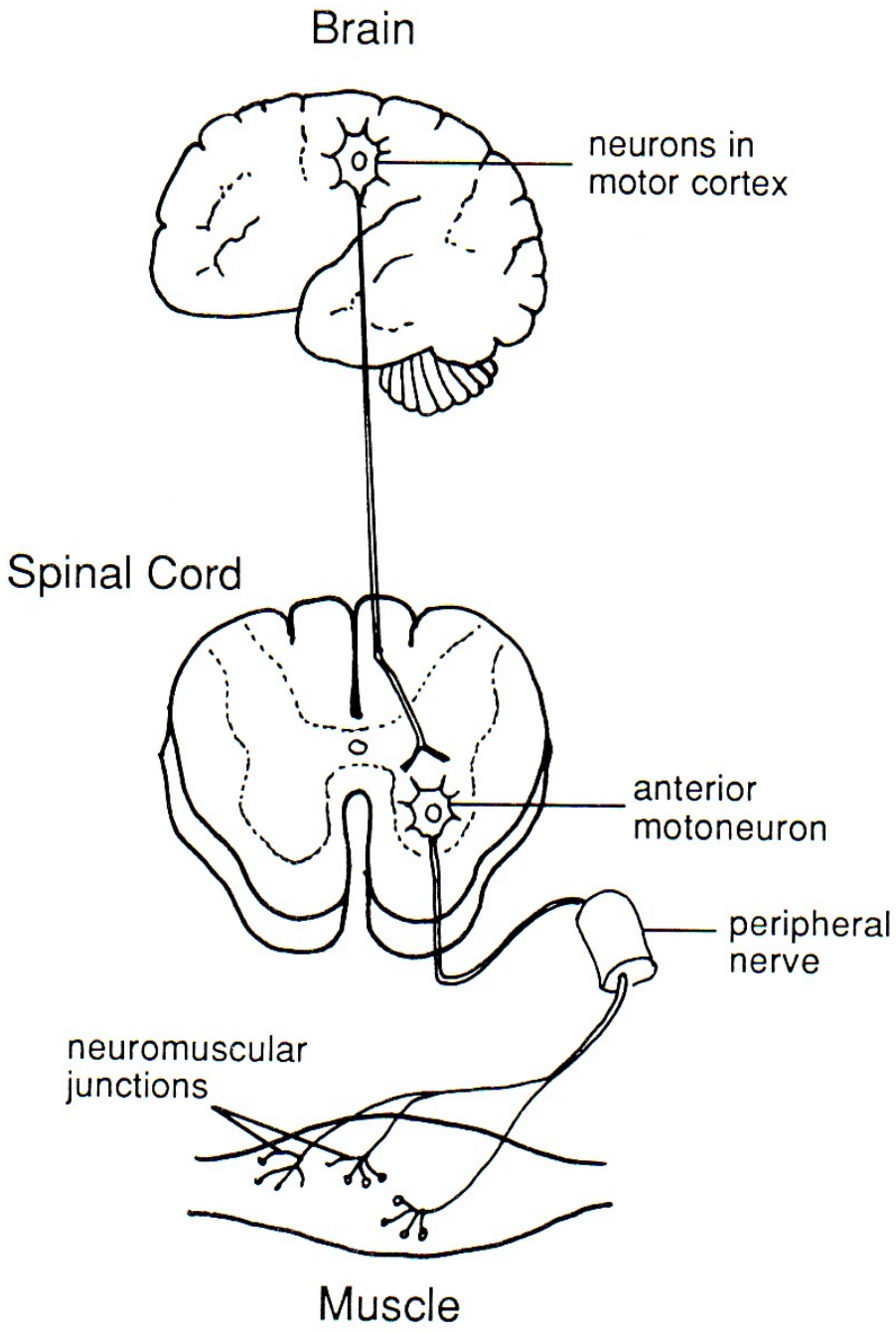
4. Binding of actin and myosin cross bridge triggers power stroke that pulls thin filament inward during contraction.

LS 2012 fig 8-6b

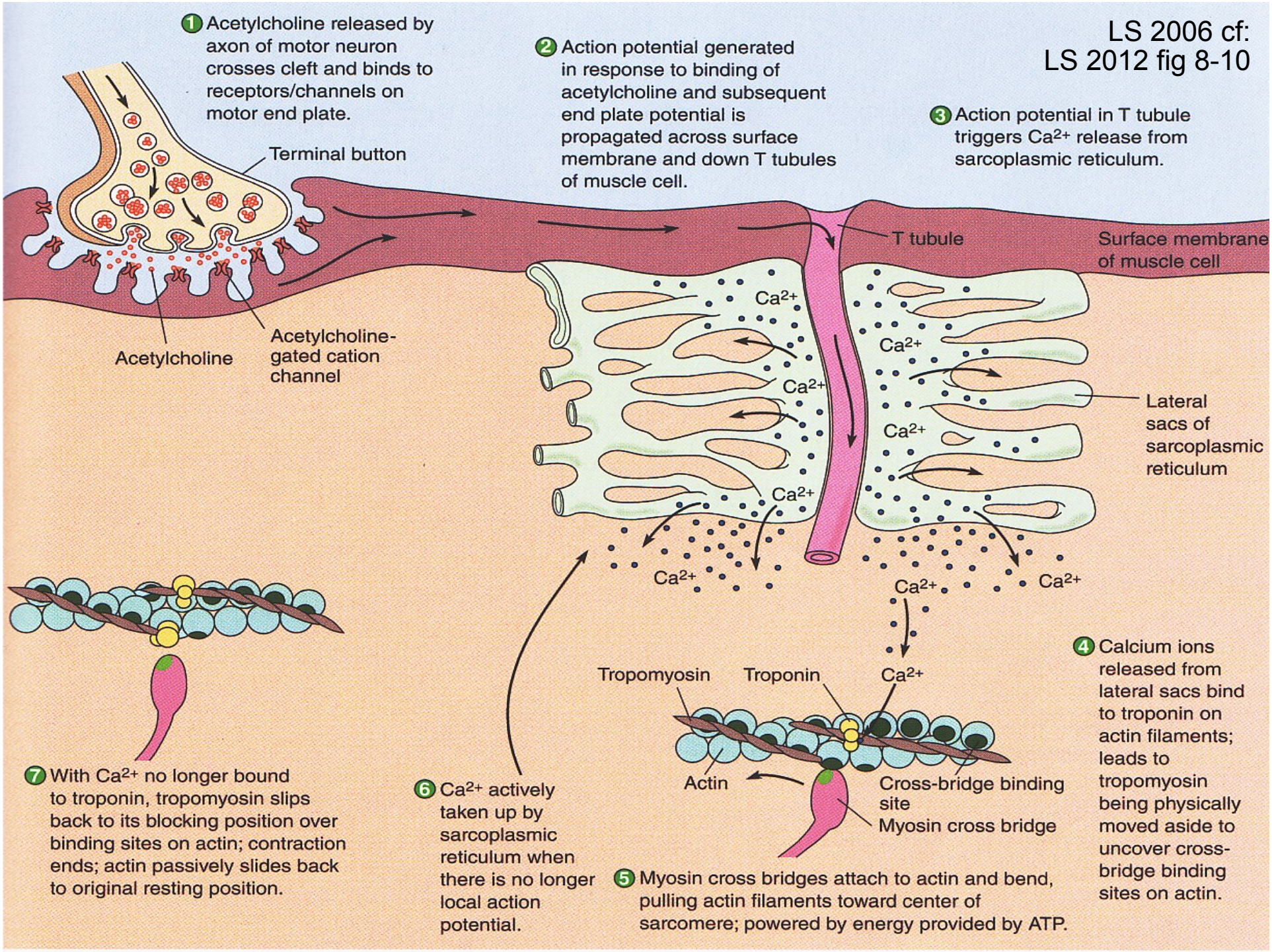
Rope Climb or Tug of War
Grasp, then Regrasp!



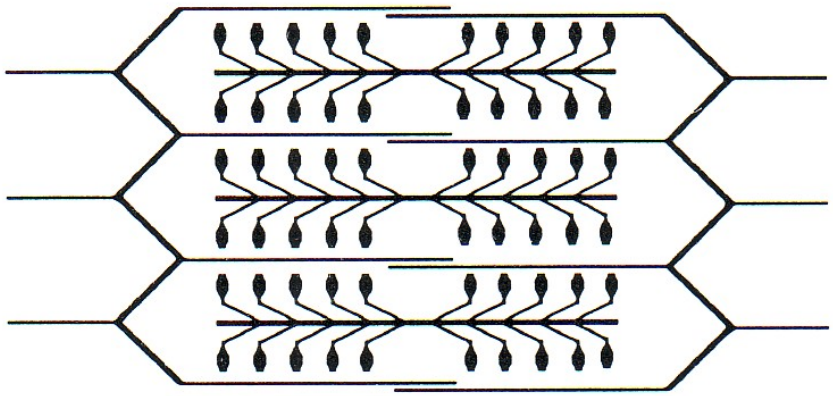
Summary


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

LS 2006 cf:
LS 2012 fig 8-10

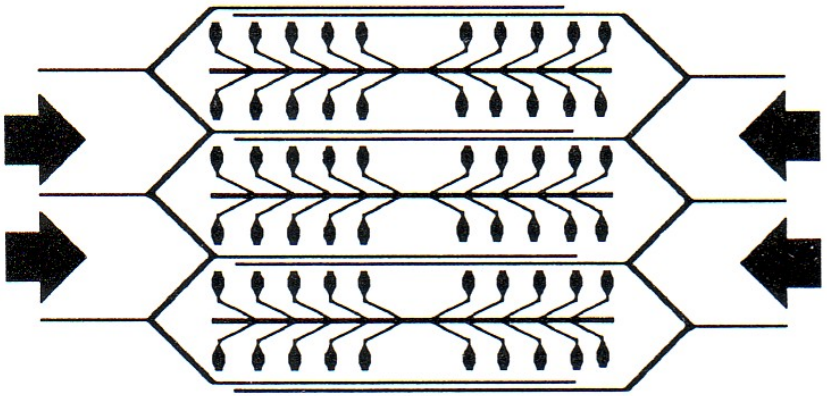


Relaxation Phase



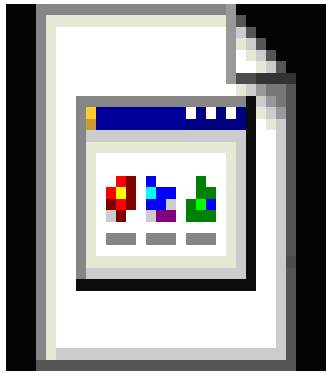
1. Excitation by nerve fiber
2. Conduction by T-tubules
3. Ca^{2+} release by SR

Contractile Phase



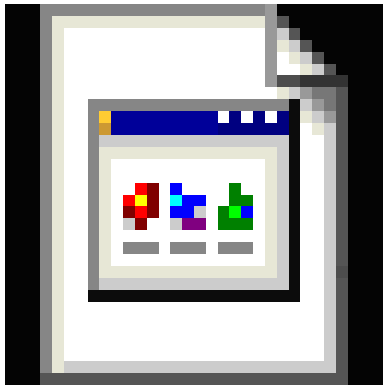
D Liang & VP Lombardi 1989

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



muscleanimation.mov

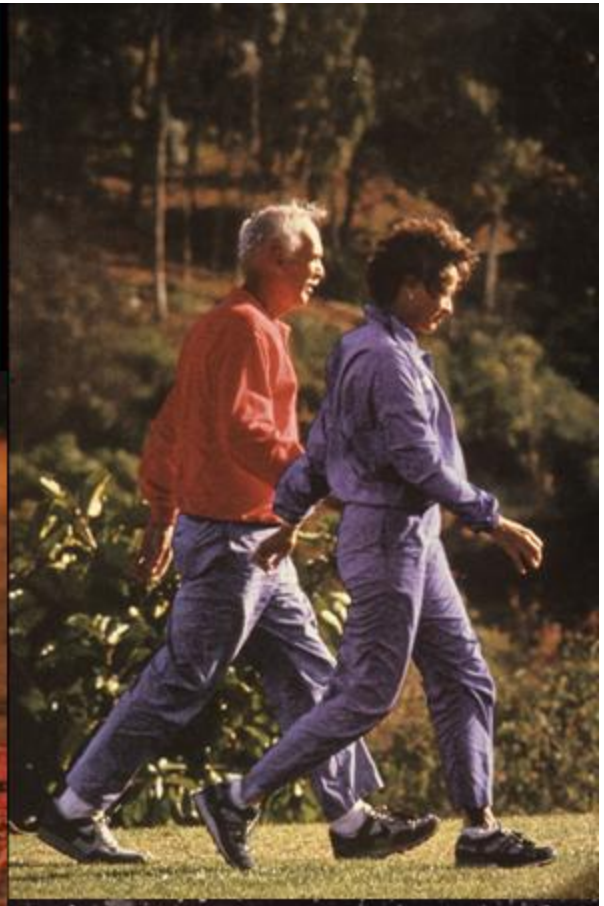
A. Malcolm Campbell
Davidson College, Davidson, NC
http://www.bio.davidson.edu/misc/movies/musclcp.mov



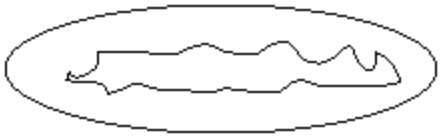
Musclcp.mov

Adaptations to Exercise?

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



AEROBIC w/O_2



MITOCHONDRIA

ANAEROBIC

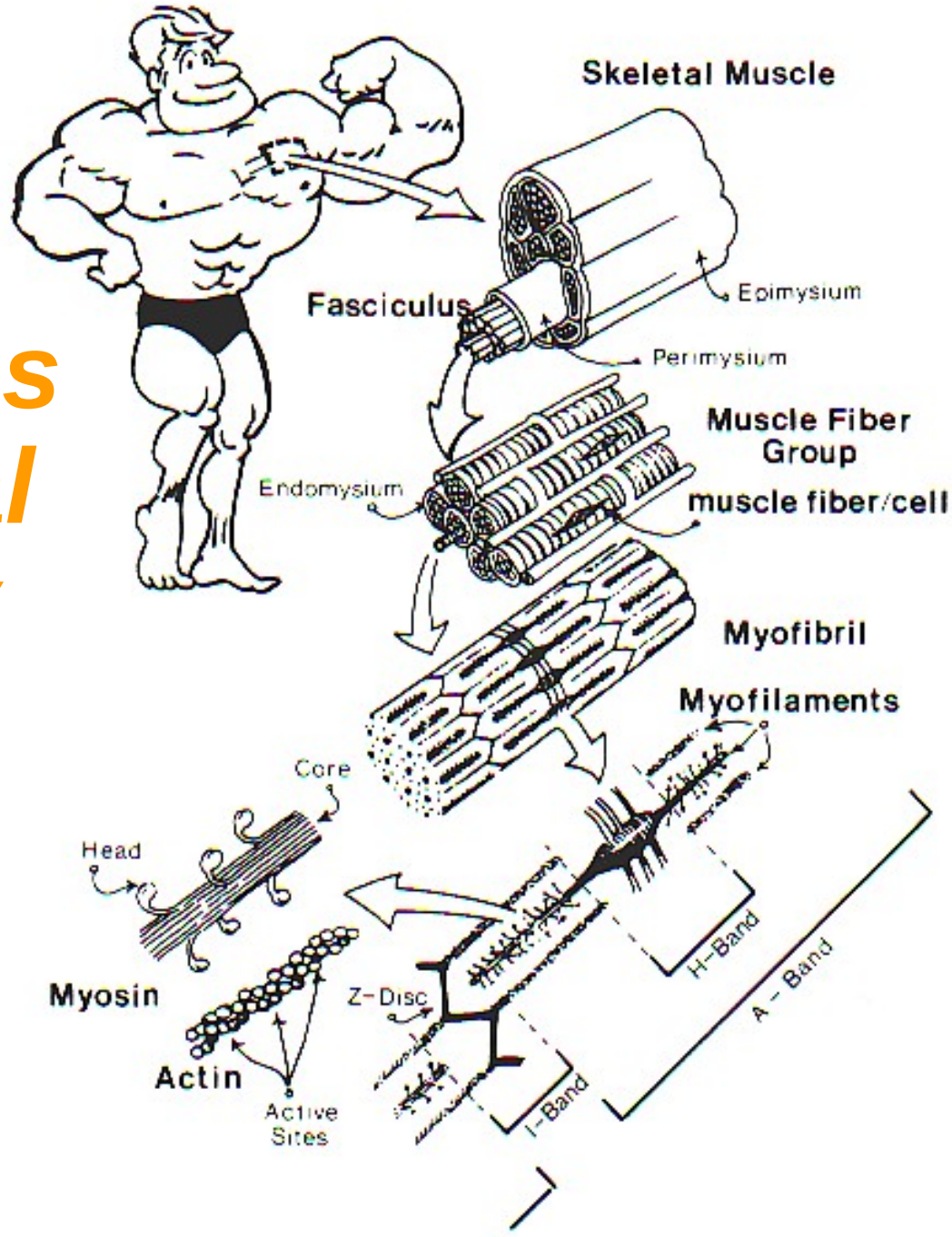
CYTOSOL

Glycolysis

Immediate/ATP-PC

PRIMARY FUEL	ACTIVITY	% AEROBIC (Oxidative Energy System)	% ANAEROBIC (Immediate & Non-Oxidative Energy Systems)	TIME (Min:Sec)
	Marathon Cross-Country Skiing	100	0	135:00
	10-K Run	90	10	29:00
FAT, CARBOHYDRATE & PROTEIN (Small Amounts)	3-Mile Run	80	20	14:00
	2-Mile Run 800-Meter Swim	70	30	
		60	40	9:00
	1-Mile Run			3:45
CARBOHYDRATE (Glucose & Glycogen)	Boxing 200-Meter Swim	50	50	
	Circuit Weight Training	40	60	
	Soccer Lacrosse	30	70	1:30
	Tennis	20	80	0:50
ATP, ADP & Creatine Phosphate (CP)	Basketball Volleyball 200-Meter Dash Football	10	90	0:20
	Conventional Weight Training	0	100	0:10

Adaptations to Skeletal Voluntary Muscle



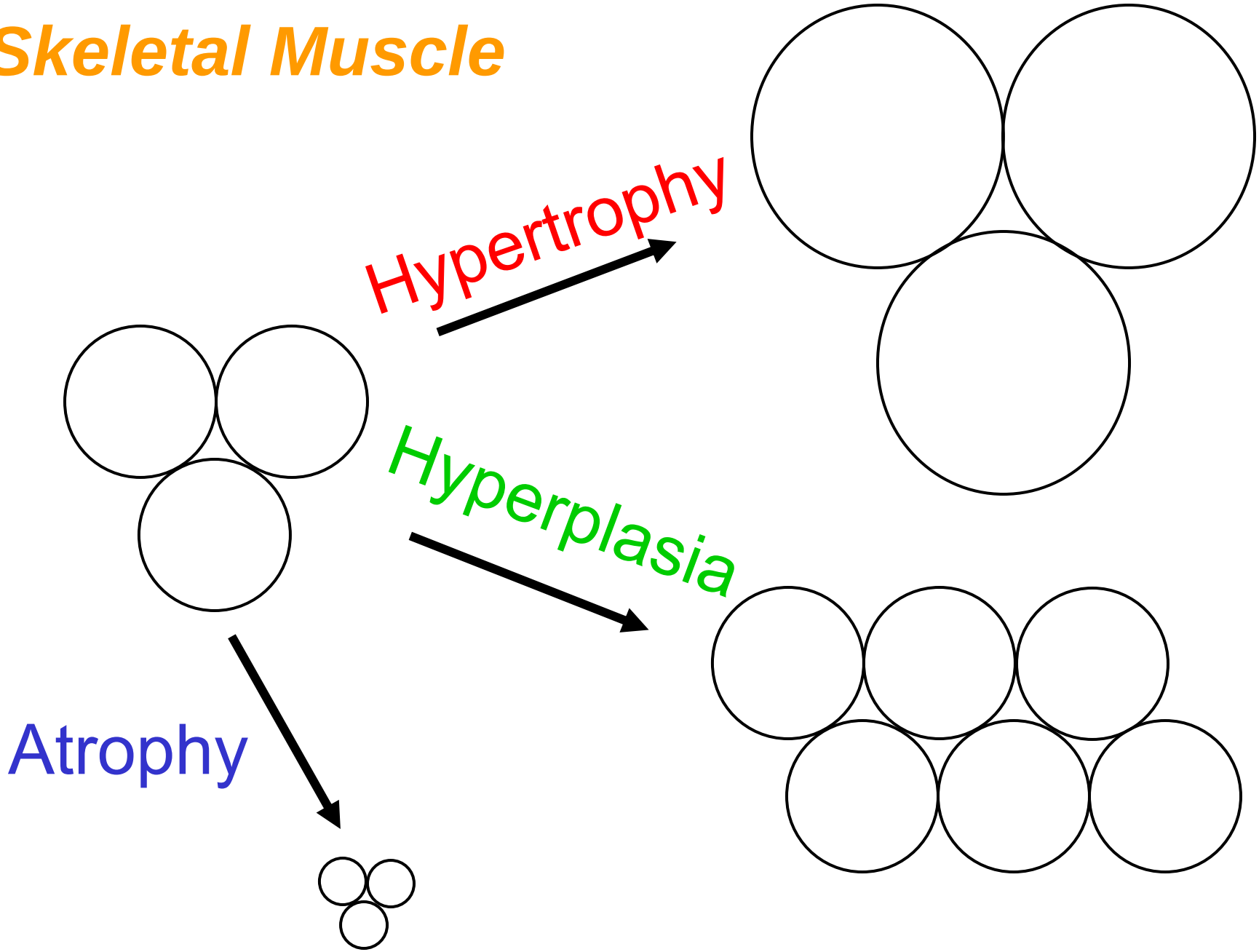
Atrophy

decrease in size & strength

Hypertrophy

increase in size & strength

Skeletal Muscle

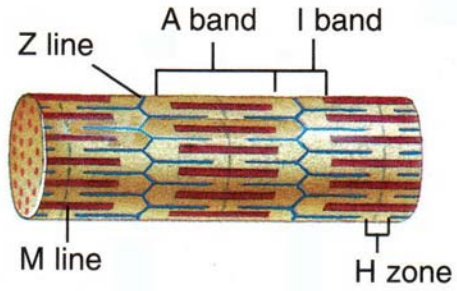


Women & Hypertrophy?

What happens in muscles at cellular & subcellular levels?

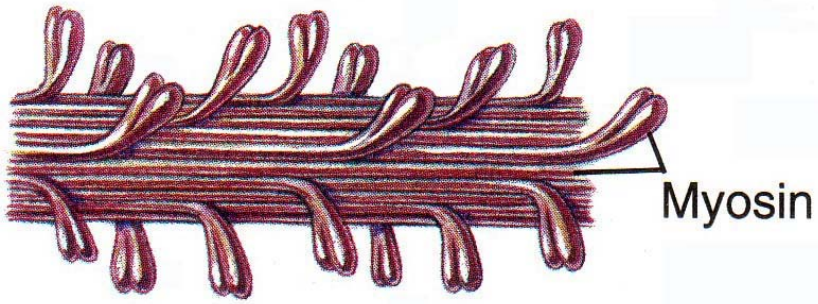
Myofibril

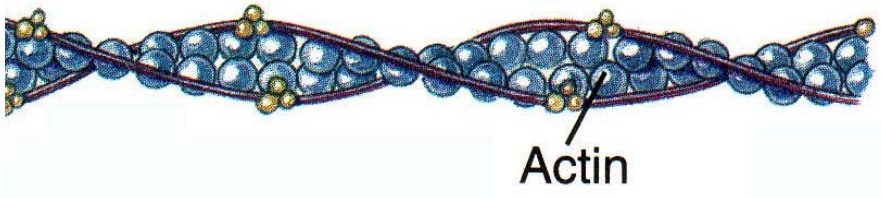
Hypertrophy: Increased Number of Myofibrils

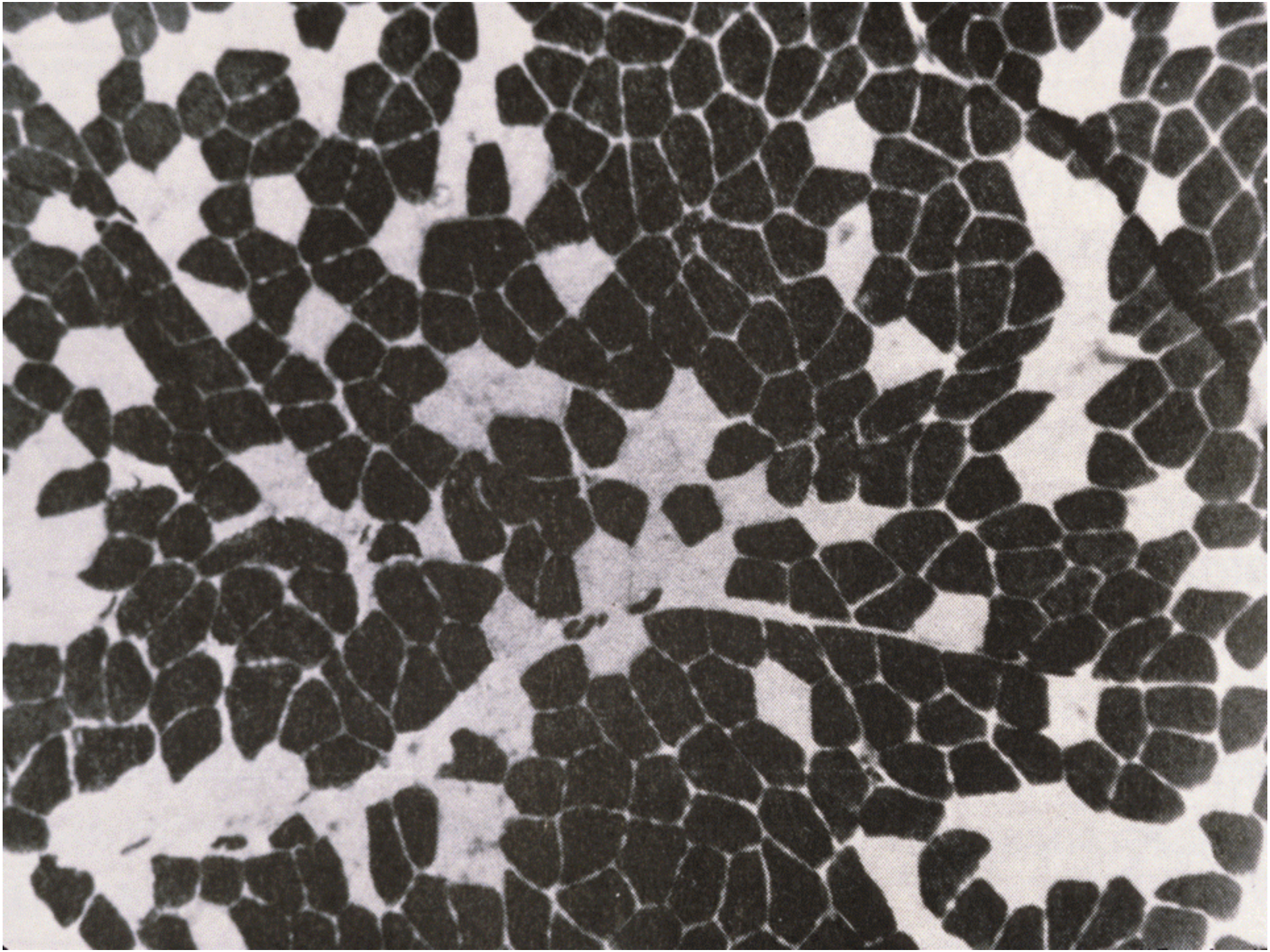


Thick & Thin Filaments

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

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:

?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