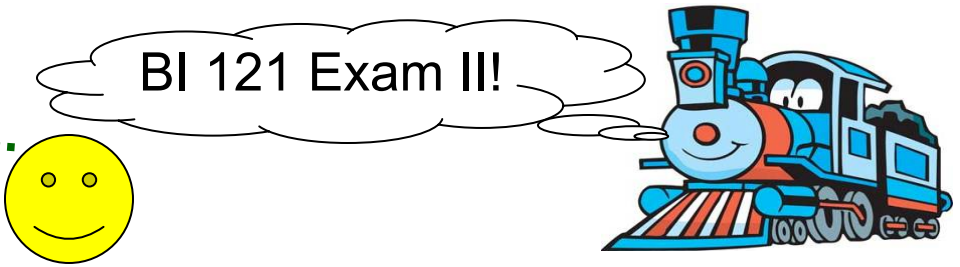
Exam II is coming! I'll be ready!!...



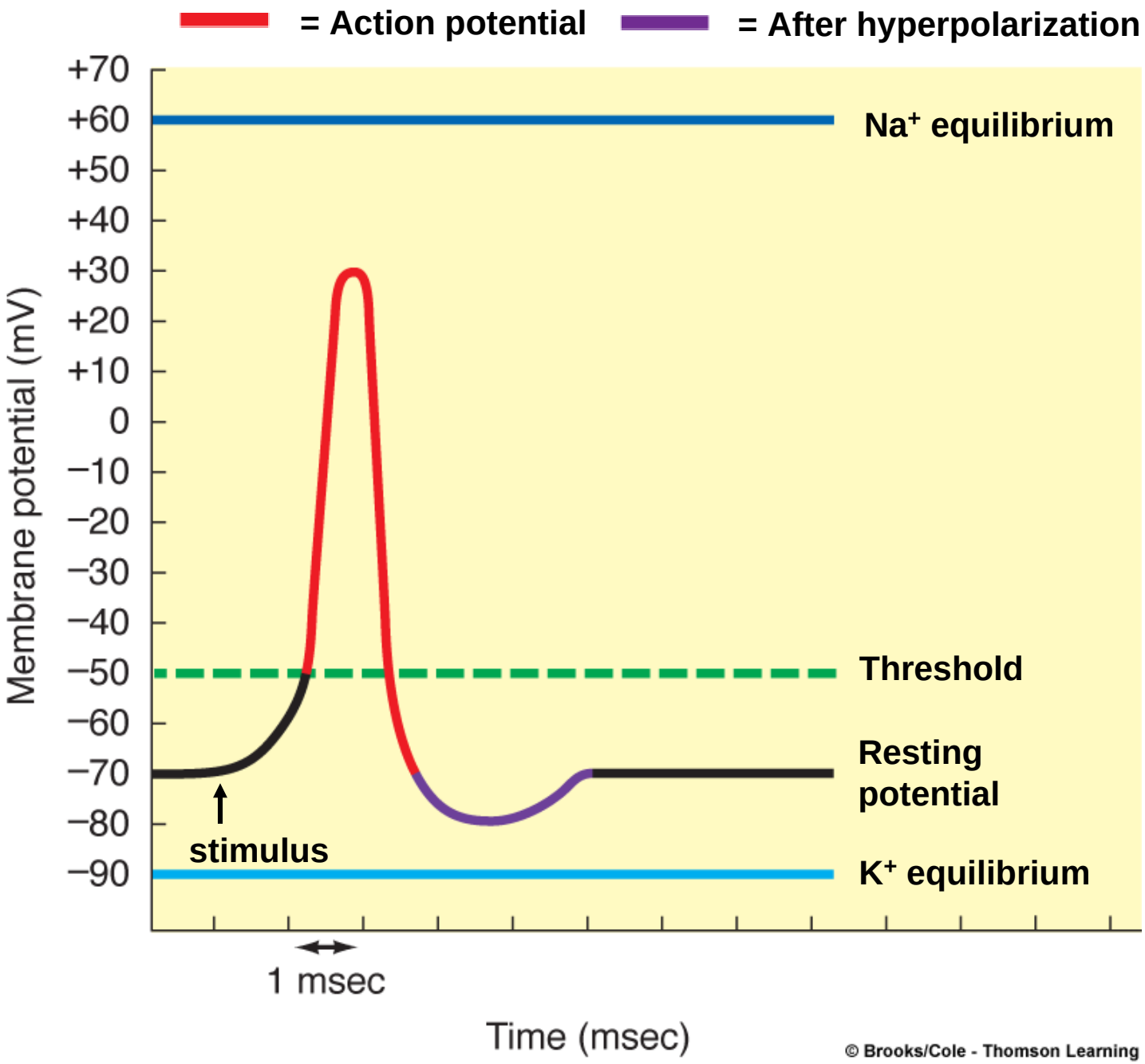

# BI 121 Lecture 14

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

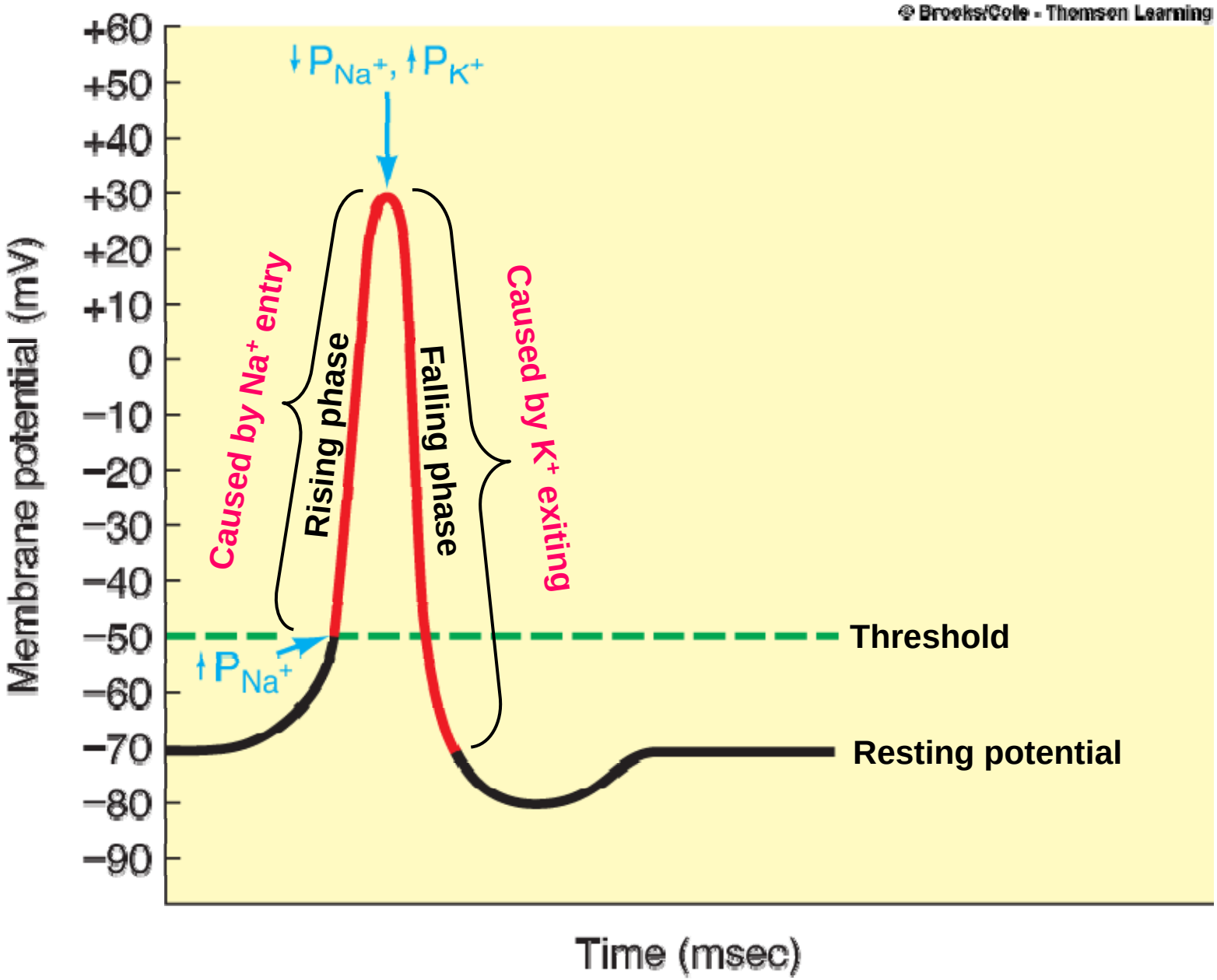
II. ***Action Potential + Neuromuscular Junction Connections*** LS 7 What's an AP? What do black widow spider venom, botulism, curare & nerve gas have in common? LS fig 7-5 p190 Botox?

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? 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 &*** **environment**?
J. Endurance *vs.* strength training continuum? fiber types...

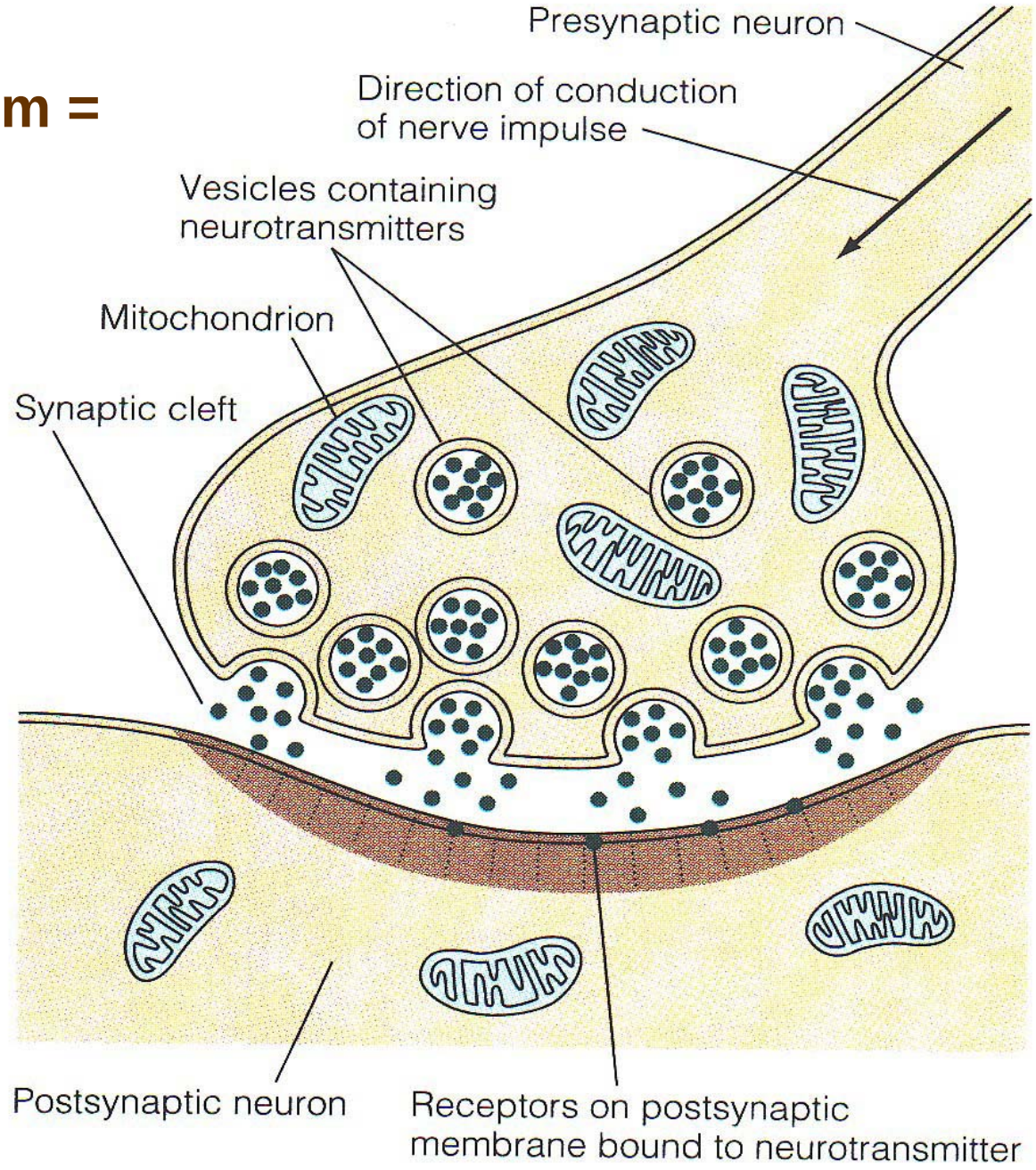



LS 2012 fig 4-5

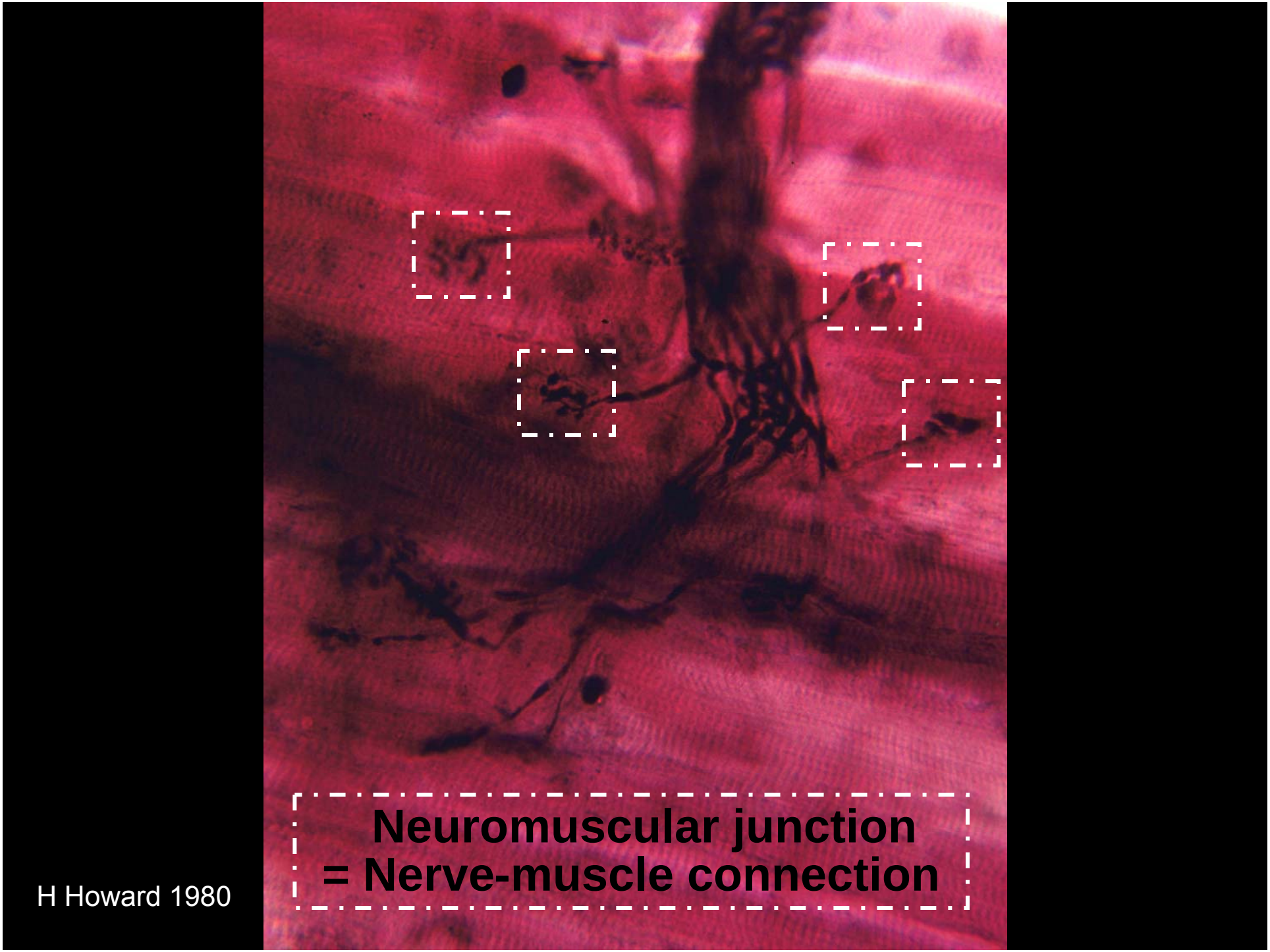



LS 2012 fig 4-8

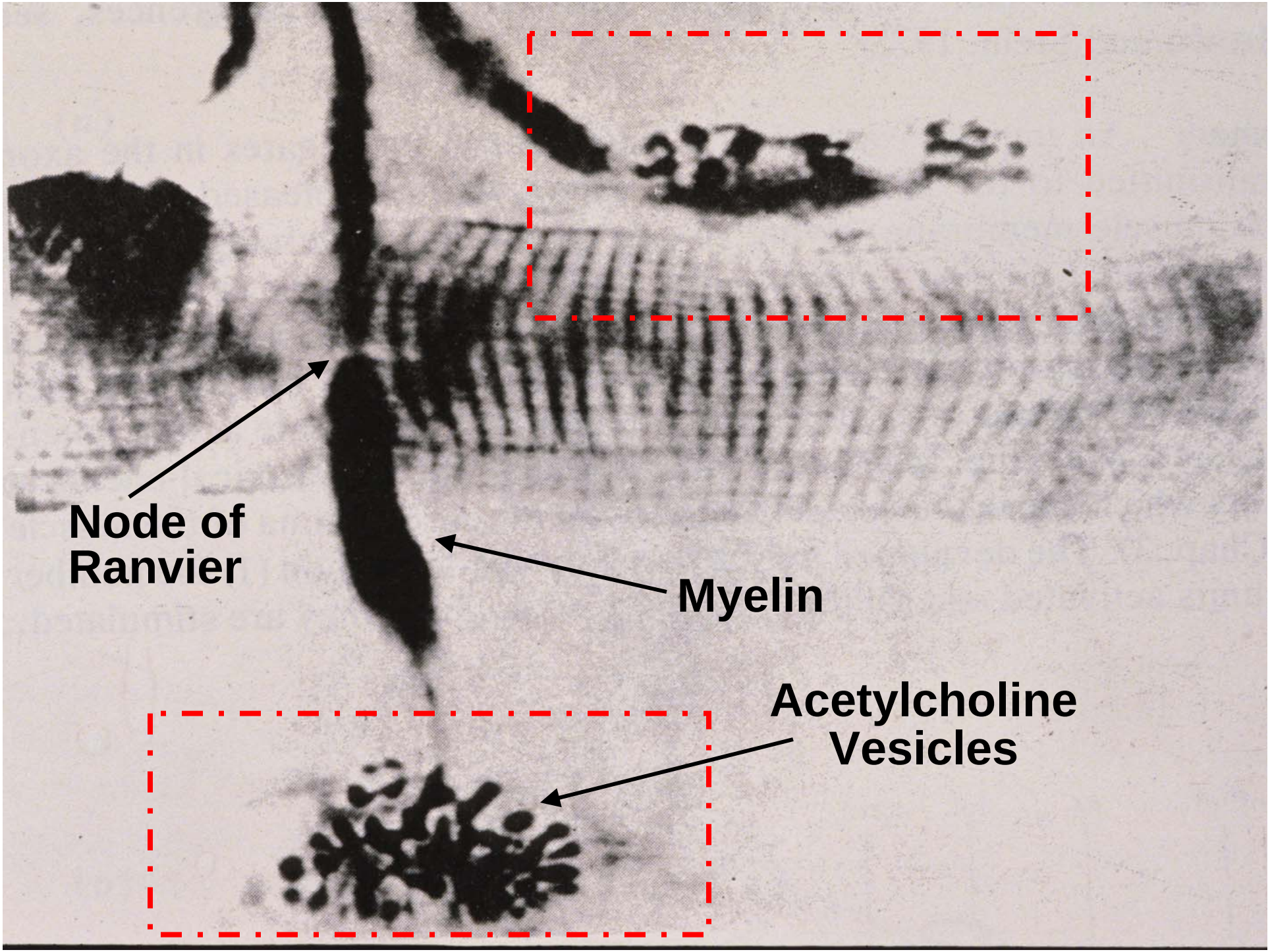
***Synapse*** **=**
**Generic term = connection between excitable cells!**




DC 2003

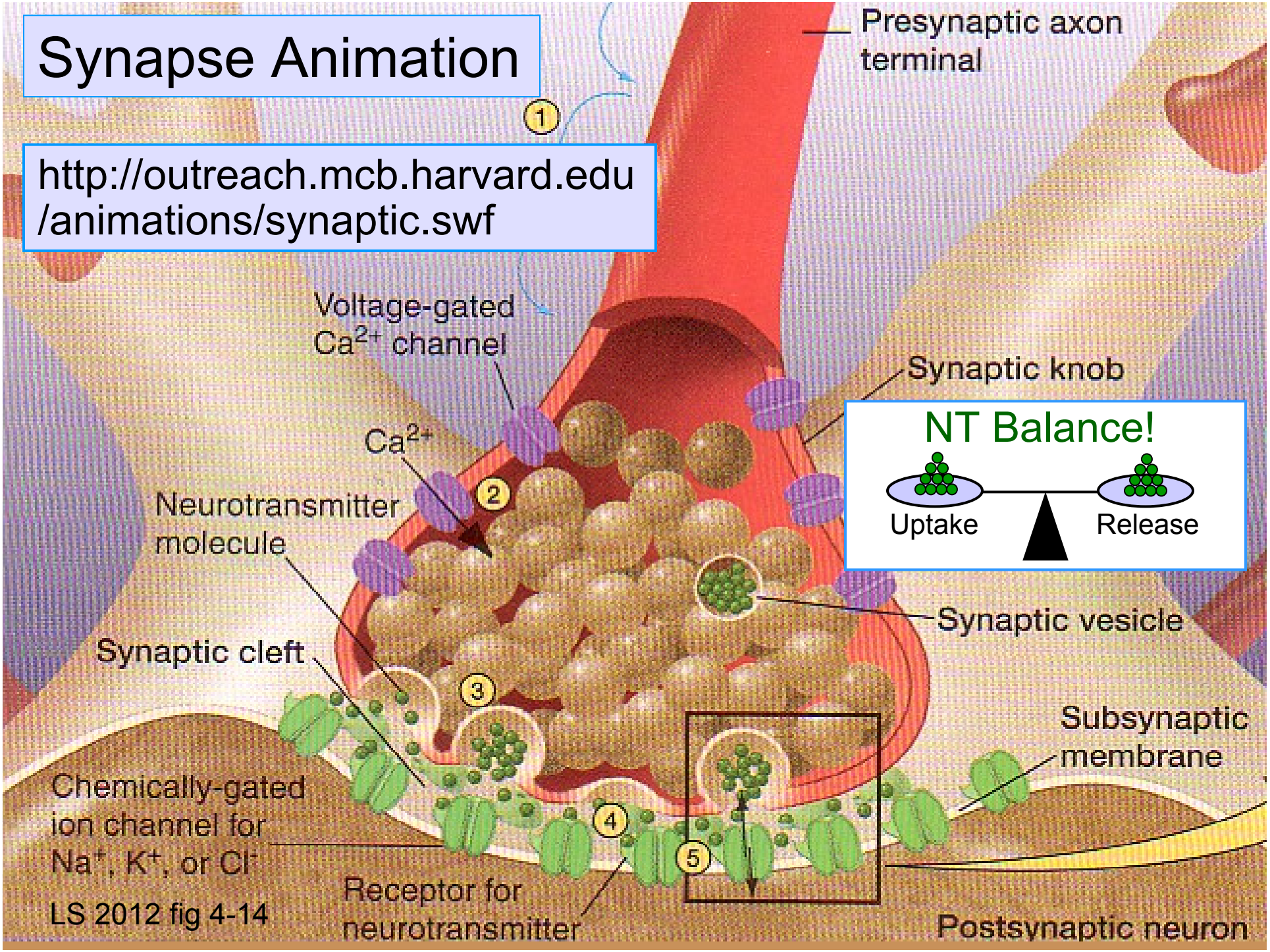



H Howard 1980

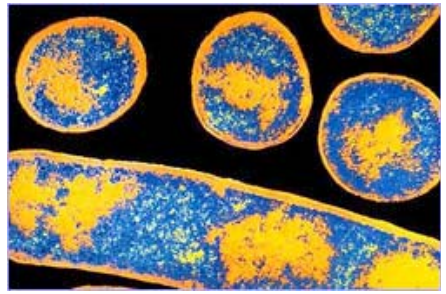

Node of
Ranvier
Myelin
Acetylcholine
Vesicles

# Synapse Animation

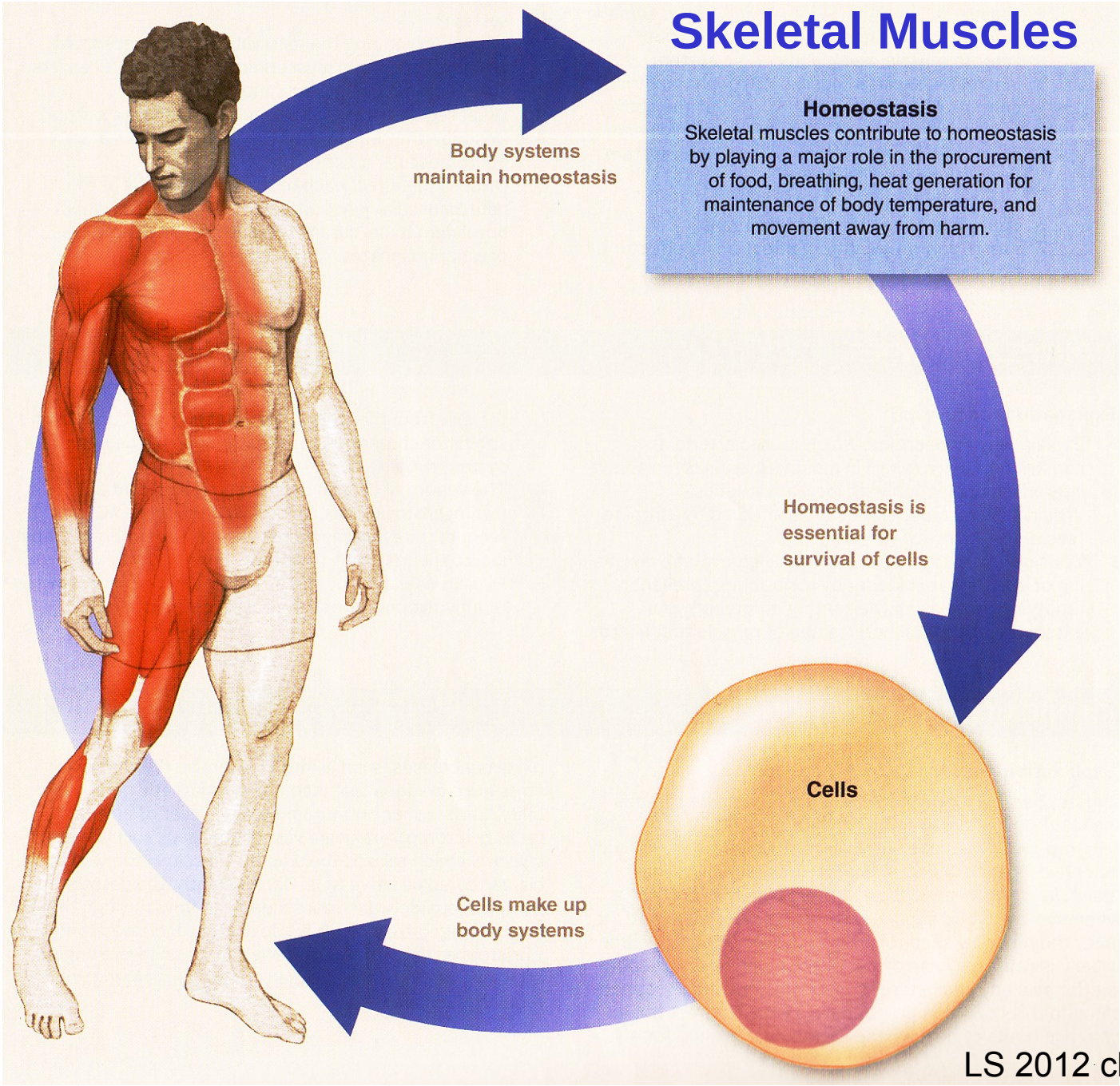
http://outreach.mcb.harvard.edu/animations/synaptic.swf



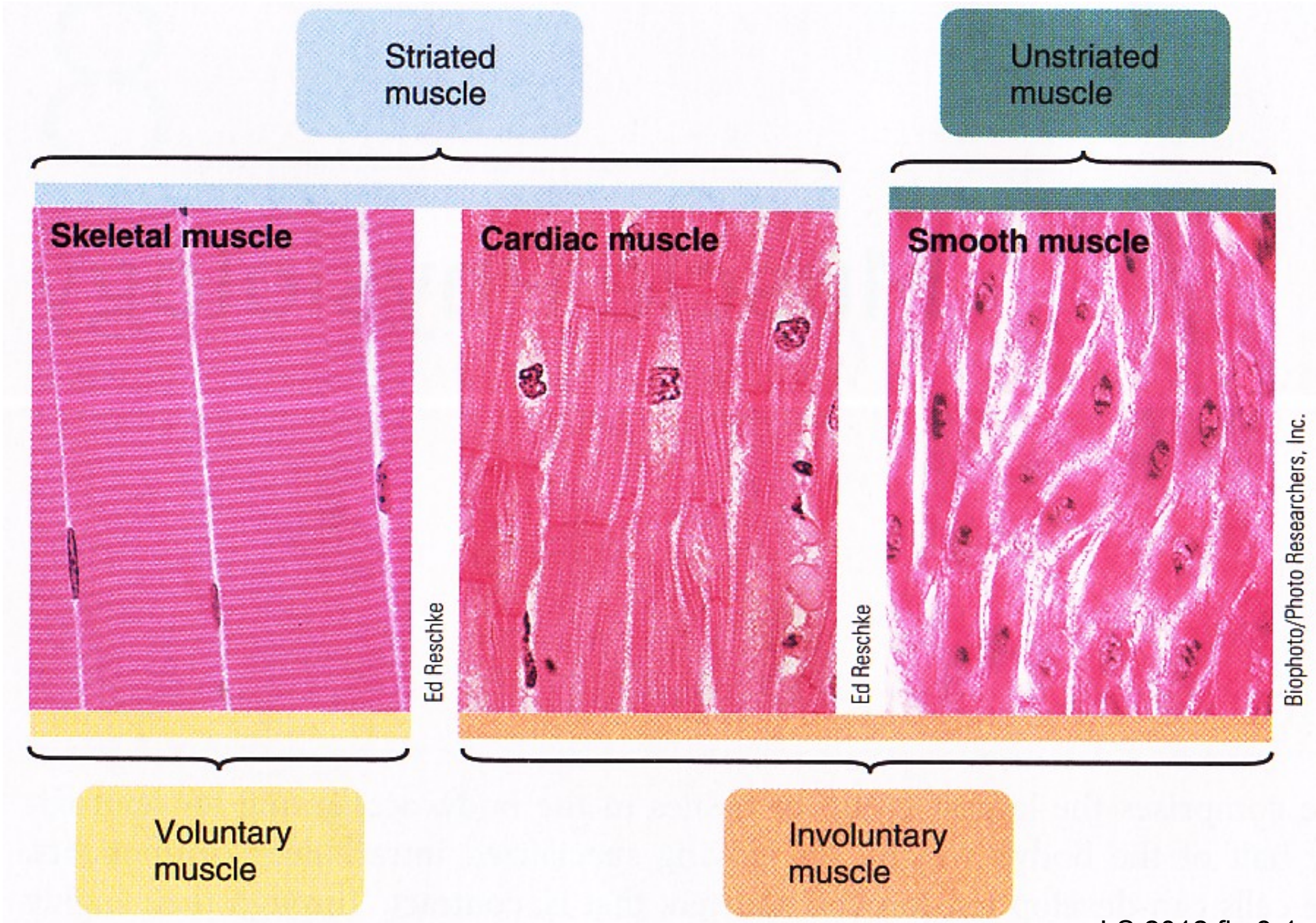

LS 2012 fig 4-14




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

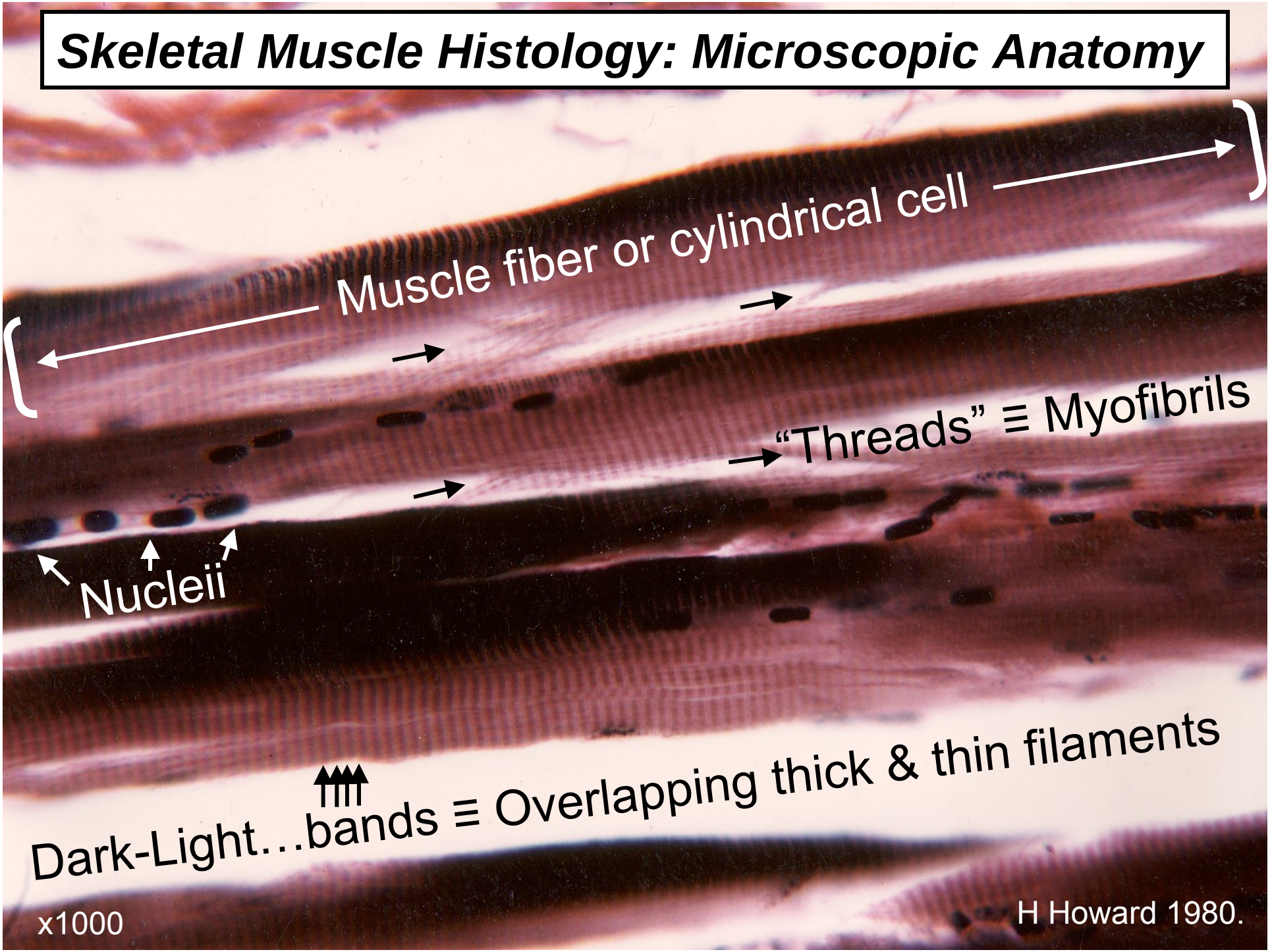



LS 2012 ch 8 vignette

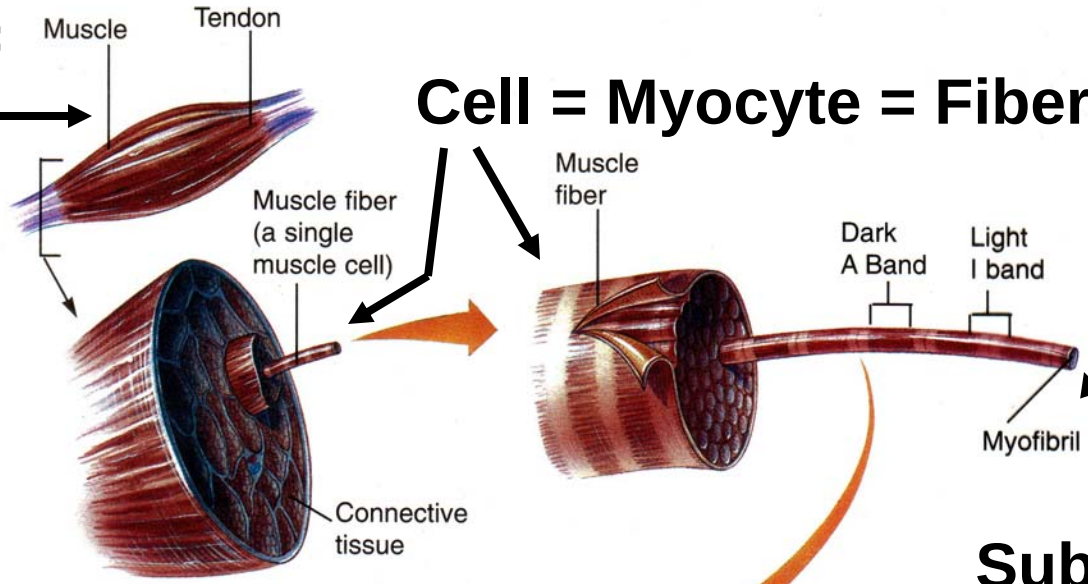



LS 2012 fig 8-1

# *Skeletal Muscle Histology: Microscopic Anatomy*



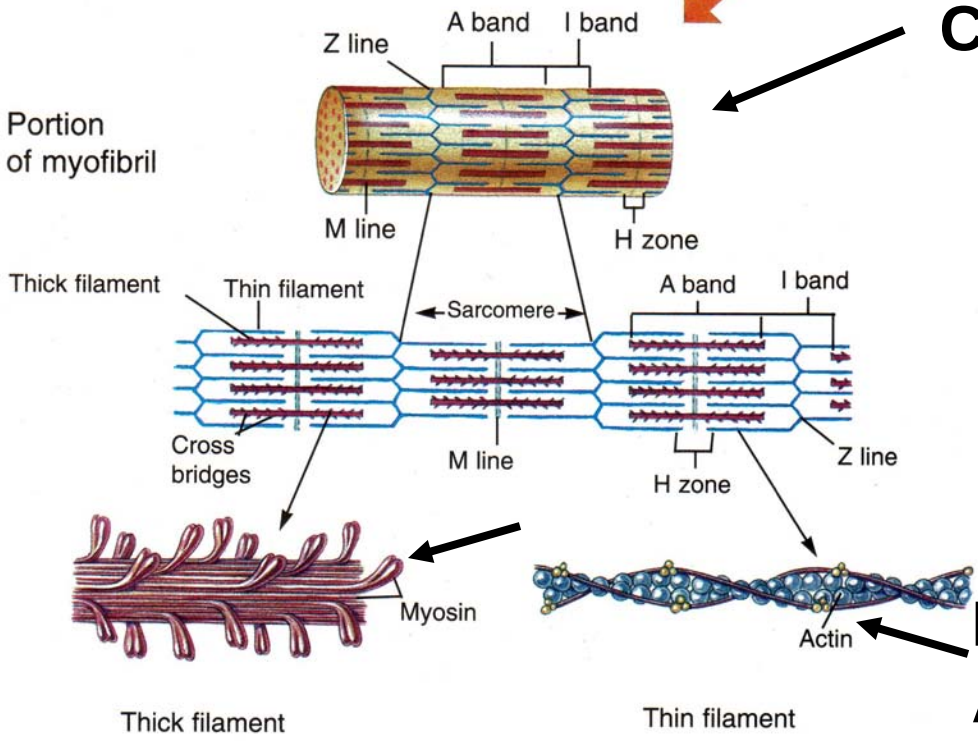
**Organ = Muscle**




**Cell = Myocyte = Fiber**




**Subcellular = Cytoskeleton**




**Molecules = Actin & Myosin**

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

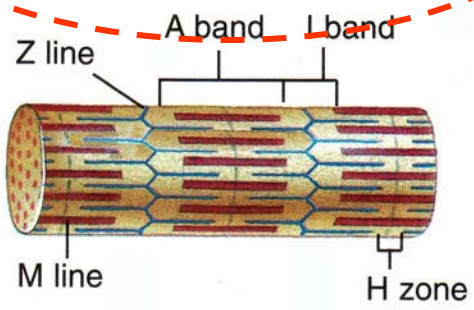
Whole Muscle

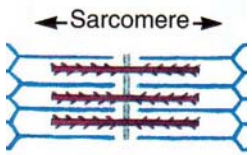
Myocyte or Muscle Fiber

Myofibril

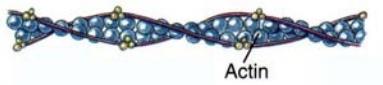
Thick & Thin Filaments

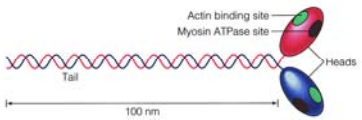
Myosin & Actin

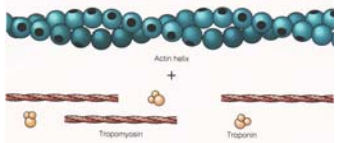






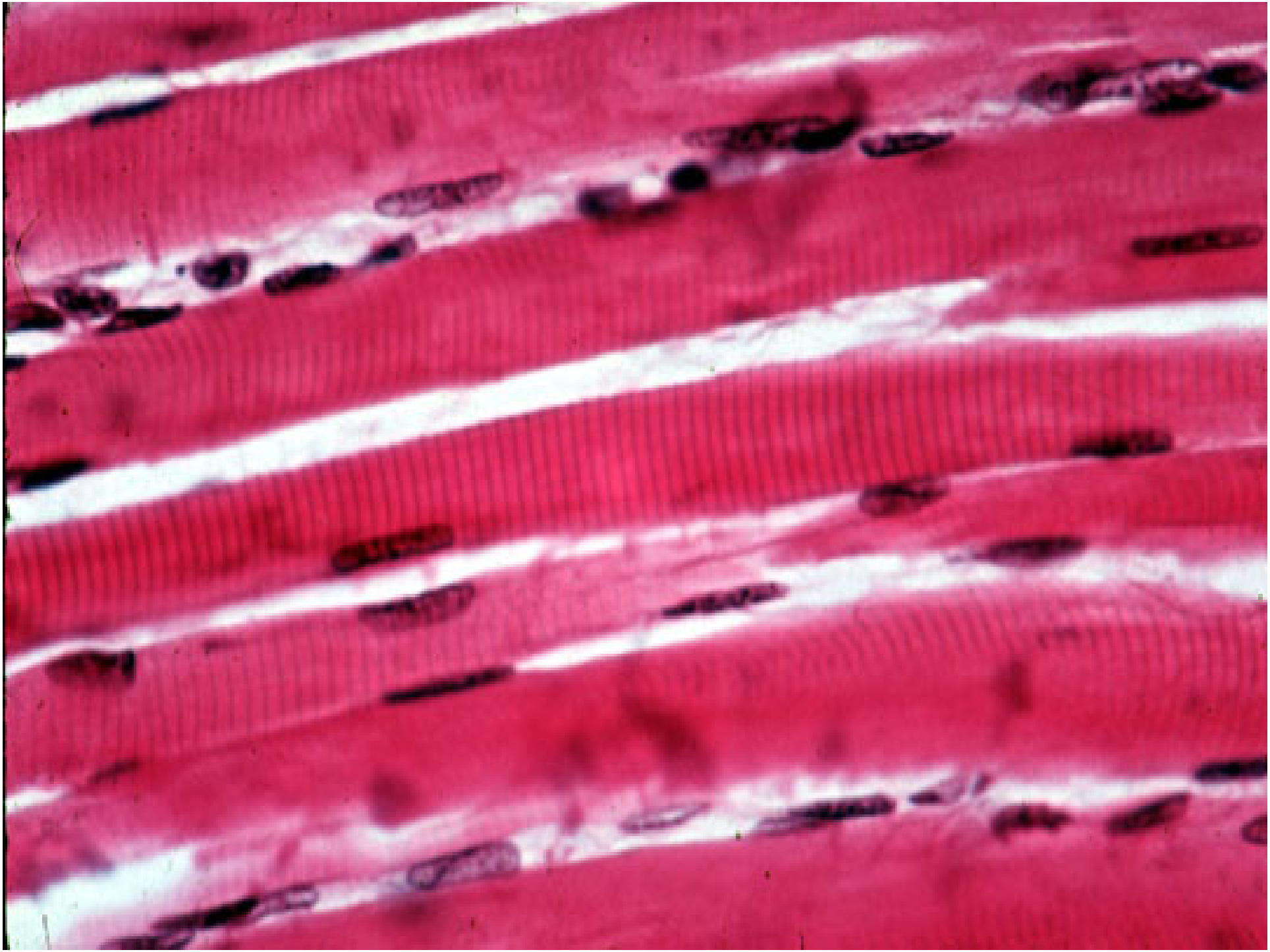



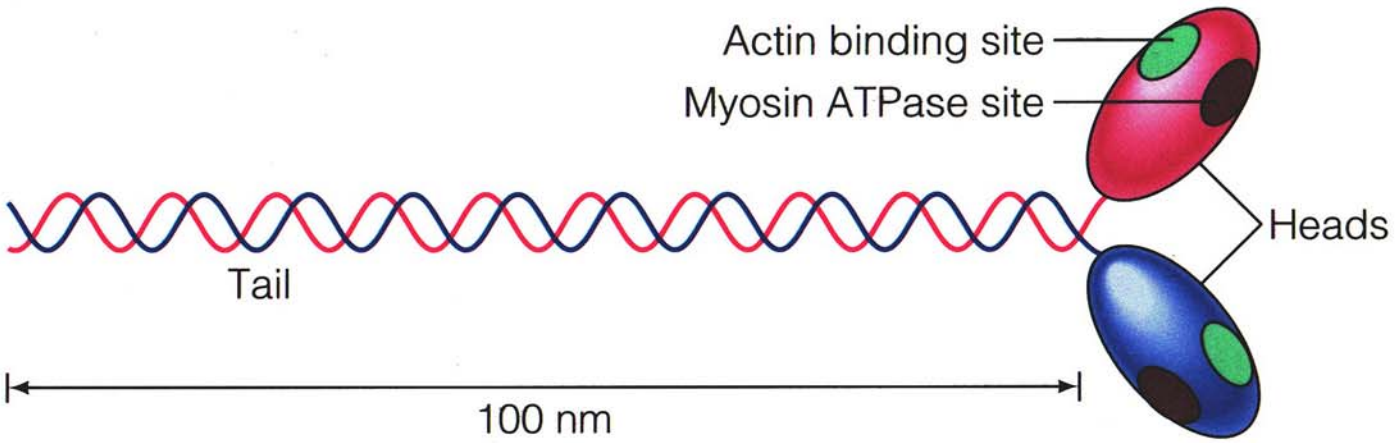
Organ

Cell

Cytoskeleton

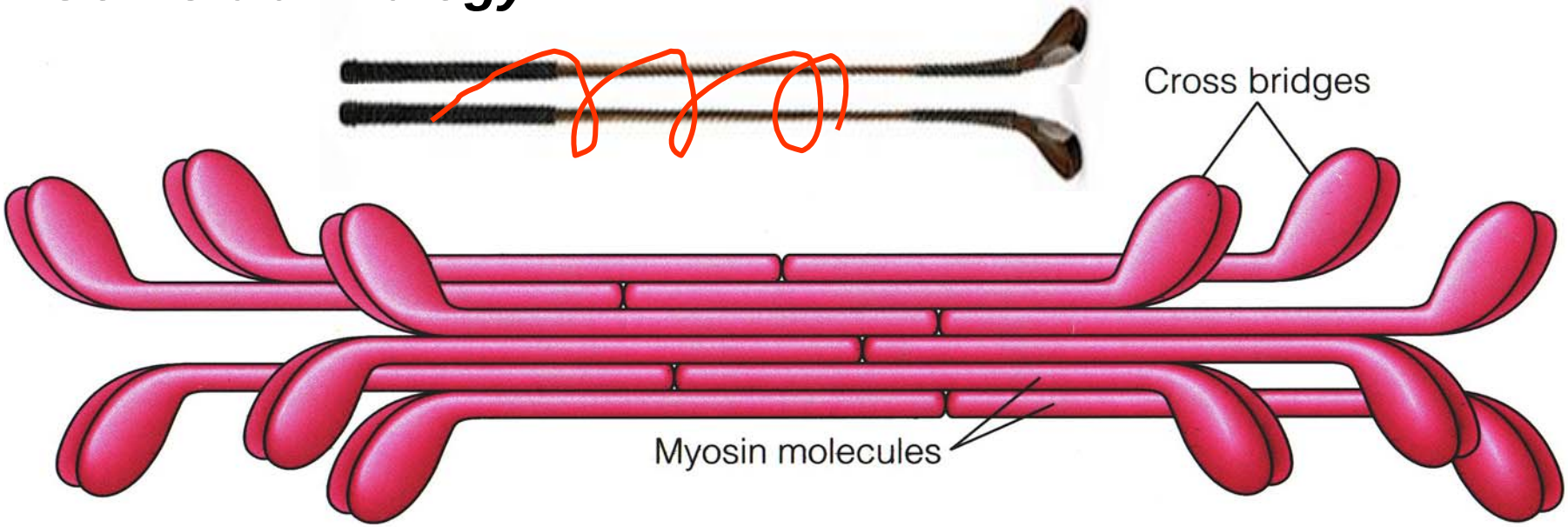
Molecules






(a)

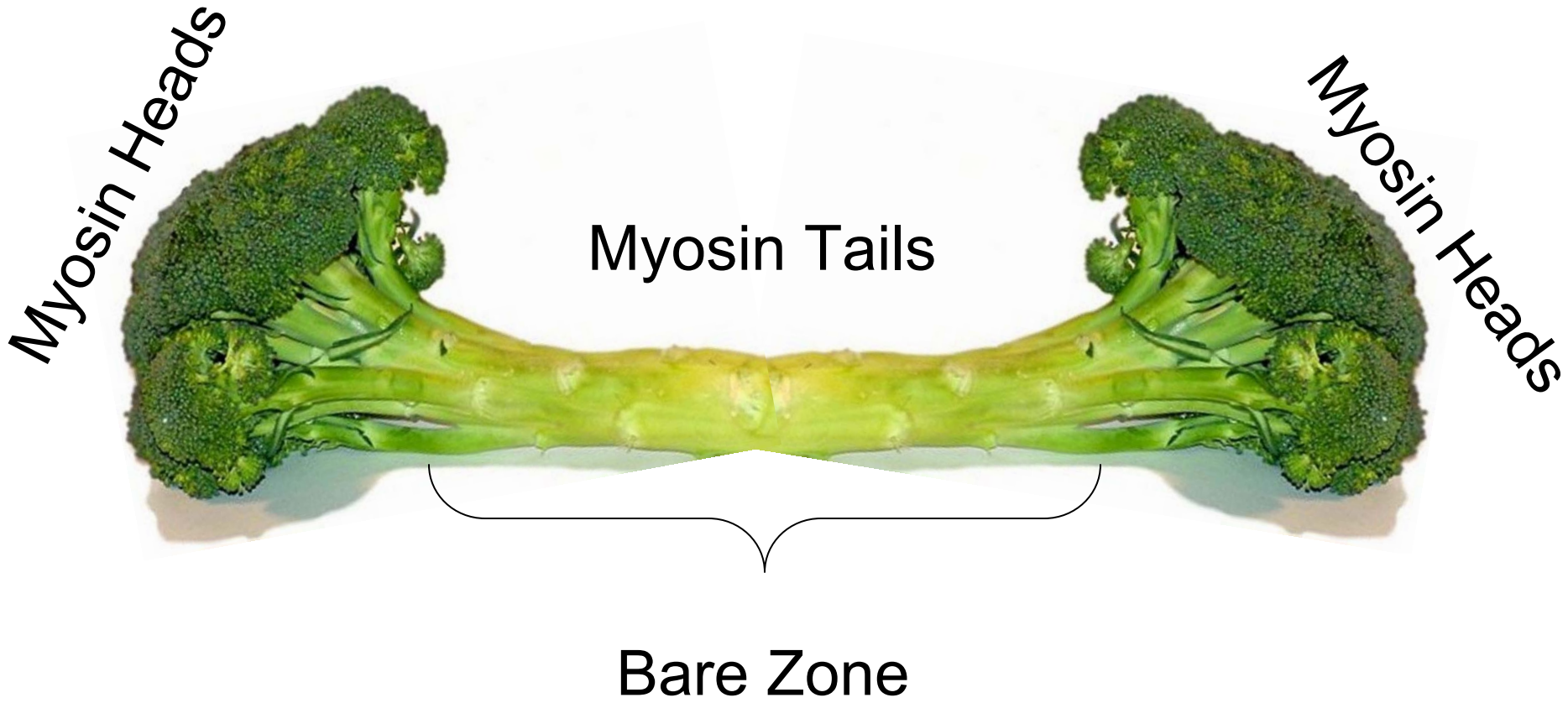
***Golf Club Analogy?***

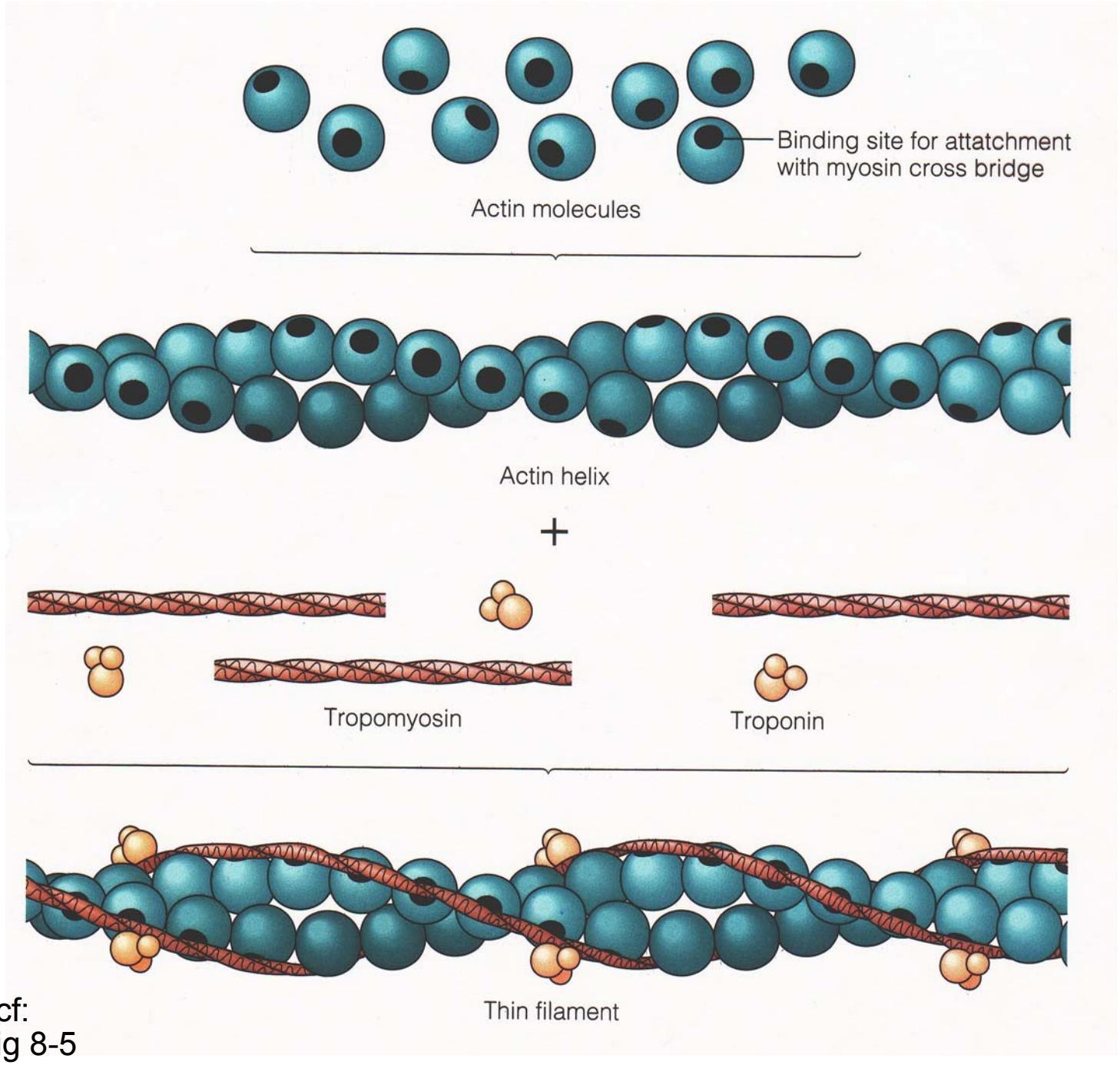



(b)

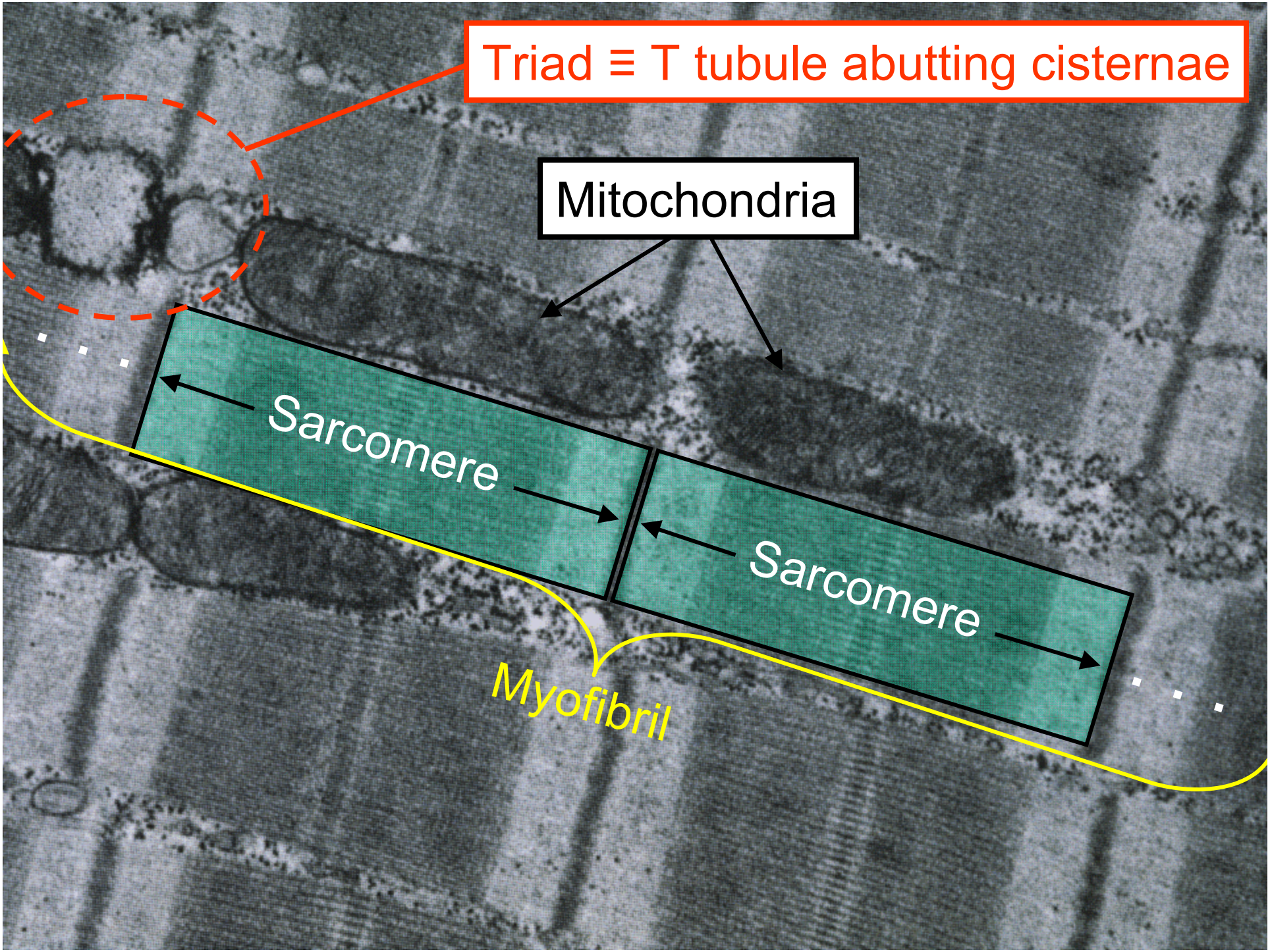
LS 2006, cf:
LS 2012 fig 8-4

# *Broccoli Analogy?*



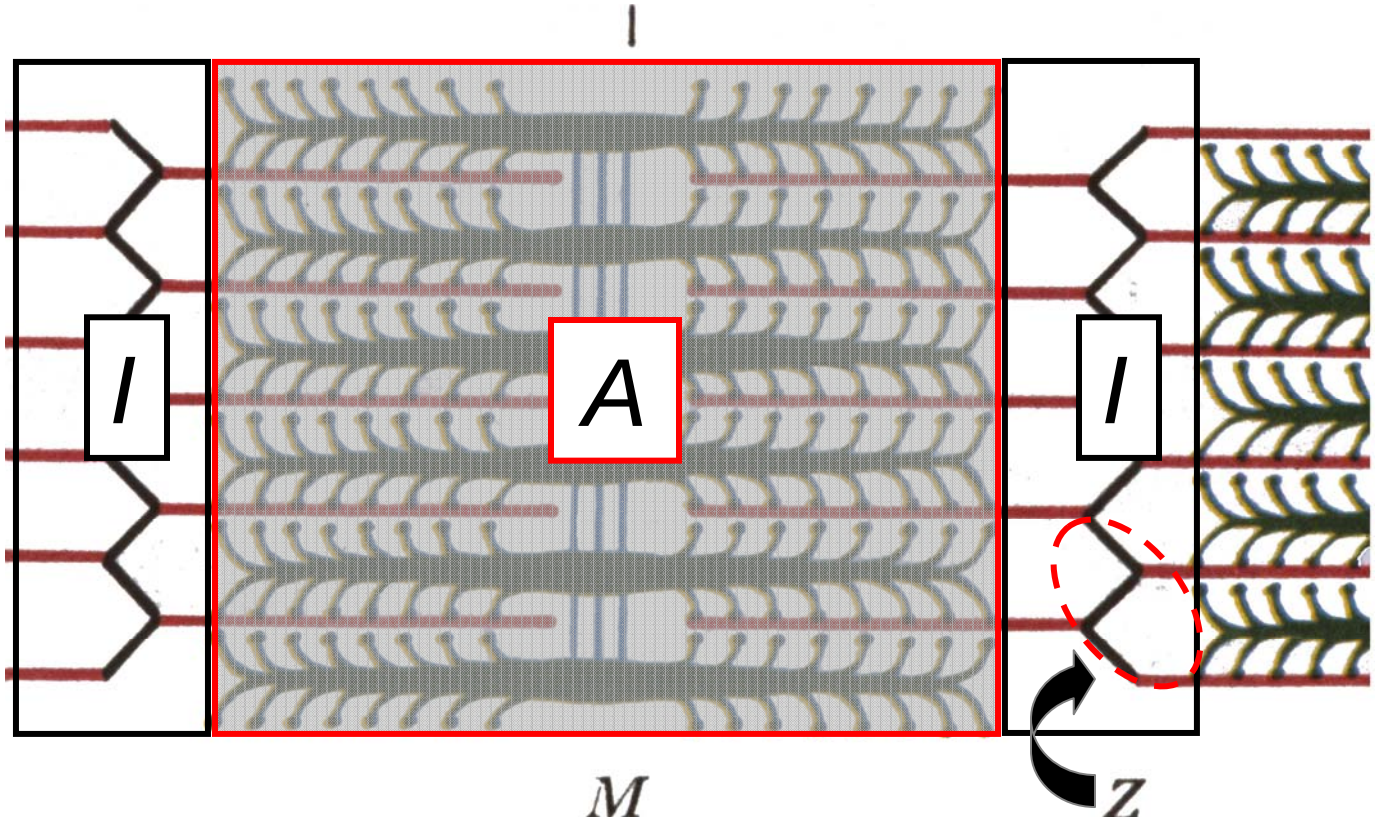



LS 2006, cf:
LS 2012 fig 8-5


Triad ≡ T tubule abutting cisternae
Mitochondria
Sarcomere
Sarcomere
Myofibril

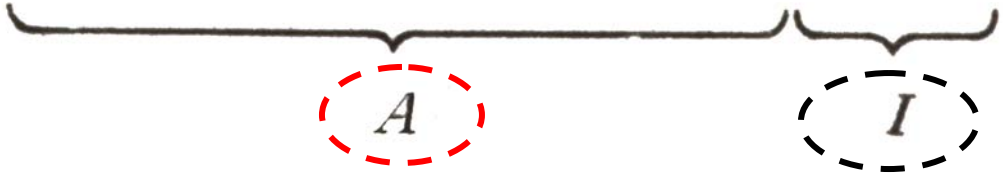
*A* Band = Dark Band

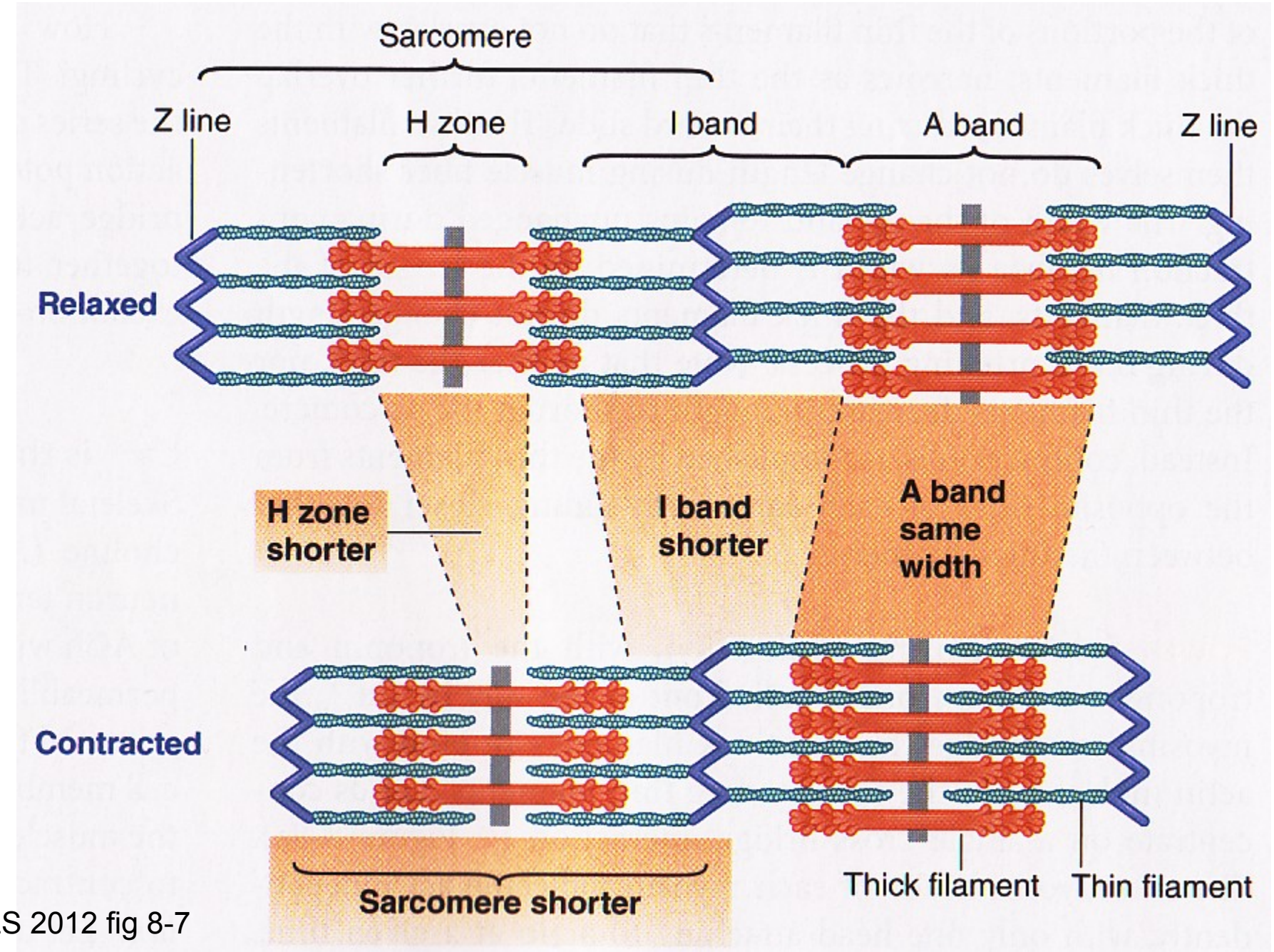
*A*nisotropic = Light Can't Shine Through




*I* Band = Light Band

*I*sotropic = Light Can Shine Through

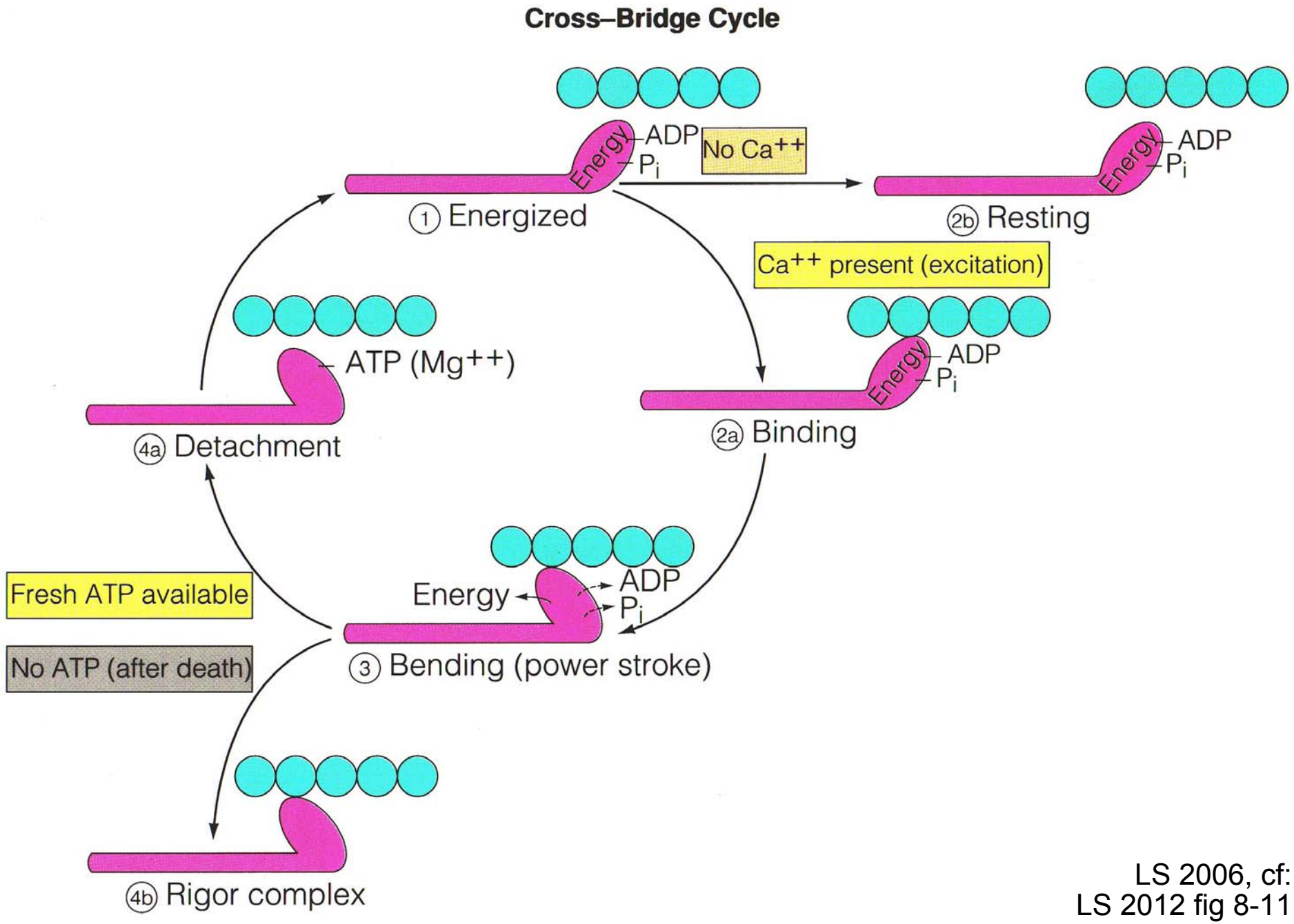





LS 2012 fig 8-7

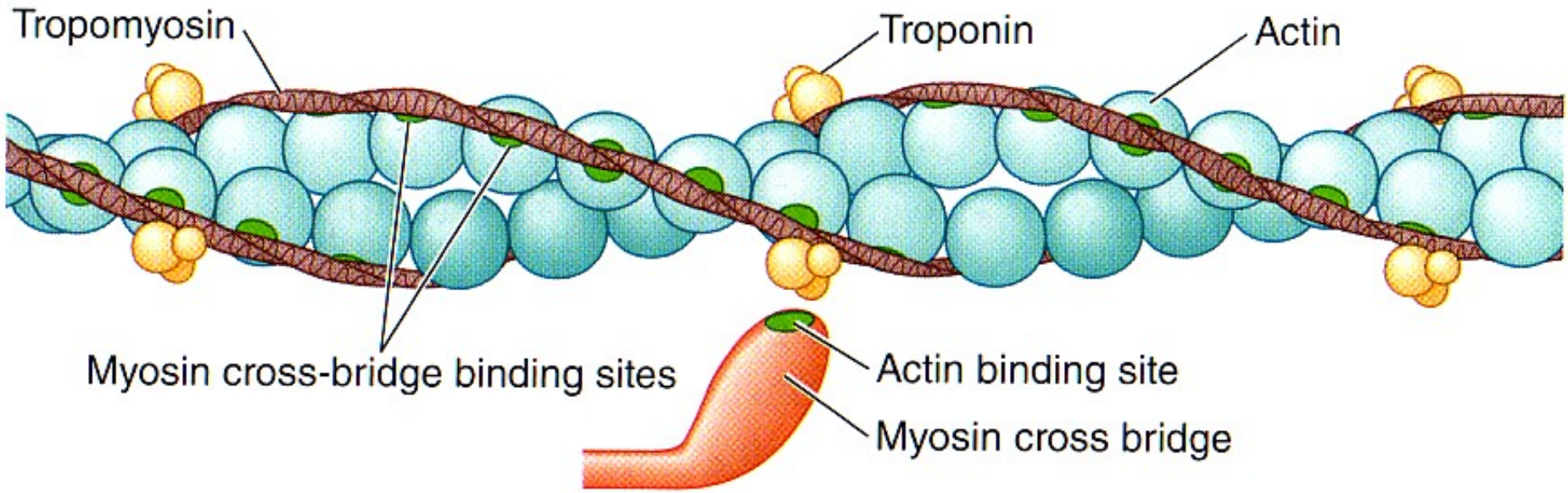
# *Discussion + Time for Questions!*

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




LS 2006, cf:
LS 2012 fig 8-11

# *Relaxed: No Cross-Bridge Binding*




**(a) Relaxed**

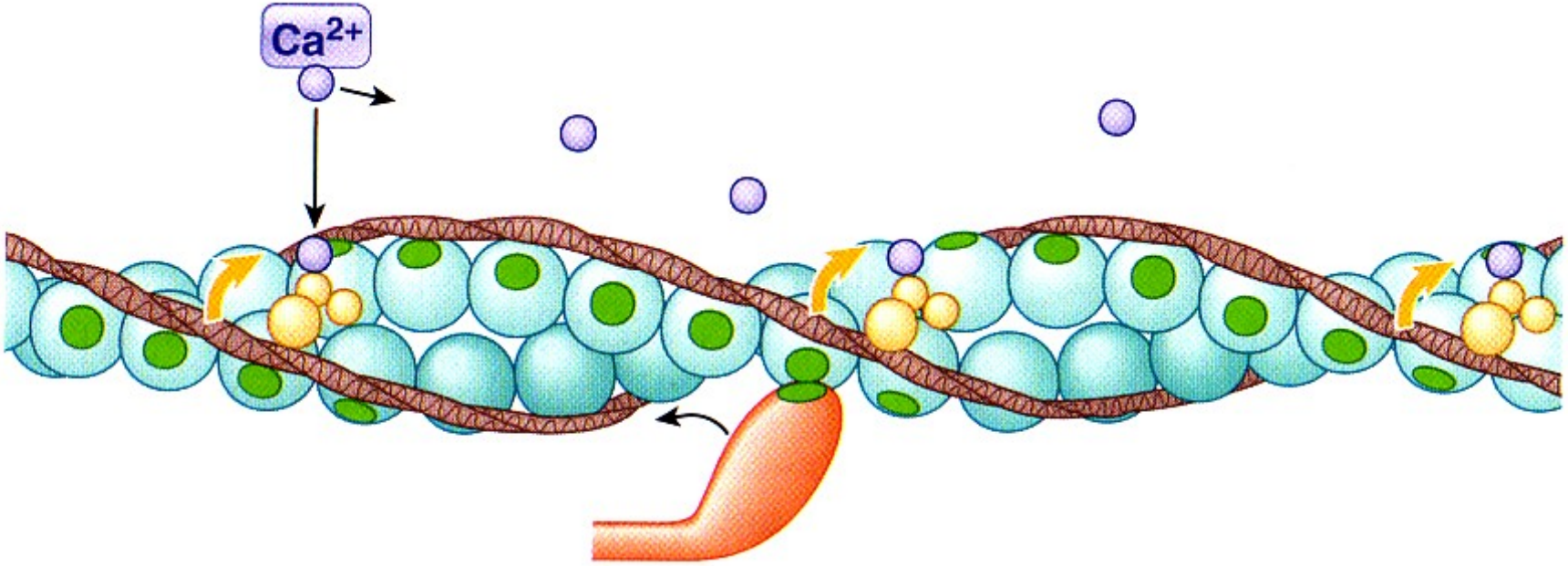
1 No excitation.

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.

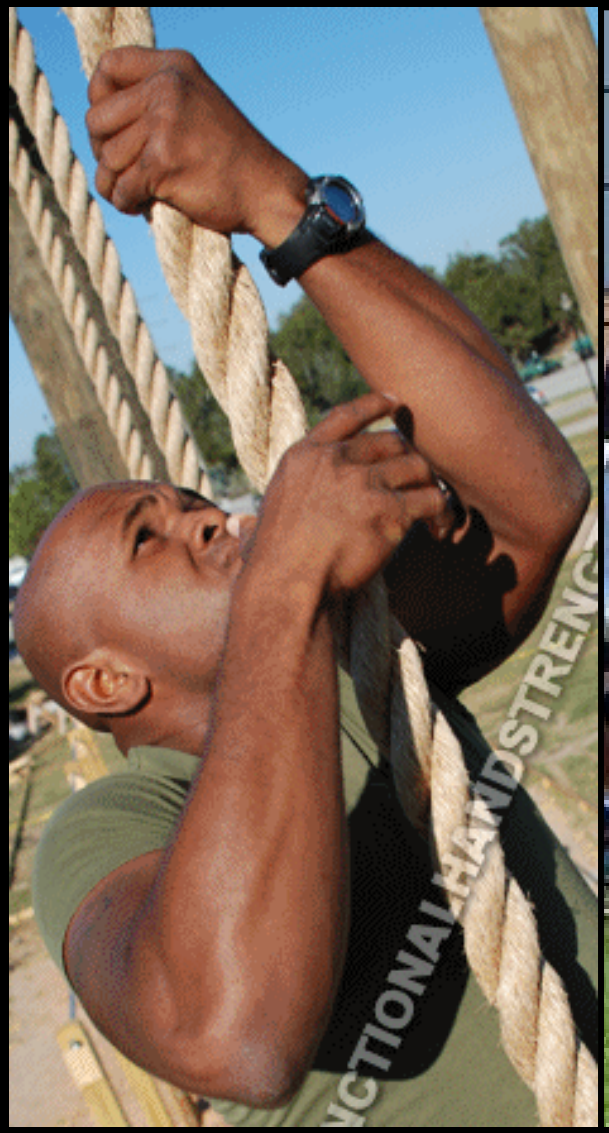
2. Released $Ca^{2+}$ binds with troponin, pulling troponin–tropomyosin complex aside to expose cross-bridge binding site.

3. Cross-bridge binding occurs.

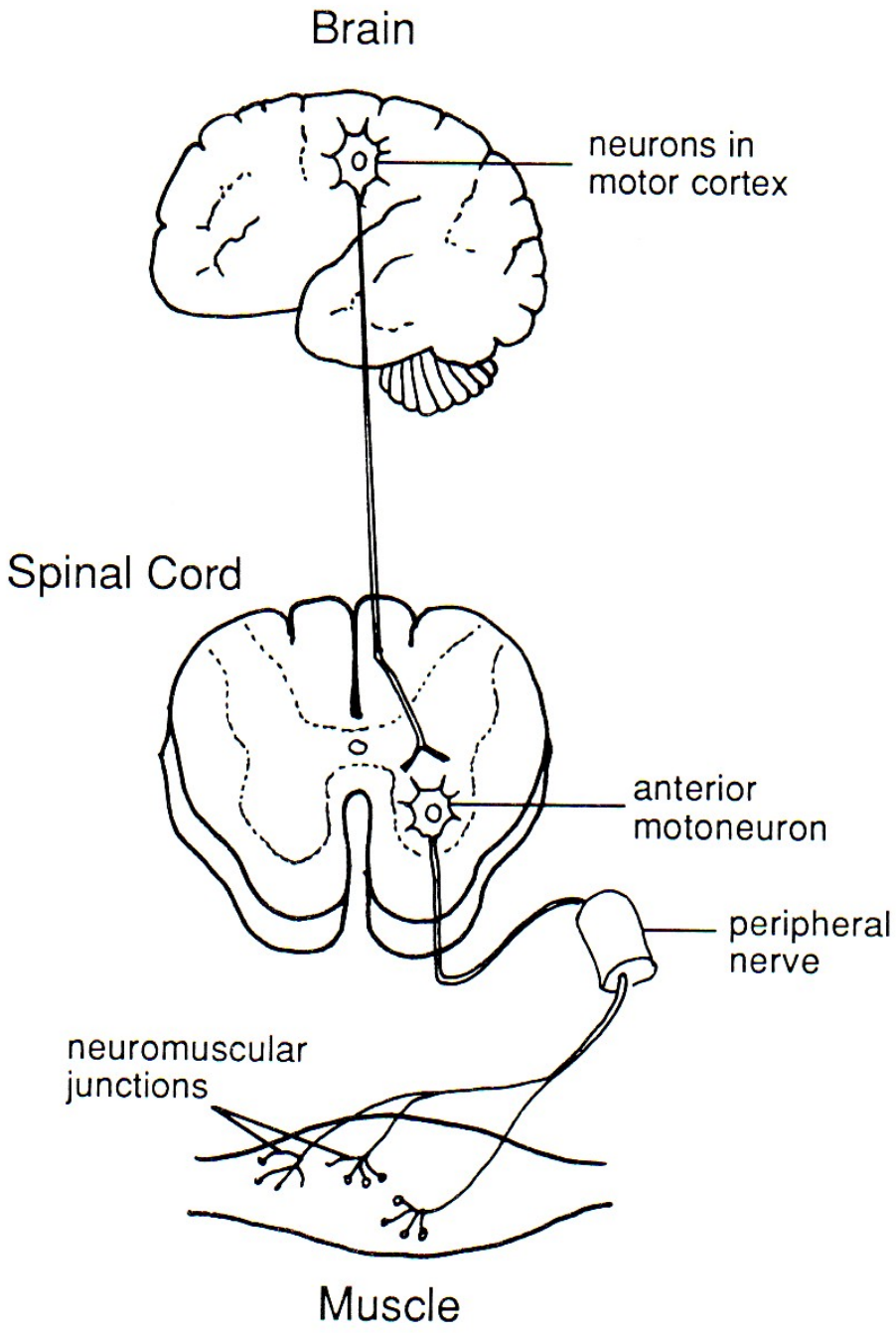
4. Binding of actin and myosin cross bridge triggers power stroke that pulls thin filament inward during contraction.

LS 2012 fig 8-6b

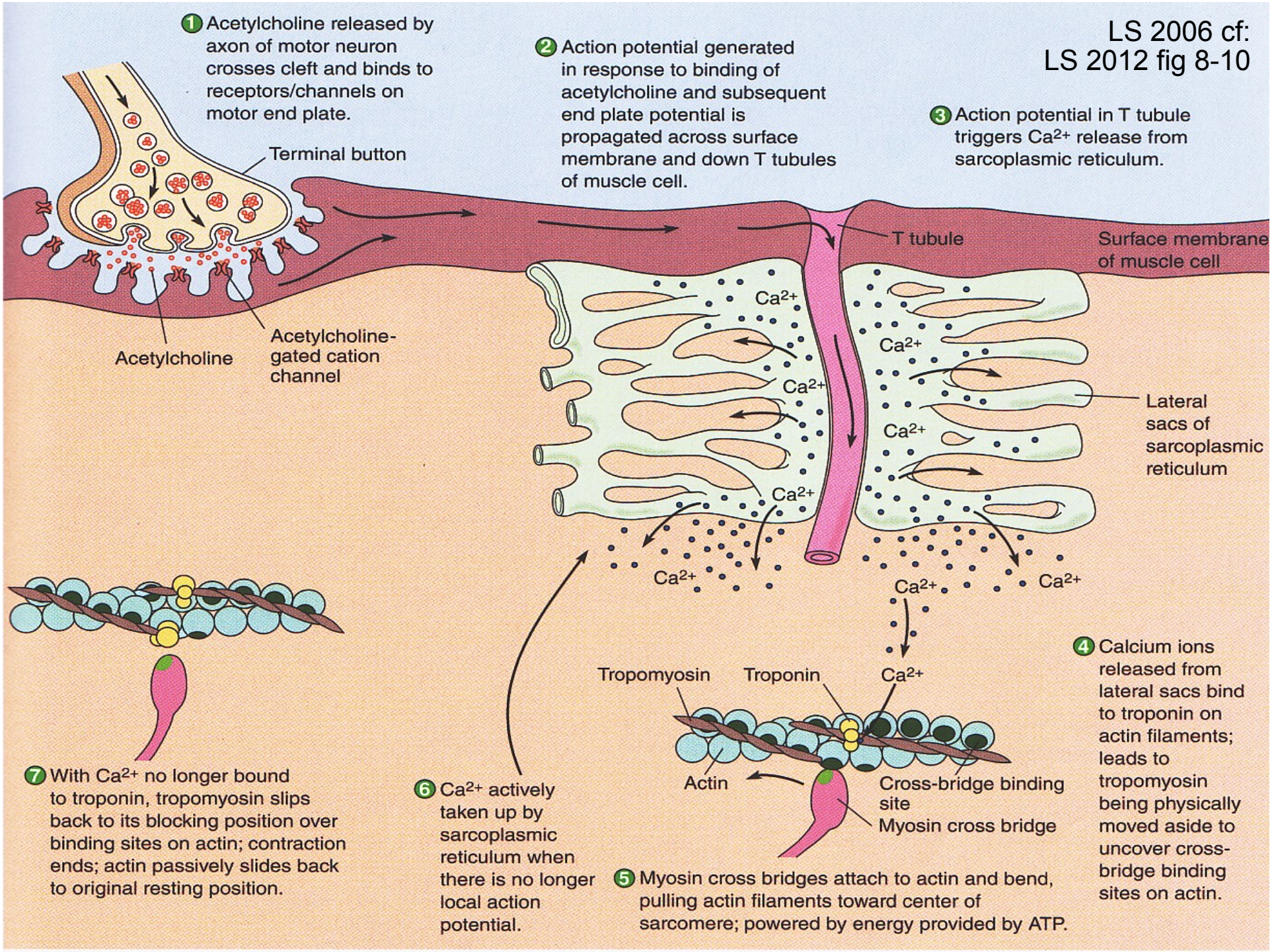
# *Rope Climb or Tug of War*
# *Grasp, then Regrasp!*



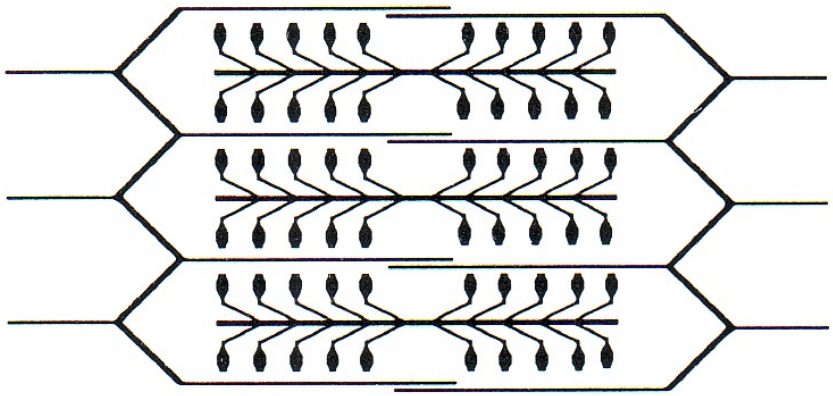

Summary
We are almost there!


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

LS 2006 cf:
LS 2012 fig 8-10

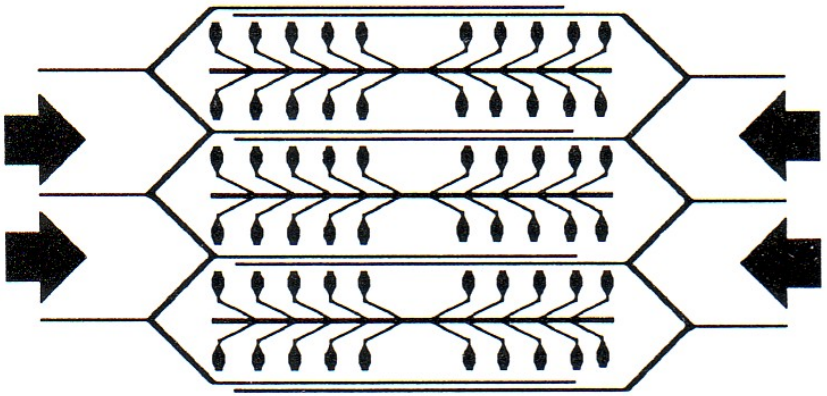


## Relaxation Phase



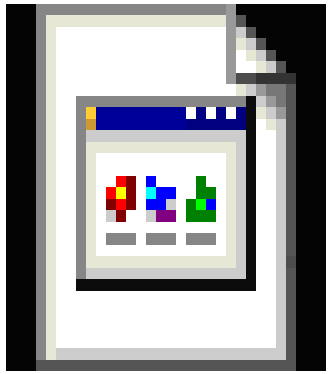
1. Excitation by nerve fiber
2. Conduction by T-tubules
3. $Ca^{2+}$ release by SR

## Contractile Phase



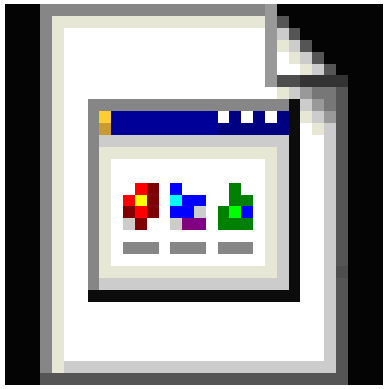
D Liang & VP Lombardi 1989

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



muscleanimation.mov

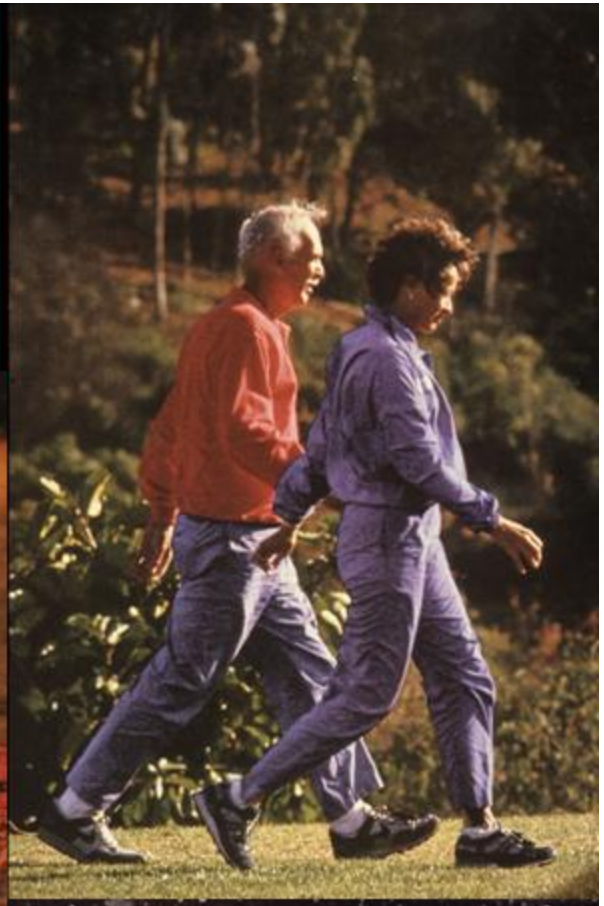
***A. Malcolm Campbell***
***Davidson College, Davidson, NC***
***http://www.bio.davidson.edu/misc/movies/musclcp.mov***



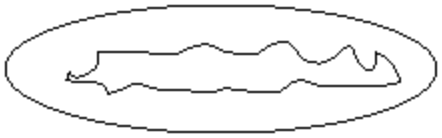
Musclcp.mov

# *Adaptations to Exercise?*

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



AEROBIC w/$O_2$



MITOCHONDRIA

ANAEROBIC

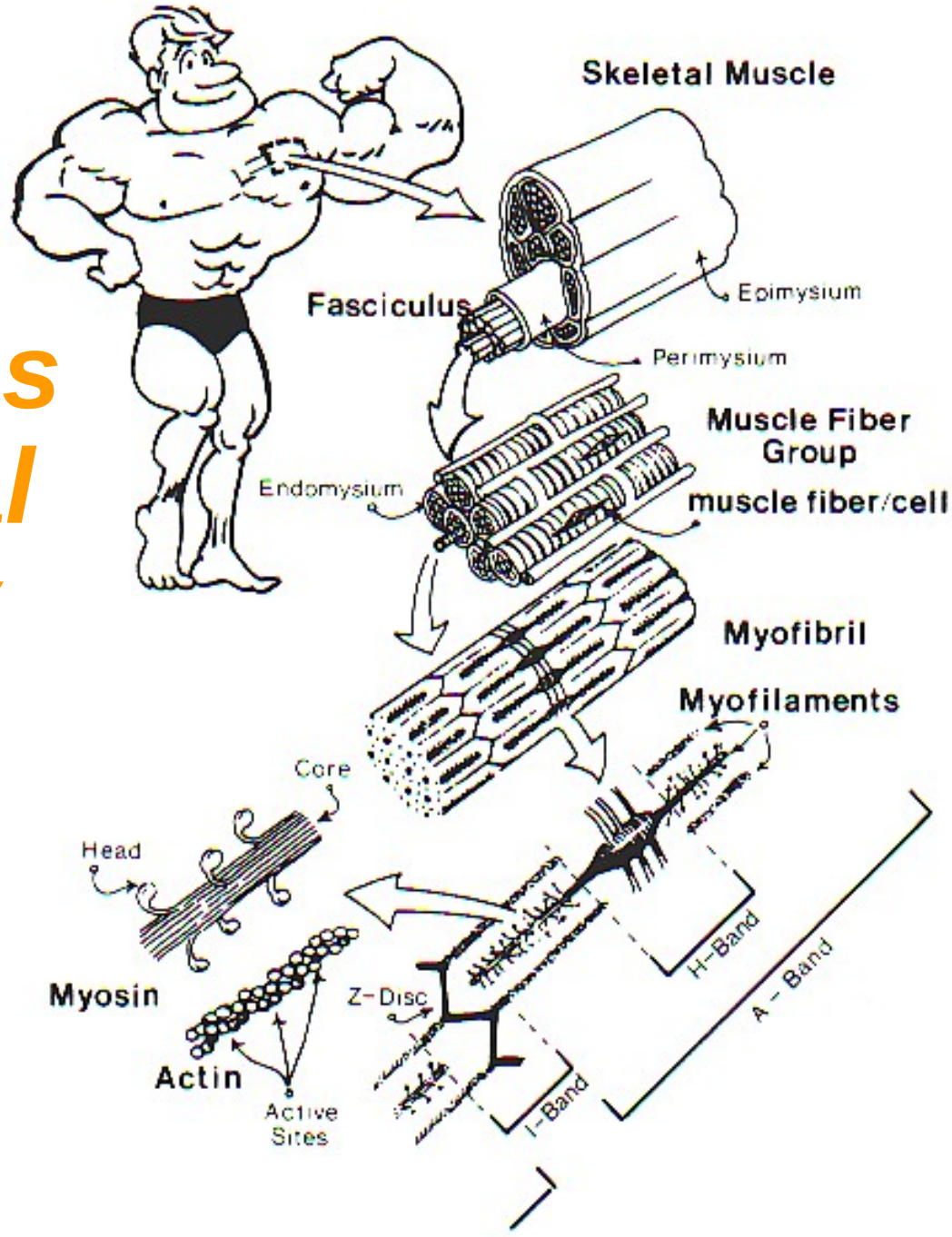
CYTOSOL

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*



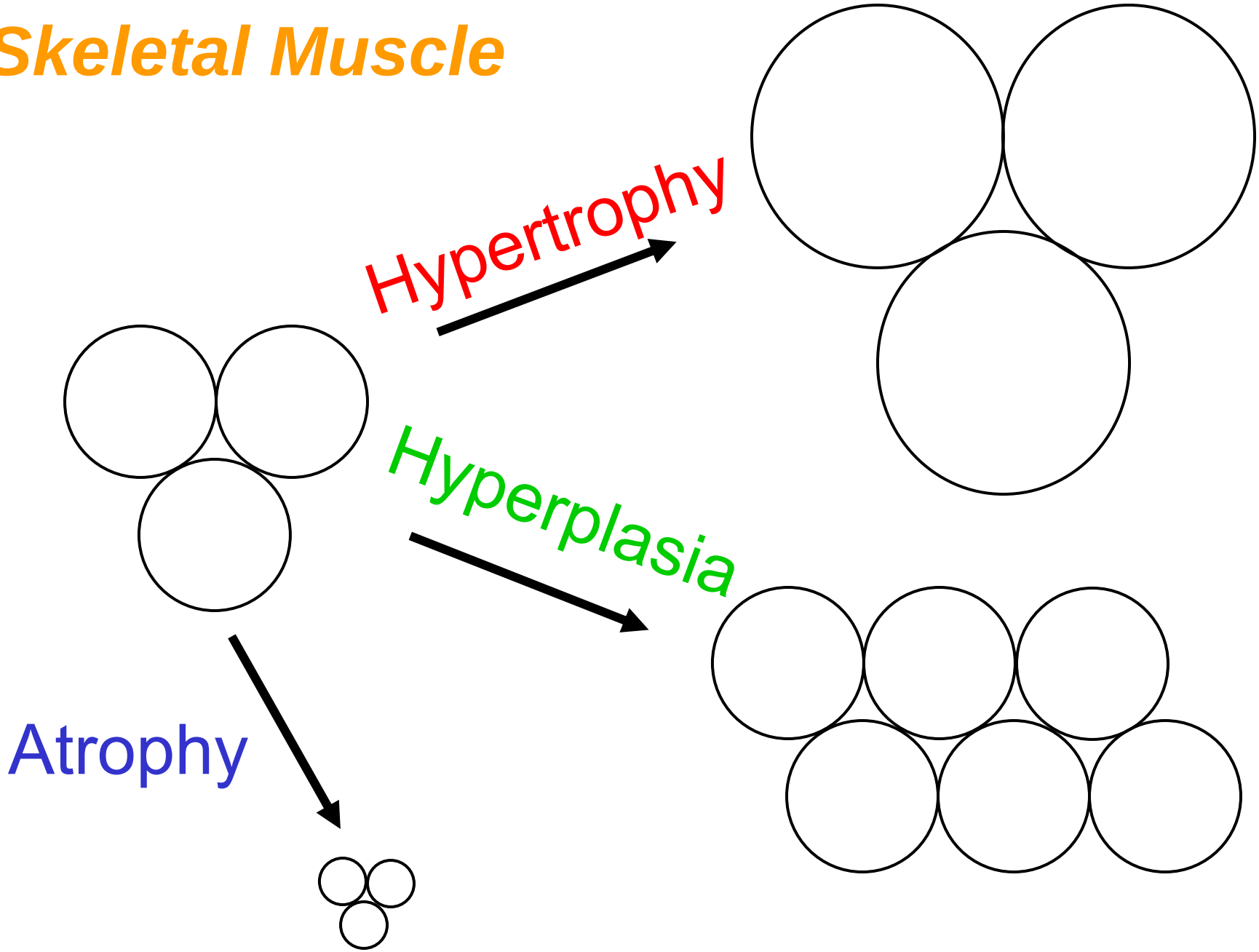

## Atrophy

*decrease in size & strength*

## Hypertrophy

*increase in size & strength*

# *Skeletal Muscle*

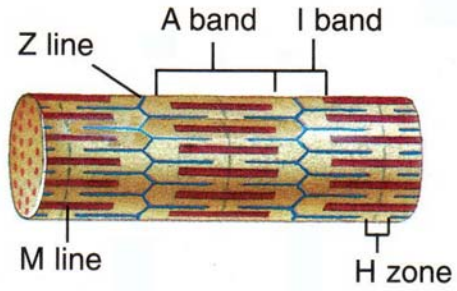


# *Women & Hypertrophy?*

# *What happens in muscles at cellular & subcellular levels?*

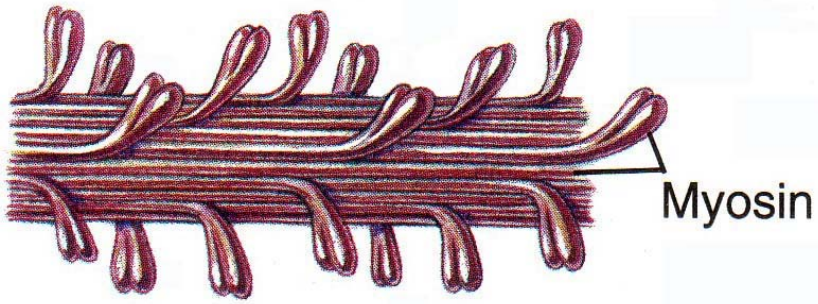
Myofibril

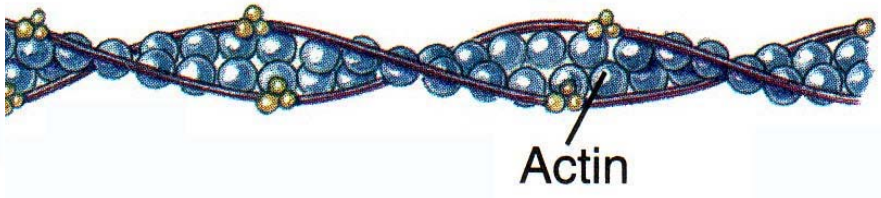
# *Hypertrophy: Increased Number of Myofibrils*

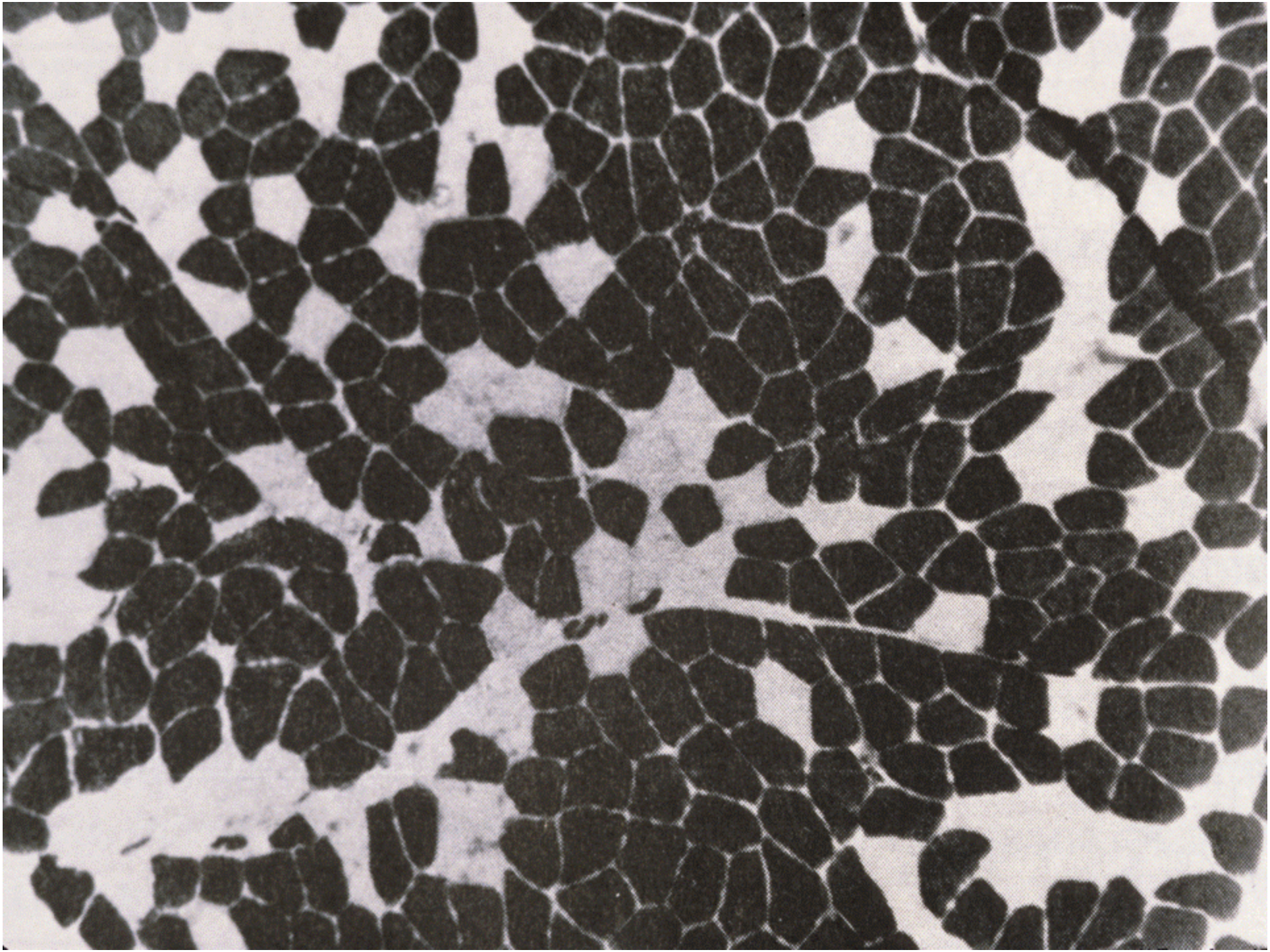



# *Thick & Thin Filaments*

# *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

# *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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