I. **Announcements** Q from lecture or lab?

II. **Cell Physiology Connections** LS ch 2 pp 20-34, fig 2-1…2-8
   B. Exocytosis vs. Endocytosis fig 2-5 a & b, p 25
   C. **Physiol News** Moms eggs execute Dad’s mitochondria?
   D. What about vaults? LS 2006, p 32 + *Science News*

III. **Anaerobic vs Aerobic Metabolism Summary** LS ch 2 pp 26-33
   A. Key differences fig 2-15 + vpl
   B. Selected details: Glycolysis, CAC, ETC, fig 2-9 thru 2-12

IV. **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

BI 121 Lecture 3 Anatomy & Physiology Lab tomorrow!
fig 2-1 LS 2012

1 e.g. Cell of 100 Trillion!
**Rough & Smooth Endoplasmic Reticulum (ER): Protein & Lipid Synthesizing Factories**

- **Rough ER**
  - Protein & Lipid Synthesizing Factories
  - Ribosomes
  - Sacs

- **Smooth ER**
  - 1. packages new proteins in transport vesicles
  - 2. stores calcium in muscles
  - Smooth ER lumen
  - Tubules

Fig 2-2 LS 2012
Electron Micrographs of **Rough** vs. **Smooth** ER
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. Secretory vesicles
5. Golgi complex
6. Lysosome
7. Secretion (exocytosis)
Golgi Complex: Final Processing, Packaging & Distribution

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

Golgi lumen

Golgi sacs

Vesicles containing finished product

Dr. Don Fawcett & R. Bullerby/Yales Unlimited

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

(b) © Don W. Fawcett/Photo Researchers, Inc.
Lysosomes vs. Peroxisomes
Phagocytosis: Cell Eating!
Film: Neutrophil engulfing bacterium

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

\[ 2H_2O_2 \rightarrow 2H_2O + O_2 \]
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

An organelle?

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

I’M CHAMP!
ATP Supplied

Performance Time

Power Output

ATP-PC/Immediate

15 - 30 s

Glycolysis

Oxygen System

> 3 - 5 m

Mitochondria

Cytosol

Anaerobic

Aerobic

Modified after Mathews & Fox
**ATP = Adenosine Tri Phosphate**

*The Common Energy Currency or the Cash Cells Understand!!*

[Diagram showing Adenosine and its 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
Stages of Cellular Metabolism/Respiration

**Anaerobic**
- Glycolysis
- Cytosol

**Aerobic**
- Metabolism
- Mitochondria

- **Glycolysis**
  - Cytosol
  - Glucose and other fuel molecules
  - Pyruvate
  - 2 ATP

- **Pyruvate to acetate**
  - Mitochondrial matrix
  - Acetyl-CoA
  - Citric acid cycle
  - 2 ATP

- **Oxidative phosphorylation**
  - Mitochondrial inner membrane
  - Electrons carried by NADH and FADH₂
  - Oxidative phosphorylation (electron transport system and chemiosmosis)
  - 28 ATP

fig 2-9 LS 2012
Glycolysis "sugar dissolving/splitting" produces small amounts of ATP

Cytosol

Glycolysis

Pyruvate to acetate

Citric acid cycle

Oxidative phosphorylation

ATP

One 6-carbon glucose molecule

2 NAD⁺

2 NADH

2 ADP + 2 Pᵢ

Ten separate steps

Two 3-carbon pyruvate molecules

fig 2-10 LS 2012
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!
Goals of Aerobic Metabolism

**AEROBIC** w/O₂ = **MITOCHONDRION**

**CITRIC ACID CYCLE**
- harvest electrons
- "cash in" for ATP Energy!!

**ELECTRON TRANSPORT CHAIN**
Cytoskeleton: Cell "Bone & Muscle"
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!!

[Diagram of DNA structure with labels for Base, Phosphate, Sugar, and Nucleotide]
Gene = Stretch of DNA that codes for a protein
What does DNA do, day-to-day?

DNA \rightarrow RNA \rightarrow Protein

Transcription \rightarrow Translation

Replication

Nucleus \rightarrow Cytoplasm

@ ribosomes

cf: LS fig C-6
DNA vs RNA?

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

1. Single-stranded
2. Ribose (with oxygen)
3. A, U, C, G
4. Needs DNA as template
5. 1^0 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>mRNA codon</th>
<th>tRNA anti-codon</th>
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<td>AUA</td>
<td>UAU</td>
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<td>UGC</td>
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Translation? Ribosomes Make Proteins

1. Large subunit
2. Small subunit
3. Amino acid
4. tRNA
5. Anticodon

1. mRNA
2. Leader sequence
3. First codon
4. Second codon
5. Ribosome
6. CGUCCGAGU
7. AUGCAU
8. GUCGA
9. Steps 5 through 8 are repeated

10. First ribosomal binding site
11. Second ribosomal binding site

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