I. Announcements

AEC Notes? [aec.uoregon.edu/peer-notetaking]

II. Connections

Q re: Homeostatic Model for BP? Active work!

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

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!
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!

Blood Pressure Homeostasis

Electrochemical Signal $I'$

CV Control Center Brain Stem

Electrochemical Signal eg, Symp Accel N

$O$

$E$

$Ef$

$+\ \text{HR}$

$+\ \text{VC}$

$\downarrow \text{BP}$

$\downarrow \text{BP}$
Active Learning
Group Work
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

Nucleus or nose?

How to live?
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
Electron Micrographs of **Rough** vs. **Smooth** ER

- Rough ER lumen
- Ribosomes
- Smooth ER lumen

fig 2-2 LS 2012
Secretion of Proteins Produced by ER

Instructions for building proteins leave the nucleus and enter the cytoplasm.

Proteins (colored strands) are assembled on ribosomes attached to the ER or free in the cytoplasm.

1. Rough ER
2. Transport vesicles
3. Smooth ER
4. Golgi complex
5. Secretory vesicles
6. Secretion (exocytosis)
7. Lysosome

fig 2-3 LS 2012
Golgi Complex: Final Processing, Packaging & Distribution

Transport vesicle from ER, about to fuse with the Golgi membrane

Golgi lumen

Vesicles containing finished product

Golgi complex

fig 2-4 LS 2012
**Exocytosis: Primary Means of Secretion**

Exocytosis is a primary means of secretion where secretory vesicles fuse with the plasma membrane, releasing their contents into the extracellular fluid. This process involves the movement of vesicles from the cytosol to the extracellular space, facilitated by the fusion of the vesicle membrane with the plasma membrane, leading to the release of secretory products into the surrounding environment.
Endocytosis: Primary Means of Ingestion

(fig 2-5b LS 2012)
Lysosomes vs. Peroxisomes
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

L. Nilsson, Nat Geog 1986
Catalase Enzyme Reaction in Peroxisomes
Neutralize Toxin at Production Site!

\[ 2\text{H}_2\text{O}_2 \xrightarrow{\text{Catalase}} 2\text{H}_2\text{O} + \text{O}_2 \]
Mitochondria: Energy Organelles
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 biospecies 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).

Vaults Hold Cell Mystery
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-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 something by this incredible structure. 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$_2$

= MITOCHONDRION

ANAEROBIC
without O$_2$

= CYTOSOL

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

I’M CHAMP!
ATP Supplied

Performance Time

Power Output

ATP-PC/Immediate
15 - 30 s

Glycolysis
1.5 – 3 m

Mitochondria

Oxygen System
≥ 3 – 5 m

Anaerobic

Aerobic

Cytosol

Modified after Mathews & Fox
ATP = Adenosine Tri Phosphate
The Common Energy Currency or the Cash Cells Understand!!

Adenosine

Phosphates

P
P
P

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

7 – 10 KiloCalories/KCal

Adenosine

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
<table>
<thead>
<tr>
<th>Primary Fuel</th>
<th>Activity</th>
<th>% Aerobic (Oxidative Energy System)</th>
<th>% Anaerobic (Immediate &amp; Non-Oxidative Energy Systems)</th>
<th>Time (Min:Sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAT, Carbohydrate &amp; Protein (Small Amounts)</td>
<td>Marathon Cross-Country Skiling</td>
<td>100</td>
<td>0</td>
<td>135:00</td>
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<tr>
<td>Carbohydrate (Glucose &amp; Glycogen)</td>
<td>10-K Run</td>
<td>90</td>
<td>10</td>
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<tr>
<td></td>
<td>3-Mile Run</td>
<td>80</td>
<td>20</td>
<td>14:00</td>
</tr>
<tr>
<td></td>
<td>2-Mile Run</td>
<td>70</td>
<td>30</td>
<td>9:00</td>
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<tr>
<td></td>
<td>800-Meter Swim</td>
<td>60</td>
<td>40</td>
<td>3:45</td>
</tr>
<tr>
<td>ATP, ADP &amp; Creatine Phosphate (CP)</td>
<td>1-Mile Run</td>
<td>50</td>
<td>50</td>
<td>1:30</td>
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<tr>
<td></td>
<td>Circuit Weight Training</td>
<td>40</td>
<td>60</td>
<td>0:50</td>
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<tr>
<td></td>
<td>Soccer Lacrosse</td>
<td>30</td>
<td>70</td>
<td>0:20</td>
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<tr>
<td></td>
<td>Tennis</td>
<td>20</td>
<td>80</td>
<td>0:10</td>
</tr>
<tr>
<td></td>
<td>Basketball Volleyball</td>
<td>10</td>
<td>90</td>
<td>0:00</td>
</tr>
</tbody>
</table>
Stages of Cellular Metabolism/Respiration

**Anaerobic**
Glycolysis
Cytosol

**Aerobic**
Metabolism
Mitochondria

**Glycolysis**
Glucose and other fuel molecules → Pyruvate → 2 ATP

**Pyruvate to acetate**
Pyruvate → Acetyl-CoA

**Citric acid cycle**
Electrons carried by NADH and FADH₂ → 2 ATP

**Oxidative phosphorylation** (electron transport system and chemiosmosis) → 28 ATP
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 = MITOCHONDRIAN

w/O₂

CITRIC ACID CYCLE

harvest electrons e⁻ e⁻ e⁻ 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!!

- **Nucleus**
- **GoGi complex**
- **Endoplasmic reticulum**
- **Cell body**
- **Lysosome**
- **Microtubular “highway”**
- **Axon**
- **Axon terminal**
- **Secretory vesicle**
- **Kinesin molecule**
- **Microtubule**
- **Dynein molecule**
- **Debris vesicle**
- **Debris**
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!!
Gene = Stretch of DNA that codes for a protein
What does DNA do, day-to-day?

DNA → Transcription → RNA → Translation → Protein

- Replication
- Nucleus
- Cytoplasm
- @ ribosomes

cf: LS fig C-6
<table>
<thead>
<tr>
<th>DNA</th>
<th>RNA</th>
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<tbody>
<tr>
<td><strong>1.</strong> Double-stranded</td>
<td><strong>1.</strong> Single-stranded</td>
</tr>
<tr>
<td><strong>2.</strong> Deoxyribose (without oxygen)</td>
<td><strong>2.</strong> Ribose (with oxygen)</td>
</tr>
<tr>
<td><strong>3.</strong> A, T, C, G Thymine</td>
<td><strong>3.</strong> A, U, C, G Uracil</td>
</tr>
<tr>
<td><strong>4.</strong> Self-replicative (can copy itself)</td>
<td><strong>4.</strong> Needs DNA as template</td>
</tr>
<tr>
<td><strong>5.</strong> Nucleus (+mitochondria)</td>
<td><strong>5.</strong> 1° Cytoplasm (but Nucleus origin)</td>
</tr>
<tr>
<td></td>
<td><strong>6.</strong> mRNA, rRNA, tRNA</td>
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</table>
**Triplets of bases code for amino acids, the building blocks of proteins**

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<th>DNA code word</th>
<th>mRNA codon</th>
<th>tRNA anti-codon</th>
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<td>AUA</td>
<td>UAU</td>
</tr>
<tr>
<td>ACG</td>
<td>UGC</td>
<td>ACG</td>
</tr>
<tr>
<td>TTT</td>
<td>AAA</td>
<td>UUU</td>
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<tr>
<td>TAC</td>
<td>AUG</td>
<td>UAC</td>
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<tr>
<td>Second base of codon</td>
<td>UUU</td>
<td>UUC</td>
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</table>

Translation? Ribosomes Make Proteins

1. mRNA
2. Large subunit
3. Small subunit
4. Amino acid
5. tRNA
6. Leader sequence
7. First codon
8. Second codon
9. Ribosome

Steps 5 through 8 are repeated.

First ribosomal binding site
Second ribosomal binding site

CGU-UCC-GAU-GUC-GAU-GUA-GGU

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