

Pulmonary Function Testing today! Hooray!....



BI 121 Lecture 15

I. Announcements Optional notebook ✓ + Lab 6

Pulmonary Function Testing today. Q?

II. Pulmonary Function Lab Overview

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

A. How is skeletal muscle organized? LS fig 8-2, DC fig 12-2

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

C. How about thin filaments? LS fig 8-5

D. Banding pattern? LS fig 8-3, fig 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

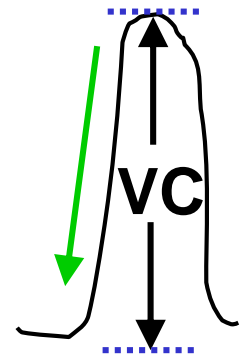
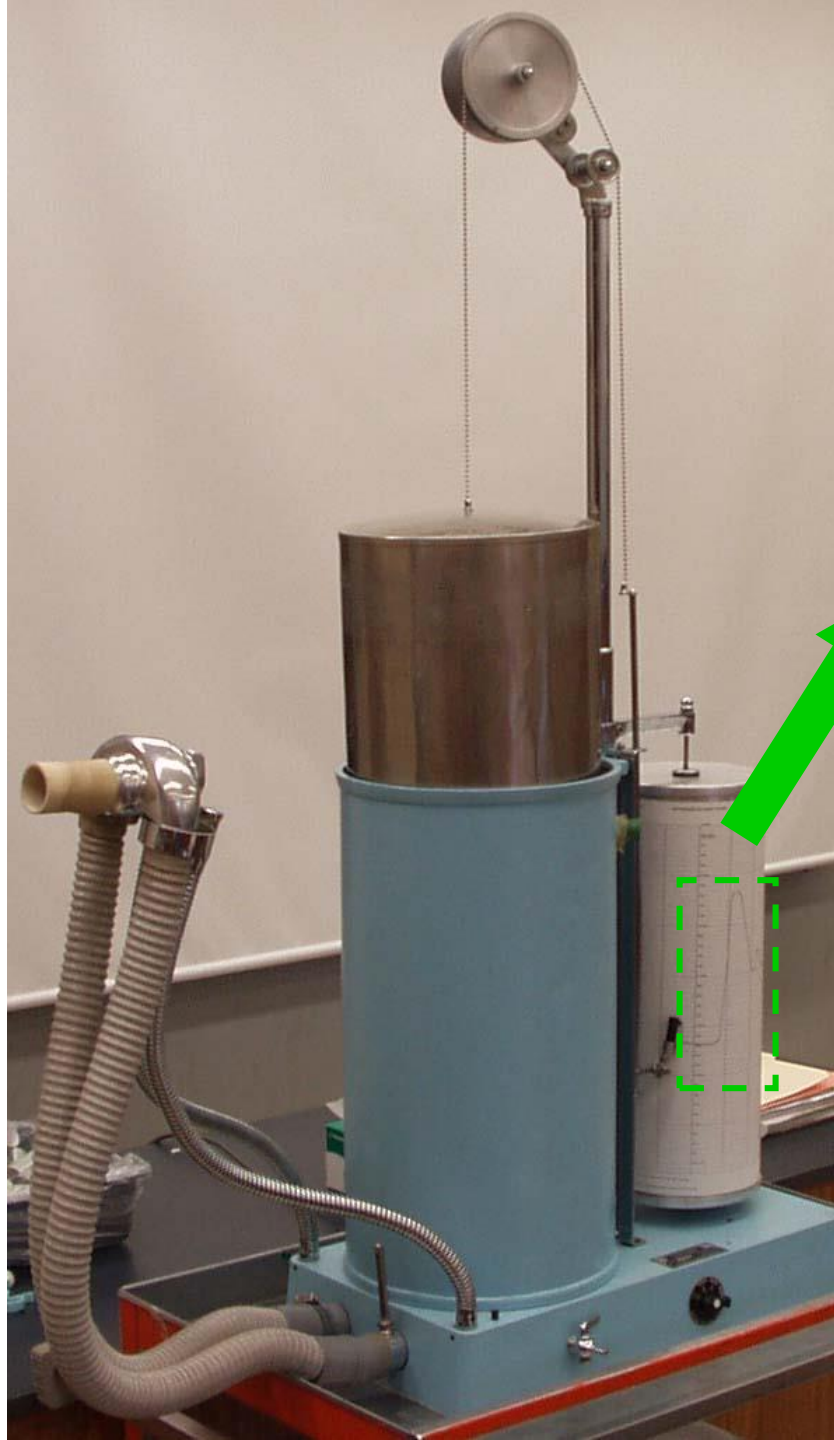
H. Exercise adaptation variables: *mode, intensity, duration, frequency, distribution, individual & environmental char...?*

I. Endurance vs. strength training continuum? fiber types...

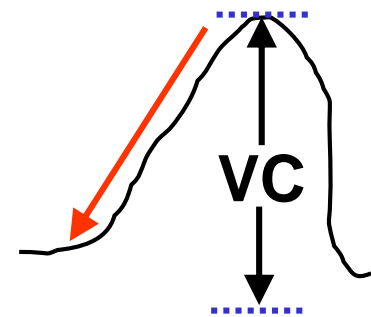


**Respirometer →
measures complete
Pulmonary Function
Test or PFT!**

**NB: Should be able to
blow out $\geq 75 - 85\%$ 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.**

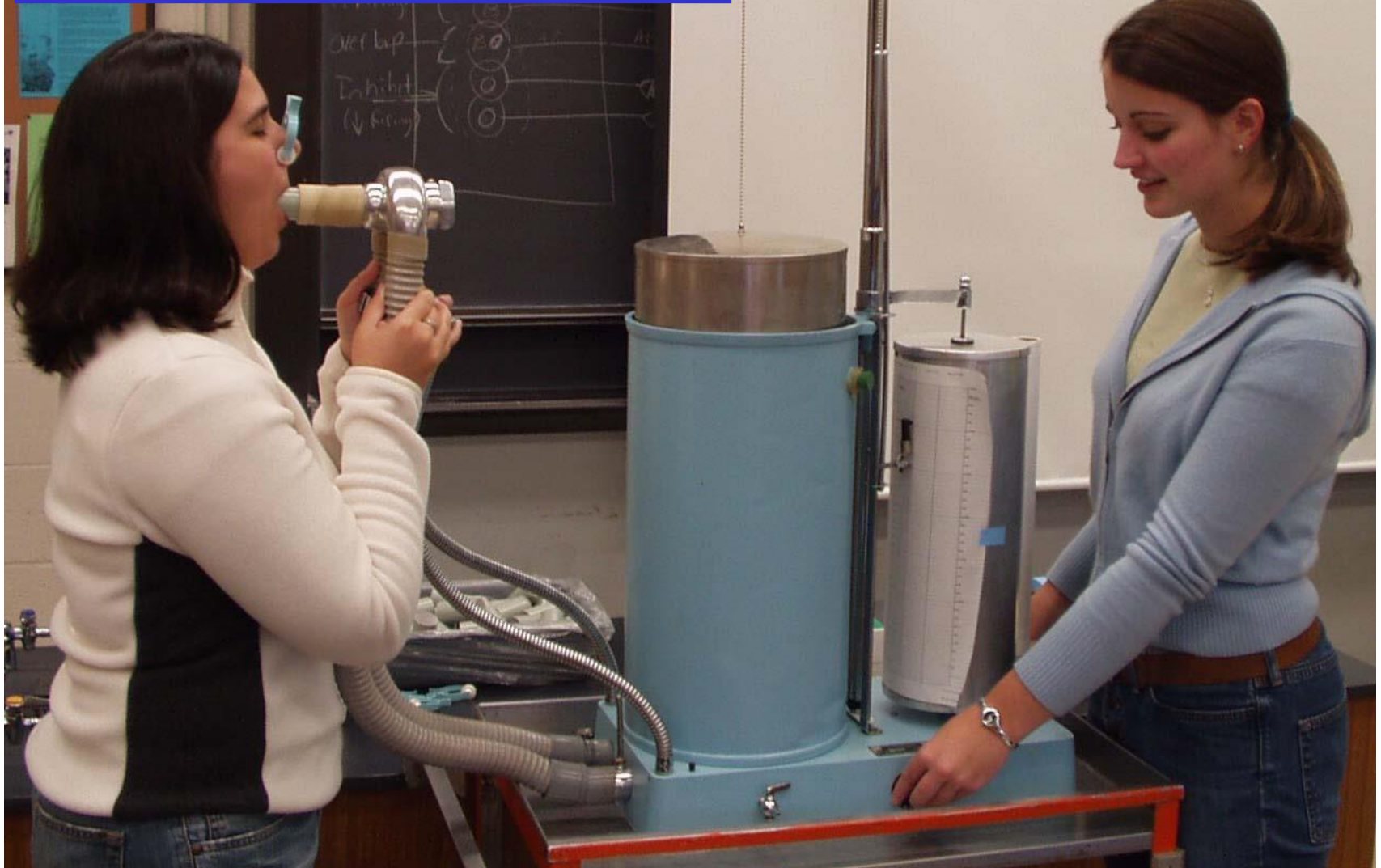


**Normal =
Steep**

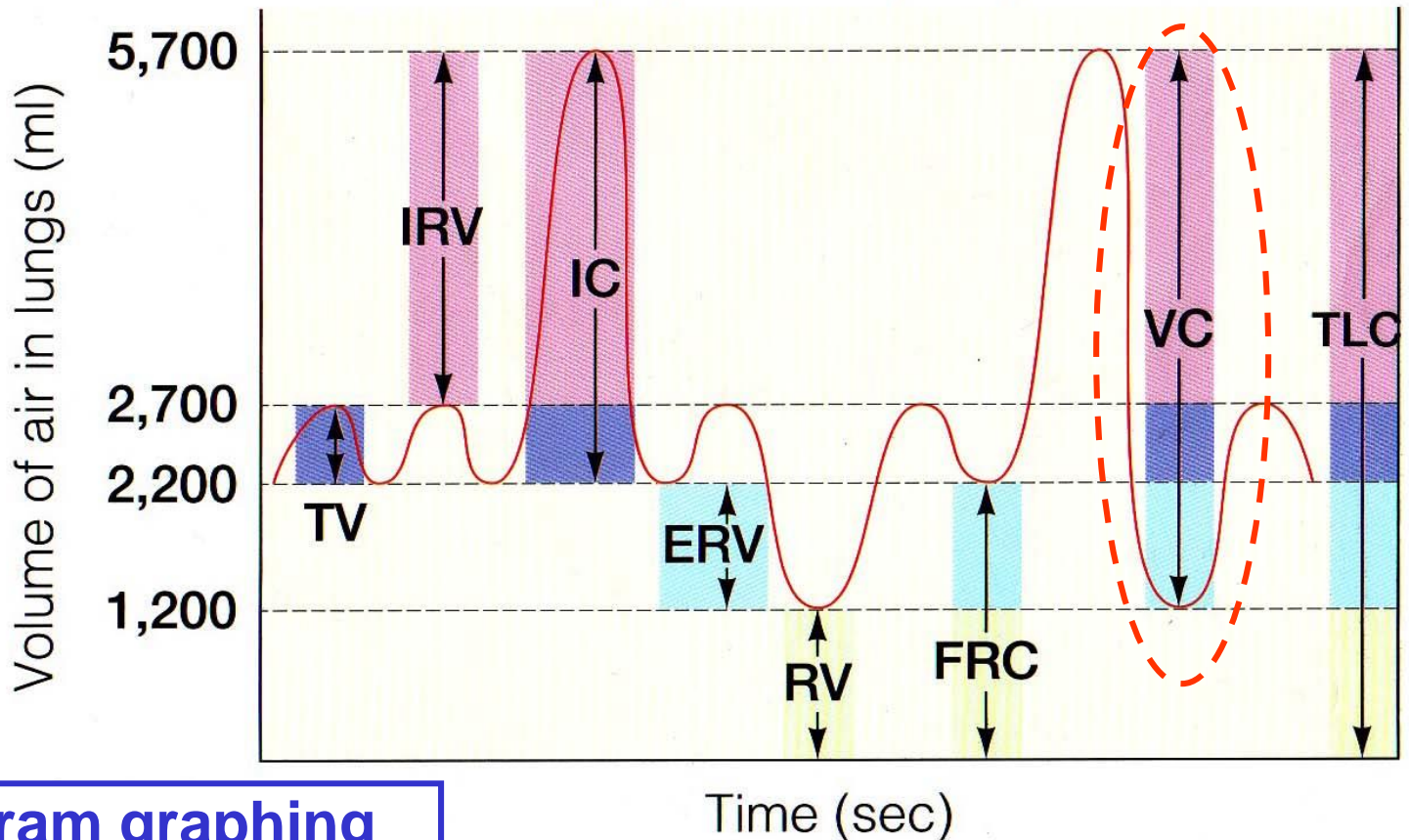


**Abnormal =
Flatter
Downslope
(eg, Asthma)**

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



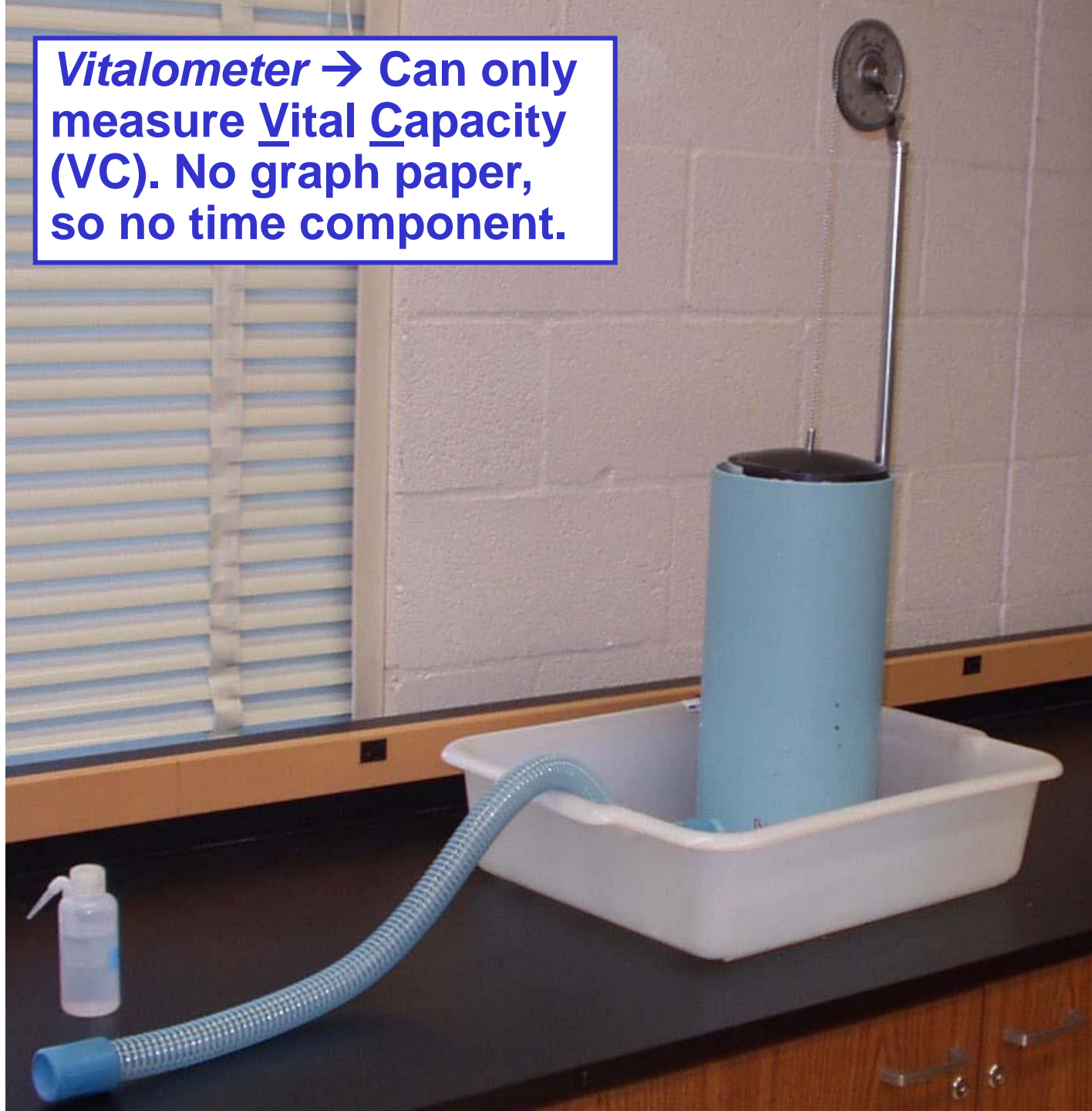
Normal Spirogram of Healthy Young Adult Male



**Spirogram graphing
complete *PFT* from
computer simulation.**

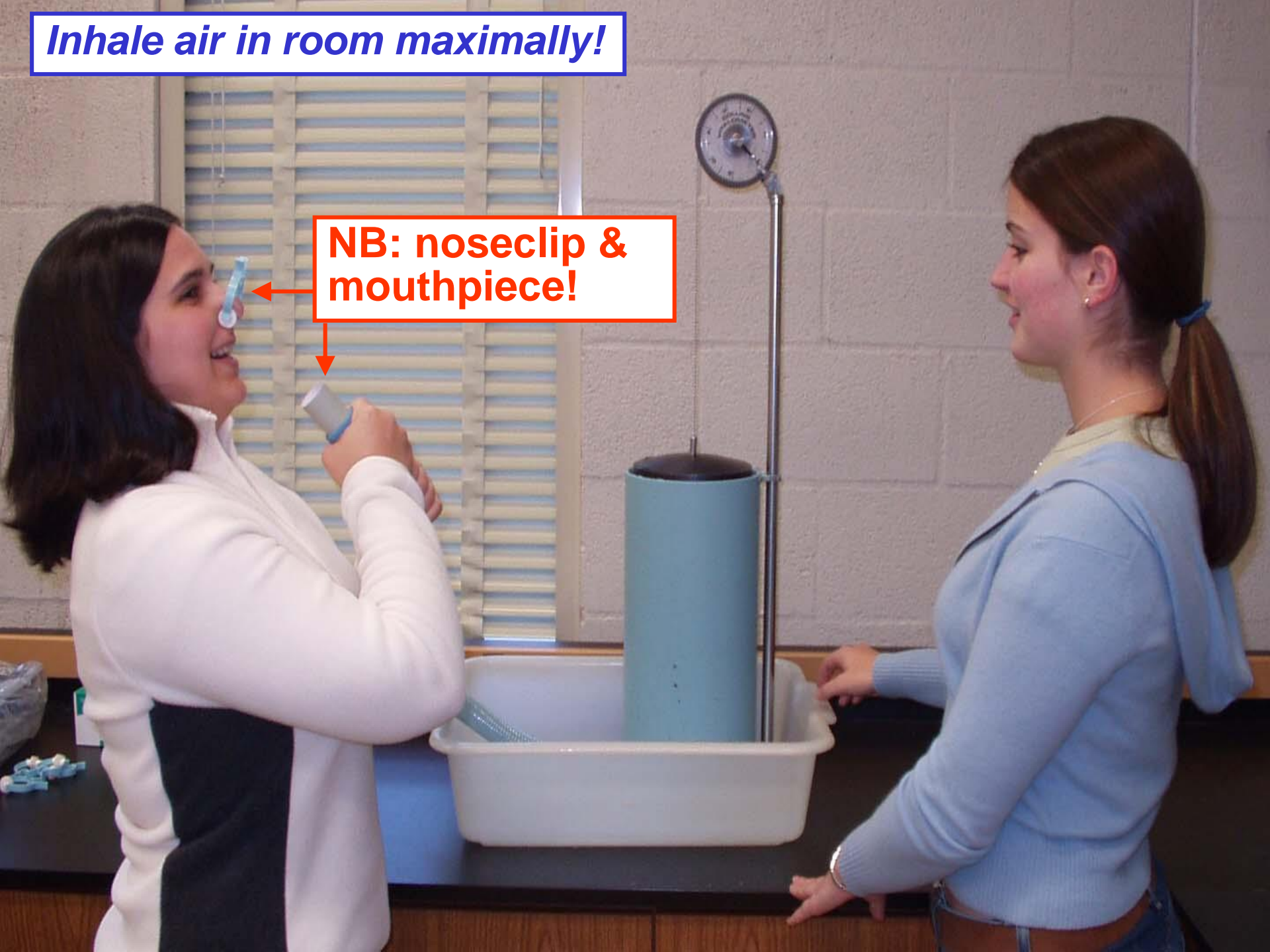
- TV = Tidal volume (500 ml)
- IRV = Inspiratory reserve volume (3,000 ml)
- IC = Inspiratory capacity (3,500 ml)
- ERV = Expiratory reserve volume (1,000 ml)
- RV = Residual volume (1,200 ml)
- FRC = Functional residual capacity (2,200 ml)
- VC = Vital capacity (4,500 ml)
- TLC = Total lung capacity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

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



Inhale air in room maximally!

NB: noseclip & mouthpiece!



Exhale into tube maximally!



More modern-day computerized Pulmonary Function Testing

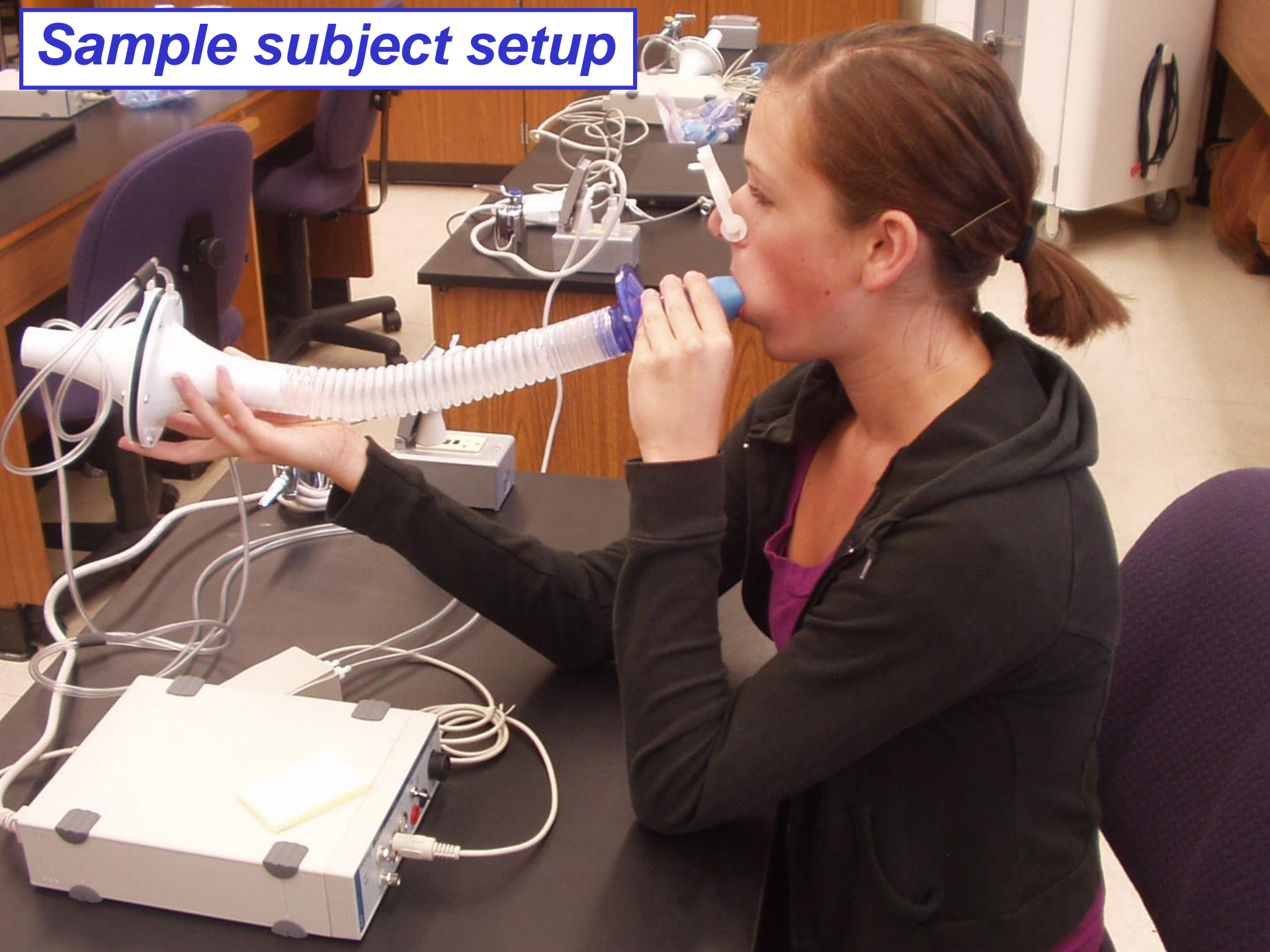


*Complete with HH!
Happy Helpers!*

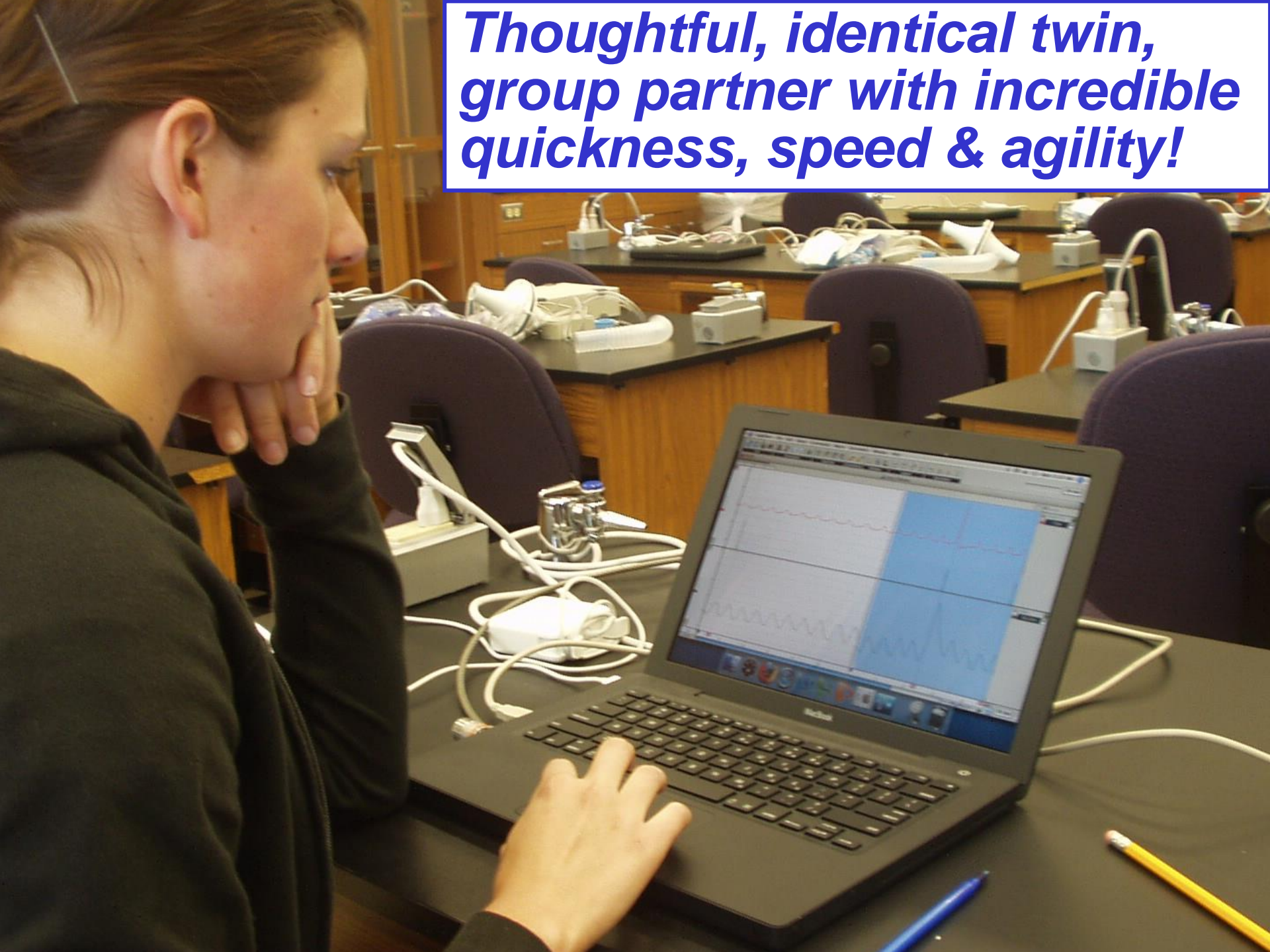
Viola!!



Sample subject setup

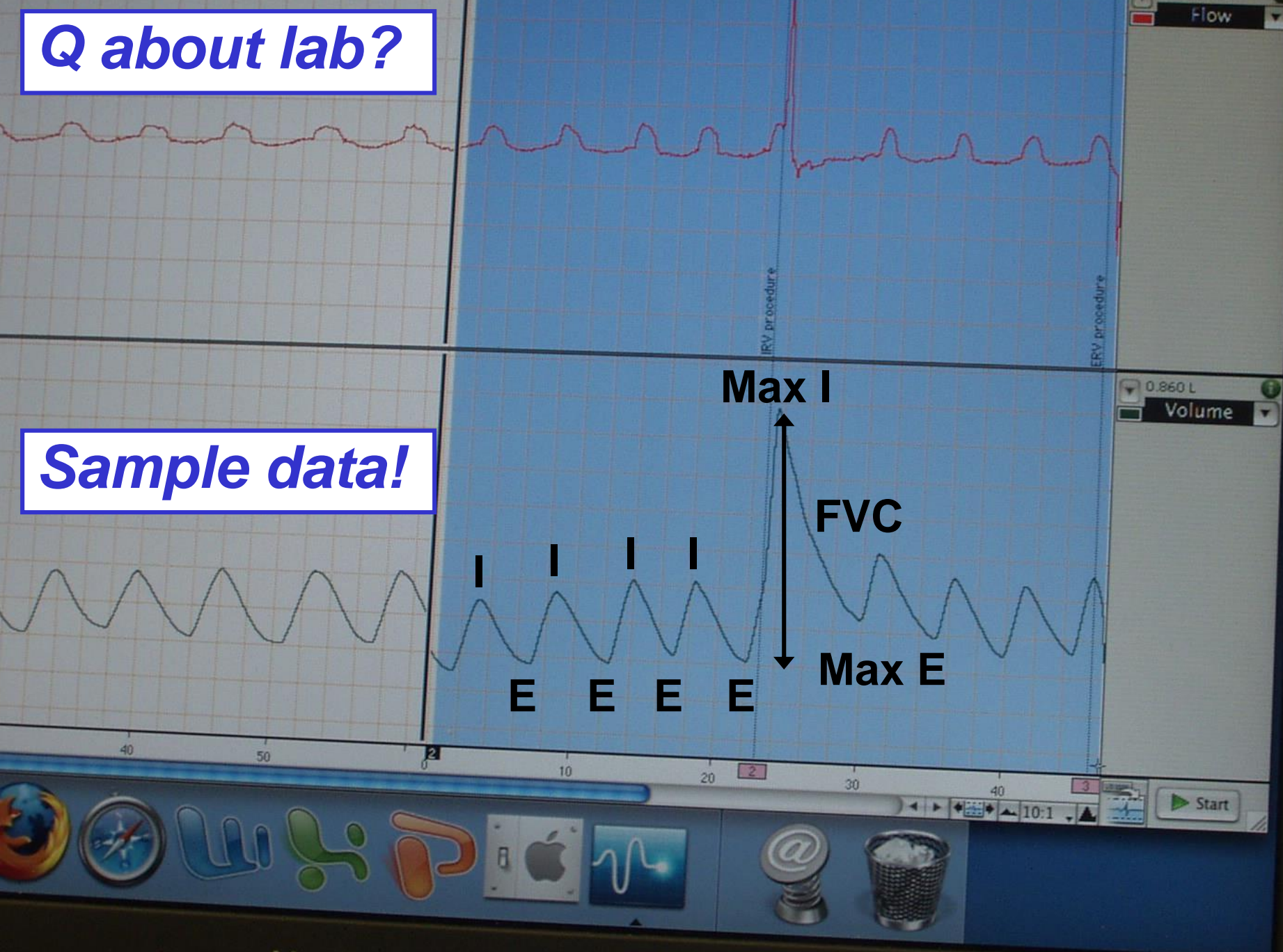


***Thoughtful, identical twin,
group partner with incredible
quickness, speed & agility!***



Q about lab?

Sample data!



IRV procedure

ERV procedure

Max I

FVC

Max E

E E E E

40

50

0

10

20

30

40

3

0.860 L

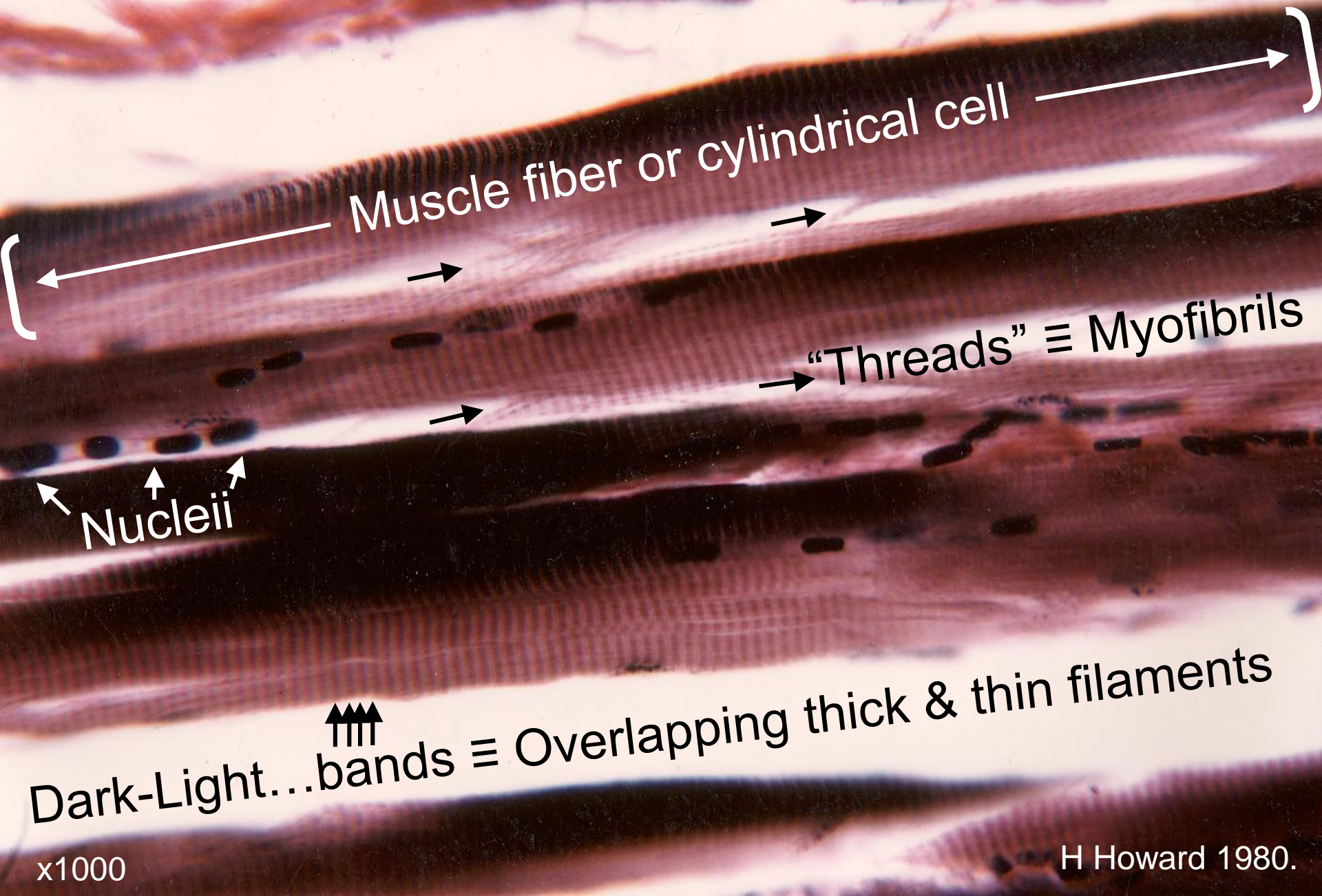
Volume

Start

10:1

MacBook

Skeletal Muscle Histology: Microscopic Anatomy



Muscle fiber or cylindrical cell

Nucleii

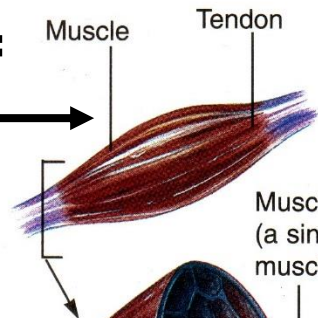
"Threads" ≡ Myofibrils

Dark-Light...bands ≡ Overlapping thick & thin filaments

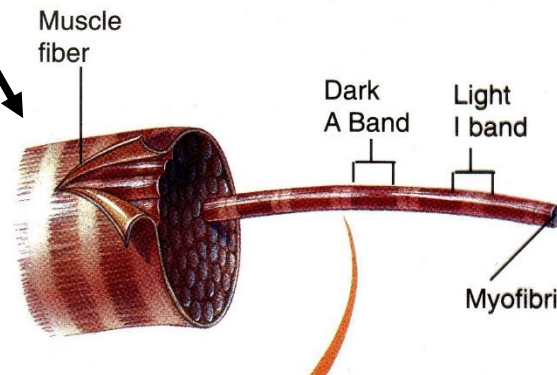
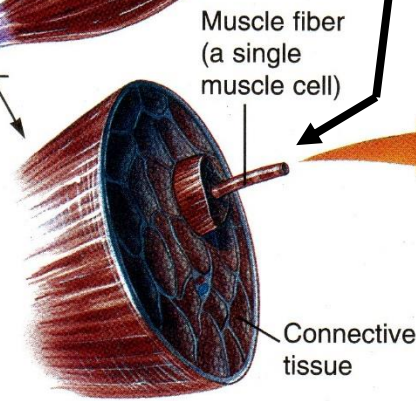
x1000

H Howard 1980.

**Organ =
Muscle**

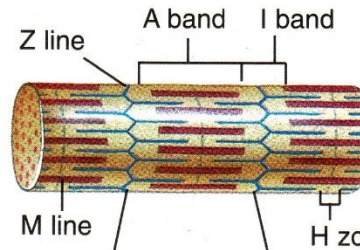


Cell = Myocyte = Fiber

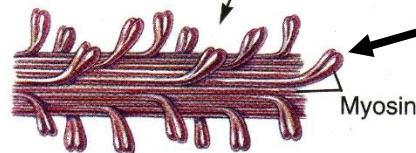
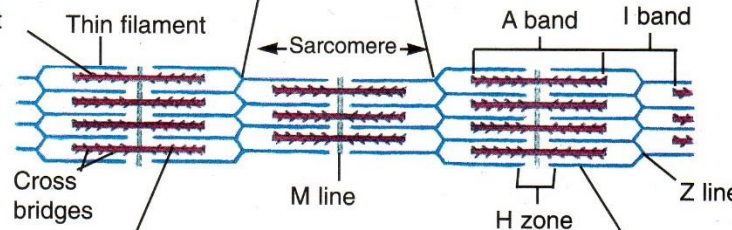


**Subcellular =
Cytoskeleton**

Portion
of myofibril



Thick filament

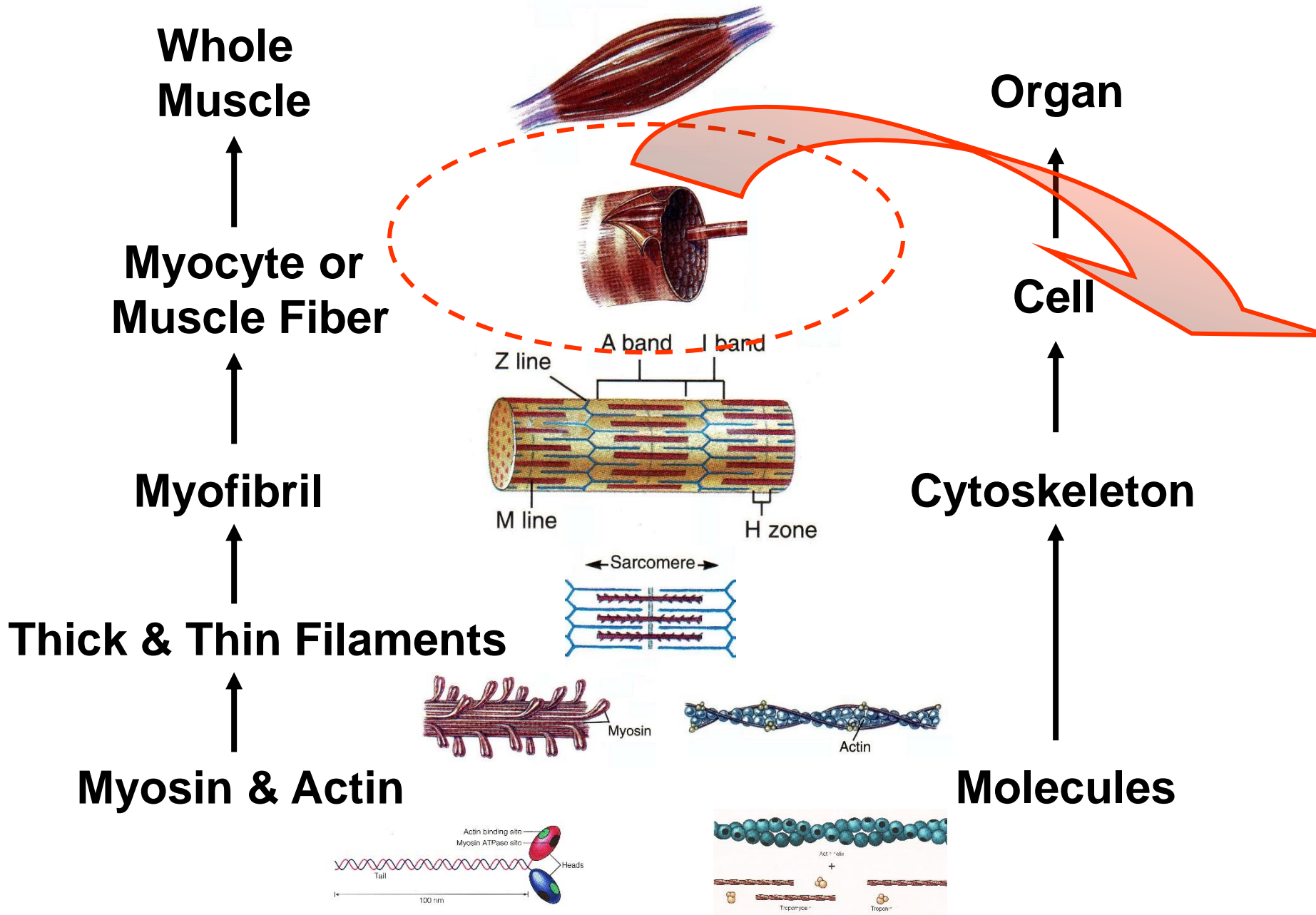


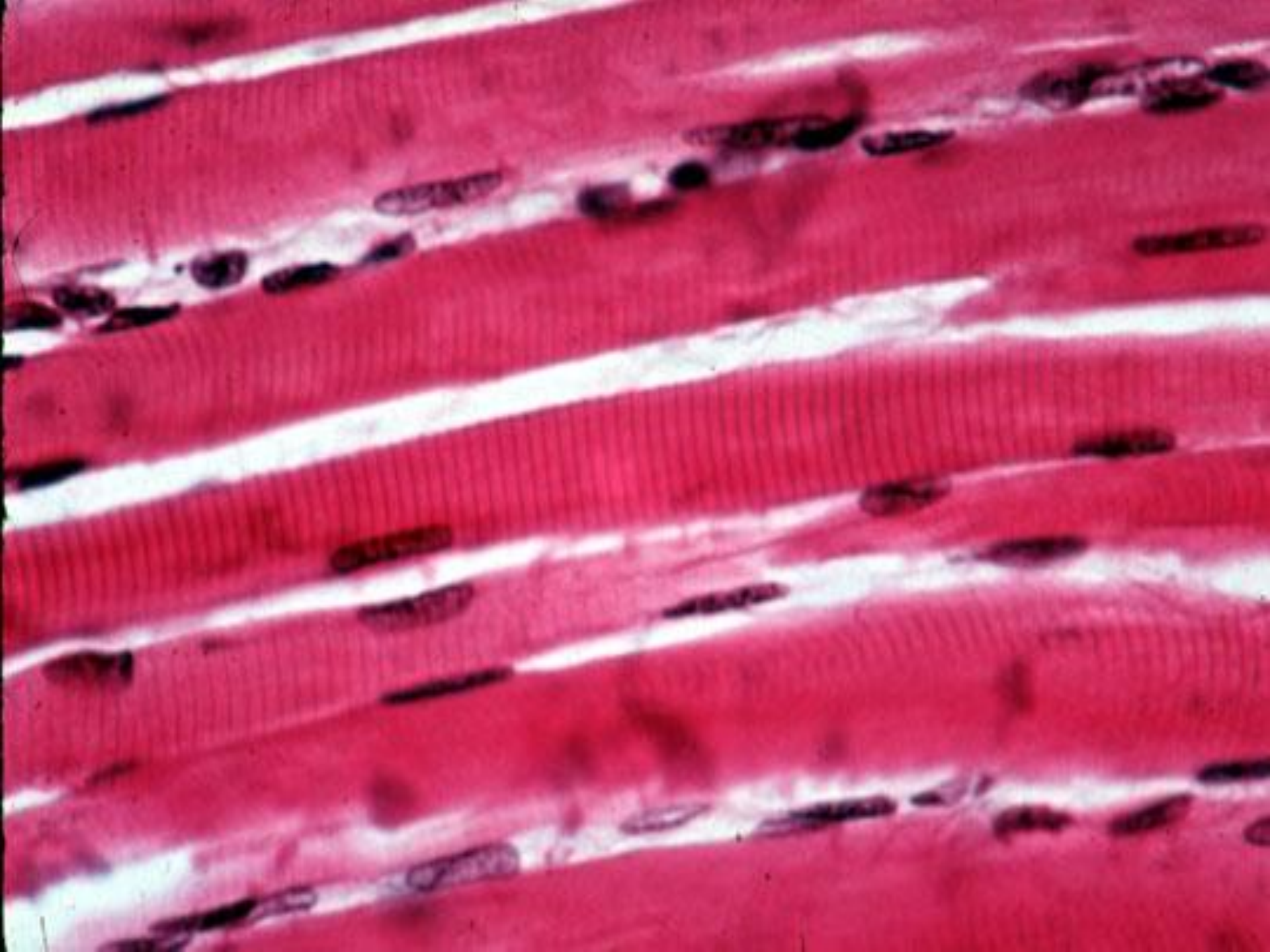
Thick filament

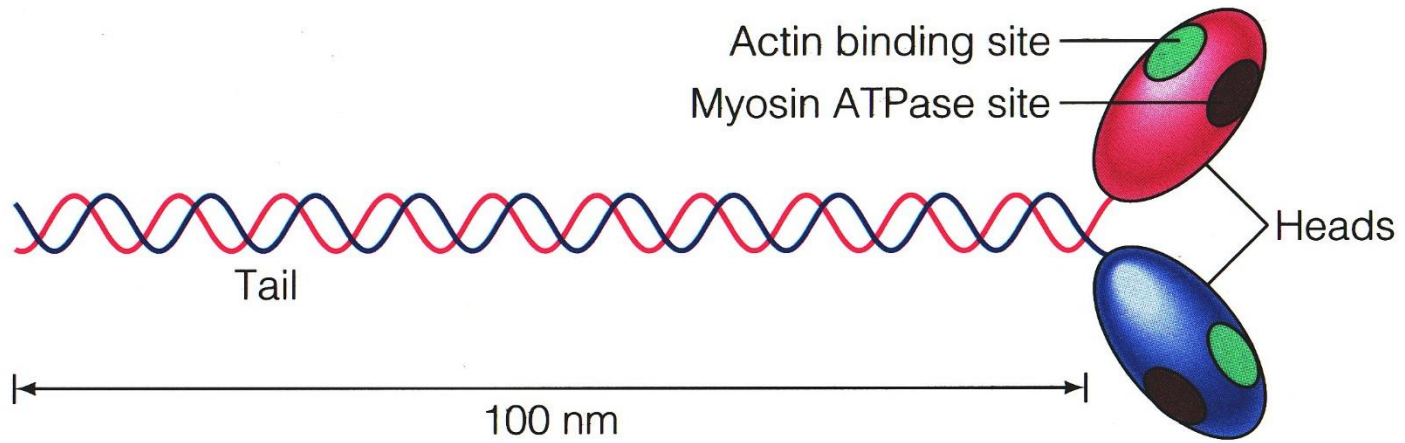


Thin filament

**Molecules =
Actin & Myosin**

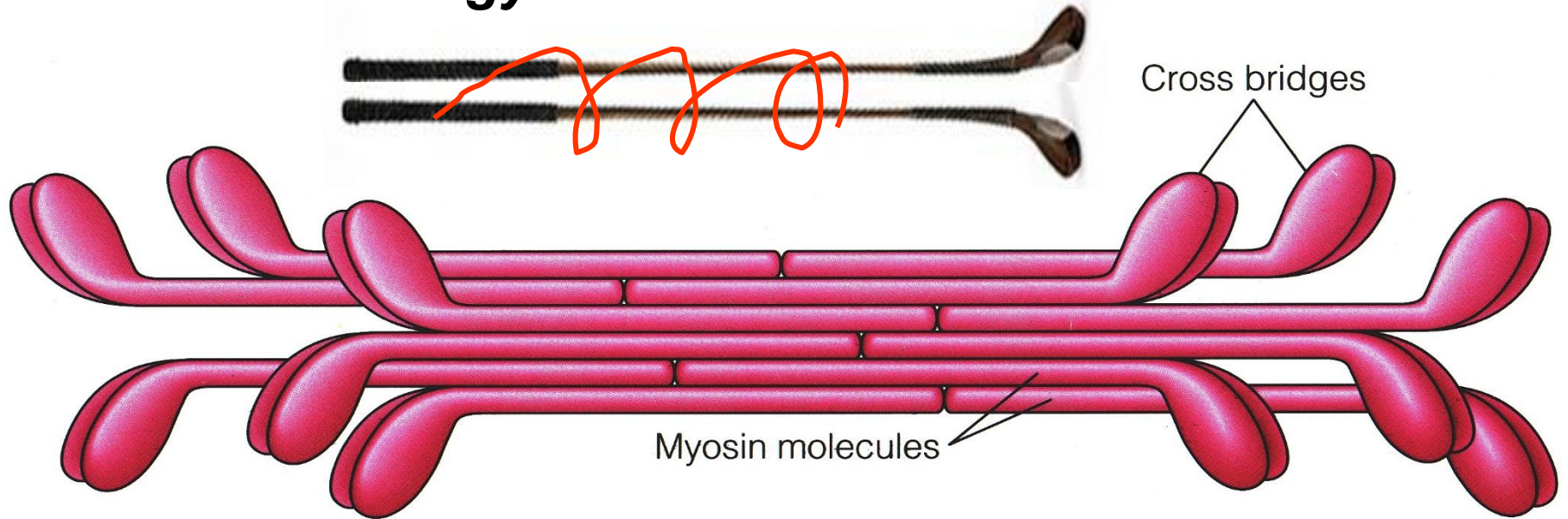






(a)

Golf Club Analogy?



(b)

Broccoli Analogy?

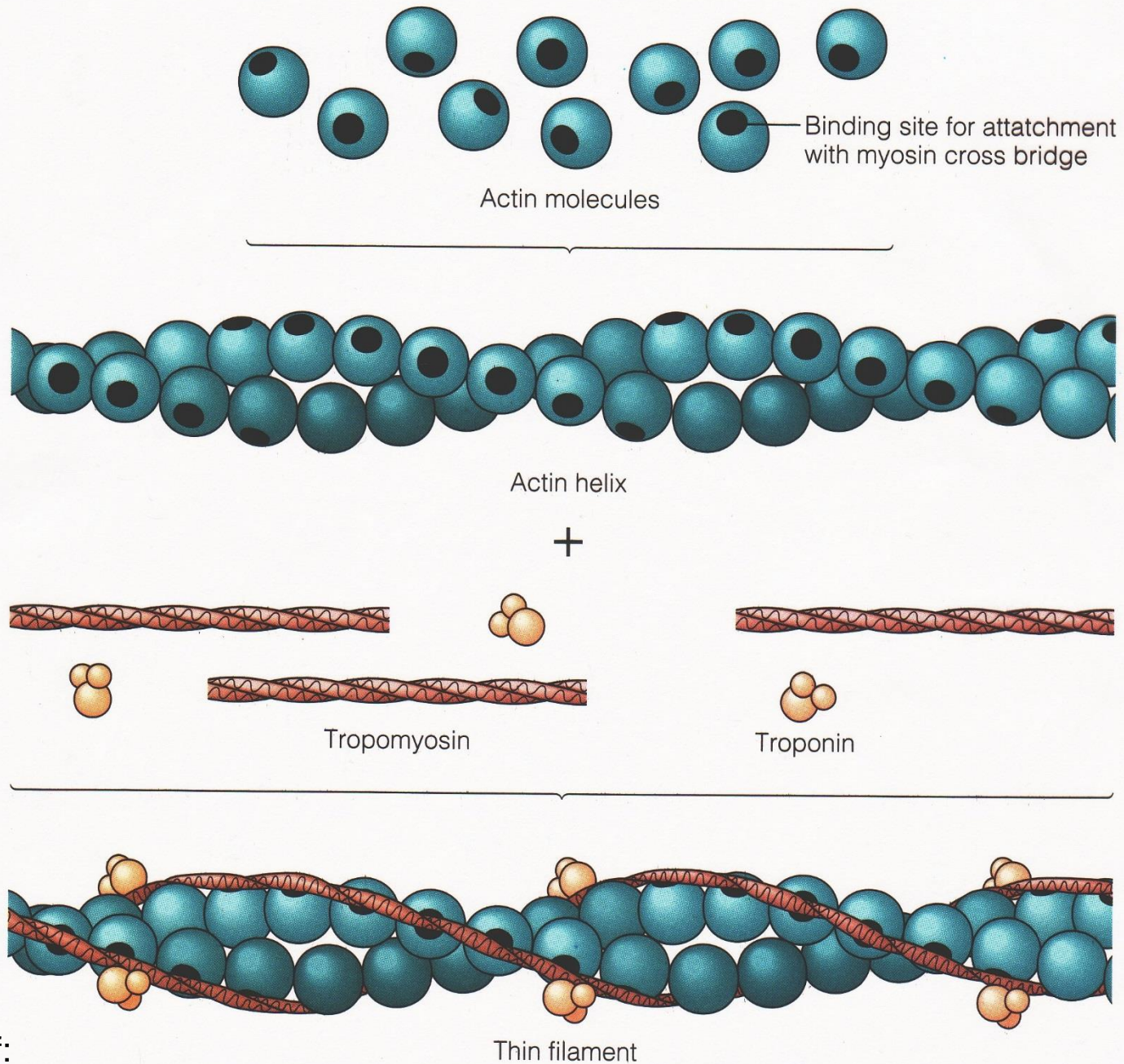
Myosin Heads

Myosin Heads

Myosin Tails

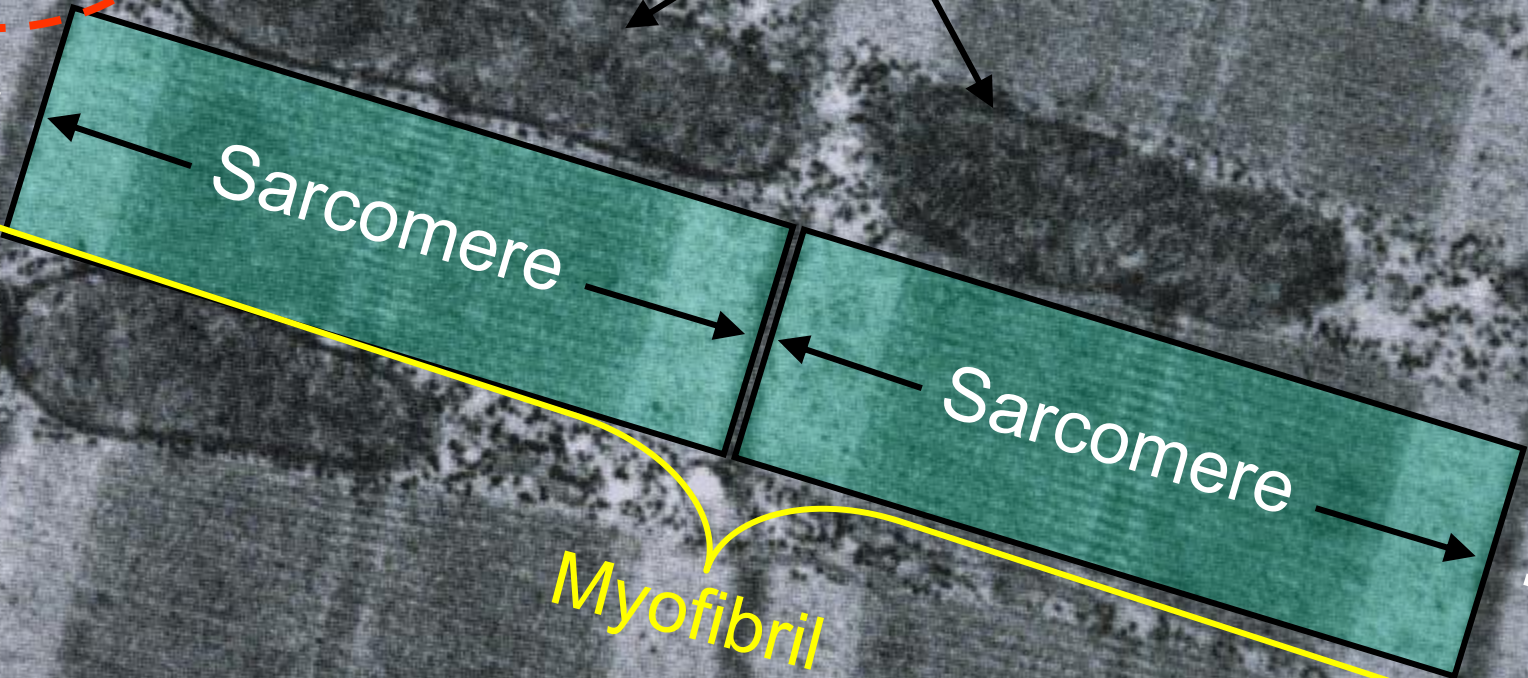


Bare Zone



Triad \equiv T tubule abutting cisternae

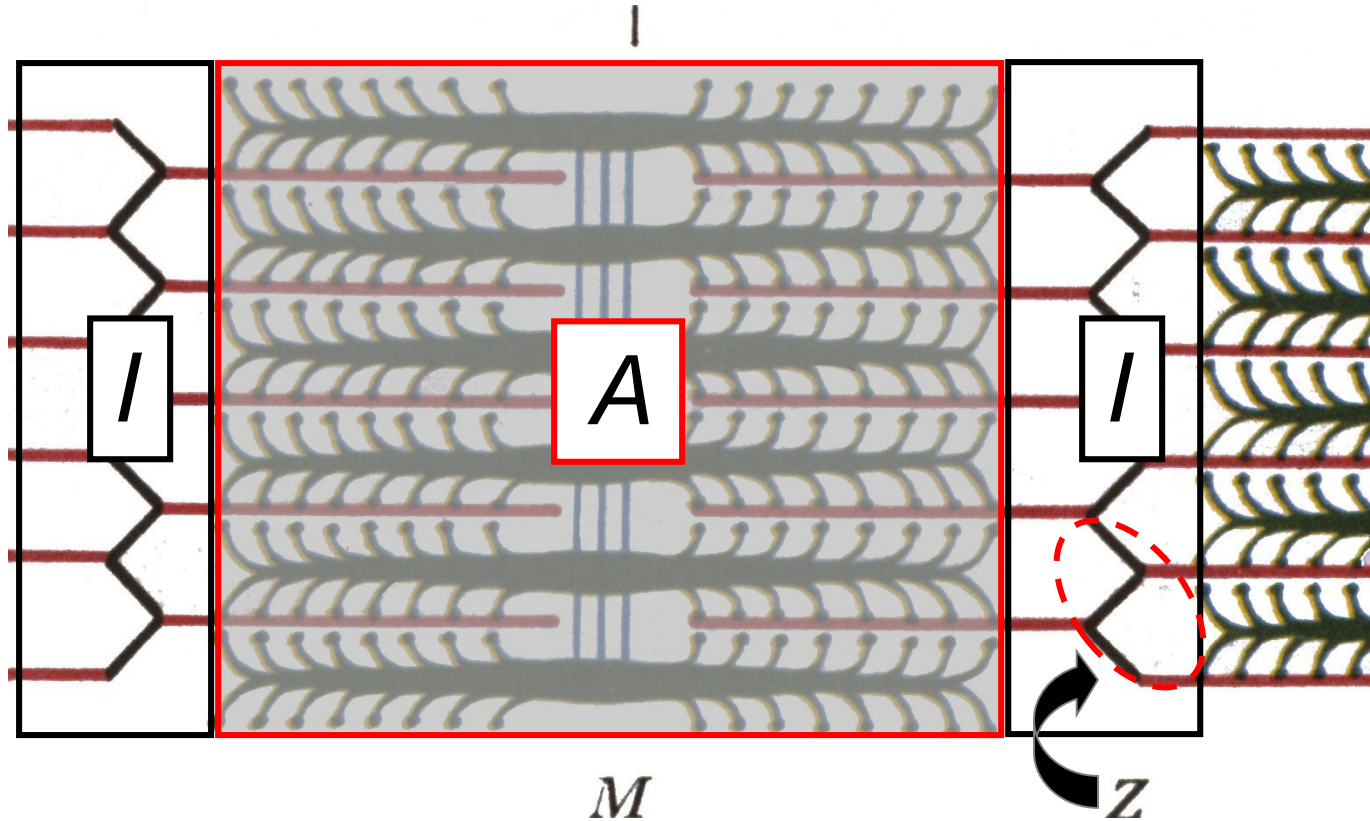
Mitochondria



Myofibril

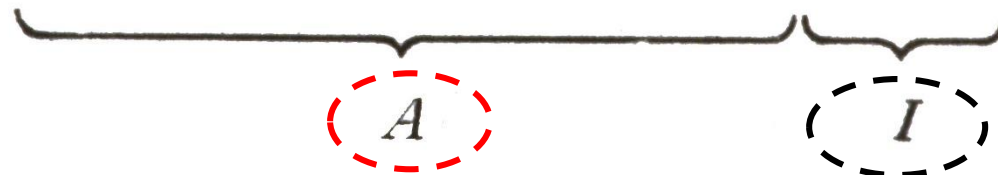
A Band = Dark Band

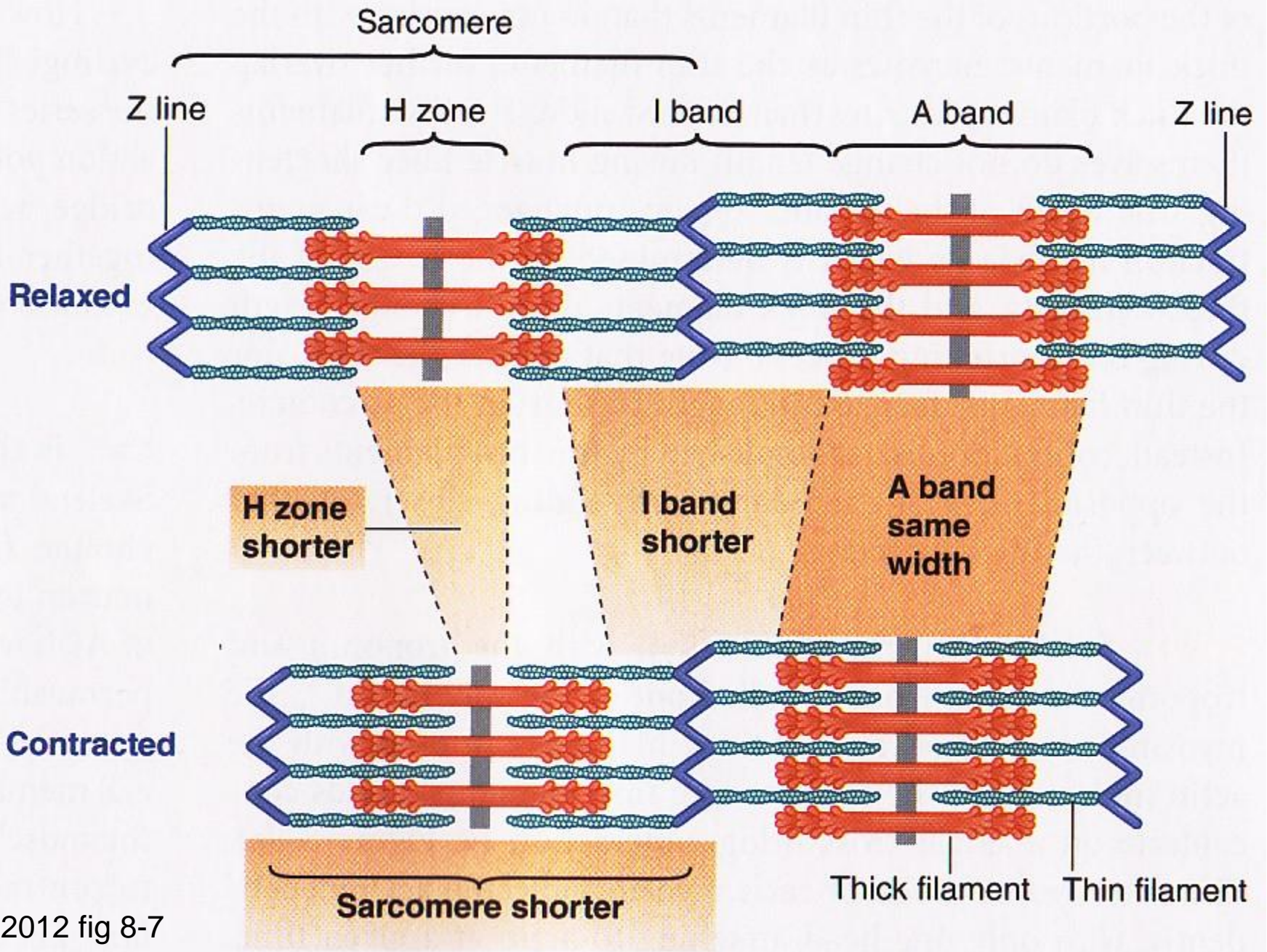
Anisotropic = Light Can't Shine Through



I Band = Light Band

Isotropic = Light Can Shine Through





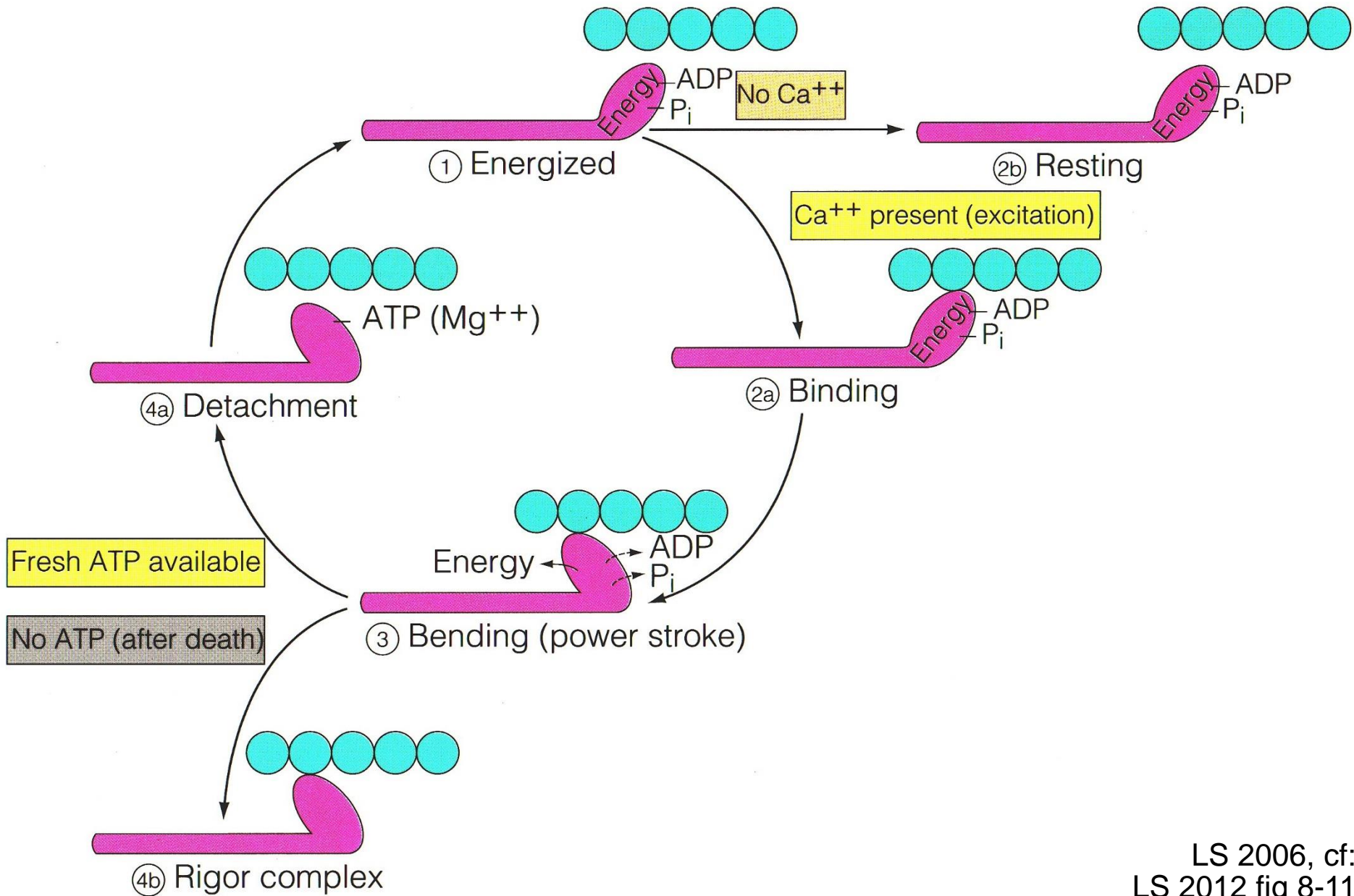
LS 2012 fig 8-7

Discussion + Time for Questions!

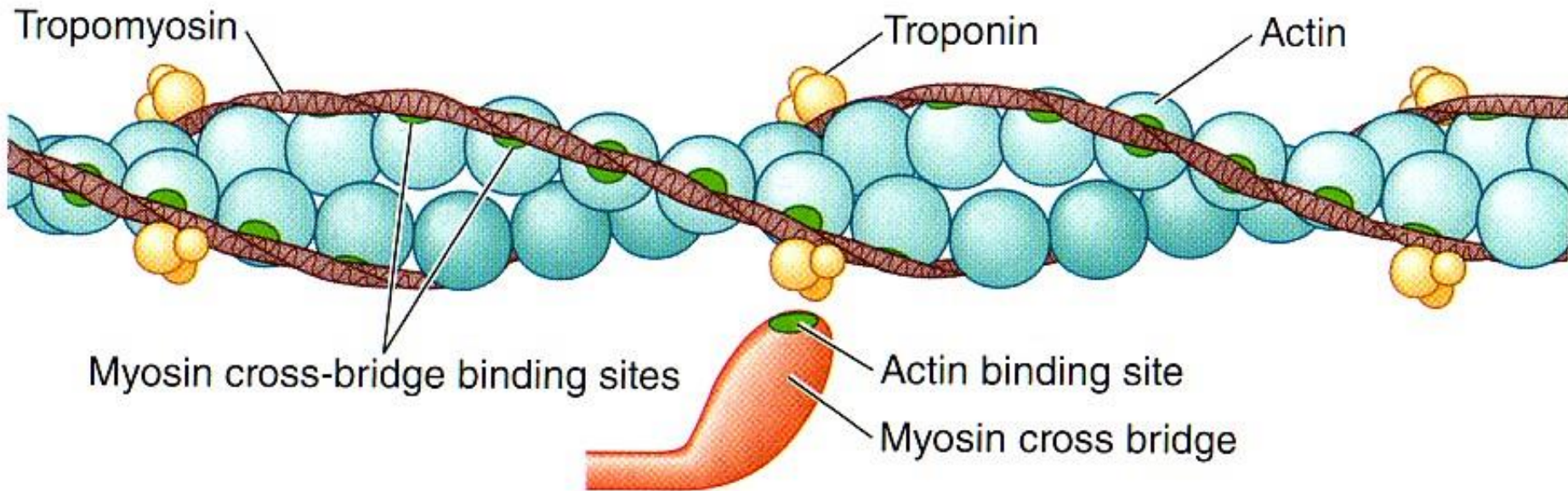


***What do we guess
happens at the
molecular level?***

Cross-Bridge Cycle



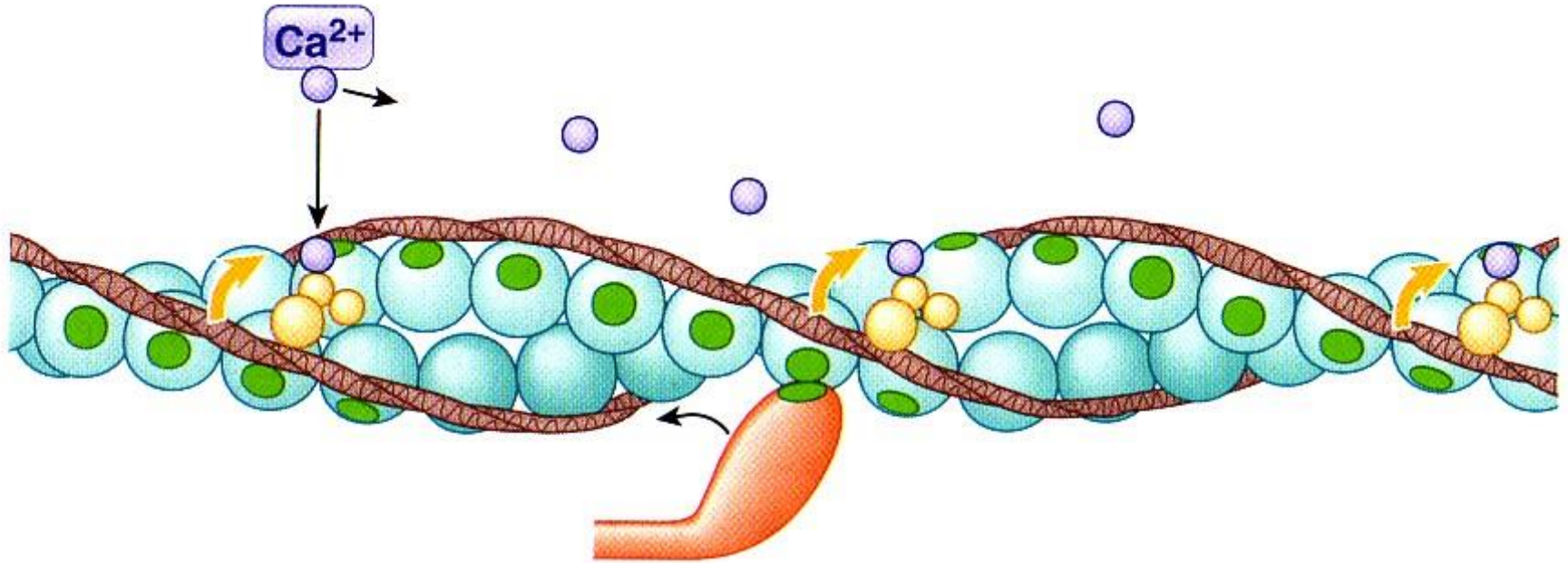
Relaxed: No Cross-Bridge Binding



(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.

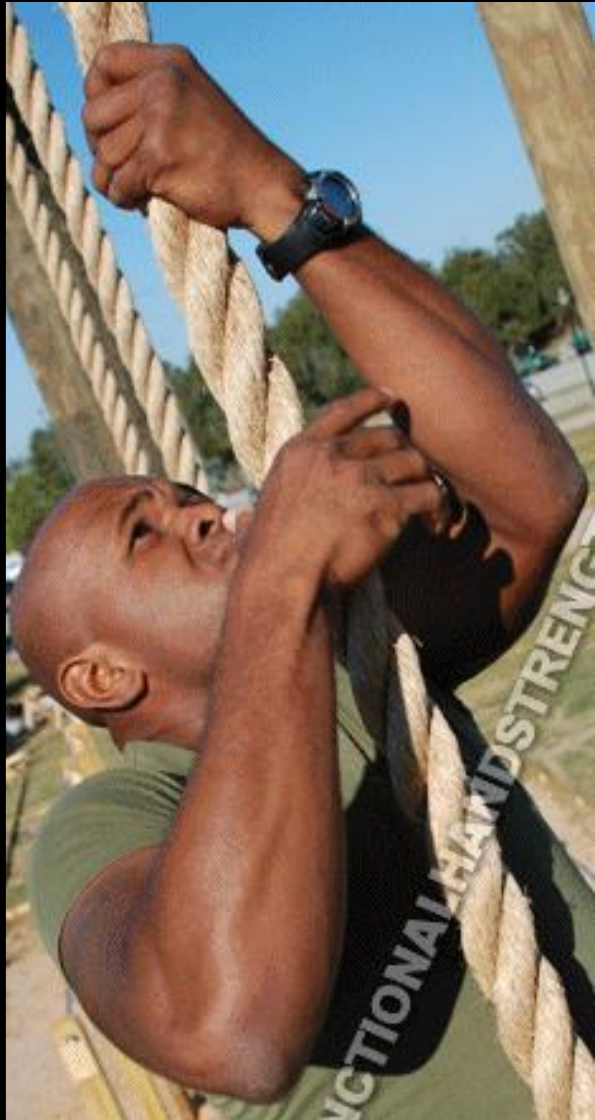
Excited: Calcium Triggers Cross-Bridge Binding



(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.

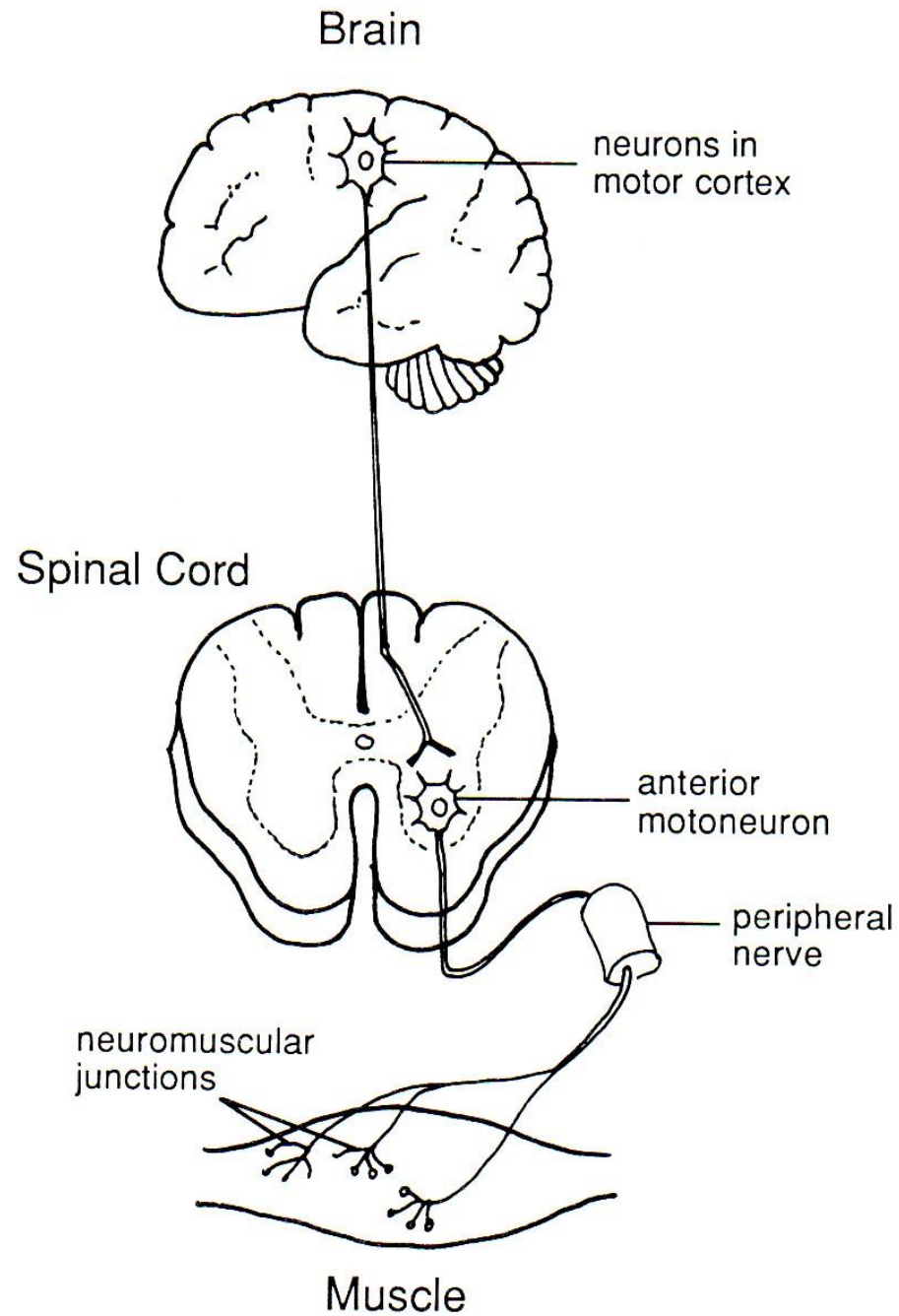
Rope Climb or Tug of War Grasp, then Regrasp!



Summary
We are
almost
there!



<https://www.youtube.com/watch?v=Ktv-CaOt6UQ>

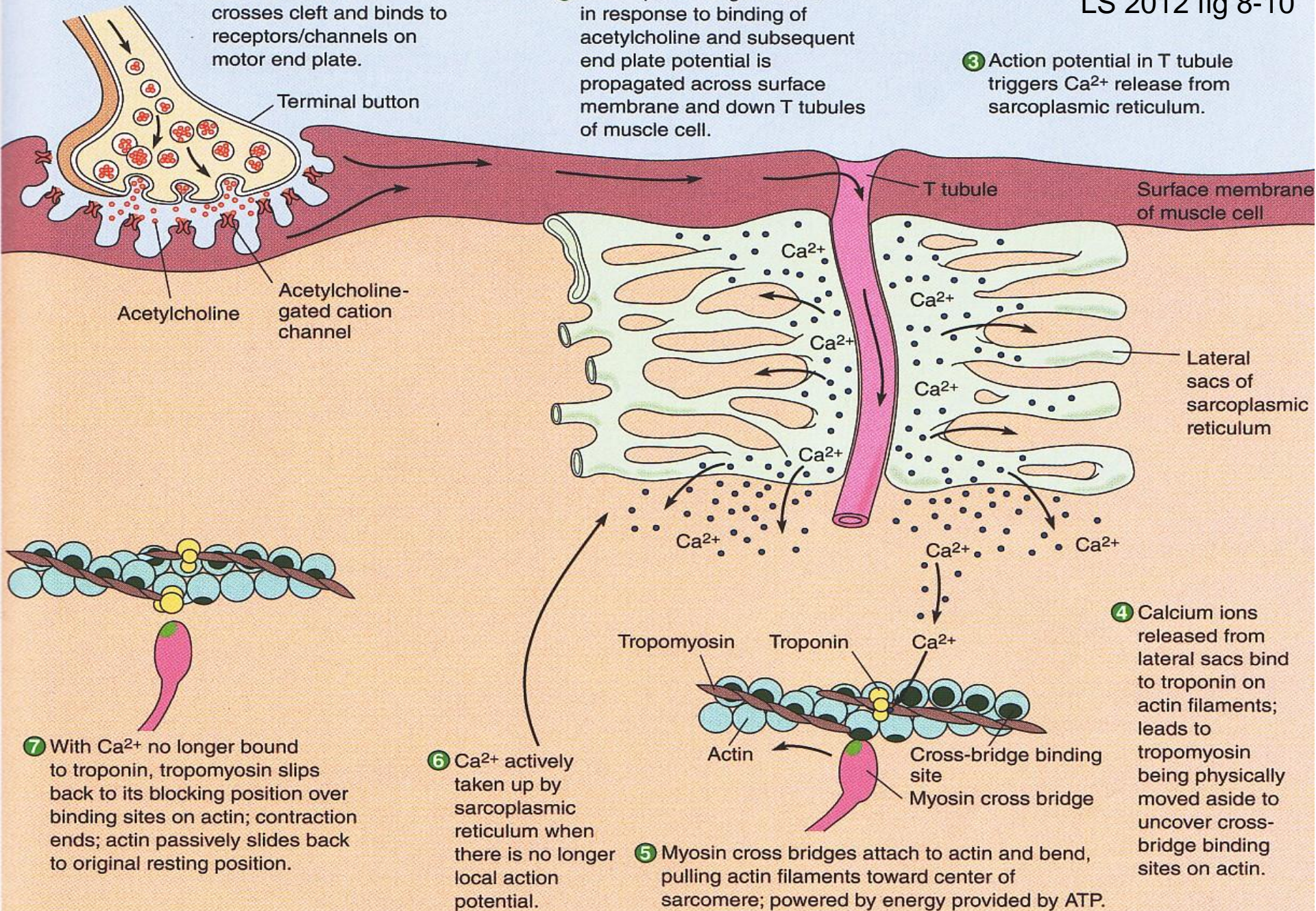


DN Laing & VP
Lombardi, 1989

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.

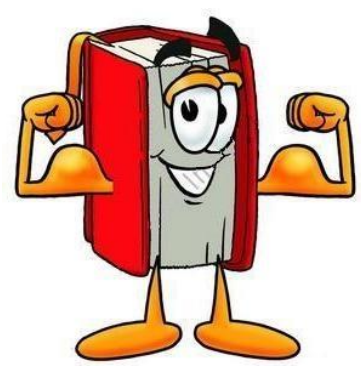


7 With Ca^{2+} no longer bound to troponin, tropomyosin slips back to its blocking position over binding sites on actin; contraction ends; actin passively slides back to original resting position.

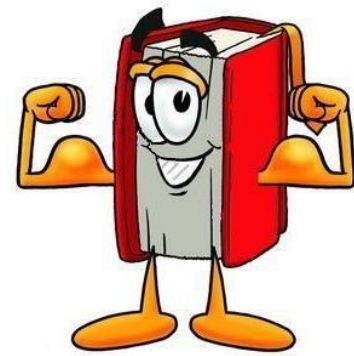
6 Ca^{2+} actively taken up by sarcoplasmic reticulum when there is no longer local action potential.

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.



Muscle Contraction Resources



<https://ed.ted.com/lessons/how-your-muscular-system-works-emma-bryce>

<https://ed.ted.com/on/s3Zzdm8u>

<https://ed.ted.com/lessons/what-makes-muscles-grow-jeffrey-siegel>

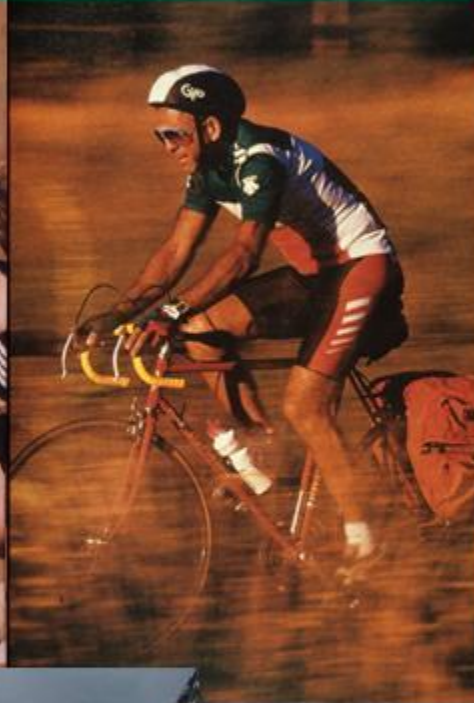
<https://www.ncbi.nlm.nih.gov/books/NBK9961/>

***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?

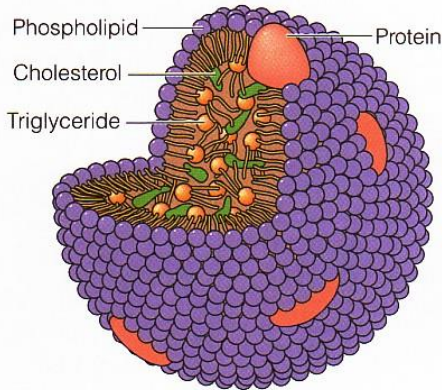
Mode, Intensity, Duration, Frequency,
Distribution of Training Sessions?
Conditions of Environment? Individual?



Adaptations to Exercise?

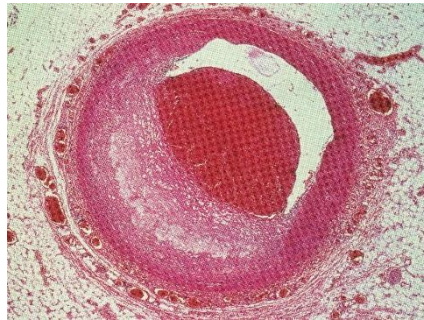
Body Levels of Organization?

Which Body System?

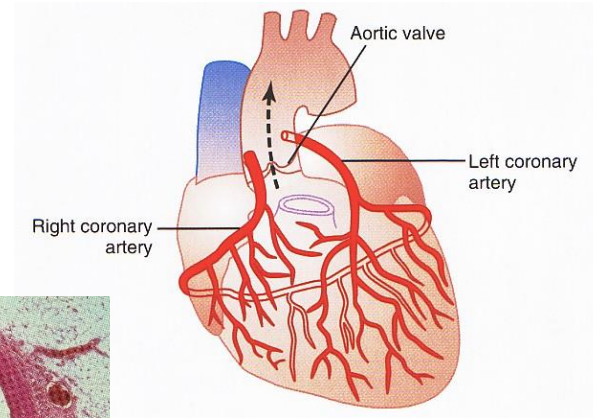


A typical lipoprotein

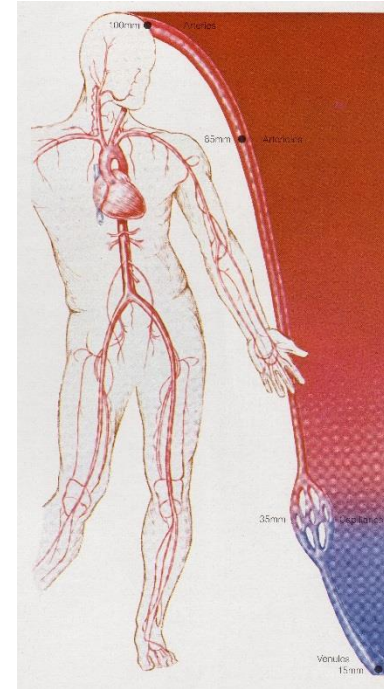
Molecular



Cell/Tissue

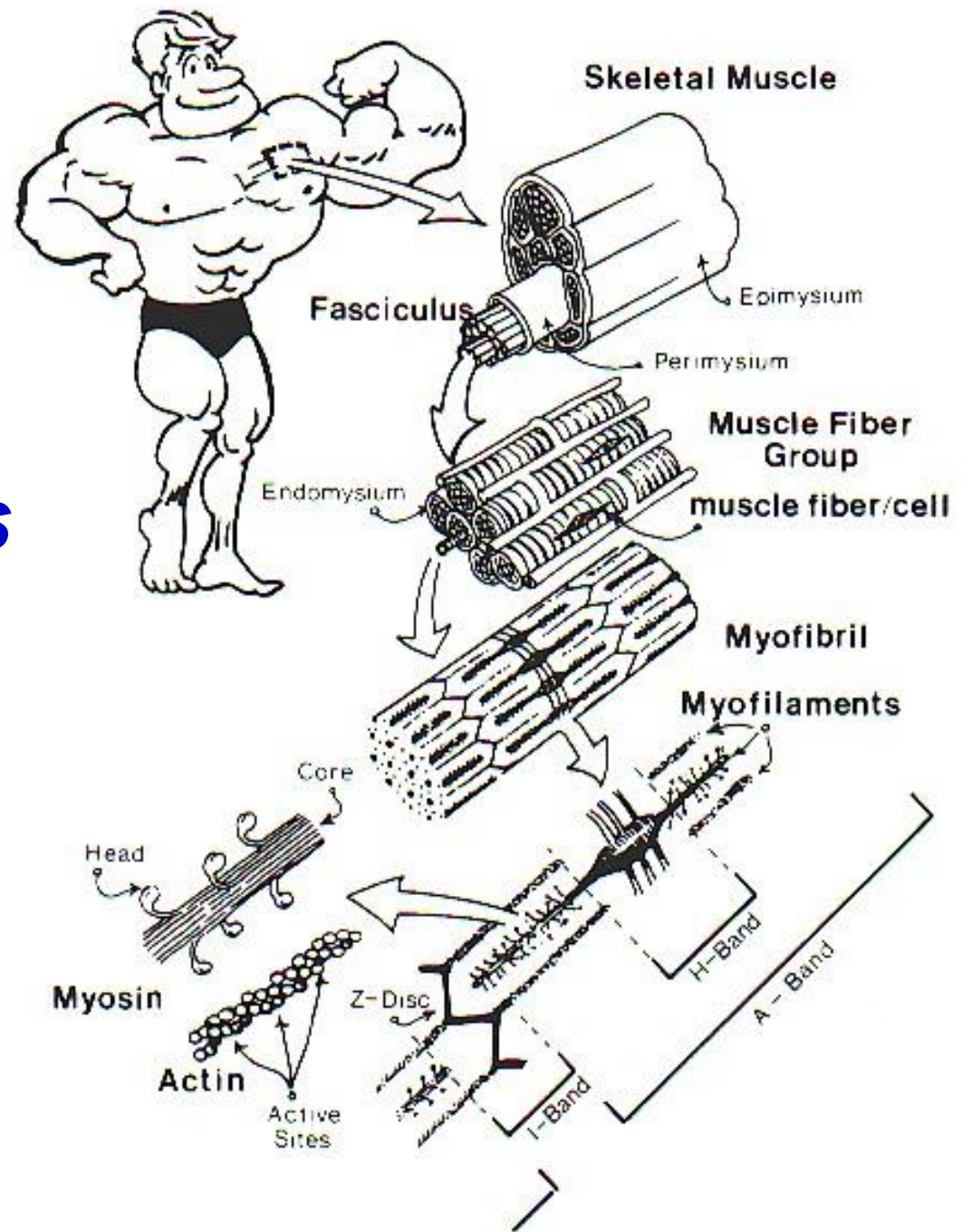


Organ

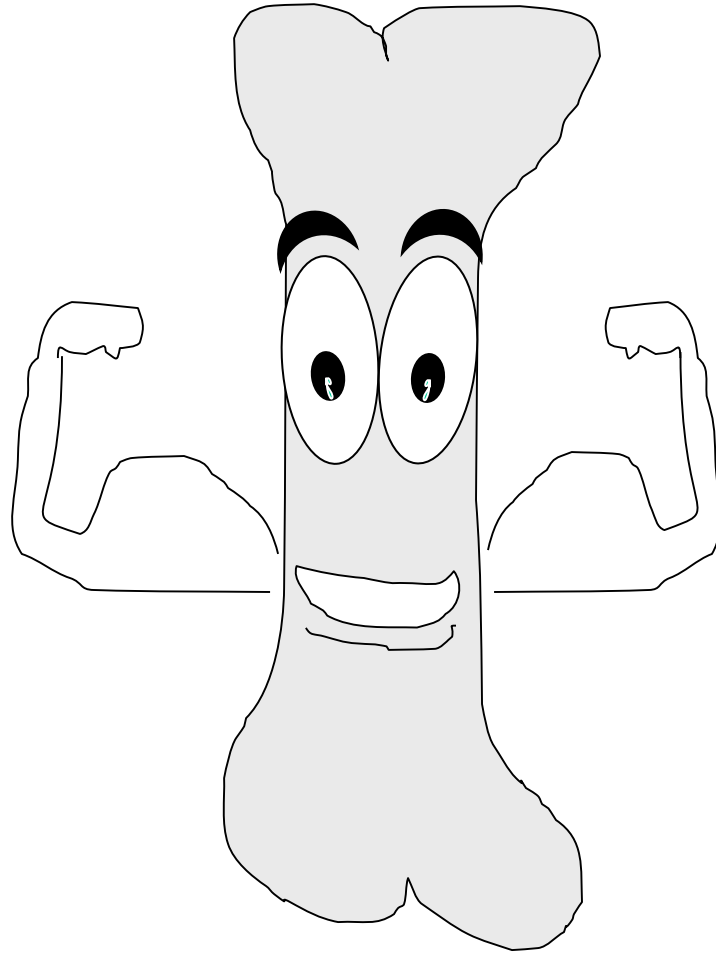


Body System

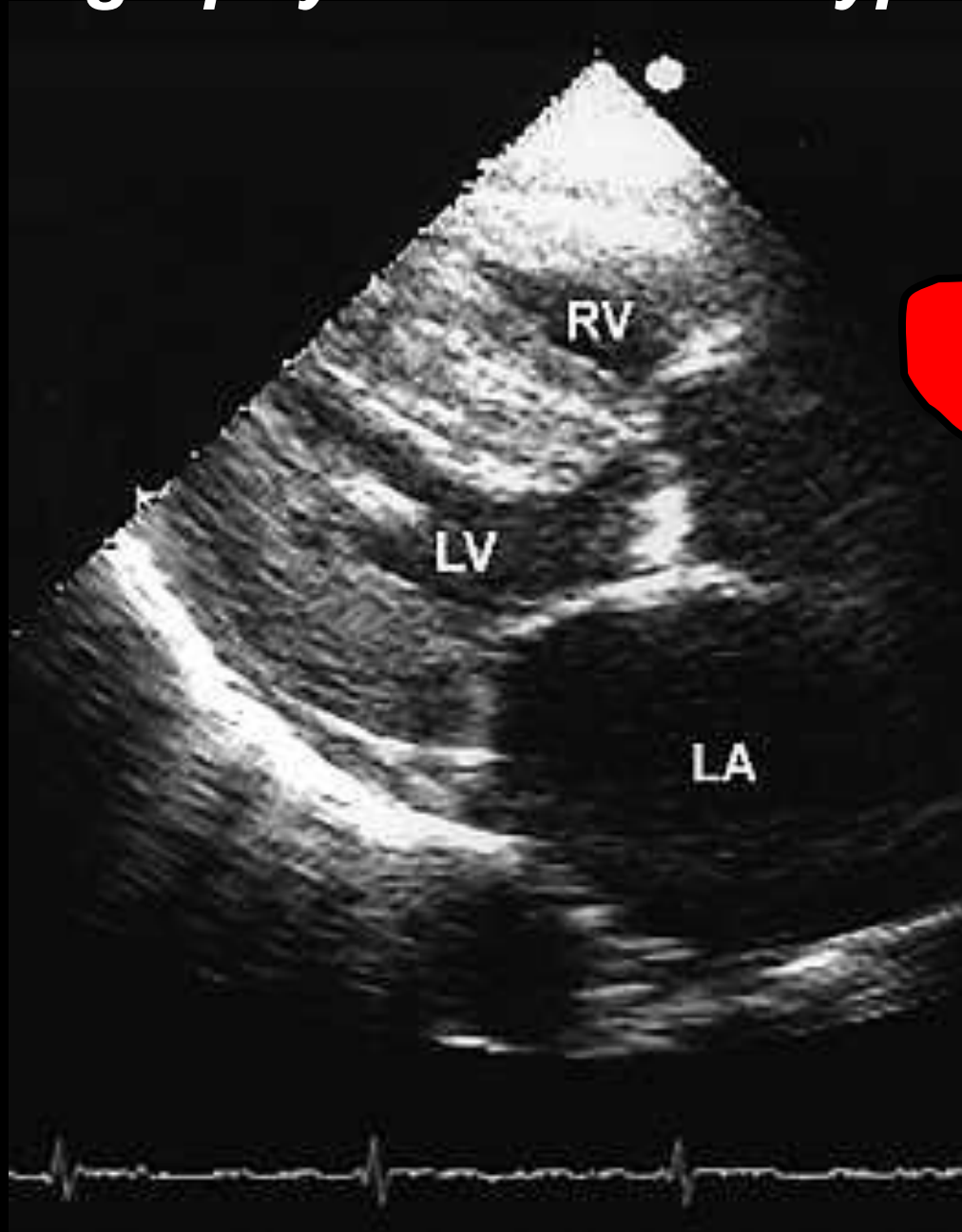
Muscle Adaptations to Exercise



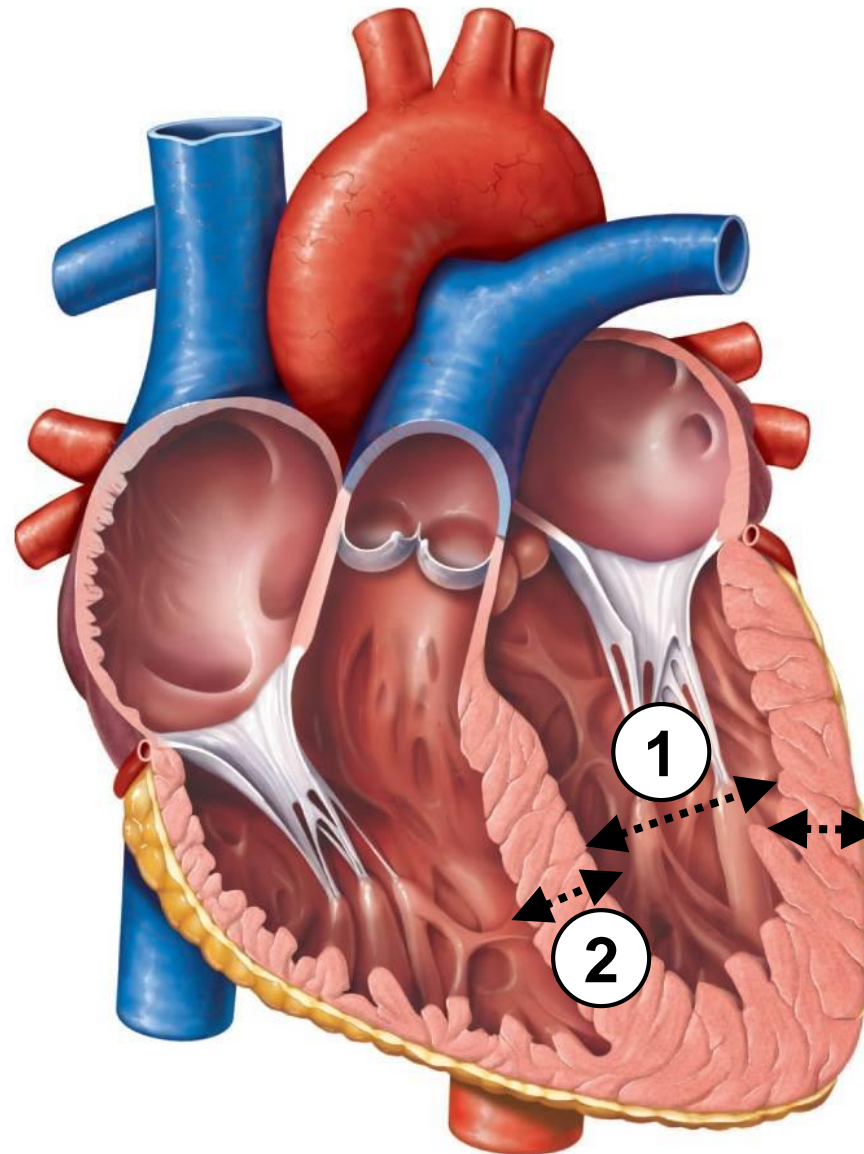
As muscles tug on bones, bones get stronger, too!...many systems adapt!!



Echocardiography documents hypertrophy...



Cardiac Adaptations to Exercise: **① Endurance vs. ② Strength Training**



NB: ① > ↑ LBM

① + ②



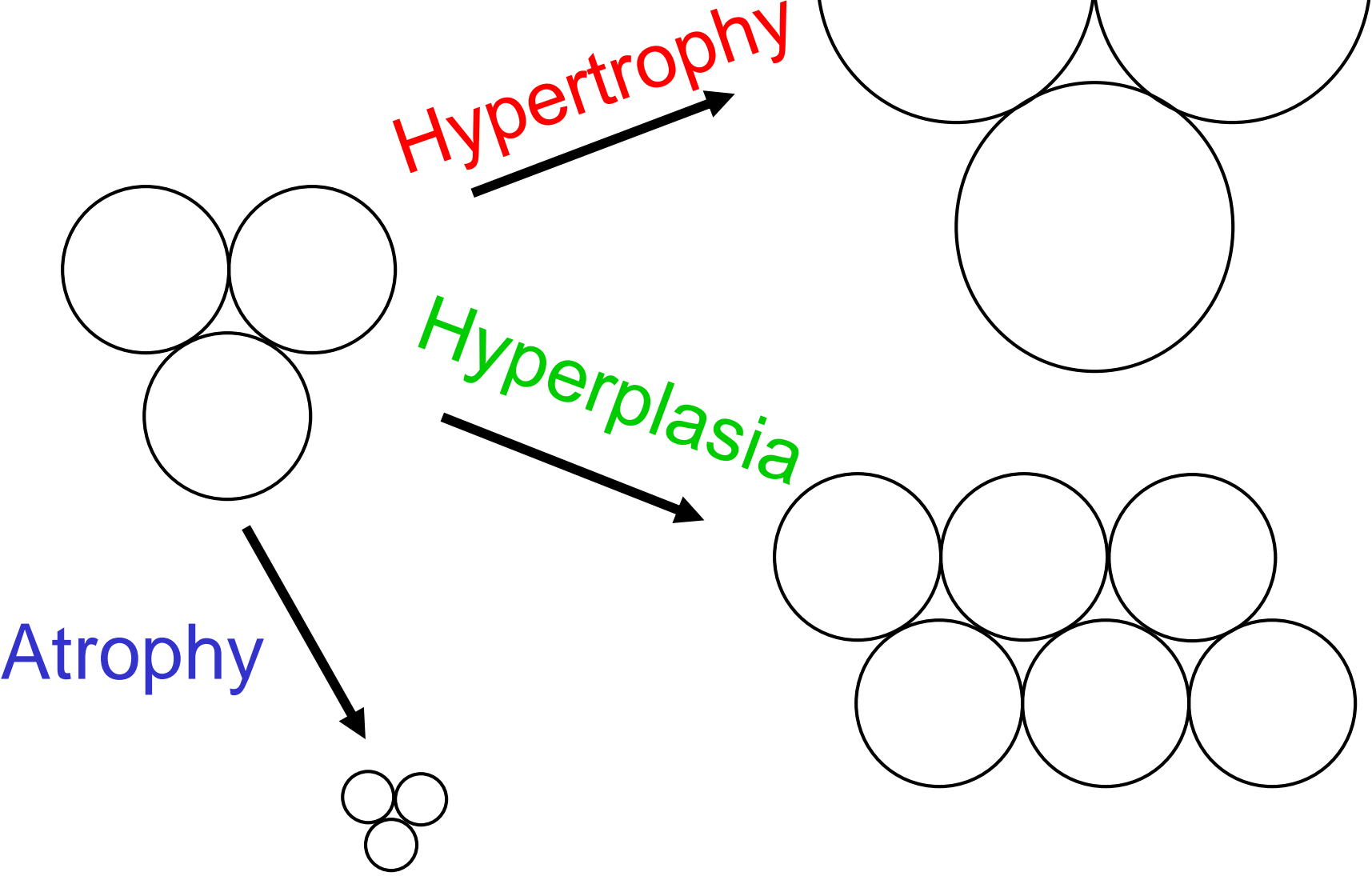
Atrophy

*decrease in size
& strength*

Hypertrophy

*increase in size
& strength*

Skeletal Muscle



Women & Hypertrophy?



What happens in muscles at cellular & subcellular levels?





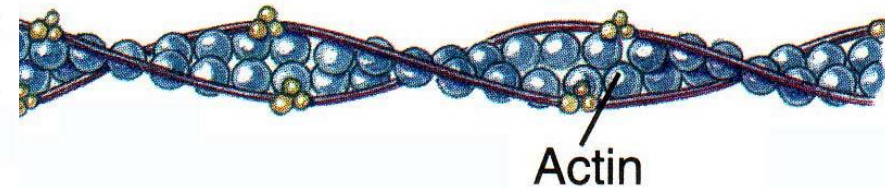
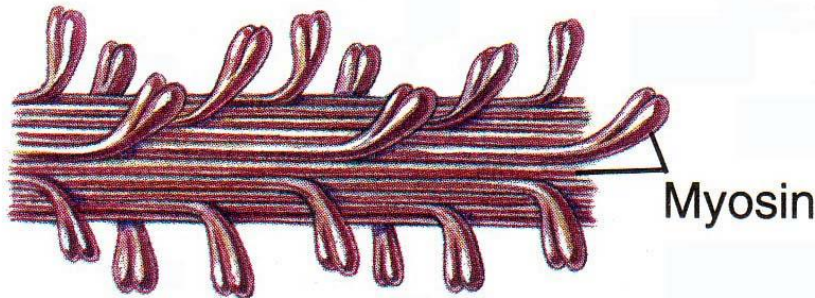
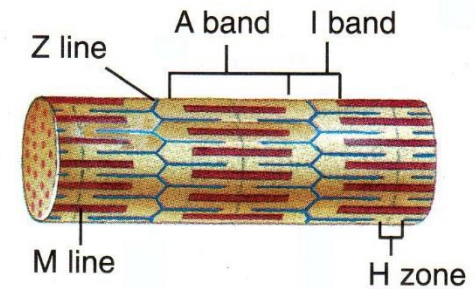
Myofibril

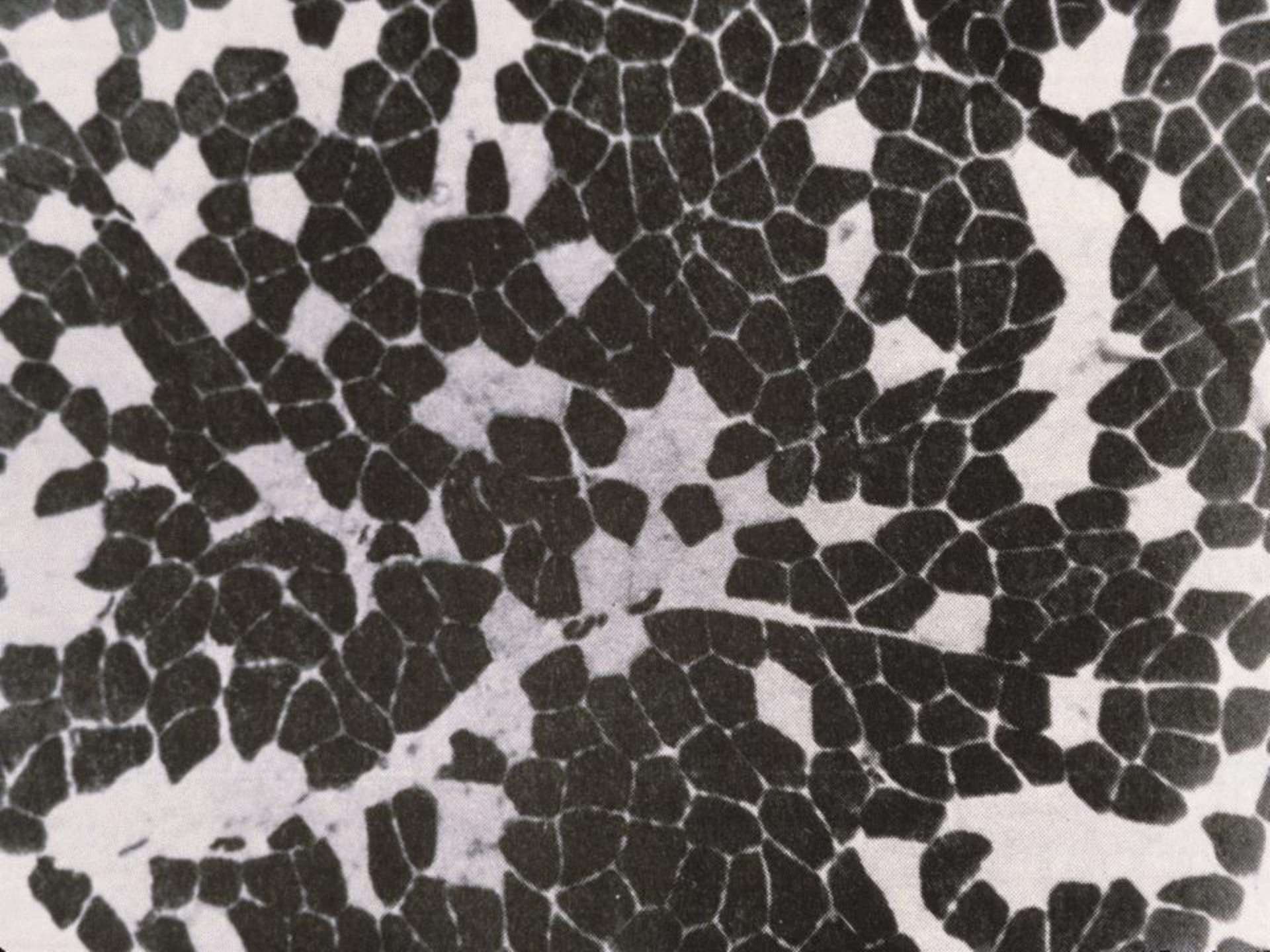
Hypertrophy: *Increased*

Number of Myofibrils

Thick & Thin Filaments

Myosin & Actin Molecules





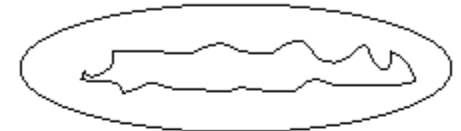
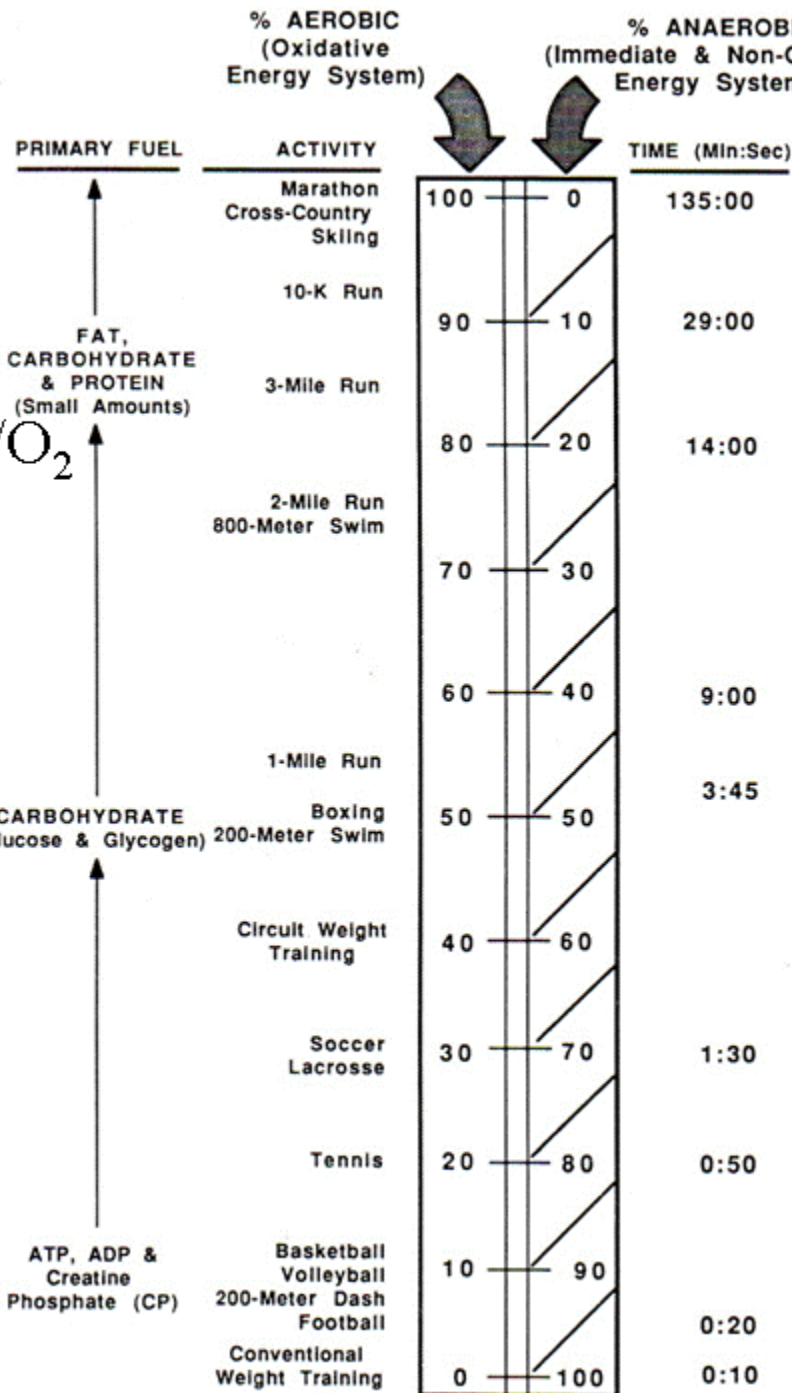
Characteristics of Skeletal Muscle Fibers

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



AEROBIC

w/O₂



MITOCHONDRIA

CYTOSOL

Glycolysis



Immediate/ATP-PC



ANAEROBIC

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:





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



Extremes of the energy continuum!

