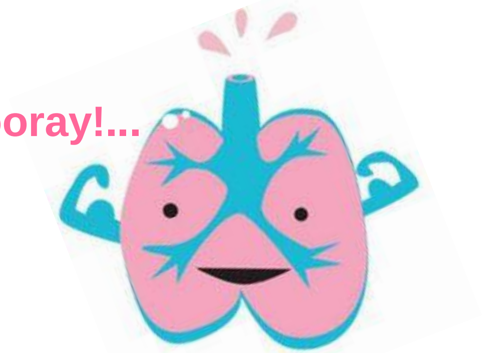
Pulmonary Function Testing today! Hooray!...



BI 121 Lecture 13

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

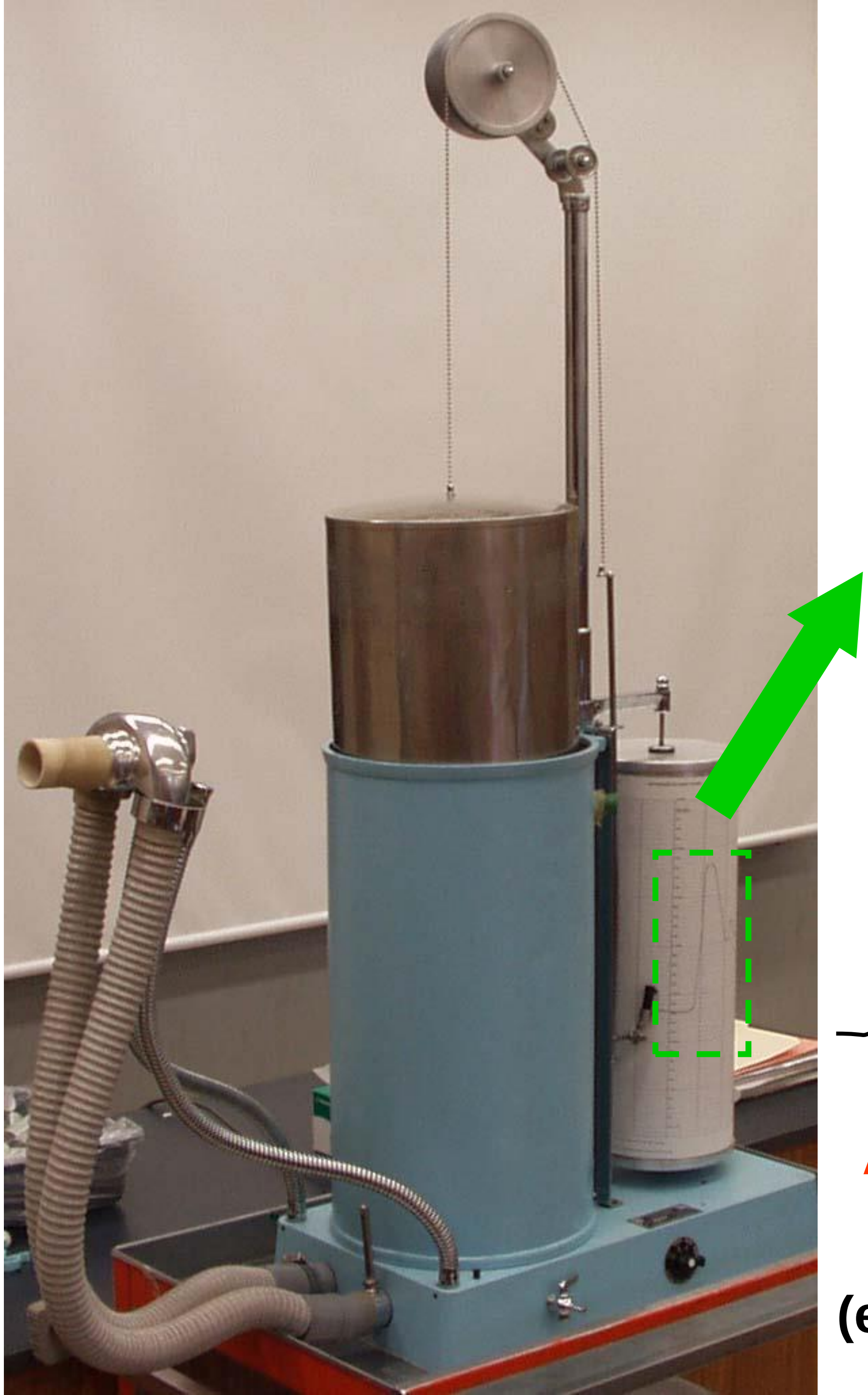
II. ***Pulmonary Function Lab Overview***

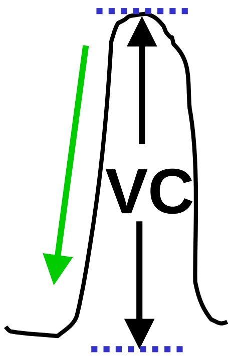
III. ***Muscle Structure, Function & Adaptation*** **LS ch 8, DC Module 12**

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...**

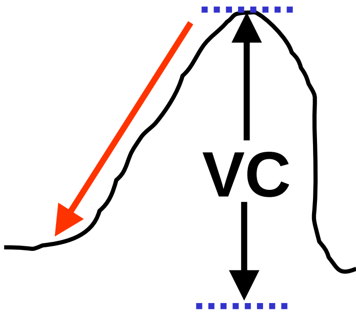
Respirometer → **measures *complete*** ***Pulmonary Function Test or PFT*!**

NB: Should be able to blow out ≥ 75 - 85% of VC/FVC in 1 second! That's $FEV_{1.0}/FVC \geq$ 0.75 – 0.85. If less, may indicate asthma or other lung disease.



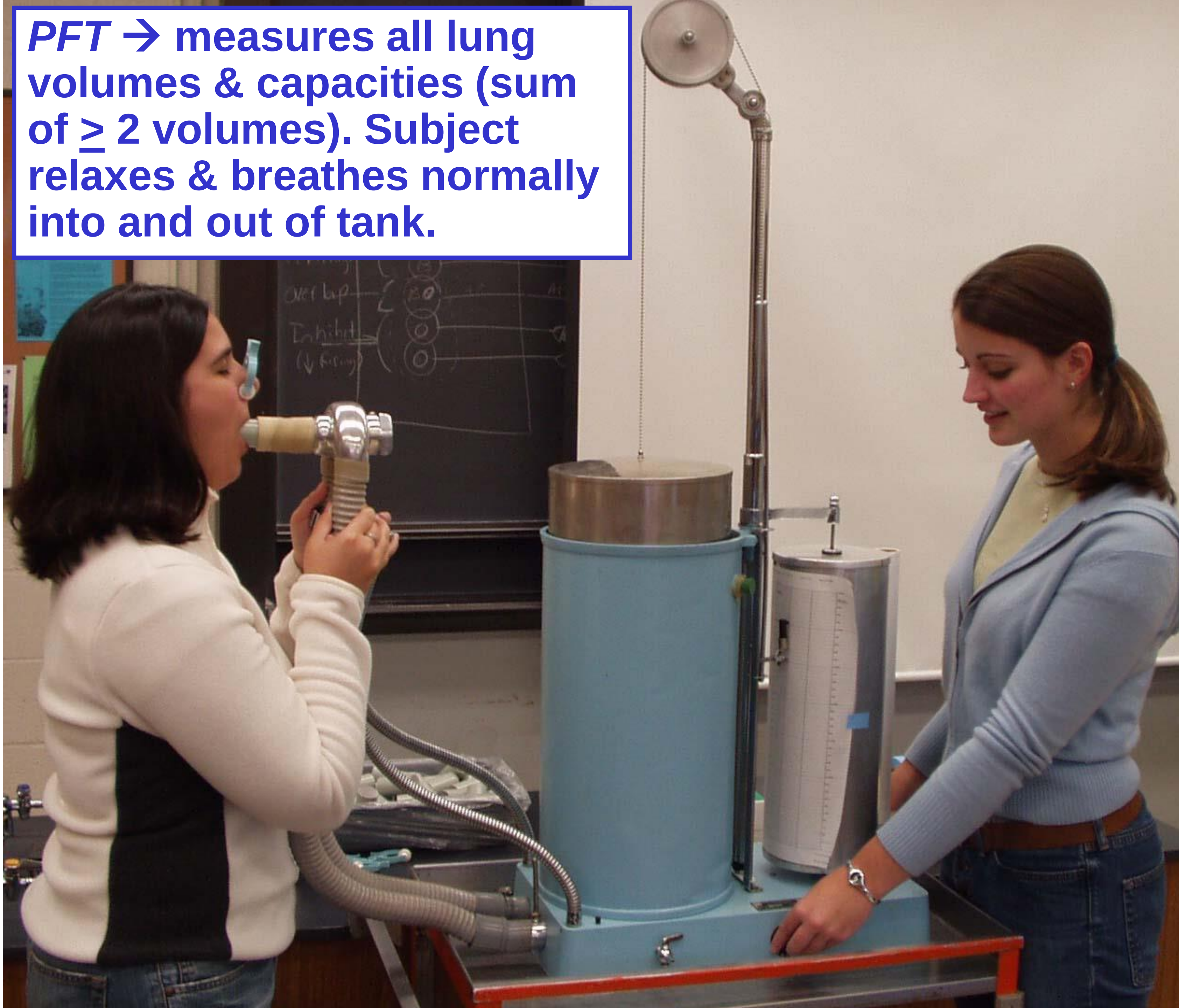


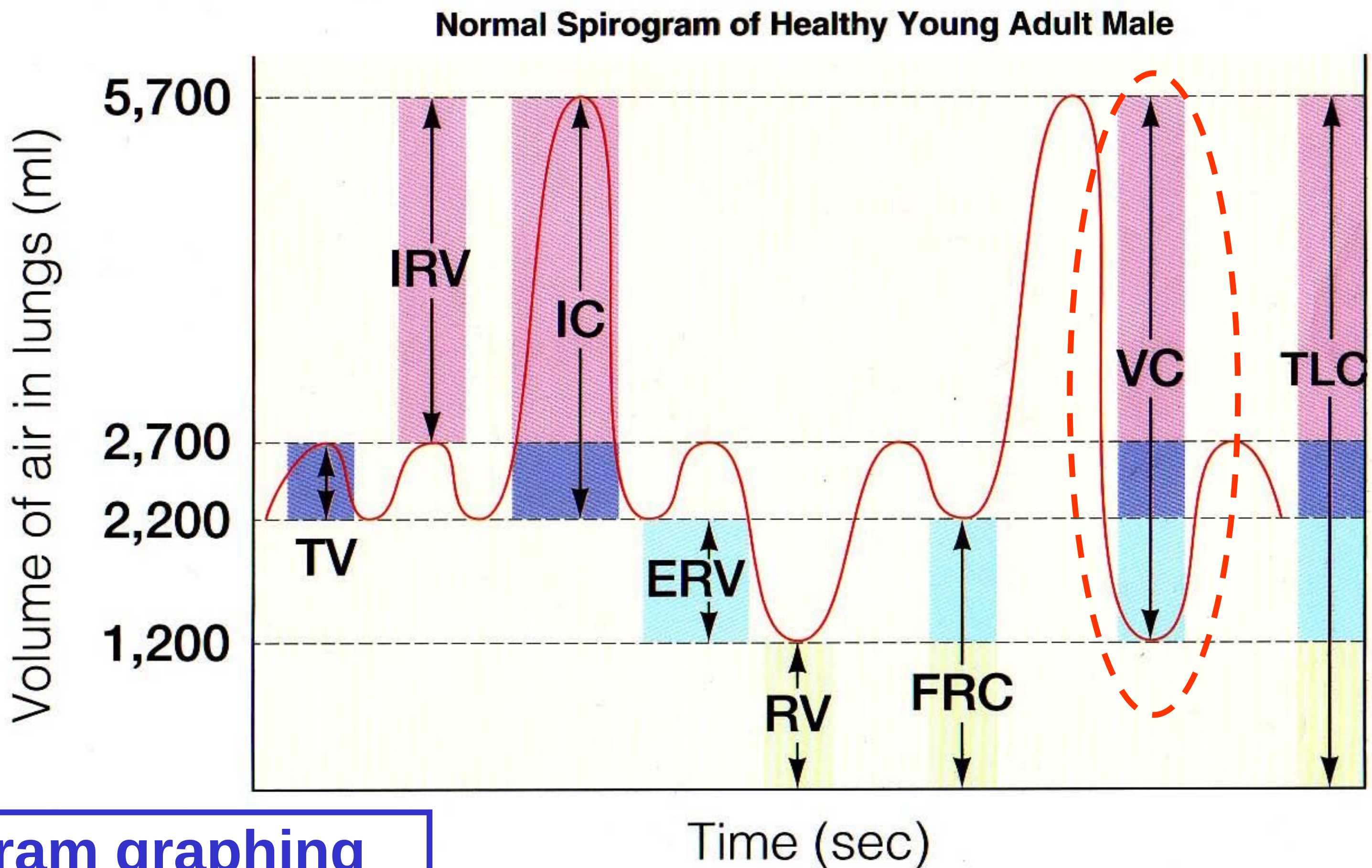
Normal = Steep



Abnormal = Flatter Downslope (eg, Asthma)

***PFT* → measures all lung volumes & capacities (sum of $\geq$ 2 volumes). Subject relaxes & breathes normally into and out of tank.**



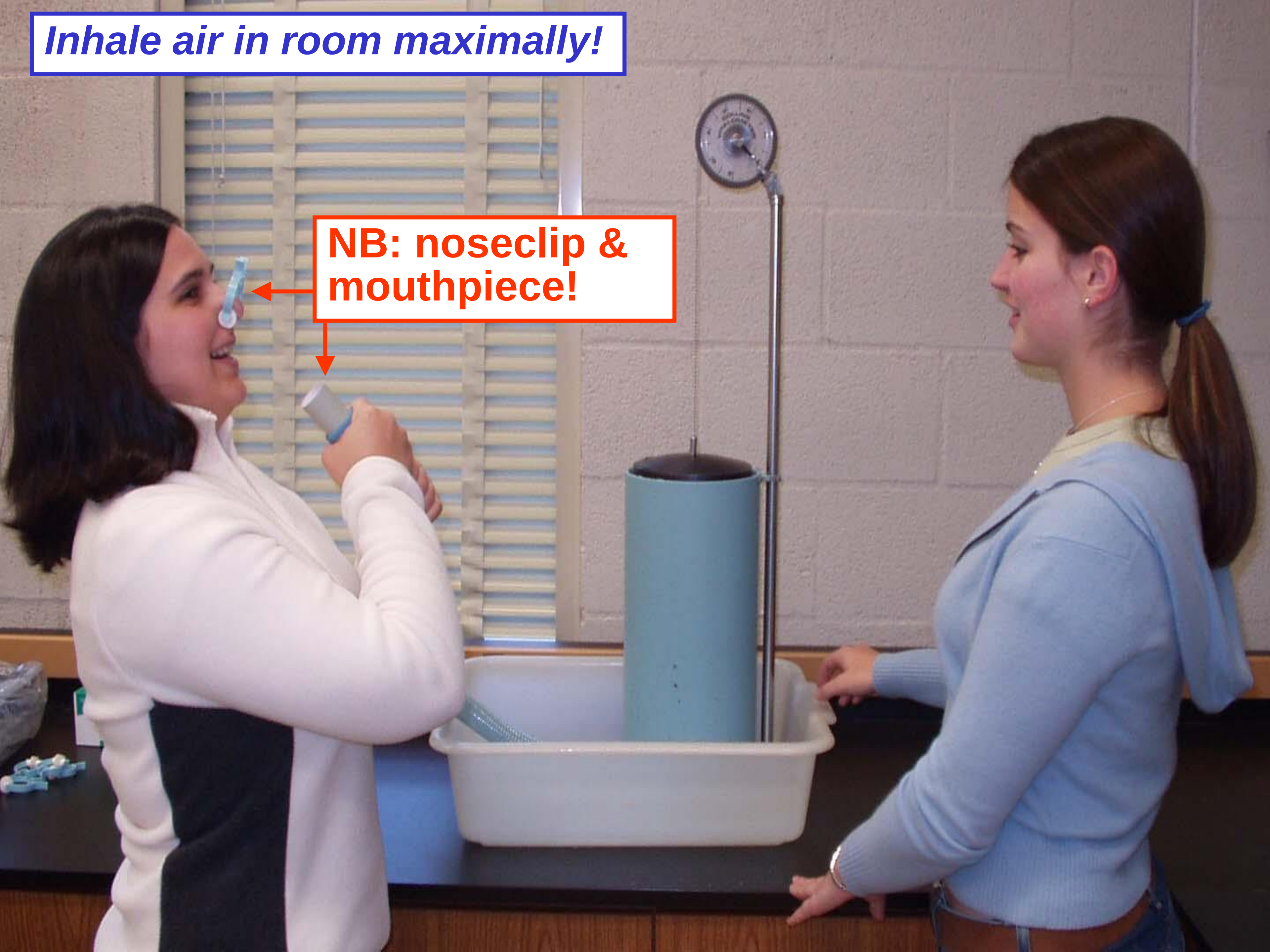


Spirogram graphing complete *PFT* from computer simulation.

TV = Tidal volume (500 ml)
IRV = Inspiratory reserve volume (3,000 ml)
IC = Inspiratory capacity (3,500 ml)
ERV = Expiratory reserve volume (1,000 ml)
RV = Residual volume (1,200 ml)
FRC = Functional residual capacity (2,200 ml)
VC = Vital capacity (4,500 ml)
TLC = Total lung capacity (5,700 ml)

***Vitalometer* → Can only measure Vital Capacity (VC). No graph paper, so no time component.**

Inhale air in room maximally!



Exhale into tube maximally!

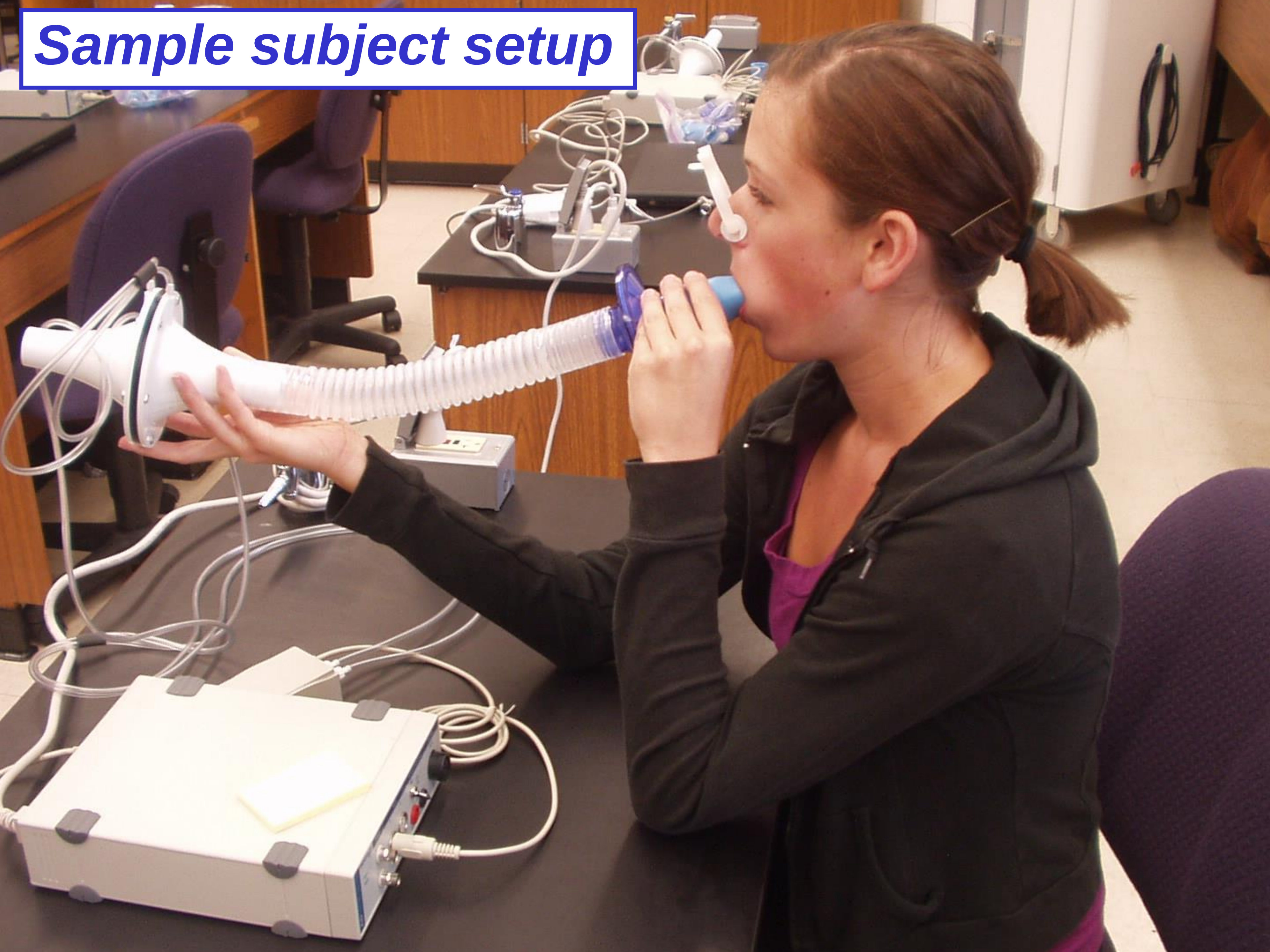
More modern-day computerized Pulmonary Function Testing

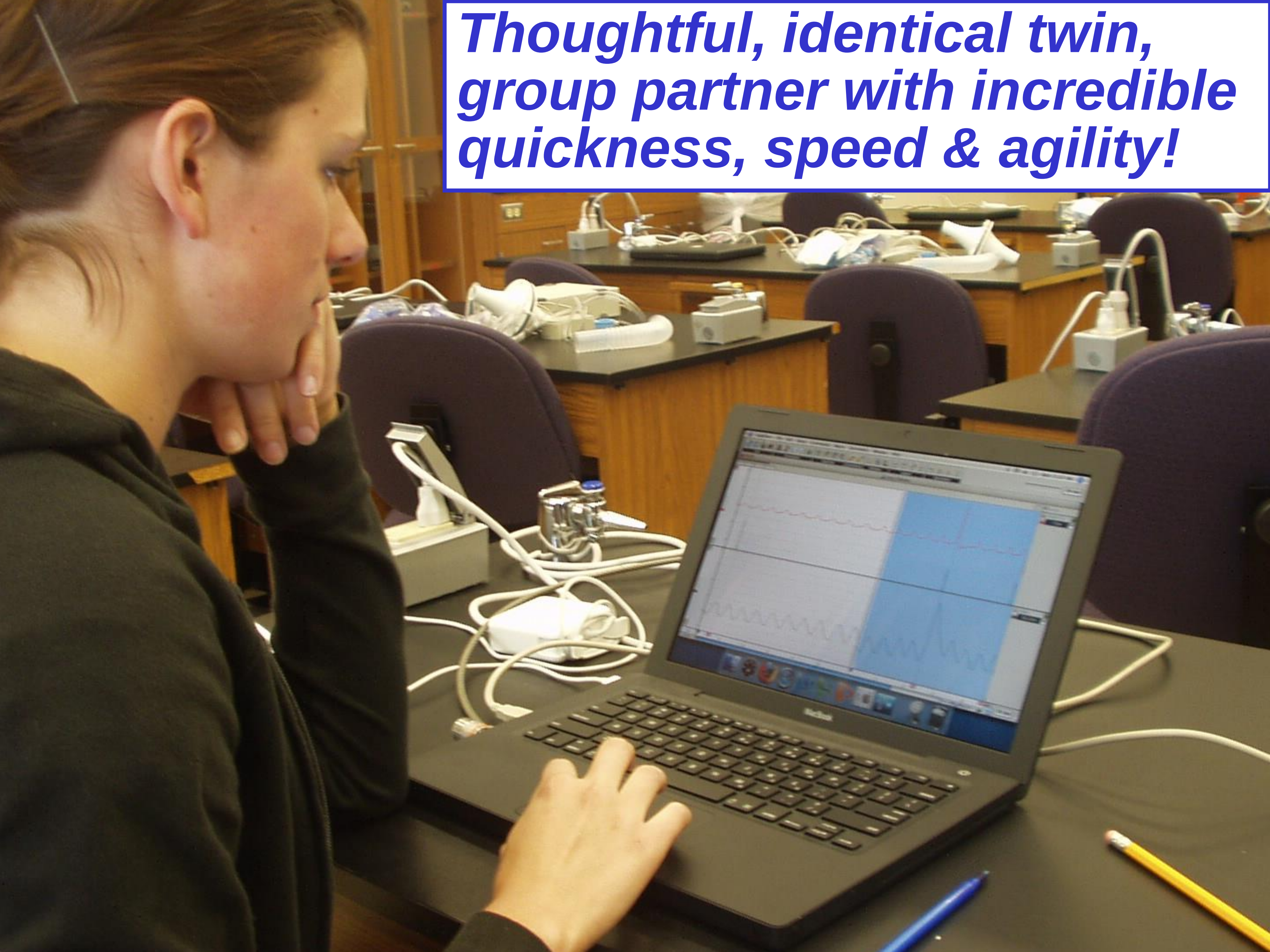
Complete with HH! Happy Helpers!


How to put together?

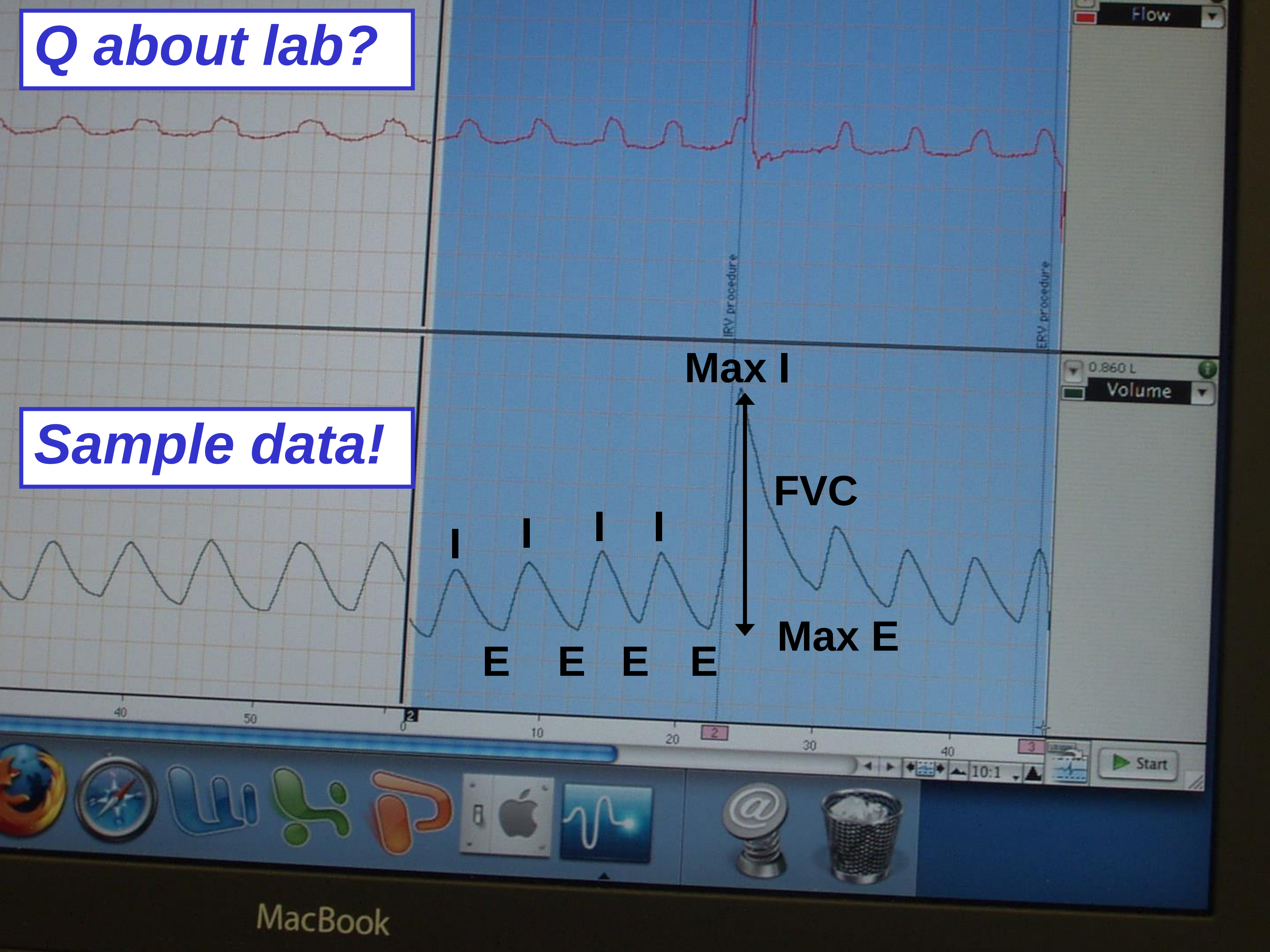

Viola!!

Sample subject setup



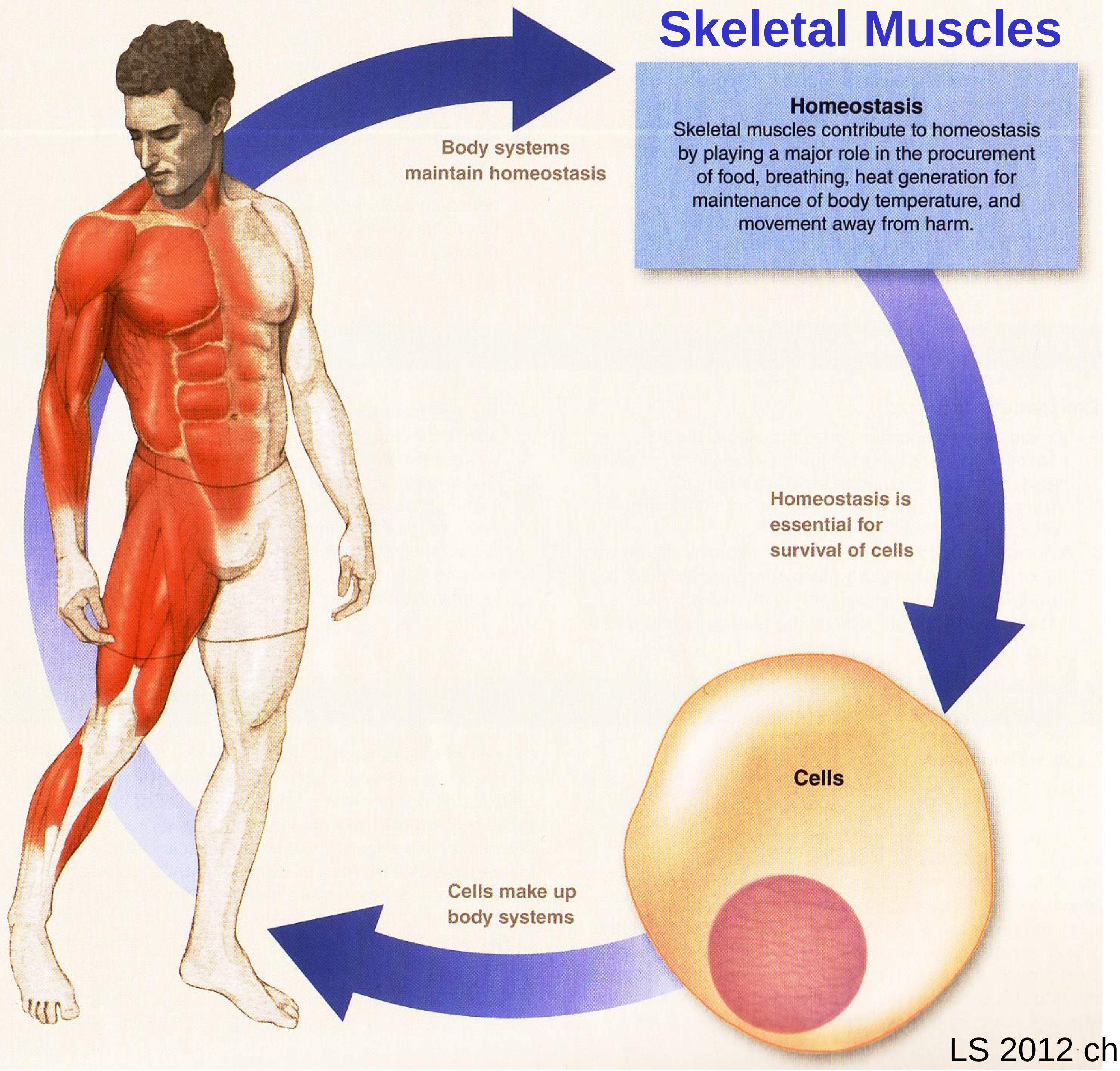


Thoughtful, identical twin, group partner with incredible quickness, speed & agility!

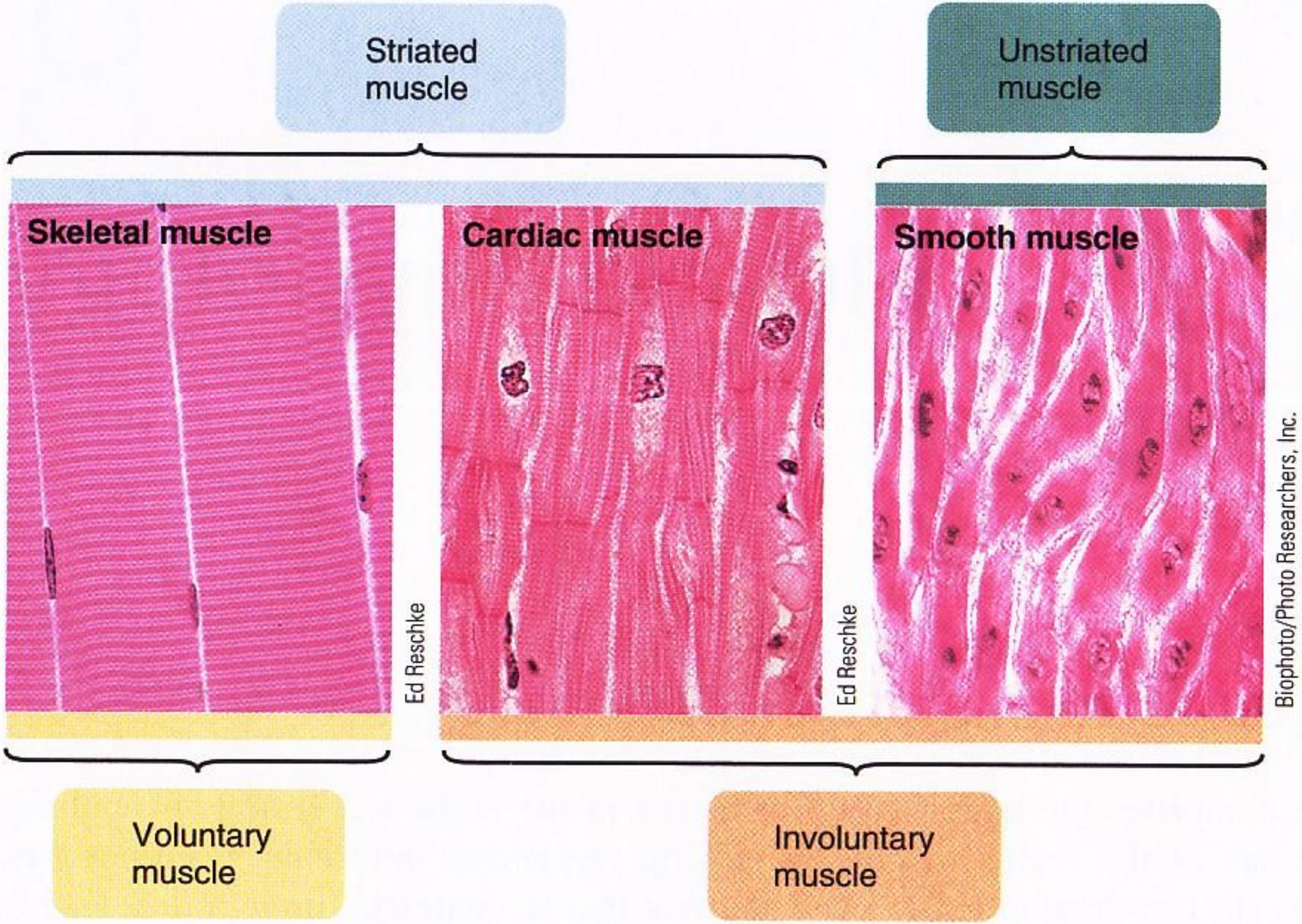


Q about lab?
Sample data!
Flow
IRV procedure
ERV procedure
0.860 L
Volume
Max I
FVC
I
I
I
I
E
E
E
E
Max E
40
50
0
10
20
30
40
2
2
3
10:1
Start
MacBook

Skeletal Muscles

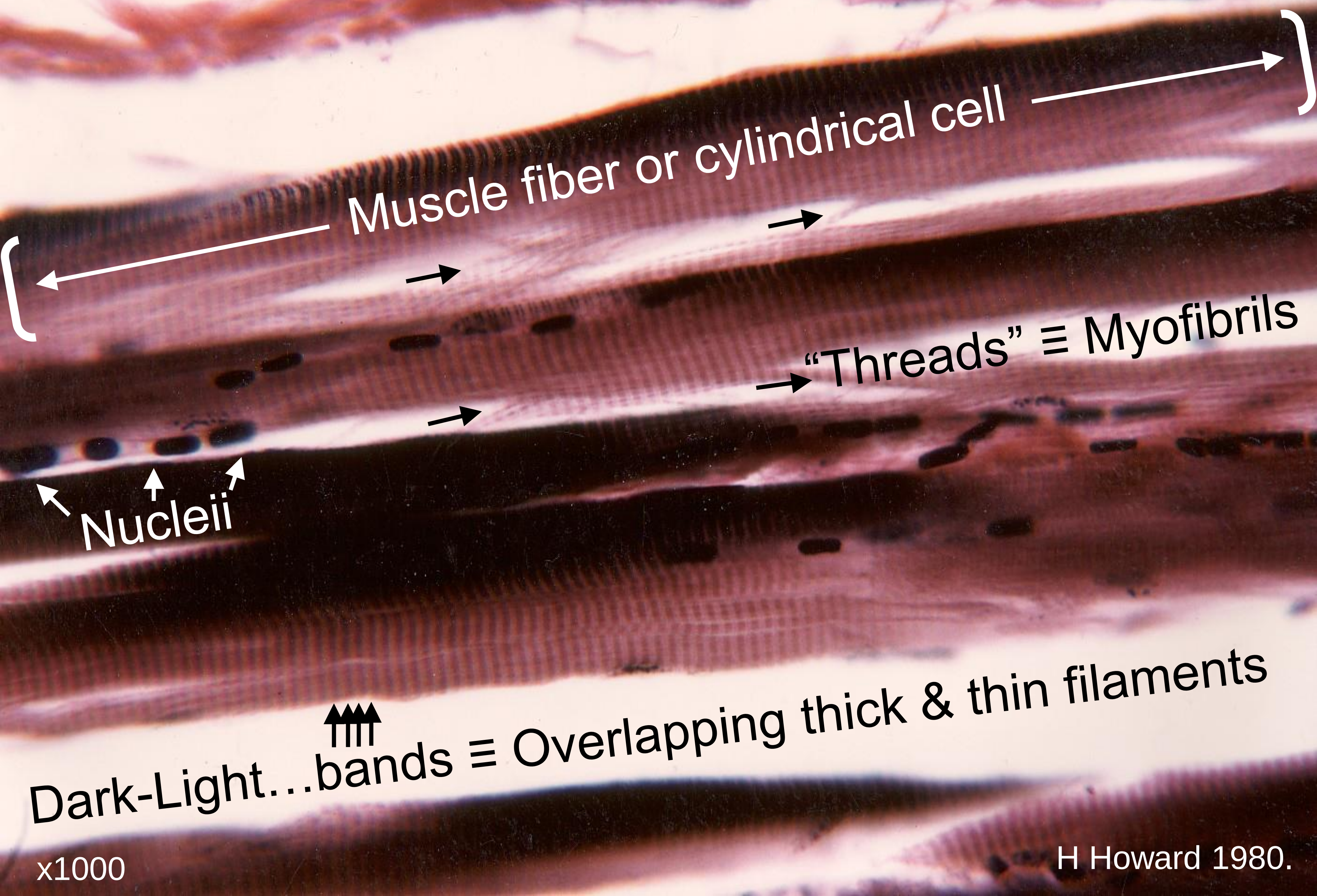


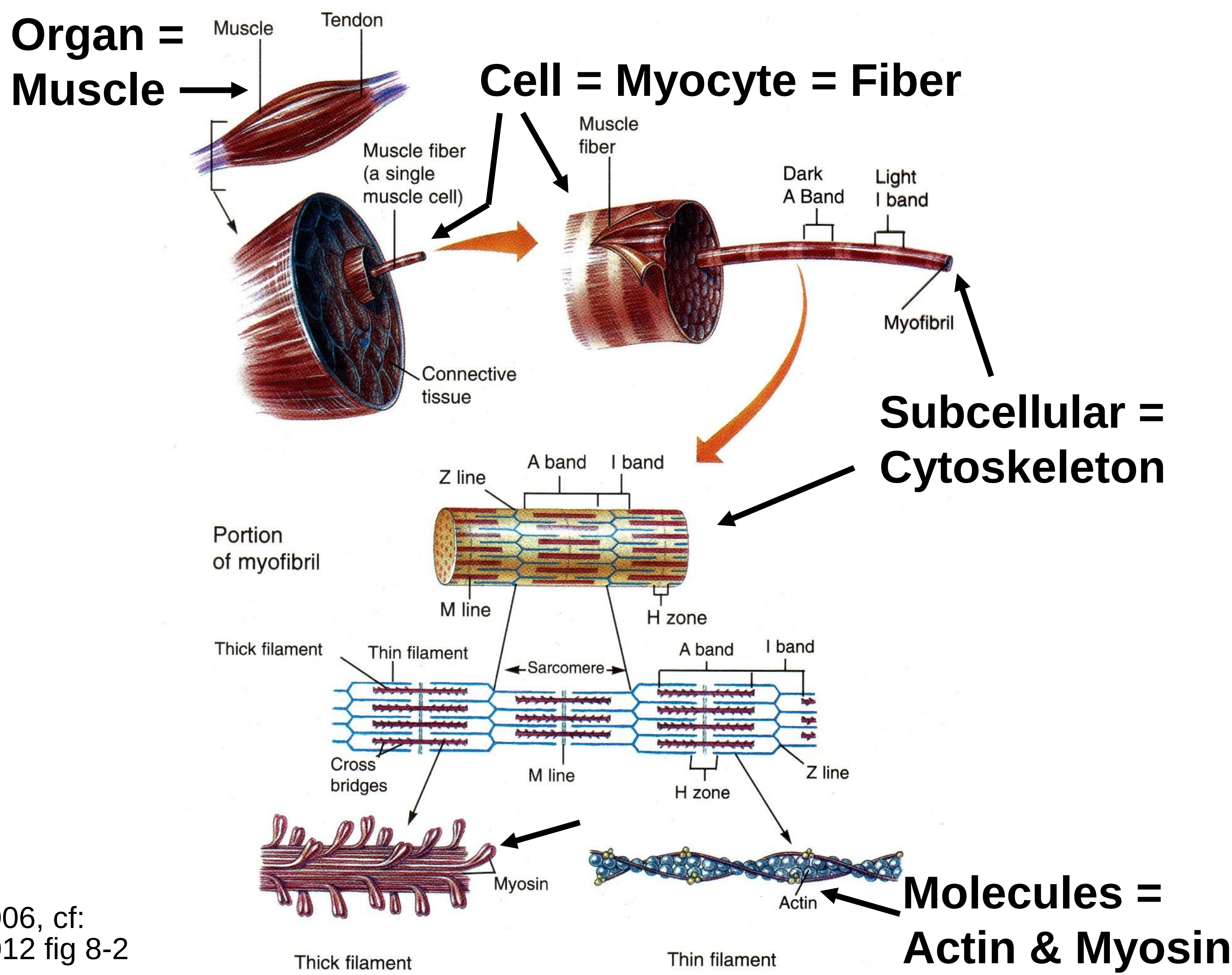
LS 2012 ch 8 vignette



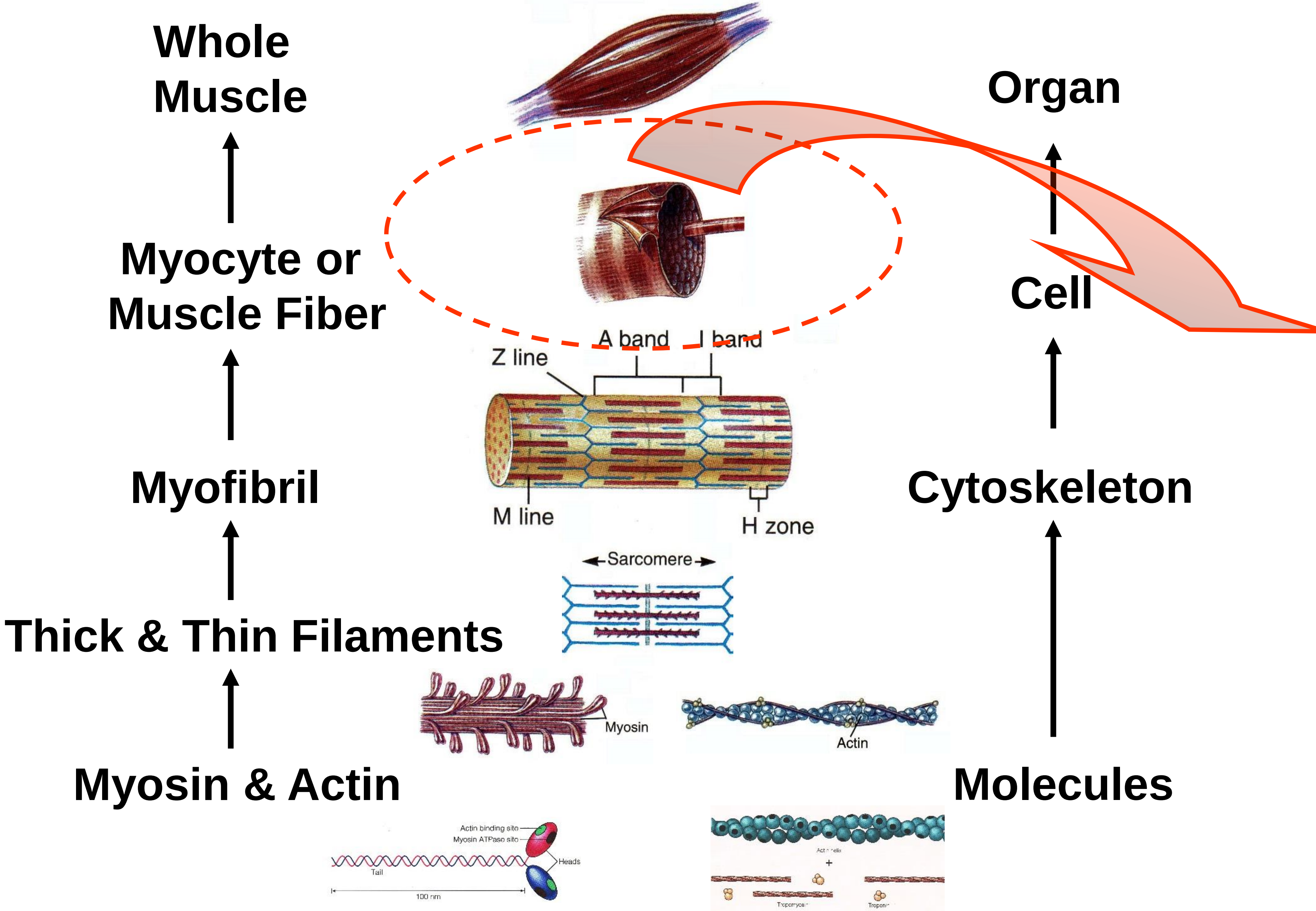
LS 2012 fig 8-1

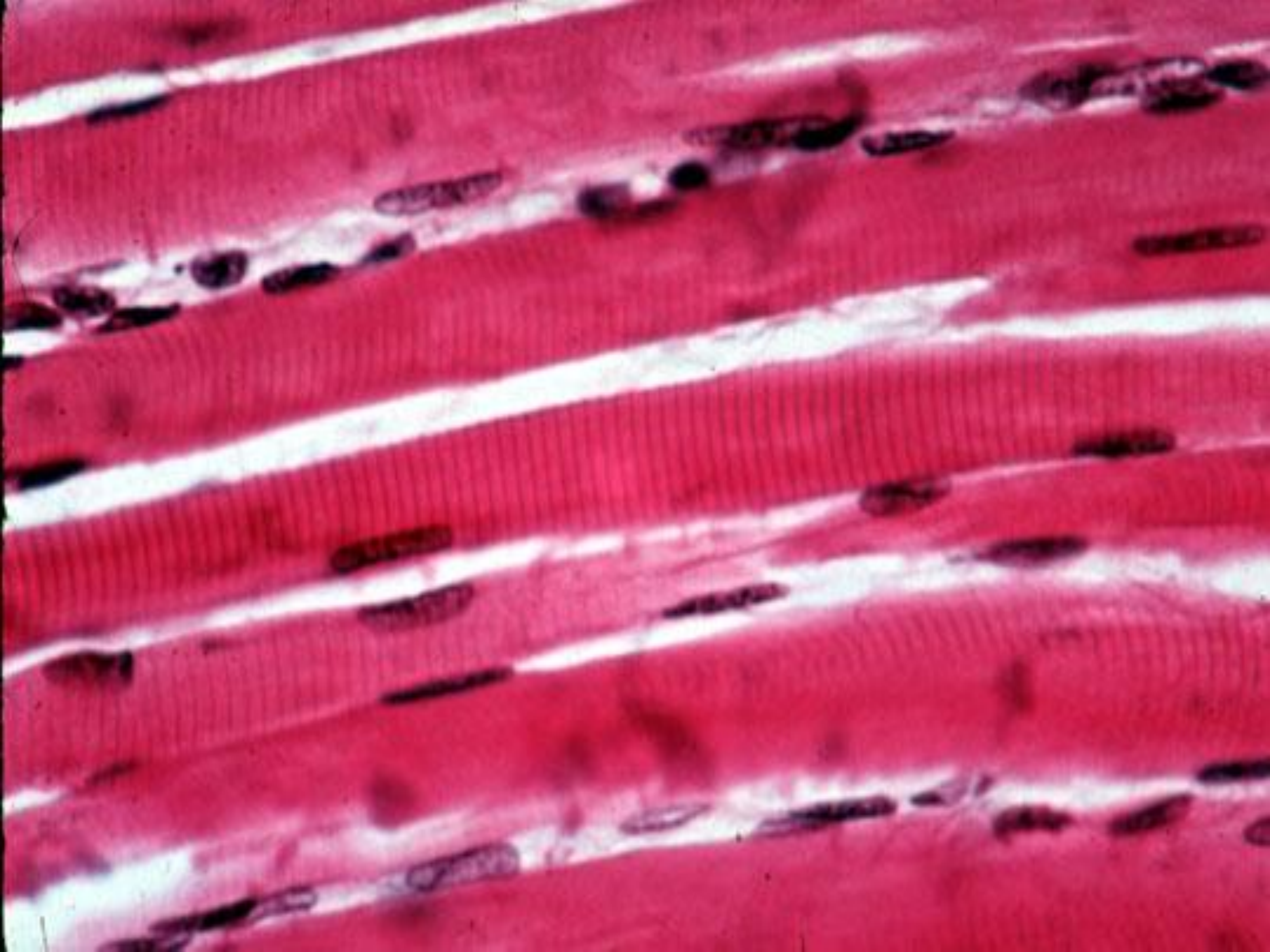
Skeletal Muscle Histology: Microscopic Anatomy

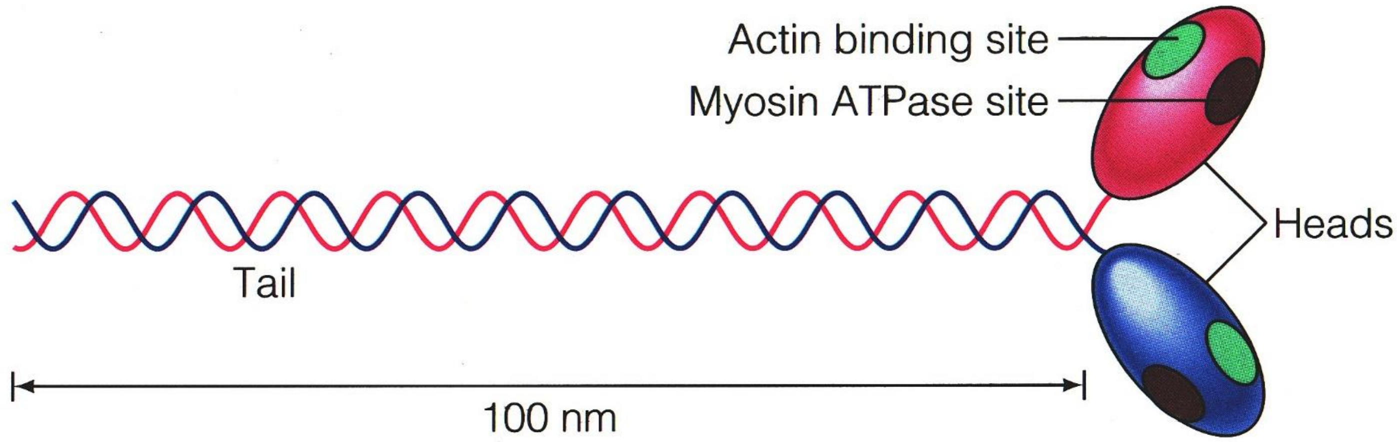




LS 2006, cf:
LS 2012 fig 8-2

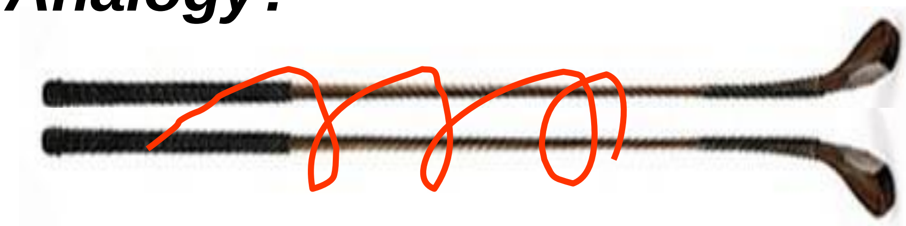

Whole Muscle
Myocyte or Muscle Fiber
Myofibril
Thick & Thin Filaments
Myosin & Actin
Organ
Cell
Cytoskeleton
Molecules
Z line
A band
I band
M line
H zone
Sarcomere
Myosin
Actin
Actin binding site
Myosin ATPase site
Heads
Tail
100 nm

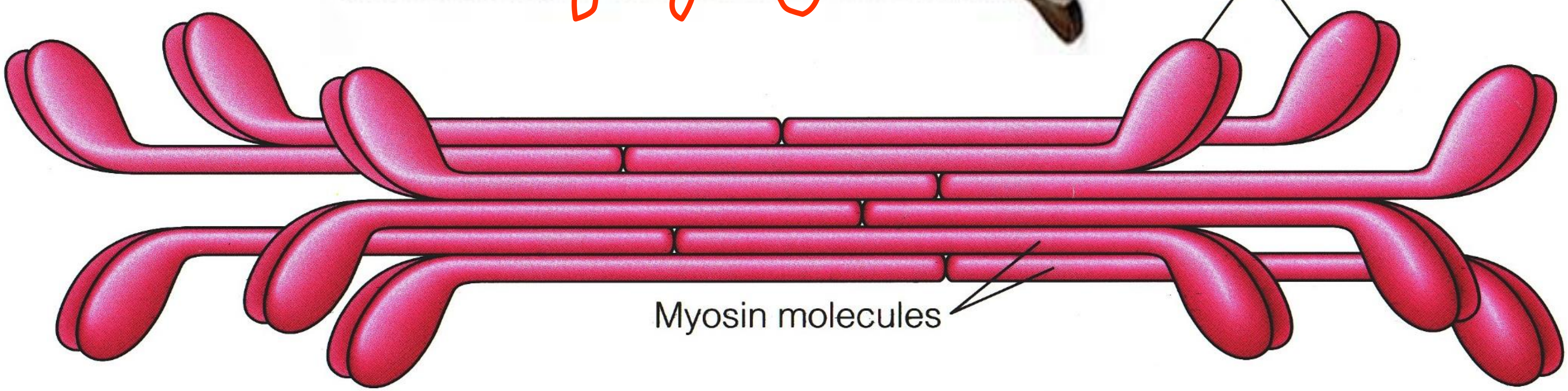




(a)

Golf Club Analogy?

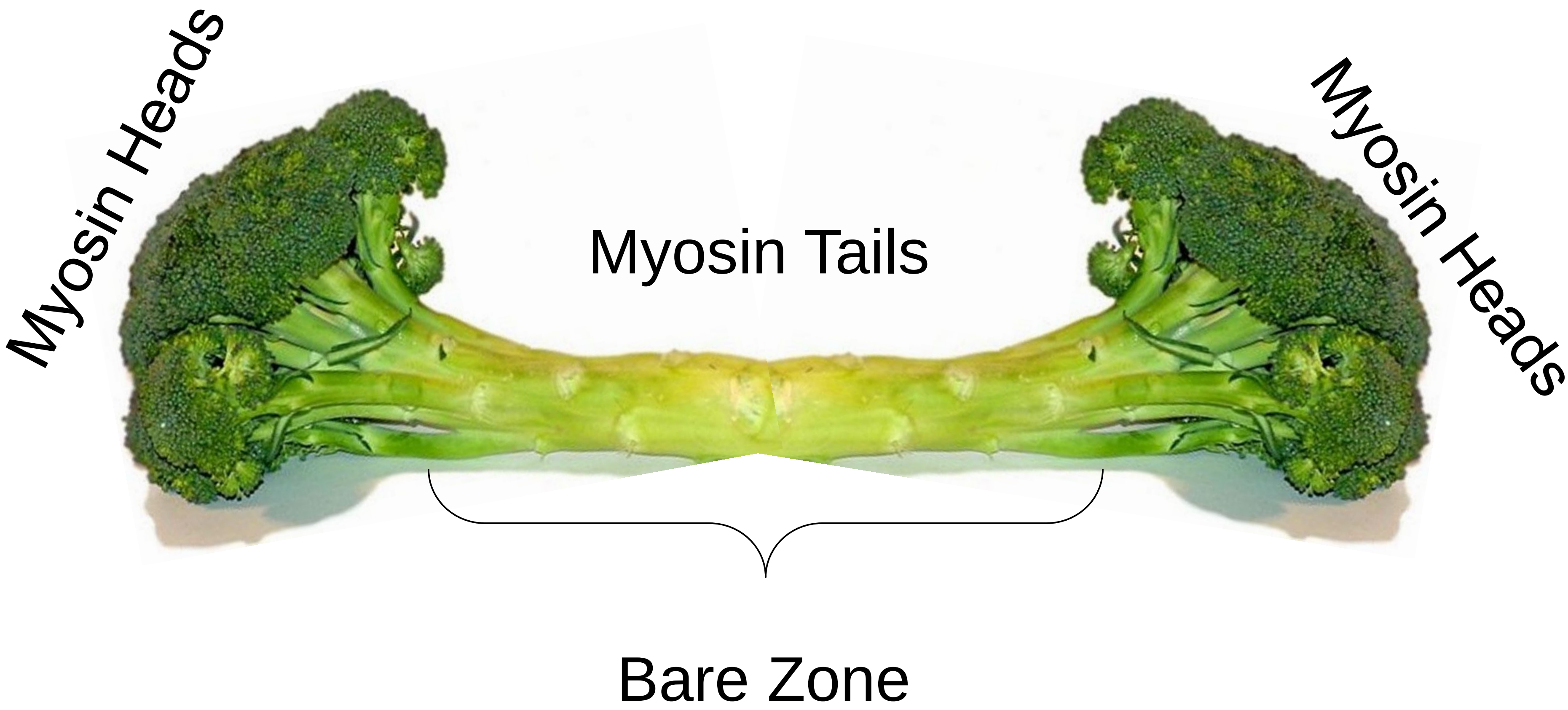


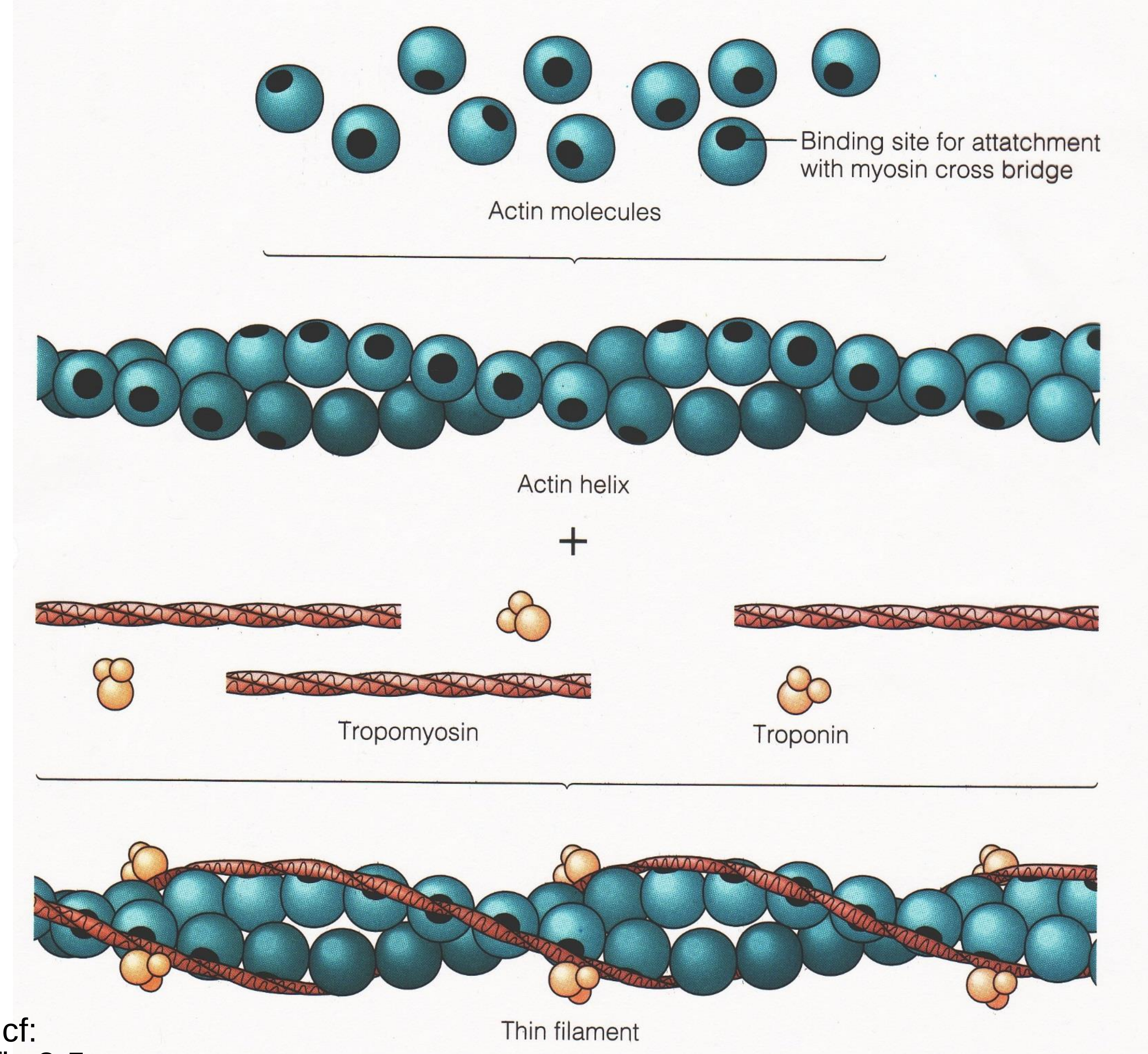


(b)

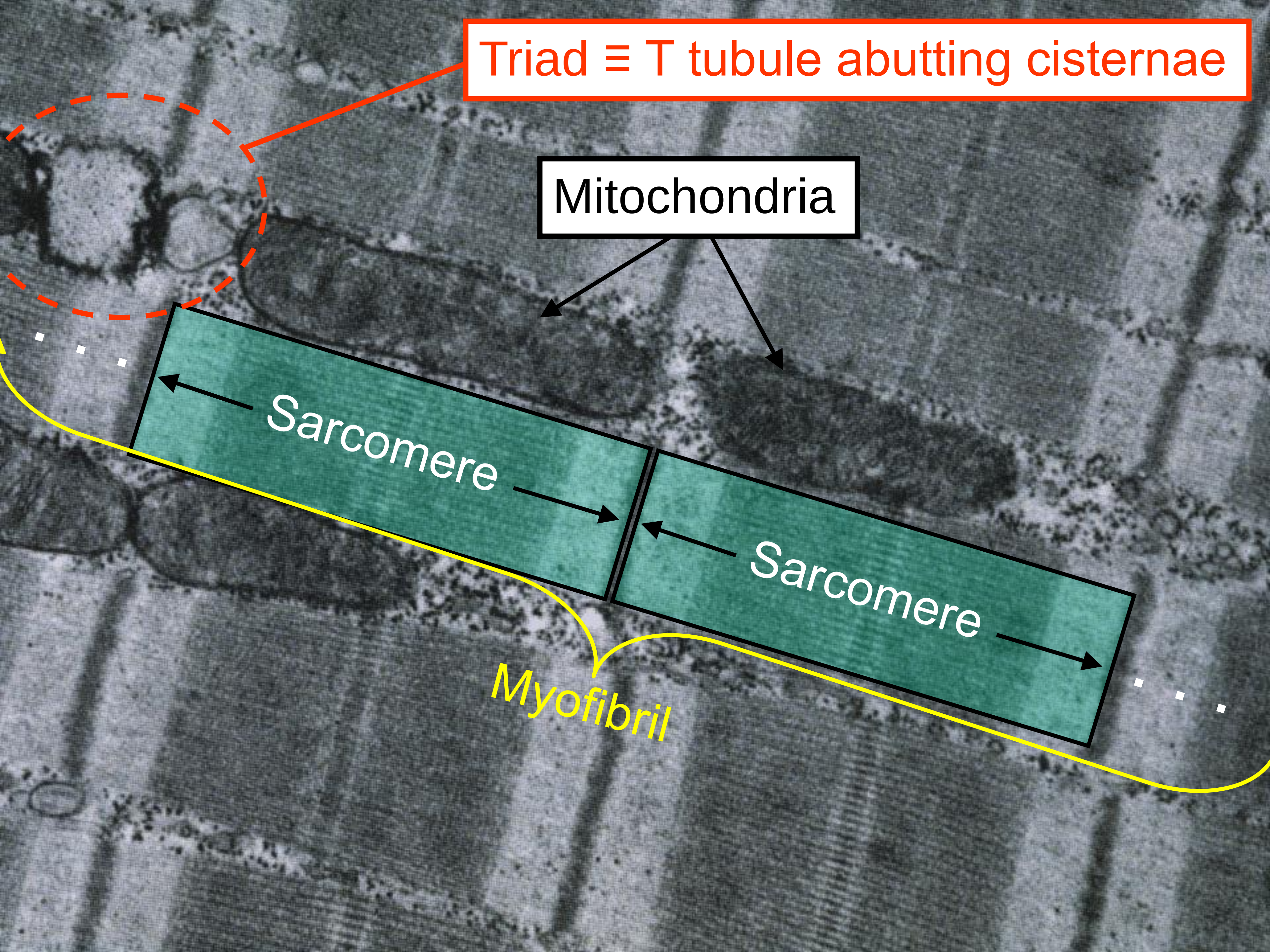
LS 2006, cf:
LS 2012 fig 8-4

Broccoli Analogy?

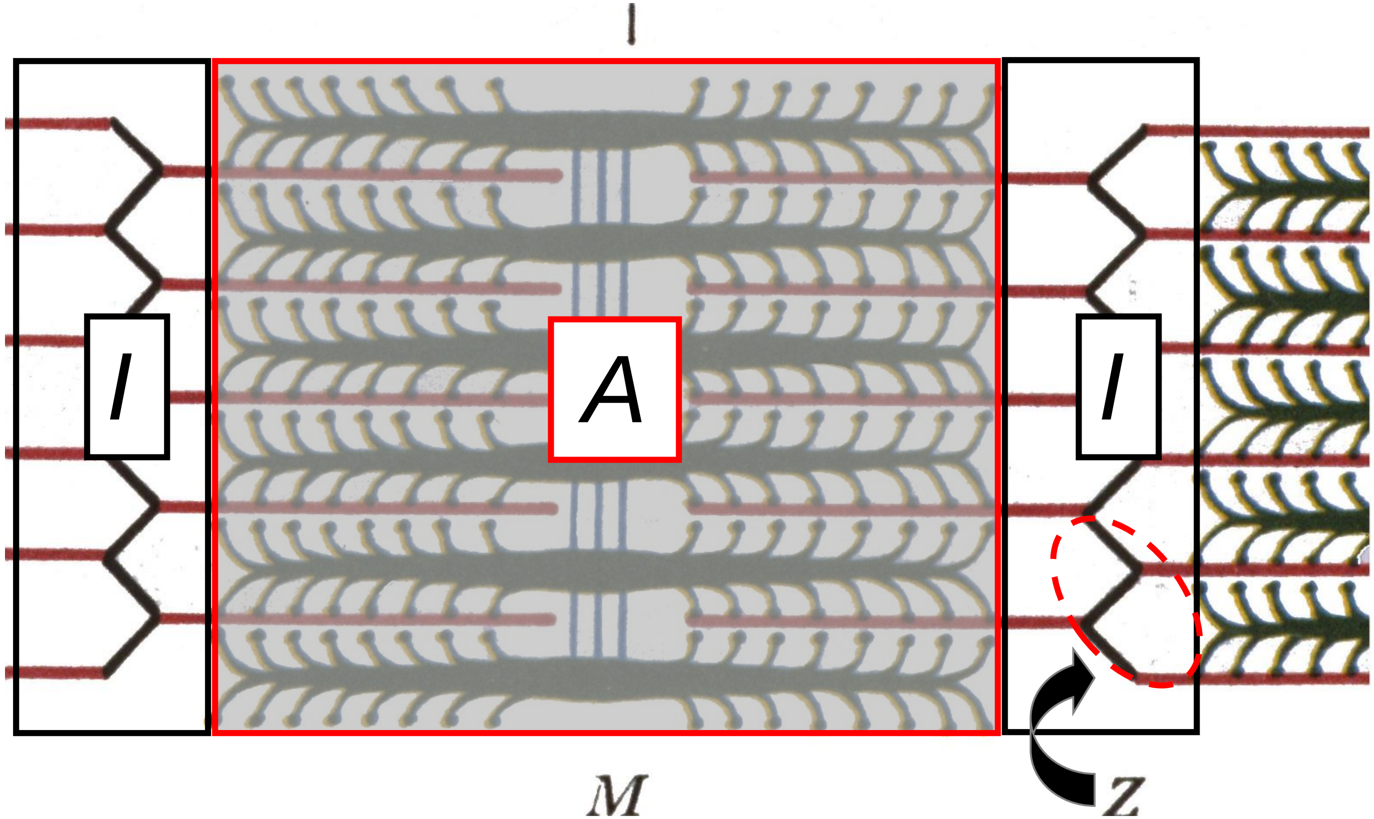




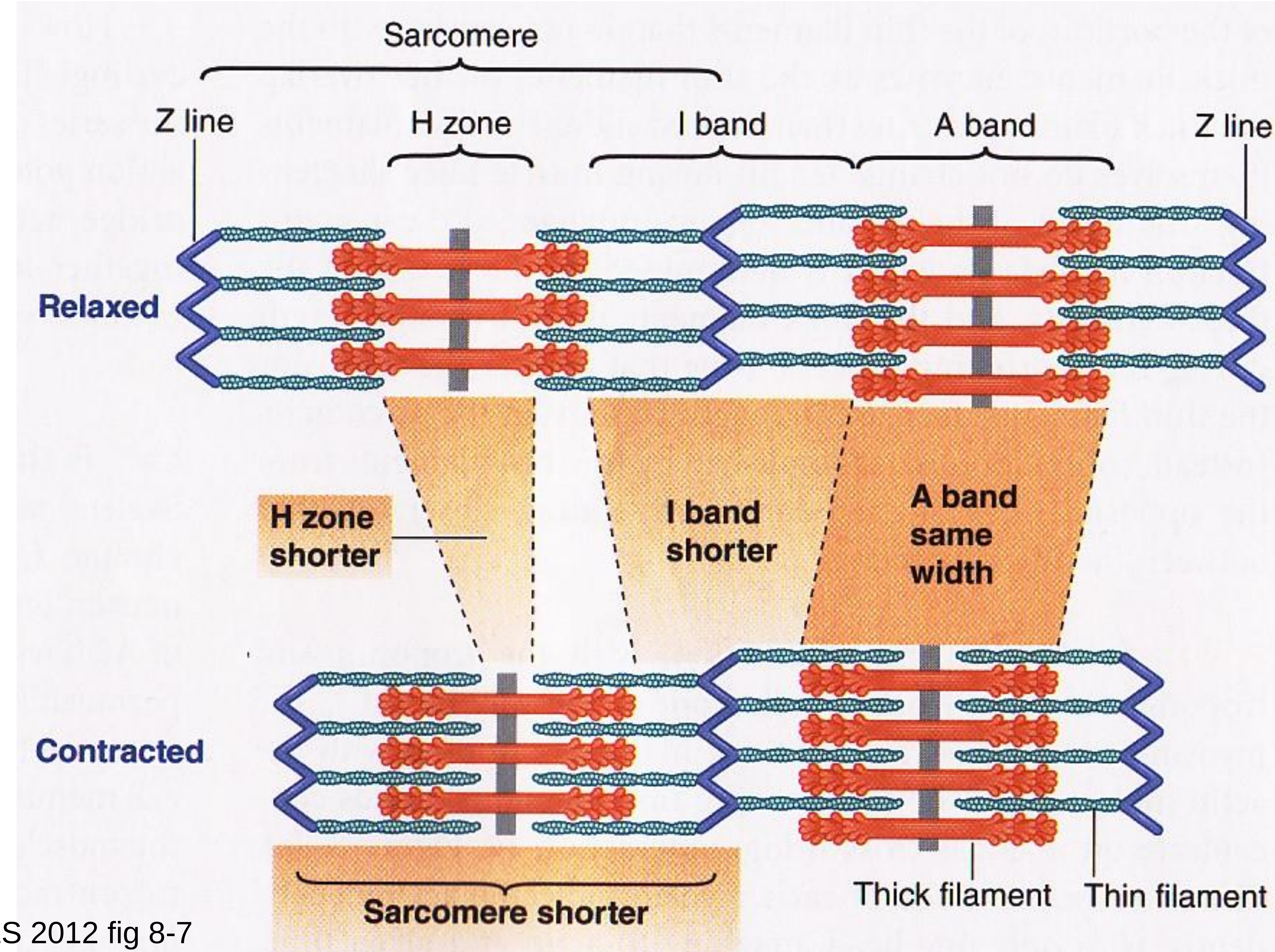
LS 2006, cf:
LS 2012 fig 8-5


Triad ≡ T tubule abutting cisternae
Mitochondria
Sarcomere
Sarcomere
Myofibril

A Band = Dark Band
*A*nisotropic = Light Can't Shine Through



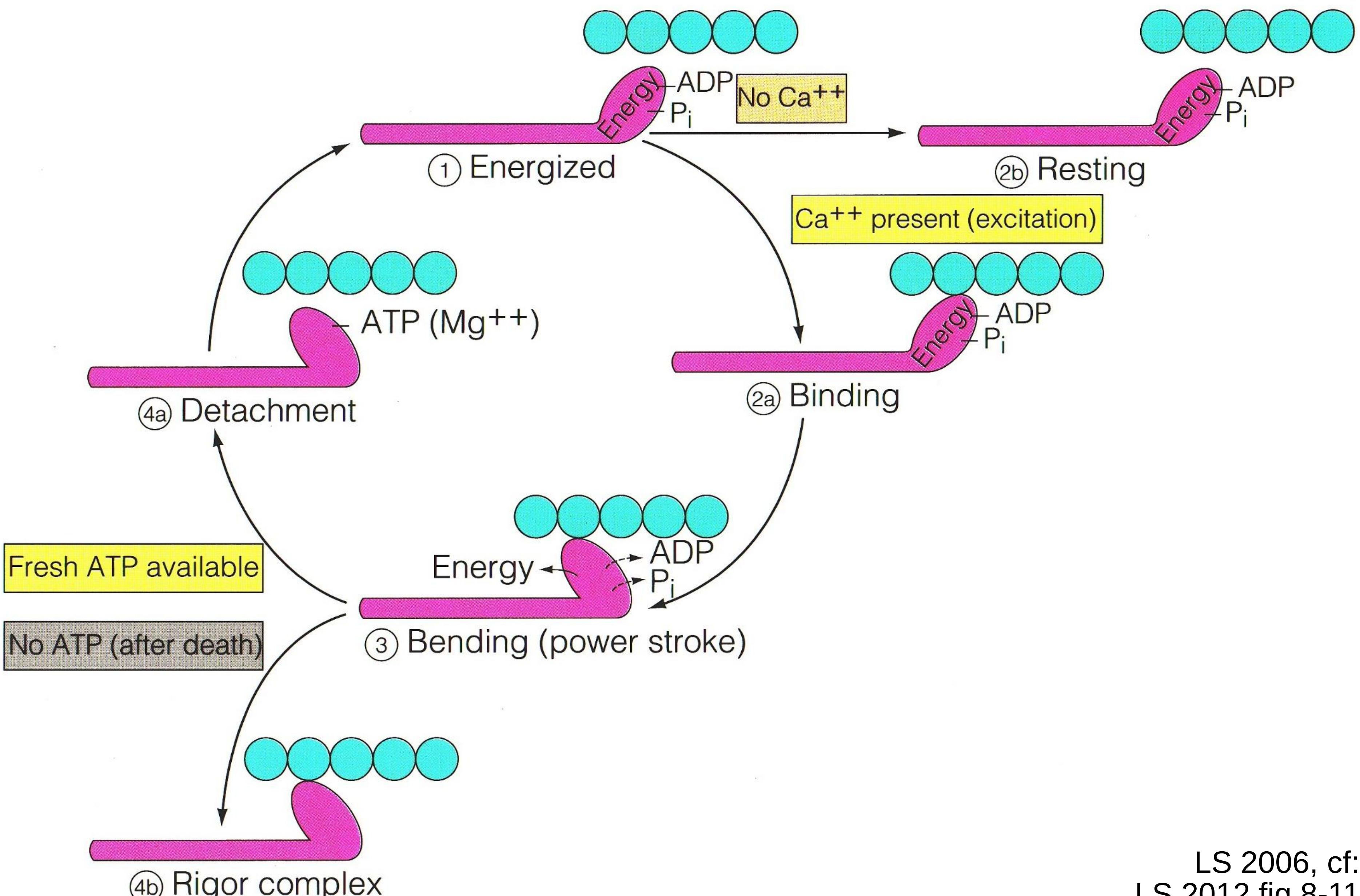
I Band = Light Band
*I*sotropic = Light Can Shine Through



LS 2012 fig 8-7

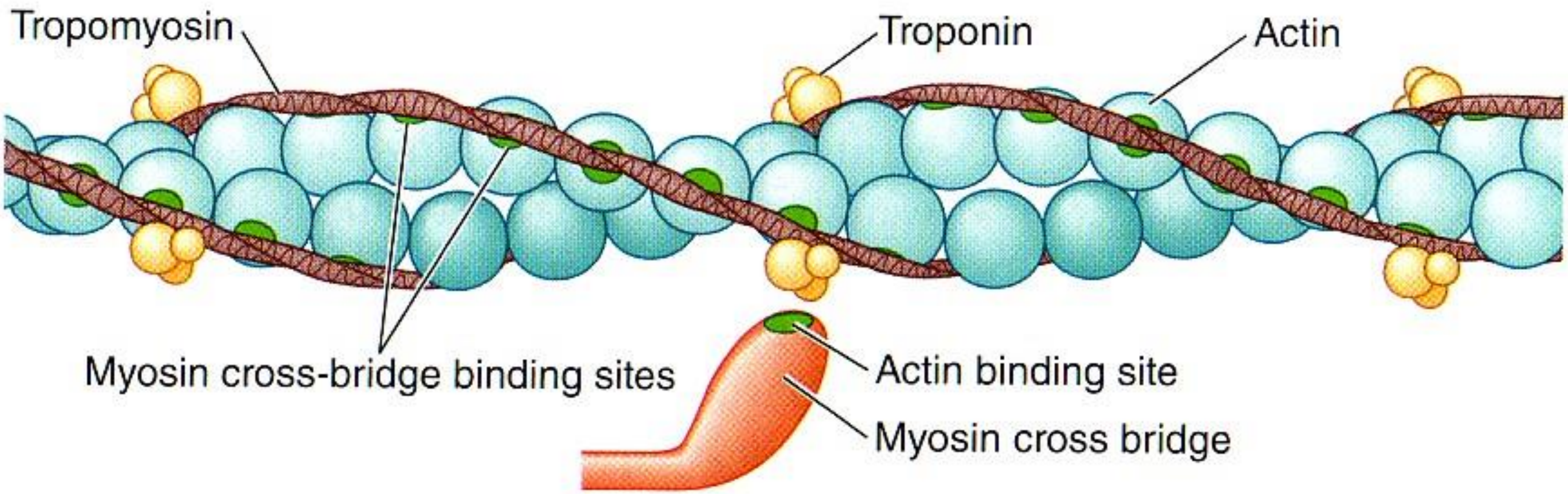
What do we guess happens at the <u>molecular</u> <u>level</u>?

Cross–Bridge Cycle



LS 2006, cf:
LS 2012 fig 8-11

Relaxed: No Cross-Bridge Binding



(a) Relaxed

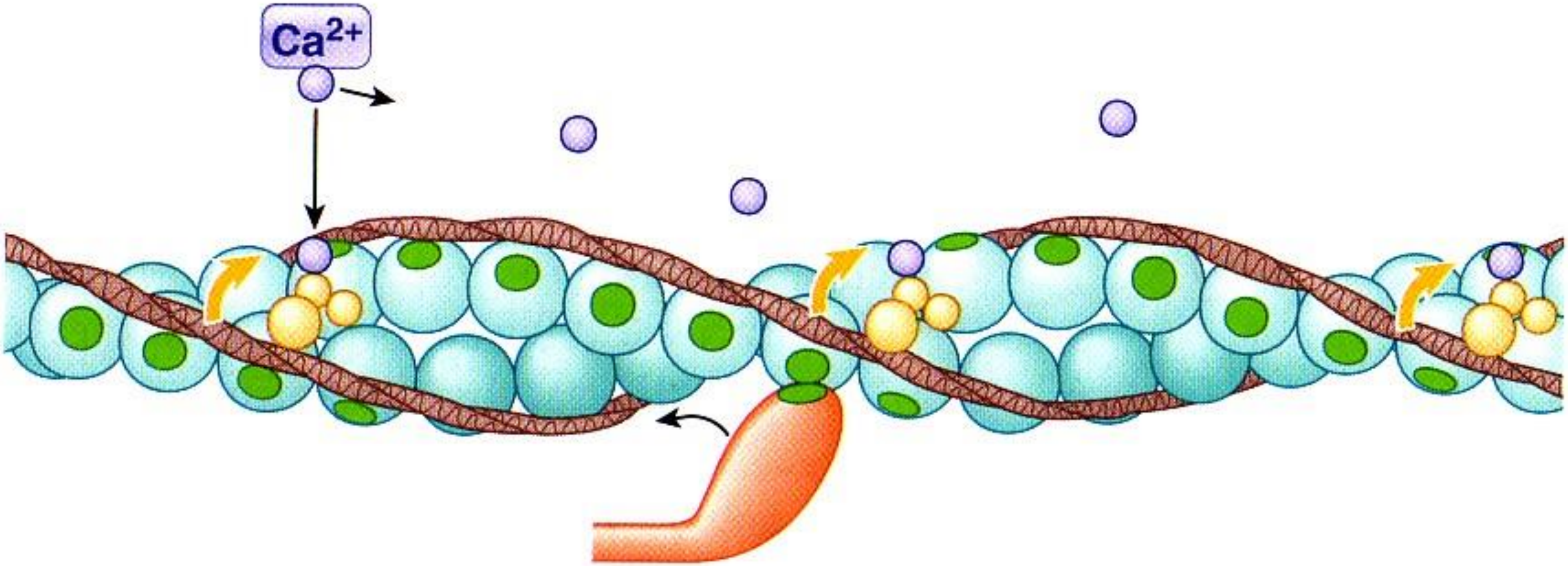
1 No excitation.

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.

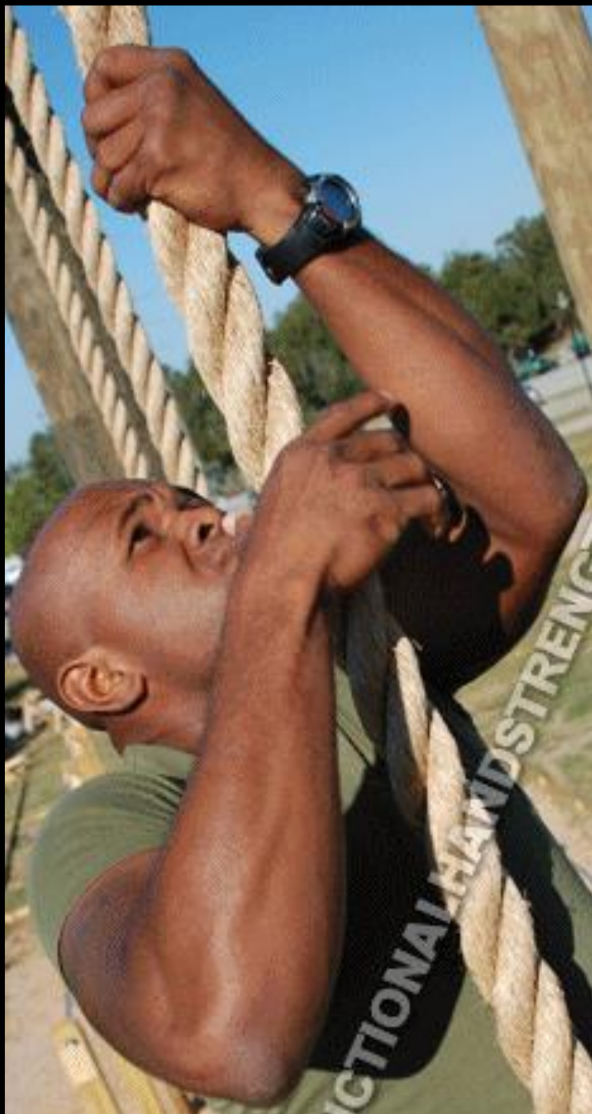
2 Released Ca^{2+} binds with troponin, pulling troponin–tropomyosin complex aside to expose cross-bridge binding site.

3 Cross-bridge binding occurs.

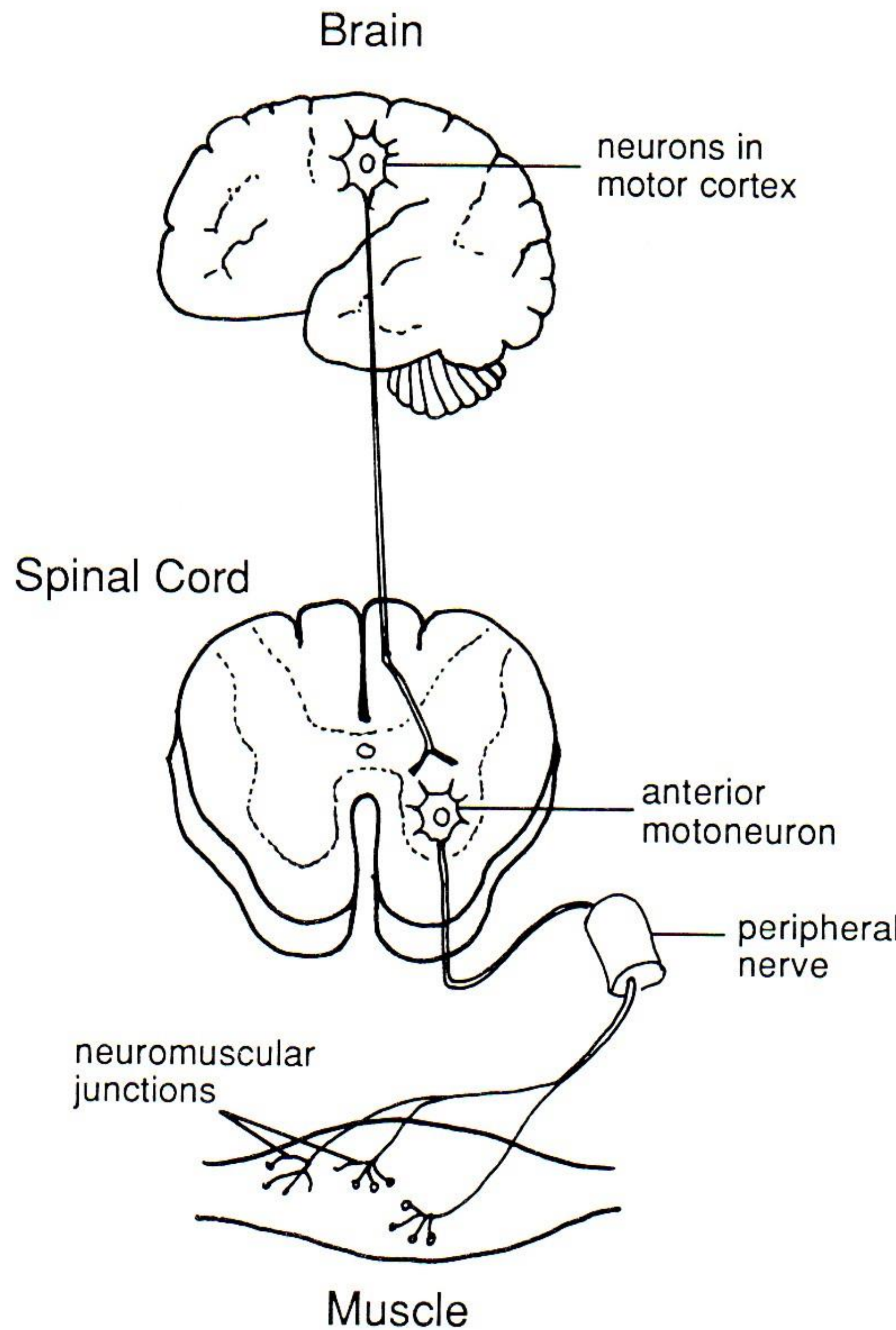
4 Binding of actin and myosin cross bridge triggers power stroke that pulls thin filament inward during contraction.

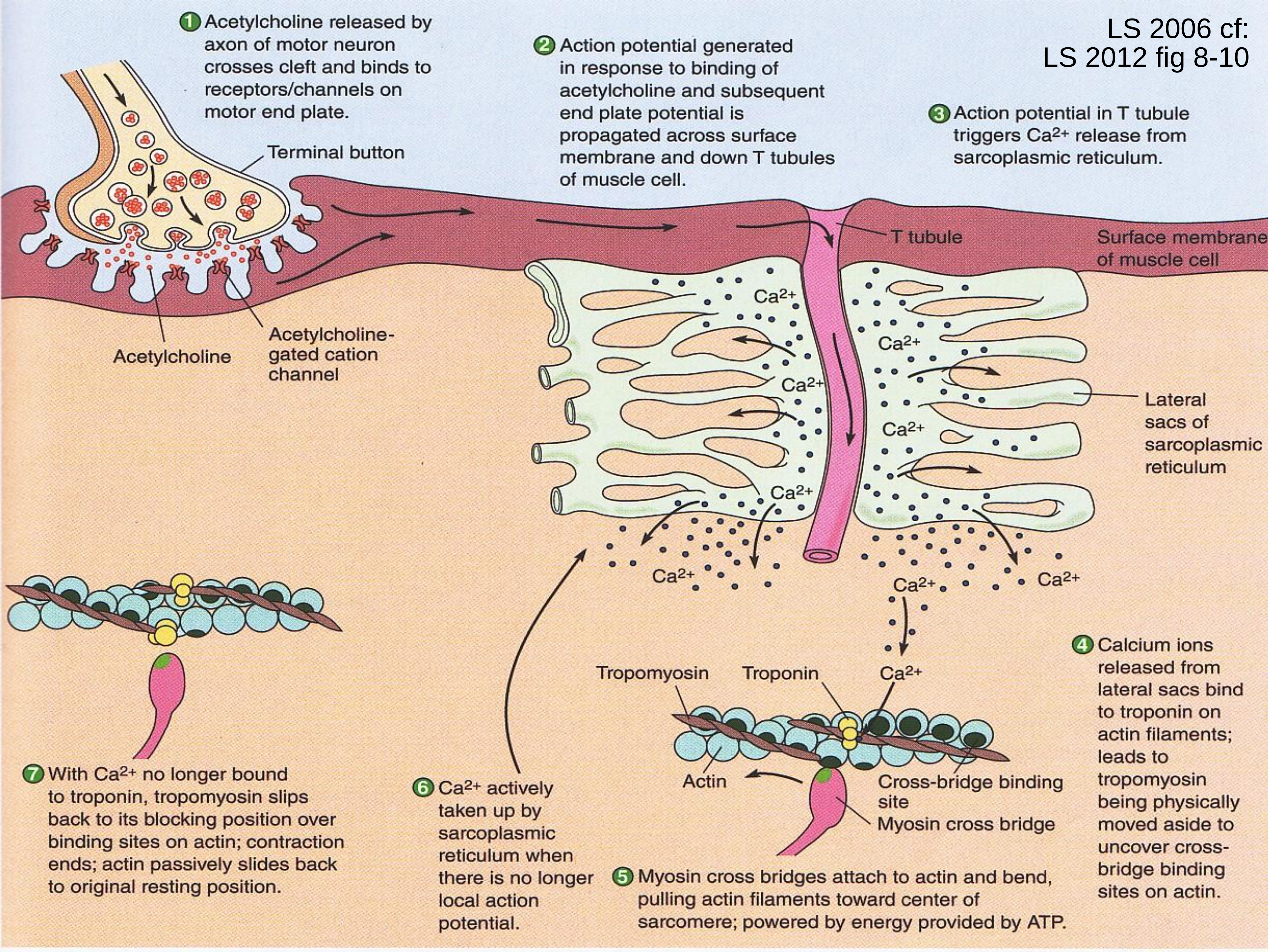
LS 2012 fig 8-6b

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
1 Acetylcholine released by axon of motor neuron crosses cleft and binds to receptors/channels on motor end plate.
Terminal button
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.
T tubule
Surface membrane of muscle cell
Acetylcholine
Acetylcholine-gated cation channel
Ca^{2+}
Lateral sacs of sarcoplasmic reticulum
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
5 Myosin cross bridges attach to actin and bend, pulling actin filaments toward center of sarcomere; powered by energy provided by ATP.
6 Ca^{2+} actively taken up by sarcoplasmic reticulum when there is no longer local action potential.
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.

David Bolinsky, XVIVO
Rocky Hill, CT

http://www.xvivo.net/

muscleanimation.mov

http://www.youtube.com/watch?v=BMT4PtXRCVA

http://www.vetmed.wsu.edu/van308/muscleanimation.htm

http://highered.mcgraw-hill.com/sites/0072495855/student_view0/chapter10/animation__action_potentials_and_muscle_contraction.html

A. Malcolm Campbell
Davidson College, Davidson, NC

www.bio.davidson.edu/courses/movies.html

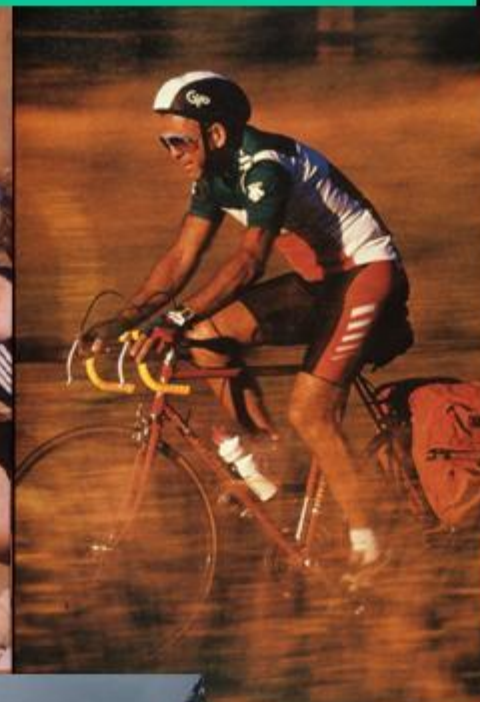
http://www.bio.davidson.edu/misc/movies/musclcp.mov

Musclcp.mov

Questions/Discussion?

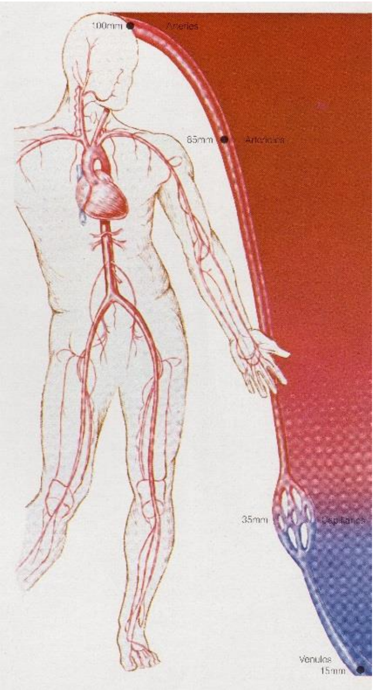
Adaptations to Exercise?

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

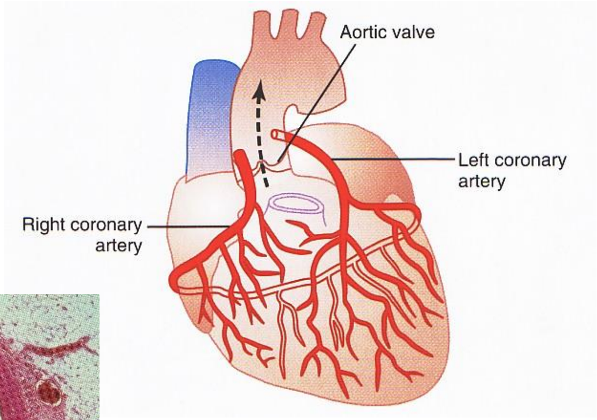


Adaptations to Exercise?

Body Levels of Organization?
Which Body System?

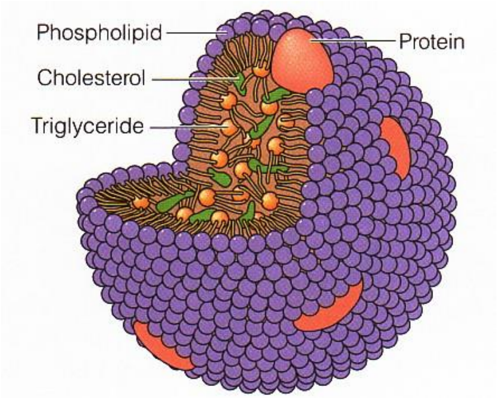


Body System



Organ

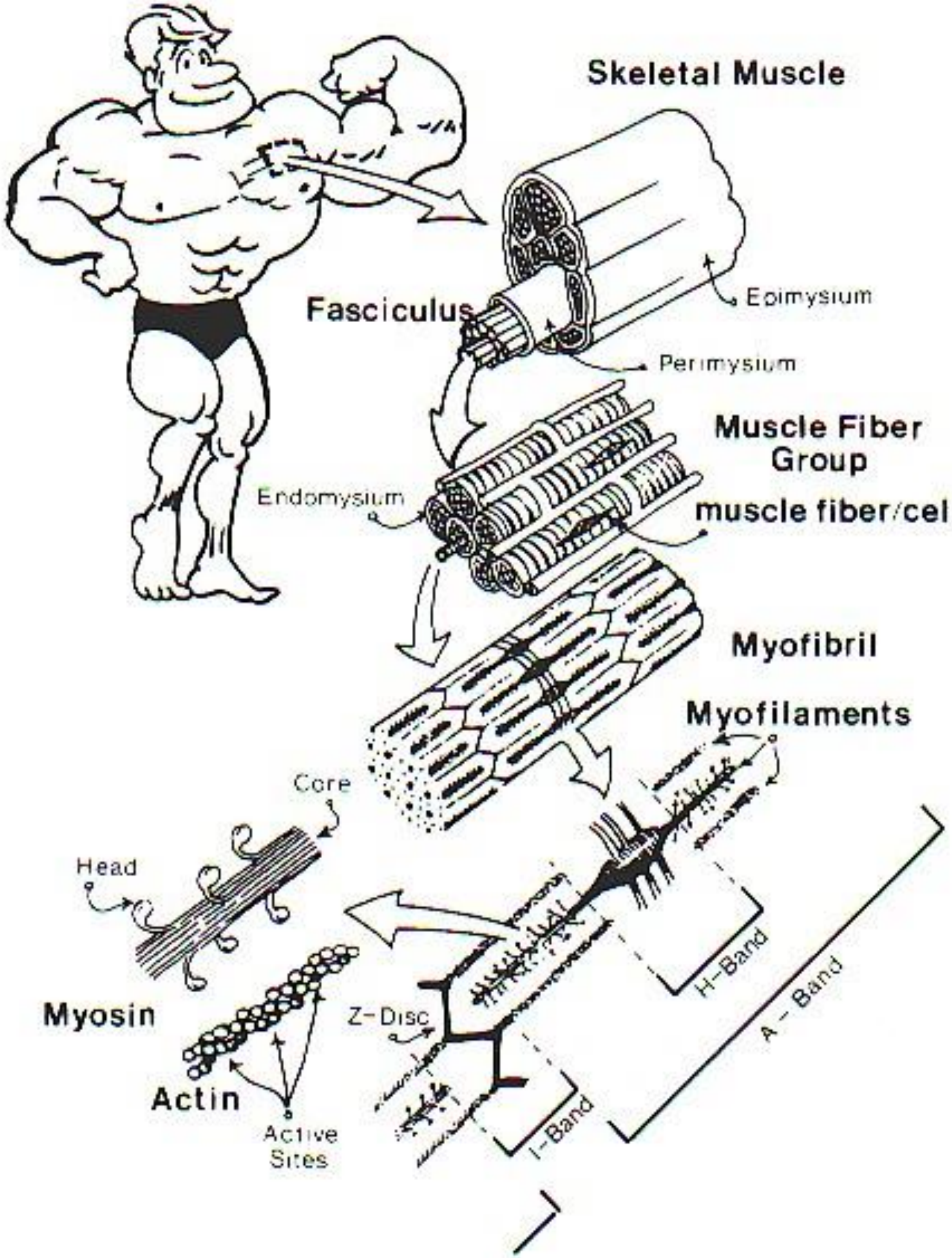
Cell/Tissue



A typical lipoprotein

Molecular

Muscle Adaptations to Exercise



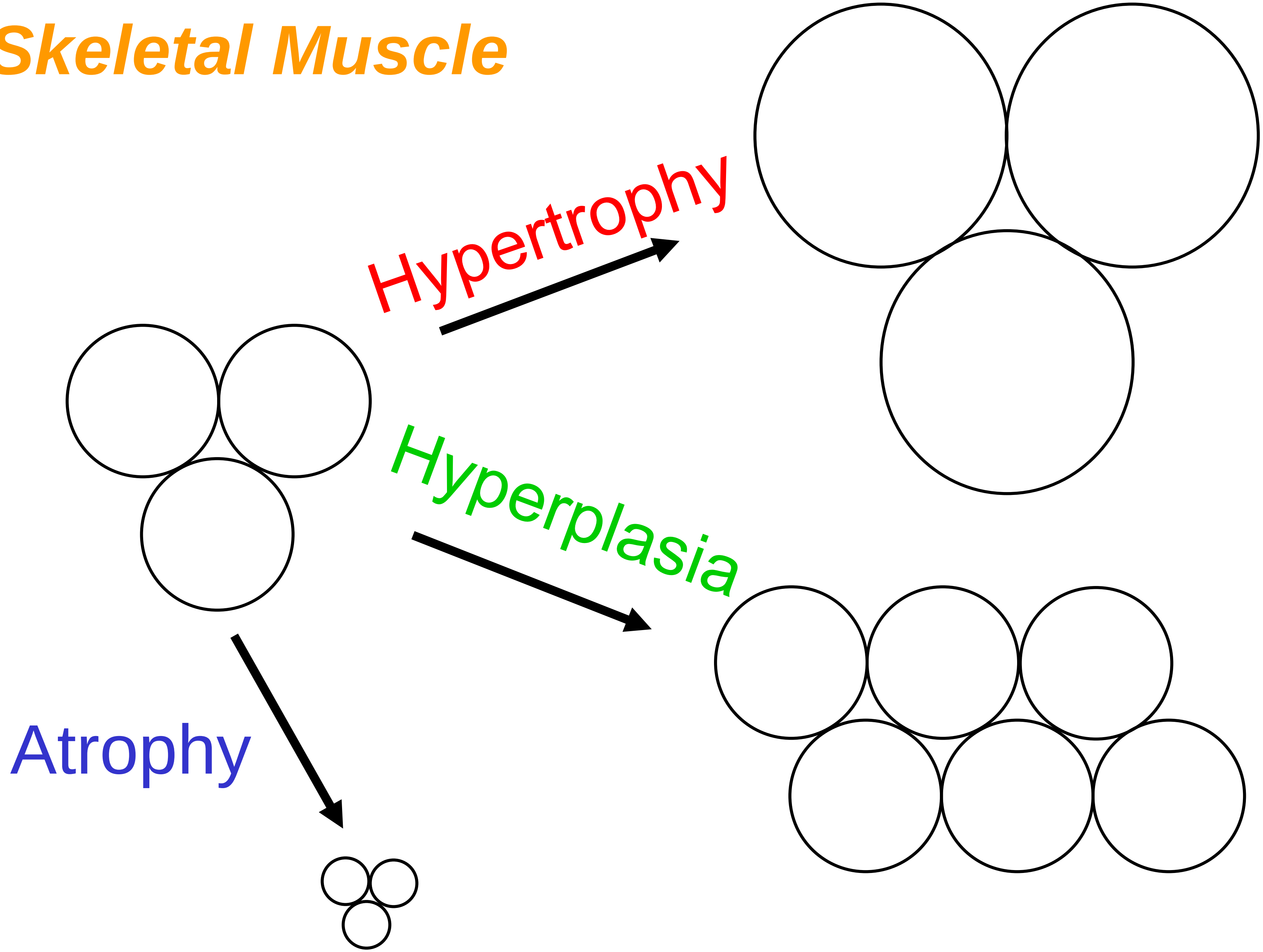
Atrophy

decrease in size & strength

Hypertrophy

increase in size & strength

Skeletal Muscle

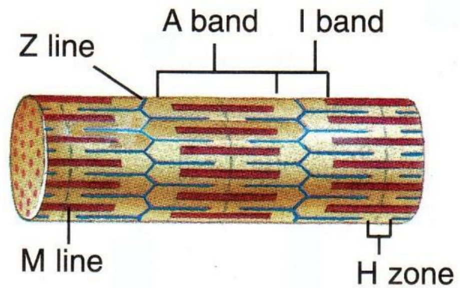


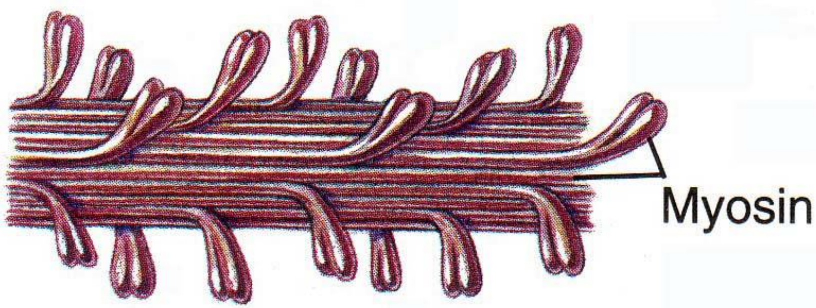
Women & Hypertrophy?

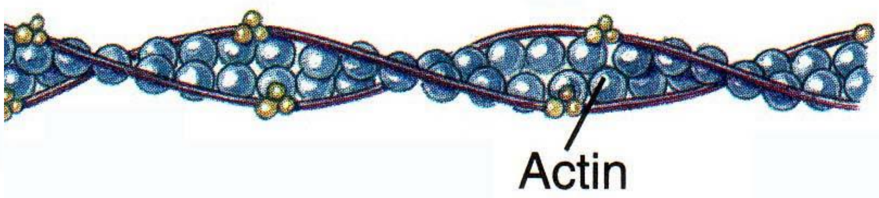
What happens in muscles at cellular & subcellular levels?

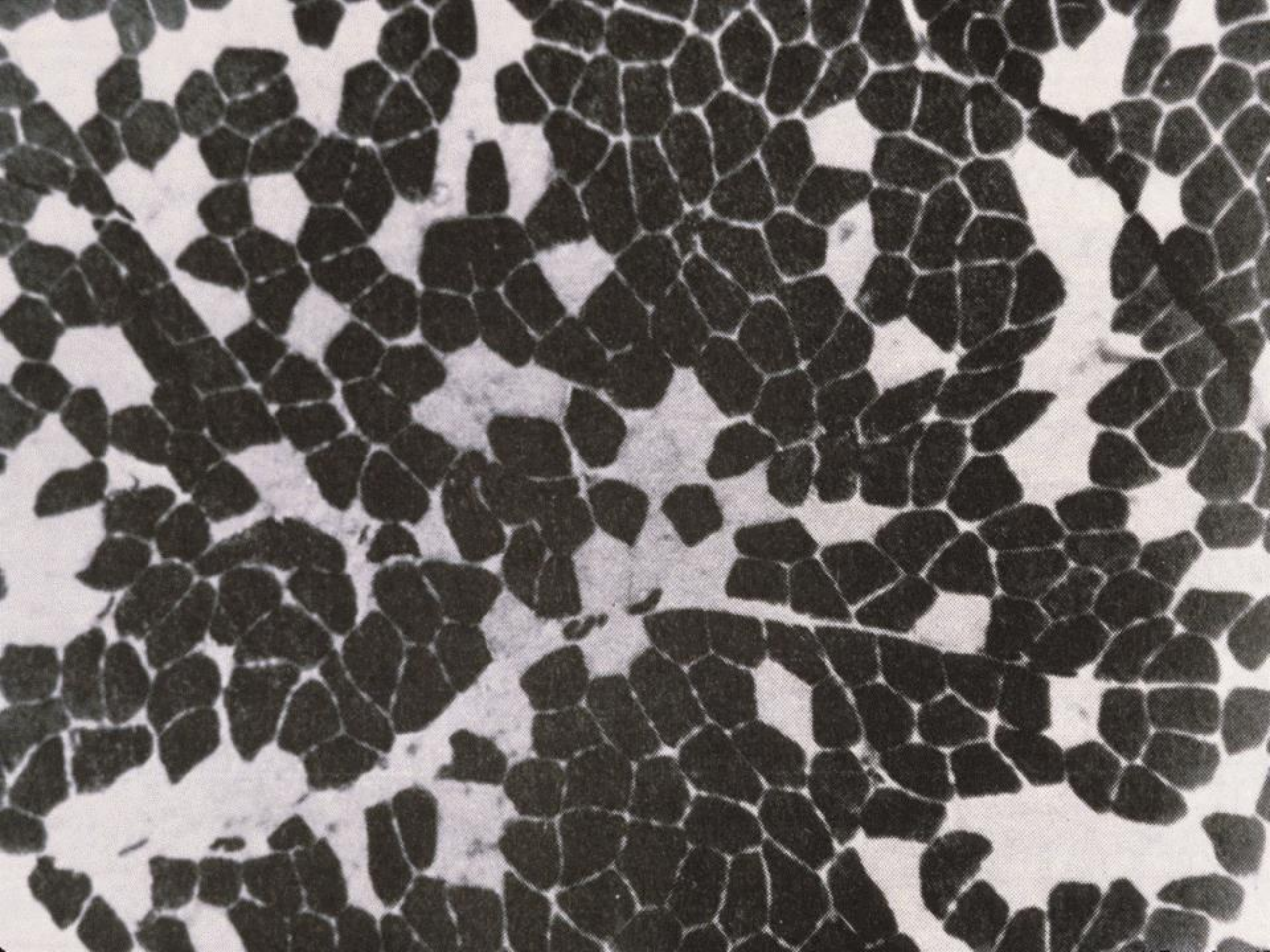
Myofibril

Hypertrophy: *Increased Number of Myofibrils Thick & Thin Filaments Myosin & Actin Molecules*





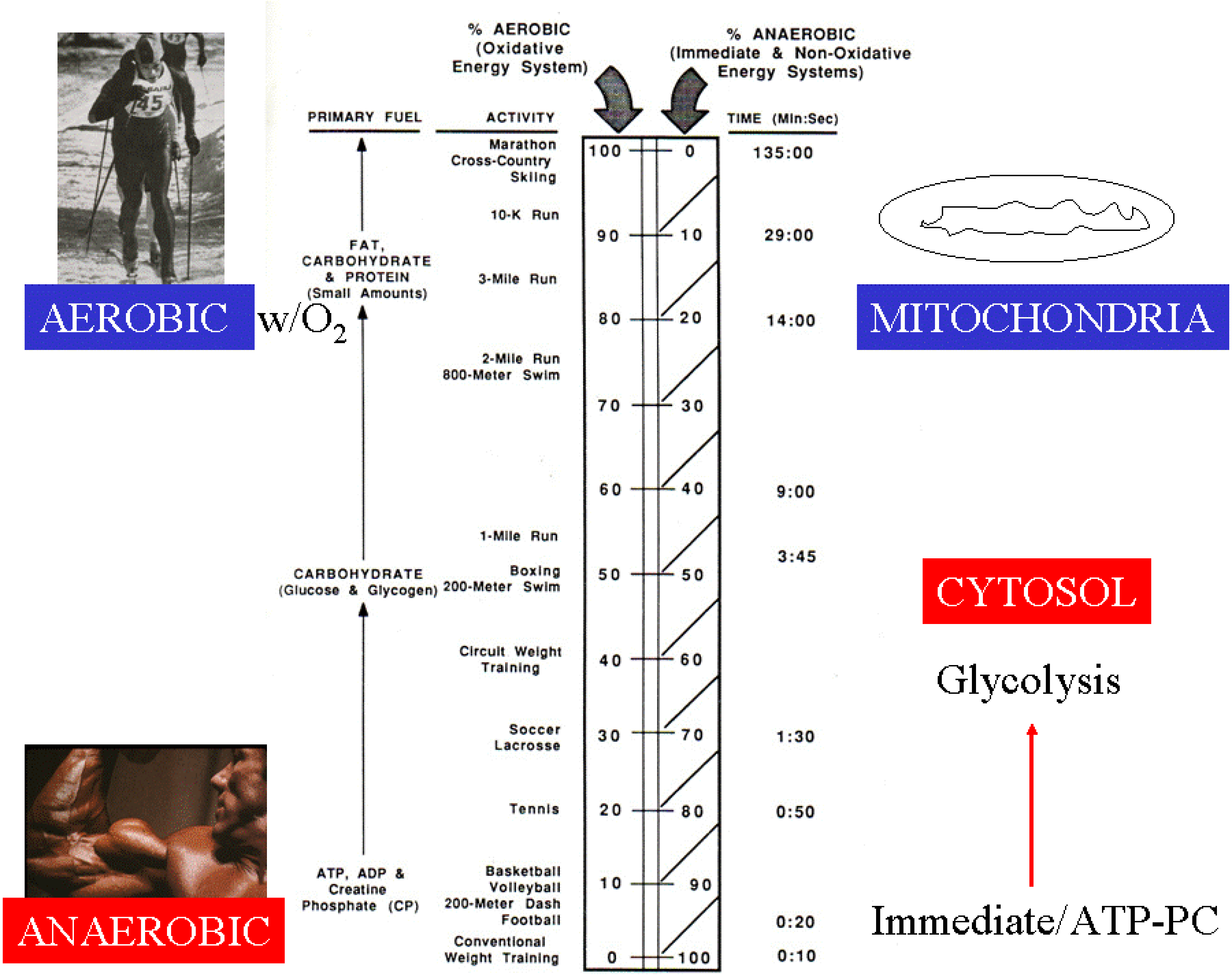




Characteristics of Skeletal Muscle Fibers

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

↑ 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!