BI 121 Lecture 3

I. **Announcements**
   Registered? AEC Notes? **Come to office hr!**

II. **Connections**
   Videos + Q about Homeostatic Model for BP

III. **Cell Anatomy, Physiology & Compartmentalization**
   LS ch 2
   B. Basic survival skills ch 1 p 3
   C. Organelles ≡ Intracellular specialty shops w/membranes
      1. Endoplasmic Reticulum (ER)
      2. Golgi
      3. Lysosomes
      fig 2-1, 2-2, 2-3, 2-4, 2-5, 2-6, 2-7, 2-8 pp 20-7 tab 2-1 p 36
   D. What about vaults? LS 2006, p 32
   E. **Physiol News** Moms eggs execute Dad’s mitochondria?

IV. **Anaerobic vs Aerobic Metabolism Overview**
    Many sources!
    Mathews & Fox 1976...LS 2012 pp 26-33, fig 2-15 p 33

V. **Introduction to Genetics**
   LS 2012 ch 2 p 20-1 + Appendix C
   A. What’s a gene? Where? p A-18, fig C-2, C-3
   B. Why are genes important? p A-18
   C. What’s DNA & what does it look like? pp A-18 thru A-20
   D. How does information flow in the cell? fig C-6
   E. How does DNA differ from RNA? pp A-20 thru A-22
   G. How are proteins made? fig C-7, C-9

...Anatomy & Physiology Lab Thurs! Fun again!
## BI 121 Office Hr Fall 2017

<table>
<thead>
<tr>
<th>Day &amp; Time</th>
<th>Instructor</th>
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<tbody>
<tr>
<td>M 9 – 10 am</td>
<td>Steph VanBeuge</td>
<td>342 WIL</td>
<td>stephv</td>
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<tr>
<td>T 10 – 11 am</td>
<td>Pat Lombardi⁺</td>
<td>65A KLA</td>
<td>lombardi</td>
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<tr>
<td>T 12:30-1:30 pm</td>
<td>Janelle Stevenson</td>
<td>SCI LIB 1&lt;sup&gt;st&lt;/sup&gt; fl</td>
<td>janelleia</td>
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<tr>
<td>W 1 – 2 pm</td>
<td>Kelsey Schultz</td>
<td>224 HUE</td>
<td>kshult7</td>
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<tr>
<td>Appt, e-mail</td>
<td>Patrick Reichhold</td>
<td>TBA</td>
<td>patrickr</td>
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⁺and by appointment. Please e-mail or call 541-346-6055.
Connections?

Interstitium?

Homeostasis?

https://www.youtube.com/watch?v=B658Yn3lNYc

https://www.khanacademy.org/partner-content/mit-k12/chem-and-bio/v/homeostasis
Blood Pressure Homeostasis

Venous Pooling

Baroreceptors/Pressure Receptors eg, in Carotids & Aorta

NB: Corrective Change \( \Delta \) Opposes Original Input \( I \)

Seated to Standing

Short-term vs long-term!

\( \downarrow BP \)

\( \uparrow BP \)

\( \rightarrow \)

Electrochemical Signal \( I' \)

CV Control Center Brain Stem

\( \downarrow O \)

Electrochemical Signal eg, Symp Accel N

\( \uparrow HR \)

\( \uparrow VC \)

\( \rightarrow \)
How Big? 100 Cells Lengthwise = 1 mm!!

1. Cell Membrane

2. Nuclear Membrane

Cytoplasm = Cell - Nucleus
[Extract nucleus; includes organelles]

Cytosol = Cytoplasm - Organelles
[Extract organelles; complex gel-liquid]
Why Compartments? Advantage?

*Incompatible* reactions can take place *Simultaneously!!*
Basic Cell Survival Skills?

1. Get food
2. Use food
3. Rid wastes
4. Move
5. Reproduce

How to live?

Nucleus or nose?
1 Sample Cartoon of 100 Trillion (100 x 10^{12}) Cells!

Rough & Smooth Endoplasmic Reticulum (ER): Protein & Lipid Synthesizing Factories

Smooth ER:
1. packages new proteins in transport vesicles
2. stores calcium in muscles

fig 2-2 LS 2012
Electron Micrographs of **Rough** vs. **Smooth** ER

- **Rough ER lumen**
- **Ribosomes**
- **Smooth ER lumen**
Golgi Complex: Final Processing, Packaging & Distribution
Exocytosis: Primary Means of Secretion
Endocytosis: Primary Means of Ingestion
Lysosomes vs. Peroxisomes

Hydrolytic enzymes

Oxidative enzymes

Peroxisome

Lysosome
Phagocytosis: Cell Eating!

(a) 
- Particle
- Surface receptor site
- Endocytotic pouch
- Endocytotic vesicle

(b) 
- White blood cell
- Phagocytic vesicle
- Lysosome
- Residual body
Film: Neutrophil engulfing bacterium

http://devreotes.johnshopkins.edu/videos
Catalase Enzyme Reaction in Peroxisomes
Neutralize Toxin at Production Site!

2H₂O₂ → 2H₂O + O₂
Mom’s eggs execute Dad’s mitochondria

In “Hamlet,” Rosencrantz and Guildenstern deliver a letter to the rulers of England that carries the ill-fated duo’s own death sentence. Perhaps Shakespeare knew a bit about reproductive biology.

Scientists have now found that during a sperm’s creation, its mitochondria—energy-producing units that power all cells—acquire molecular tags that mark them for destruction once the sperm fertilizes an egg. This death sentence, a protein called ubiquitin, may explain why mammals inherit the DNA within mitochondria only from their mothers, a bio-

species mitochondrial inheritance. Sperm mitochondria sometimes avoid destruction when two different species of mice mate, and Schatten’s team has shown this also holds true in cattle. It’s hard to understand how an egg distinguishes between paternal mitochondria of closely related species, says Schon.

When paternal mitochondria escape destruction in normal mating, the resulting embryo may suffer. Schatten notes that a colleague has found sperm mitochondria in some defective embryos from infertility clinics.

Inside a fertilized egg, with its two sets of chromosomes (blue), the protein ubiquitin (red) tags sperm mitochondria (yellow).

What’s in the Vault?

An ignored cell component may often account for why chemotherapy fails

By JOHN TRAVIS

Can you imagine exploring the anatomy of the human body and missing the heart, the organ that sends life-giving blood coursing through the body? Of course not. Or not noticing the brain, the custodian of memories and creator of thoughts? Don’t be ridiculous.

Yet cell biologists may soon have to acknowledge an equally unimaginable oversight in their field. For decades, their powerful microscopes have failed to spot a basic cell component of animals and perhaps any organism with a nucleus. Known as vaults, the barrel-shaped particles are three times the size of ribosomes, the easy-to-spot particles that manufacture proteins and are visible through a microscope. But if it were contaminated with objects that shrug off the stain, that sea would be dotted with white islands. Rome likens the strategy to finding an invisible person by looking for an unexplained shadow in the beam of a spotlight.

To Kedersha’s surprise, unstained ovoid objects appeared among her coated vesicles. Since some of the stain settled into furrows on top of the unexpected shapes, the negative staining revealed fine details of the exterior of these mysterious interlopers, including arches that reminded Rome and Kedersha of the cell’s nuclear envelope. And the one thing we might surmise from the structure [of vaults] is that they might contain something,” says Rome.

That shape also hints that vaults may pick up their unknown cargo at the nuclear membrane, the barrier that separates the cell’s cytoplasm from its nucleus. The nucleus is a fluid-filled sac containing DNA and the machinery required to translate the instructions encoded by that DNA into molecules called messenger RNA. These mRNA strands, as well as other molecules, must somehow exit out of the cell.
I NEED A BREAK

but I'd rather have a breakthrough.
AEROBIC w/O_2 = MITOCHONDRIUM

ANAEROBIC without O_2 = CYTOSOL

1. Immediate/ATP-PC
2. Glycolysis
WOW!

I’M CHAMP!
**ATP = Adenosine Tri Phosphate**

The Common Energy Currency or the Cash Cells Understand!!

High Energy Phosphate Bonds
Cleave One High Energy Phosphate Bond To Do Work!!

7 – 10 KiloCalories/KCal

1. Synthesis of Macromolecules
   - Make big things from little things!

2. Membrane Transport
   - Move things! Microscopic!

3. Mechanical Work
   - Move things! Macroscopic!
Anaerobic vs. Aerobic Metabolism

**Anaerobic Glycolysis**
"sugar dissolving" without $O_2$. Net of 2 ATP per molecule of glucose

**Aerobic Metabolism**
+ mitochondrial processing of glucose with $O_2$. Net of 32 ATP per molecule of glucose
AEROBIC w/ O₂

**Primary Fuel**: Fat, Carbohydrate & Protein (Small Amounts)

**Activity**
- Marathon Cross-Country Skilling
- 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
- Conventional Weight Training

**% Aerobic (Oxidative Energy System)**
- Marathon Cross-Country Skilling: 100%
- 10-K Run: 90%
- 3-Mile Run: 80%
- 2-Mile Run: 70%
- 1-Mile Run: 60%
- Boxing: 50%
- 200-Meter Swim: 40%
- Circuit Weight Training: 30%
- Soccer Lacrosse: 20%
- Tennis: 10%

**% Anaerobic (Immediate & Non-Oxidative Energy Systems)**
- Marathon Cross-Country Skilling: 0%
- 10-K Run: 10%
- 3-Mile Run: 20%
- 2-Mile Run: 30%
- 1-Mile Run: 40%
- Boxing: 50%
- 200-Meter Swim: 60%
- Circuit Weight Training: 70%
- Soccer Lacrosse: 80%
- Tennis: 90%

**Time (Min:Sec)**
- Marathon Cross-Country Skilling: 135:00
- 10-K Run: 29:00
- 3-Mile Run: 14:00
- 2-Mile Run: 9:00
- 1-Mile Run: 3:45
- Boxing: 1:30
- 200-Meter Swim: 0:50
- Circuit Weight Training: 0:20

**Mitochondria**

**Cytoplasm**

**Glycolysis**

**Immediate/ATP-PC**
Stages of Cellular Metabolism/Respiration

**Anaerobic**
- **Glycolysis**
- **Cytosol**

**Aerobic**
- **Metabolism**
- **Mitochondria**

**Glycolysis**
1. Glucose and other fuel molecules
2. Pyruvate

**Pyruvate to acetate**
1. Acetyl-CoA

**Citric acid cycle**

**Electrons carried by NADH and FADH$_2$**

**Oxidative phosphorylation**
- (electron transport system and chemiosmosis)
  - 28 ATP

**Matrix**

**Inner Membrane**
Glycolysis "sugar dissolving/splitting" produces small amounts of ATP
Citric Acid Cycle produces pairs of electrons for cashing in at the nearby electron transport chain (ETC)
Cashing in electrons at the Electron Transport Chain (ETC) produces an abundance of ATP energy molecules!

Cytosol

Outer mitochondrial membrane

Rod Capaldi
U of O Biology

fig 2-12 LS 2012
Goals of Aerobic Metabolism

AEROBIC w/O₂ = MITOCHONDRION

CITRIC ACID CYCLE
harvest electrons

e⁻ e⁻ e⁻

“cash in”

ELECTRON TRANSPORT CHAIN

for ATP Energy!!
Cytoskeleton: Cell "Bone & Muscle"

Microtubule

Intermediate filament

Microfilament

Tubulin subunit

Polypeptide strand

Actin subunit

LS 2012 fig 2-17
Microtubular Highway!!
4th Component: Microtrabecular Lattice?
Time-out for questions!
What are DNA’s major functions?
Heredity + Day-to-Day Cell Function
What does DNA look like? Double-helix!!

LS fig C-2
Gene = Stretch of DNA that codes for a protein
What does DNA do, day-to-day?

DNA → RNA → Protein

- **Replication**
- **Transcription**
- **Translation** @ ribosomes

Nucleus → Cytoplasm
cf: LS fig C-6
DNA vs RNA?

1. Double-stranded  
2. Deoxyribose (without oxygen)  
3. A, T, C, G  
   Thymine  
4. Self-replicative (can copy itself)  
5. Nucleus (+mitochondria)

1. Single-stranded  
2. Ribose (with oxygen)  
3. A, U, C, G  
   Uracil  
4. Needs DNA as template  
5. 1\textsuperscript{0} Cytoplasm (but Nucleus origin)  
6. mRNA, rRNA, tRNA
**Triplets of bases code for amino acids, the building blocks of proteins**

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<th>tRNA anti-codon</th>
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Translation? Ribosomes Make Proteins

1. Large subunit
2. Small subunit
3. Amino acid
4. tRNA
5. Anticodon
6. mRNA
7. Leader sequence
8. First codon
9. Second codon
10. Ribosome
11. First ribosomal binding site
12. Second ribosomal binding site

Steps 5 through 8 are repeated

LS 2012 fig C-7
Transfer RNA (tRNA)
A Polyribosome. Which Way is Synthesis?
Questions + Discussion