I. **Announcements** Nutrition Analysis Lab next Thursday! Please record your diet on p 3-7 LM & complete analysis by tomorrow using [https://www.supertracker.usda.gov/](https://www.supertracker.usda.gov/) Q?

II. **Physiol News** Moms eggs execute Dad’s mitochondria?

III. **Cell Physiology, Mitochondria & Metabolism Connections**

   LS 2012 fig 2-9 thru 2-12, 2-15 +…Mathews & Fox 1976

IV. **Introduction to Genetics** LS ch 2 p 20-1 + Appendix C

   B. How does information flow in the cell? fig C-6
   C. How does DNA differ from RNA? pp A-20 thru A-22
   E. How & where are proteins made? fig C-7, C-9
   F. Class skit: Making proteins @ ribosomes!

V. **Nutrition Primer** DC Module 2, Sizer & Whitney(S&W) Sci Lib

   A. Essential Nutrients: H$_2$O, 1$^0$ Carbohydrates, 2$^0$ Fats, 3$^0$ Proteins, Vitamins, Minerals; Macro- vs Micro-?
   B. Dietary Guidelines: USDA, AICR, Eat Like the Rainbow!
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 biparental 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).

1. Immediate/ATP-PC
2. Glycolysis
ATP Supplied

Performance Time

Power Output

ATP-PC/Immediate

15-30 s

Cytosol

Mitochondria

Oxygen System

≥ 3-5 m

1.5-3 m

Glycolysis

Anaerobic

Aerobic

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

Adenosine

Phosphates

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
Stages of Cellular Metabolism/Respiration

Anaerobic Glycolysis
Cytosol

Glycolysis
Glucose and other fuel molecules
Pyruvate

Aerobic Metabolism
Mitochondria

Pyruvate to acetate
Acetyl-CoA
Electrons carried by NADH and FADH$_2$

Citric acid cycle
2 ATP

Oxidative phosphorylation
(electron transport system and chemiosmosis)
28 ATP

Matrix
Inner Membrane

fig 2-9 LS 2012
Glycolysis produces small amounts of ATP.

One 6-carbon glucose molecule

Ten separate steps:
- 2 NAD$^+$
- 2 NADH
- 2 ADP + 2 $P_i$
- 2 ATP

Result:
- 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)

fig 2-11 LS 2012
+ David Oganesyan
http://pixdaus.com
Cashing in electrons at the Electron Transport Chain (ETC) produces an abundance of ATP energy molecules!

Cytosol

Outer mitochondrial membrane

Inner ...

fig 2-12 LS 2012
Goals of Aerobic Metabolism

AEROBIC \( \text{w/O}_2 \) = MITOCHONDRION

CITRIC ACID CYCLE

harvest electrons \( e^- \) "cash in" \( e^- \)

ELECTRON TRANSPORT CHAIN for ATP Energy!!
Time-out for questions!
What are DNA’s major functions? Heredity + Day-to-Day Cell Function
What does DNA look like? Double-helix!!

[Diagram showing the structure of DNA with labels for base, phosphate, sugar, and nucleotide]
Gene = *Stretch of DNA that codes for a protein*

Gene

DNA Double Helix

Histones

Supercoiling

cf: LS fig C-3
What does DNA do, day-to-day?

DNA → RNA → Protein

Replication
Transcription
Translation

Nucleus
Cytoplasm

@ ribosomes

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° Cytoplasm (but Nucleus origin)
6. mRNA, rRNA, tRNA
### Triplets of bases code for amino acids, the building blocks of proteins

<table>
<thead>
<tr>
<th>DNA code word</th>
<th>mRNA codon</th>
<th>tRNA anti-codon</th>
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<tbody>
<tr>
<td>TAT</td>
<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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## Second base of codon

<table>
<thead>
<tr>
<th></th>
<th>U</th>
<th>C</th>
<th>A</th>
<th>G</th>
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<tbody>
<tr>
<td>U</td>
<td>UUU</td>
<td>UCU</td>
<td>UAU</td>
<td>UGU</td>
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<tr>
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<td>UUC</td>
<td>UCC</td>
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<td></td>
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<td>UCA</td>
<td>UAA</td>
<td>UGA</td>
</tr>
<tr>
<td></td>
<td>UUG</td>
<td>UCG</td>
<td>UAG</td>
<td>UGA</td>
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<tr>
<td></td>
<td>Phe</td>
<td>Ser</td>
<td>Tyr</td>
<td>Cys</td>
</tr>
<tr>
<td></td>
<td>Leu</td>
<td></td>
<td>Stop</td>
<td>Stop</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Trp</td>
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</table>

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>C</td>
<td>CUU</td>
<td>CCU</td>
<td>CAU</td>
<td>CGU</td>
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<tr>
<td></td>
<td>CUC</td>
<td>CCC</td>
<td>CAC</td>
<td>CGC</td>
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<td>CCA</td>
<td>CAA</td>
<td>CGA</td>
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<td></td>
<td>CUG</td>
<td>CCG</td>
<td>CAG</td>
<td>CGG</td>
</tr>
<tr>
<td></td>
<td>Leu</td>
<td>Pro</td>
<td>His</td>
<td>Arg</td>
</tr>
</tbody>
</table>

| First base of codon |    |        |        | | First base of codon |
|---------------------|----|--------|--------| |---------------------|
| A                   | AUU| ACU    | AAA    | Asn    |
|                     | AUC| ACC    | AAA    | Asn    |
|                     | AUA| ACA    | AAA    | Asn    |
|                     | AUG| ACG    | AAA    | Asn    |
|                     | Ile| Thr    | Ser    | Ser    |
|                     |    |        |        |        |
| G                   | GUU| GCU    | GAU    | GGU    |
|                     | GUC| GCC    | GAC    | GGC    |
|                     | GUA| GCA    | GAA    | GGA    |
|                     | GUG| GCG    | GAG    | GGG    |
|                     | Val| Ala    | Asp    | Gly    |

Translation? Ribosomes Make Proteins

1. Translation begins with the mRNA binding to the ribosome.
2. tRNA molecules carry specific amino acids, and their anticodons interact with the mRNA codons.
3. The ribosome moves along the mRNA, incorporating each amino acid in sequence.
4. As the ribosome translates the mRNA, tRNA molecules bring the next amino acid to the ribosome, allowing for the formation of a peptide bond.
5. Steps 5 through 8 are repeated until the end of the mRNA sequence is reached.

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

[Image of polyribosome with ribosomes, mRNA, and protein]
Class Skit, Questions & Discussion!

What's a ribosome?

A protein synthesizing factory, where translation takes place!

What's a ribosome?

You rock, baby!
BREAK!
# Macronutrients & Micronutrients

**Essential for Life**

## Macronutrients

<table>
<thead>
<tr>
<th>Type</th>
<th>Sample Food Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂O/Water</td>
<td>Water, other drinks, fruits &amp; vegetables</td>
</tr>
<tr>
<td>1° Carbohydrates</td>
<td>Grains, vegetables, fruits, dairy products</td>
</tr>
<tr>
<td>2° Fats/Triglycerides/Lipids</td>
<td>Meats, full-fat dairy products, oils</td>
</tr>
<tr>
<td>3° Proteins</td>
<td>Meats, legumes, dairy vegetables</td>
</tr>
</tbody>
</table>

## Micronutrients

- **Vitamins** (A, D, E, K; C + B)
- **Minerals** (K⁺, Na⁺, Ca²⁺, Mg²⁺, Fe²⁺, Zn²⁺,…)

**NB:** Need only minute quantities!

- Vegetables, vegetable oils, fruits, citrus, grains, dairy
- Fruits, vegetables, grains, nuts, dairy, meats, processed foods

**Energy nutrients = yield ATP**
USDA Food Pyramid 1992

Fats, oils, and sweets

Use Sparingly

Milk, yogurt, and cheese group

2-3 Servings

Vegetable group

3-5 Servings

Meat, poultry, fish, dry beans, eggs, and nuts group

2-3 Servings

Fruit group

2-4 Servings

Bread, cereal, rice, and pasta group

6-11 Servings

Key

- Fat (naturally occurring and added)
- Sugars (added)
Willett & Stampfer Suggestions 2003

- Plant oils: olive, canola, soy, corn, sunflower, peanut, and other vegetable oils
- Whole grain foods: AT MOST MEALS
- Vegetables: IN ABUNDANCE
- Nuts and legumes: 1 TO 3 SERVINGS
- Dairy or calcium supplement: 1 TO 2 SERVINGS
- Fish, poultry, and eggs: 0 TO 2 SERVINGS
- White rice, white bread, potatoes, pasta, and sweets: USE SPARINGLY
- Red meat and butter: USE SPARINGLY
- Multiple vitamins: FOR MOST
- Alcohol: in moderation UNLESS CONTRAINDICATED

NEW FOOD PYRAMID

Daily exercise and weight control
US Modifications to 1992 Food Pyramid 2005

Regular Physical Activity: Exercise! Exercise!!

- Fats, oils, and sweets: Use sparingly
  - “good” fats!
  - saturated & trans fats!

- Milk, yogurt, and cheese group: 2–3 servings
  - 3 or more!

- Vegetable group: 3–5 servings
  - 5 or more!

- Meat, poultry, fish, dry beans, eggs, and nuts group: 2–3 servings
  - eg, fish, nuts
  - 4 or more!

- Fruit group: 2–4 servings
  - 1/2 whole grain

- Bread, rice, and pasta group: 6–11 servings
Dietary Guidelines for Americans 2005
Food Guidance System

1. ↑emphasis on ↓kcal + ↑exercise.
2. 9-A-Day! 4 fruit + 5 vegetable servings.
3. ≥ 3 of 6 whole grains → ½ whole grains!
4. 3 servings of dairy, eg 3 c fat-free milk.
5. ↓saturated + trans fats + ↑unsaturated/“good” fats, eg Ω-3 fish, walnuts.
6. Drink in moderation if at all.
7. Practice food safety.
1. **Vary your veggies.** Fill ½ your plate with fruits & vegetables!

2. **Focus on fruits.** Whole fruit preferable to juice, but any fruit counts! Fill ½ your plate with fruits & vegetables!

3. **Make at least ½ of your grains whole grains!**

4. **Go lean with protein.** Keep protein to < ¼ plate! Nuts, beans, peas, seeds, poultry, lean meat, seafood,…

5. **Get your calcium-rich foods.** Buy skim or 1% milk. Go easy on cheese!

---

*MyPlate launched June 2, 2011*
Diet & Health Guidelines for Cancer Prevention

1. Choose a diet rich in variety of plant-based foods.
2. Eat plenty of vegetables & fruits.
3. Maintain a healthy weight & be physically active.
4. Drink alcohol only in moderation, if at all.
5. Select foods low in fat & salt.

And always, remember...

Do not smoke or use tobacco in any form.

American Institute for Cancer Research (AICR)
Your plate should be the size of a Frisbee, not a manhole cover.

When it comes to colorful foods, Fruit Loops don’t count.

A surprising number of people get 1/5 of their calories from sodas or other liquids.

If you look at the label & need a chemistry degree to read it, put the item back on the shelf!


NB: Each group 500 kcal deficit/day, 16 weeks
Exercise is better than dieting in lowering body fat & preserving muscles!
Dietary Composition & Physical Endurance

- High-fat diet: ~1/3 endurance!
- Normal mixed diet: 57 min
- High-carbohydrate diet: 114 min
- Maximum endurance time: 167 min

eg, Atkins!
Negative Effects of Low Carbohydrate

1. ↑ fatigue/exhaustion, central & peripheral!
2. ↓ glucose – brain+spinal cord, rbcs thrive upon.
3. ↓ variety which reduces intake of phytochemicals, vitamins, minerals & fiber.
4. ↑ risk of respiratory infections.

+ gall stones, ↓ thermoregulation...
We’re better at storing fat vs carbohydrate!

Dietary Fat

3 % Kcal

Body Fat

23 % Kcal

Dietary Carbohydrate
To Help Lower Body Wt & %Fat
EXERCISE!! +Minimize These!!

FAT  9 Kcal/g
ETOH 7 Kcal/g
CARB 4 Kcal/g
PRO  4 Kcal/g

NB: Minimize not Eliminate! Moderation not Abstinence!!
I'm not sure I believe you! Why can't I just starve to lose weight?
TOTAL FAST = No Energy Nutrients (No Carbohydrates, Fats or Proteins)

ONLY

1. Water
2. Vitamins
3. Minerals

ML Pollock & JH Wilmore 1990.
60-day Fast???

Lost 60 lb!! Wow!!

Yet

\[ \begin{align*}
&\text{26 lb Water} \\
&\text{20 lb Lean Body Mass} \\
&\text{14 lb Fat}
\end{align*} \]

\[ Fat < \frac{1}{4} \text{ total wt loss!} \]
You can lose weight by starving – but it's mostly water & muscle! Also, there can be complications!
Potential Complications of Total Fasting

Nausea, diarrhea, persistent vomiting, postural hypotension, nutritional deficiencies, menstrual irregularities, and…sudden death.

Positive Aspect??

General loss of appetite within first 2 days, maintained throughout fasting period.
Well-controlled studies of energy-reduced diets conducted in controlled environments showed that the macronutrient composition of the diet did not affect weight loss (1). Nonetheless, theories persisted that specific macronutrients would be superior for weight loss. For example, the traditional paradigm for low-fat, high-carbohydrate diets was based on the lower energy density of carbohydrate compared to fat, and the metabolic efficiency of converting dietary fat to body fat (2). Indeed strict vegetarians sustain lower body weight for years on low-fat diets (3). However, meaningful differences in body weight usually were not achieved in population-based trials of conventional low-fat diets (4). Thus, higher-fat, Mediterranean-style diets were proposed to be better for long-term weight loss because of their variety and satisfaction. Two trials found that Mediterranean diets were superior to low-fat diets for weight loss (5,6). Others claimed that a radically different approach that used low-carbohydrate, high-fat, and high-protein foods could produce weight loss without attention to reducing intake because of the satiety of protein-rich foods. Low-carbohydrate diets succeeded in the first few months with more rapid weight loss than low-fat diets but by one year, none of the trials found that weight loss on low-carbohydrate...
Dr. Sacks’ Conclusions:
We conclude that healthful diets with varying emphases on carbohydrate, fat & protein levels can all achieve clinically meaningful weight loss & maintenance of weight loss over a 2-yr period. The results give people who need to lose weight the flexibility to choose a diet that they can stick with, as long as it’s heart healthy. Such diets can also be tailored for individuals based on their personal & cultural preferences & in this regard may have the best chance for long-term success.
US Dietary Recommended Intakes (DRI) Committee Acceptable Macronutrient Distribution Ranges (AMDR)!

<table>
<thead>
<tr>
<th>Energy Nutrient</th>
<th>% Total Calories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrate</td>
<td>45-65%</td>
</tr>
<tr>
<td>Fat</td>
<td>20-35%</td>
</tr>
<tr>
<td>Protein</td>
<td>10-35%</td>
</tr>
</tbody>
</table>
Emphasize ABCs + Variety & Moderation!
All of these factors help to build a nutritious diet.
Kleiner's & Monaco's Top 10 Hit List for Nutrition Quackery

1. Treatment based on **unproven theory** calling for non-toxic, painless therapy.

2. Author's/purveyor's **credentials aren't recognized** in scientific community.

3. No reports in scientific, peer-reviewed literature but rather mass media used for marketing.

4. Purveyors claim **medical establishment is against them** & play on public's paranoia about phantom greed of medical establishment.

5. Treatments, potions, drugs manufactured according to **secret formula**.

6. Excessive claims promising **miraculous cures**, disease prevention or life extension.

7. **Emotional images** rather than facts used to support claims.

8. Treatments require **special nutritional support** including health food products, vitamins and/or minerals.

9. Clients are cautioned about discussing program to avoid negative.

10. Programs based on **drugs or treatments not labeled** for such use.
Lower Carbohydrate
Eliminate calories or food groups
Encourage fasting

Lower Fat
Adequacy
Balance
Consistency
& Moderation

AHA + DASH + Trade Books

Peer-reviewed = Texts → Research

Not peer-reviewed = Trade Books