BI 121 Lecture 16

I. **Announcements** Notebooks? Exam II, December 8th Tuesday 8 am. Review session in class next Thursday. Q?

II. **Muscle + Adaptation Connections** LS ch 8, DC Module 12

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
   E. Gas exchange LS fig 12-19 pp 362-5
   F. Gas transport LS tab 12-3 pp 365-70
Muscle Contraction

Summary
1st signal starts in the brain!

Let’s look @ one bouton & one muscle fiber!
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 Ca²⁺ 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. Ca²⁺ actively taken up by sarcoplasmic reticulum when there is no longer local action potential.

7. With Ca²⁺ 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

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
AEROBIC

with \( O_2 \)

ANAEROBIC

MITOCHONDRIA

CYTOSOL

Glycolysis

Immediate/ATP-PC
## Characteristics of Skeletal Muscle Fibers

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Slow Oxidative (Type I)</th>
<th>Fast Oxidative (Type Ila)</th>
<th>Fast Glycolytic (Type Ilb)</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>
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 O₂ 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!
Time-out for discussion!
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 O₂ and CO₂ between air in the alveoli and the blood in the pulmonary capillaries.
3. Transport of O₂ and CO₂ by the blood between the lungs and the tissues.
4. Exchange of O₂ and CO₂ between the blood in the systemic capillaries and the tissue cells.

LS 2012 fig 12-1 modified
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 which approximate (move closer together) during *Valsalva’s* maneuver!
Pulmonary Latex Cast with Colored Segmentation
Bronchograms (posteroanterior)

Source: Gardner, Gray, O’Rahilly, Anatomy, fig 29-11, p 295.
No Gas Exchange

1st alveolar outpouching!

Gas Exchange

SI Fox
The last cilium on a smoker's lung
Alveoli

Bronchiole

Si Fox
Capillaries with rbcs!

← Alveoli →

White Blood Cell
**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!
**Gas Exchange**

**Across pulmonary capillaries:**
O₂ partial pressure gradient from alveoli to blood = 60 mm Hg (100 → 40)
CO₂ partial pressure gradient from blood to alveoli = 6 mm Hg (46 → 40)

**Across systemic capillaries:**
O₂ partial pressure gradient from blood to tissue cell = 60 mm Hg (100 → 40)
CO₂ partial pressure gradient from tissue cell to blood = 6 mm Hg (46 → 40)

Numbers are mm Hg pressure.

cf: LS 2012 fig 12-19
O₂ is carried mainly by red blood cell hemoglobin!

Each hemoglobin molecule carries 4 O₂ on 4 iron-containing disks!

Carbon monoxide, CO, binds ≥ 200x more powerfully to these same sites, thus poisoning the hemoglobin!

LS 2012 fig 11-2
# TABLE 12-3
Methods of Gas Transport in the Blood

<table>
<thead>
<tr>
<th>GAS</th>
<th>METHOD OF TRANSPORT IN BLOOD</th>
<th>PERCENTAGE CARRIED IN THIS FORM</th>
</tr>
</thead>
<tbody>
<tr>
<td>$O_2$</td>
<td>Physically dissolved</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Bound to hemoglobin</td>
<td>98.5</td>
</tr>
<tr>
<td>$CO_2$</td>
<td>Physically dissolved</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Bound to hemoglobin</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>As bicarbonate ($HCO_3^-$)</td>
<td>60</td>
</tr>
</tbody>
</table>

American Cancer Society Great American Smoke Out!

http://www.cancer.org/healthy/stayawayfromtobacco/greatamericansmokeout/
Be safe in travel! Peace! Have a Happy Turkey Day!!!

You'd better get out of the sun, Ralph... looks like you're done.