I. Announcements  Notebooks? Exam II, Dec 7th Friday 8 am. Review session in class next Thurs. Q?

II. Muscle Contraction & Adaptation  LS ch 8, DC Mod 12
A. Banding pattern? LS fig 8-3, fig 8-7
B. How do muscles contract? LS fig 8-6, 8-10
C. What's a cross-bridge cycle? LS fig 8-11 +…
D. Summary of skeletal muscle contraction
E. Exercise adaptation variables: *mode, intensity, duration, frequency, distribution, individual* & environmental char...?
F. Endurance vs. strength training continuum? fiber types...

III. Respiratory System  LS ch 12, DC Module 7, Fox +…
A. Steps of respiration? External vs. cellular/internal?
   LS fig 12-1 pp 345-347
B. Respiratory anatomy LS fig 12-2 p 347, DC, Fox +…
C. Histology LS fig 12-4 pp 347-349, DC
D. How do we breathe? LS fig 12-12, fig 12-25 pp 349-356, pp 373-378

We're on a roll! Bring on Exam II!
Be safe in travel! Peace!
Have a Happy Turkey Day!!!
A Band = Dark Band
Anisotropic = Light Can’t Shine Through

/ Band = Light Band
/I isotropic = Light Can Shine Through
What do we guess happens at the molecular level?
Cross-Bridge Cycle

1. Energized
2a. Binding
2b. Resting
3. Bending (power stroke)
4a. Detachment
4b. Rigor complex

- ATP (Mg++)
- Energy
- ADP
- P_i
- No Ca^{++}
- Ca^{++} present (excitation)

Fresh ATP available
No ATP (after death)
(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.
(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
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.

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.

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.
Muscle Contraction Resources

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

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


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?
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
Atrophy  
*decrease in size & strength*

Hypertrophy  
*increase in size & strength*
Women & Hypertrophy?
What happens in muscles at cellular & subcellular levels?
Hypertrophy: *Increased Number of Myofibrils*

*Thick & Thin Filaments, Myosin & Actin Molecules*
## Characteristics of Skeletal Muscle Fibers

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Slow Oxidative (Type I)</th>
<th>Fast Oxidative (Type IIa)</th>
<th>Fast Glycolytic (Type IIb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myosin-ATPase Activity</td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Speed of Contraction</td>
<td>Slow</td>
<td>Fast</td>
<td>Fast</td>
</tr>
<tr>
<td>Resistance to Fatigue</td>
<td>High</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>Aerobic Capacity</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Anaerobic Capacity</td>
<td>Low</td>
<td>Intermediate</td>
<td>High</td>
</tr>
<tr>
<td>Mitochondria</td>
<td>Many</td>
<td>Many</td>
<td>Few</td>
</tr>
<tr>
<td>Capillaries</td>
<td>Many</td>
<td>Many</td>
<td>Few</td>
</tr>
<tr>
<td>Myoglobin Content</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Color of Fibers</td>
<td>Red</td>
<td>Red</td>
<td>White</td>
</tr>
<tr>
<td>Glycogen Content</td>
<td>Low</td>
<td>Intermediate</td>
<td>High</td>
</tr>
</tbody>
</table>
AERobic w/O₂

Mitochondria

Cytoplasm

Glycolysis

Immediate/ATP-PC
Muscle Changes Due to Strength Training

↑ Size of larger fast vs smaller slow fibers
↑ CP as well as _creatinine 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)?
Muscle Changes 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 ($\beta$-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?
Dancing can be super aerobic exercise, too, & you don’t have to be a star!
Extremes of the energy continuum!
Hey baby, what's your sign?

Cancer.
Lombo’s simplified steps!

1. Breathe in & out!

2. Cross membranes!

3. Move with blood!
   Go with the flow!

4. Cross membranes!

Steps of external respiration:

1. Ventilation or gas exchange between the atmosphere and air sacs (alveoli) in the lungs.

2. Exchange of $\text{O}_2$ and $\text{CO}_2$ between air in the alveoli and the blood in the pulmonary capillaries.

3. Transport of $\text{O}_2$ and $\text{CO}_2$ by the blood between the lungs and the tissues.

4. Exchange of $\text{O}_2$ and $\text{CO}_2$ between the blood in the systemic capillaries and the tissue cells.

Cellular reaction:

$\text{Food} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{ATP}$
**NB:** *In vivo,* Cupola or peak of each lung goes into neck > clavicle line!
16-20 C-shaped bars of hyaline cartilage to prevent collapse
Vocal cords approximate (move closer together) during Valsalva's maneuver!
Pulmonary Latex Cast with Colored Segmentation
Bronchograms (posteroanterior)

No Gas Exchange

1st alveolar outpouching!

Gas Exchange

SI Fox
The last cilium on a smoker's lung

Shoot... If only I had a red five.
Capillaries with rbcs!

← Alveoli →

White Blood Cell

L Brilla 1983
Muscles of Ventilation

**NB:** Diaphragm is the chief muscle of ventilation!
**Inhale (active)**

Contract & flatten diaphragm

**Exhale (passive @ rest)**

Relax & pouch up diaphragm!
Brain stem ≡ Control Center for automatic breathing!
Respiratory membrane separates air from blood, is 6 layers, yet 1/50th thickness of tracing paper!
Alveoli are surrounded by jackets of capillaries!

Alveolus surrounded by pulmonary capillaries

Pulmonary capillary networks

Alveolus with capillary cut away
Gas Exchange

Across pulmonary capillaries:
\( O_2 \) partial pressure gradient from alveoli to blood = 60 mm Hg (100 → 40)

\( CO_2 \) partial pressure gradient from blood to alveoli = 6 mm Hg (46 → 40)

Across systemic capillaries:
\( O_2 \) partial pressure gradient from blood to tissue cell = 60 mm Hg (100 → 40)

\( CO_2 \) partial pressure gradient from tissue cell to blood = 6 mm Hg (46 → 40)

Numbers are mm Hg pressure.

cf: LS 2012 fig 12-19