BI 121 Lecture 4

Anatomy & Physiology Lab today!...
Exam I next Wednesday < 4th of July!!

I. Announcements Nutrition Analysis Lab next Tuesday!
Thanks for recording your diet on p 3-7 in LM. Estimating serving sizes, hints for recording (do sooner vs. later)…Q?

II. Cell Physiology, Mitochondria & Metabolism Connections
LS 2012 fig 2-9 thru 2-12, 2-15 +…Mathews & Fox 1976!

III. 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!

IV. Nutrition Primer DC Module 2, Sizer & Whitney(S&W) Sci Lib
A. Essential Nutrients: H₂O, ¹⁰ Carbohydrates,
   ²⁰ Fats, ³⁰ Proteins, Vitamins, Minerals; Macro- vs Micro-?
B. Dietary Guidelines: USDA, AICR, Eat Like the Rainbow!
C. Blue Zones? Pondering Paleo, Marlene Zuk, NAHL 2015…
D. Carbohydrate confusion. Minimize what? Simple sugars
Biology can help you with all phases of your life! In fact, it is the science of life!
4 oz $\rightarrow$ 3 oz

raw $\rightarrow$ cooked

Deck of Cards

or

1 c

1/3 c

1 oz

1.5 oz
Cell type, size, number?

Scientists don’t know everything!

Estimating numbers is always a challenge!

300 x $10^{12}$? $10^{15}$?

30 x $10^{12}$? 100 x $10^{12}$?

$10^9$? $10^{12}$?

$10^3$ ✓
1. Immediate/ATP-PC
2. Glycolysis
WOW!

I’M CHAMP!
ATP Supplied

Performance Time

Power Output

ATP-PC/Immediate
15 - 30 s

Oxygen System
≥ 3 – 5 m

Modified after Mathews & Fox

Cytosol

Mitochondria

Glycolysis

1.5 – 3 m

Anaerobic

Aerobic

% ATP Supplied

Performance Time

Power Output
ATP = Adenosine Tri Phosphate
The Common Energy Currency
or the Cash Cells Understand!!

Phosphates

Adenosine

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

7 – 10 KiloCalories/KCal

Synthesis of Macromolecules

Make big things from little things!

Membrane Transport

Move things! Microscopic!

Mechanical Work

Move things! Macroscopic!
I’m the Mighty Mitochondrion. I give the cell energy.
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 \text{ w/}\text{O}_2

ANAEROBIC

% AEROBIC
(Oxidative Energy System)

% ANAEROBIC
(Immediate & Non-Oxidative Energy Systems)

PRIMARY FUEL

ACTIVITY

TIME (Min:Sec)

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
Football
Conventional Weight Training

135:00

29:00

14:00

9:00

3:45

1:30

0:50

0:20

0:10

FAT,
CARBOHYDRATE
& PROTEIN
(Small Amounts)

CARBOHYDRATE
(Glucose & Glycogen)

ATP, ADP & Creatine Phosphate (CP)

CYTOSOL

Glycolysis

MITOCHONDRIA

Immediate/ATP-PC
Stages of Cellular Metabolism/Respiration

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

**Aerobic Metabolism**
- **Mitochondria**
  - **Pyruvate to acetate**
  - **Acetyl-CoA**
  - **Citric acid cycle**
    - Electrons carried by NADH and FADH₂
    - 2 ATP
  - **Oxidative phosphorylation**
    - (electron transport system and chemiosmosis)
    - 28 ATP

fig 2-9 LS 2012
Glycolysis

sugar dissolving/splitting

produces small amounts of ATP

One 6-carbon glucose molecule

Ten separate steps

2 NAD+

2 NADH

2 ADP + 2 P_i

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

Rod Capaldi
U of O Biology

fig 2-12 LS 2012
Goals of Aerobic Metabolism

AEROBIC = MITOCHONDRION

w/O₂

CITRIC ACID CYCLE

harvest electrons

e⁻ e⁻ e⁻ e⁻ e⁻ e⁻

“cash in”

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!!
Gene = Stretch of DNA that codes for a protein
What does DNA do, day-to-day?

Replication

DNA → Transcription → RNA → Translation → Protein

@ 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° 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>UAU</td>
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Translation? Ribosomes Make Proteins

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

Steps 5 through 8 are repeated.

LS 2012 fig C-7
Transfer RNA (tRNA)
A Polyribosome. Which Way is Synthesis?
What's a ribosome?

A protein synthesizing factory, where translation takes place!

You rock, baby!

Class Skit, Questions & Discussion!
Questions + Discussion
**Macronutrients & Micronutrients Essential for Life**

### Macronutrients

- **H₂O/Water**
- **1️⃣ Carbohydrates**
- **2️⃣ Fats/Triglycerides/Lipids**
- **3️⃣ Proteins**

### Micronutrients

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

### Sample Food Sources

- **Water, other drinks, fruits & vegetables**
- **Grains, vegetables, fruits, dairy products**
- **Meats, full-fat dairy products, oils**
- **Meats, legumes, dairy vegetables**
- **Vegetables, vegetable oils, fruits, citrus, grains, dairy**
- **Fruits, vegetables, grains, nuts, dairy, meats, processed foods**

**NB: Need only minute quantities!**

**✓ Energy nutrients = yield ATP**
2. Focus on fruits. Whole fruit preferable to juice, but any fruit counts! Fill ½ your plate with fruits & vegetables!

1. Vary your veggies. 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
A healthy eating pattern includes:

- **Variety of vegetables** from all subgroups: dark green, red & orange, legumes, starchy & other
- **Fruits**, especially whole fruits
- **Grains**, at least half of which are whole grains
- **Fat-free or low-fat dairy**, including milk, yogurt, cheese &/or fortified soy beverages
- **Variety of protein foods** including seafood, lean meats & poultry, eggs, legumes & nuts, seeds & soy products
- **Oils** (healthy)

A healthy eating pattern limits:

- **Saturated fats** & **trans fats**, added **sugars** & **sodium**
- **Balance calories with physical activity** to manage weight.

http://health.gov/dietaryguidelines/2015/
**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!

The World’s Longest-Lived People!  
Blue Zones!

1. Eat a little bit better!
2. Move a little bit more!
3. Socialize more!
4. Strong sense of purpose!

Plant-based!

https://en.wikipedia.org/wiki/Blue_Zone
https://bluezones.com/
85% Carbohydrates
9% Protein
6% Fat
85-10-5
1785 Calories

Note: These are the Actual Food Measurements of the Centenarians, not the diet of All island Okinawans or the ones who died, but the ones who lived.

OKINAWA LONGEVITY DIET

- 70% Sweet Potatoes
- 12% Rice
- 7% Grains & Wheat
- 6% Soy & legumes
- 4% Additional vegetables
- 3% Fruit
- 2% Oils
- 1% Nuts (Protein)
- 1% Other potatoes
- 1% Seaweed
- 1% Sugars
- 1% Fish
- 1% Dairy
- 1% Eggs
- 1% Pork-Meat
- 1% Flavorings & Alcohol

96% Vegan Diet
98% Vegetarian
99% PescaVeg
<4% Animal Prod
<1% Fish
<1% Meat-Pork
Pondering Paleo?

Evolutionary Biologist
Behavioral Ecologist
U Minnesota

http://www.nutritionaction.com/daily/how-to-diet/pondering-paleo/
How much protein do you need?

Not much! 0.8 g/kg or 0.36 g/lb of body wt/d

50 kg or 110 lb female? ~ 40 g/d
80 kg or 176 lb male? ~ 64 g/d

Boneless, skinless, cooked chicken breast 6-8 oz, 53 - 70 g of protein!

Average US woman gets 35% > RDA!
Average US man 65% > RDA!
WHO says to cut down on meat?

When I saw the headlines in October that meat was linked to cancer, I braced myself for the inevitable brouhaha. The news was that the International Agency for Research on Cancer (IARC), part of the World Health Organization (WHO), concluded that processed meats like hot dogs, bacon, and ham almost certainly increase the risk of colorectal cancer—by 18% per daily serving—and that red meat probably does as well.

But we've heard about this link many times before. Over the past 20 years, many observational studies have found that people who regularly eat red or processed meats have higher rates of several cancers, notably of the colon and rectum. And lab studies have shown that compounds formed when meat is processed (that is, smoked, salted, or cured) or cooked at high temperatures can cause cancer in animals or cells. All that research served as the basis of the IARC conclusions. But even in 2007 the World Cancer Research Fund, another key group of experts, concluded that there was "convincing" evidence that these meats increase the risk of colorectal cancer. And since 2002, WHO has advised people to moderate their consumption of processed meat, as do the still-pending 2015 Dietary Guidelines for Americans.

What elicited the most heated reaction in the press and blogosphere and especially from the meat industry was the fact that the IARC put processed meats in its Group 1—"carcinogenic to humans"—which includes tobacco smoking and asbestos. (It put red meats in Group 2A—"probably carcinogenic") The IARC clearly explained that this classification merely indicates the strength of the evidence that something causes cancer, not the degree of risk. In fact, it said that the increased risk from red or processed meat is "small" for individuals, though potentially important for public health since so many people eat meat.

What about that 18% increase in risk? The IARC estimated that for every serving of processed meat (just under 2 ounces) or red meat (3½ ounces) eaten daily for years, the lifetime risk of colorectal cancer goes up by about 18%. But this is what's known as relative risk, which can be misleading. For instance, the lifetime risk of developing colorectal cancer in the U.S. is about 5%. An 18% increase does not mean 5% + 18% = 23%, but rather 5% + (18% of 5%) = 6%. That means one extra case of colorectal cancer per 100 meat eaters. In contrast, smoking increases the lifetime risk of lung cancer by roughly 2,000%—from about 1 per 100 people to about 20 per 100. So while IARC may classify both processed meat and smoking as Group 1 carcinogens, there's no comparison in their risks.

In fact, IARC cited estimates that 34,000 cancer deaths per year worldwide can be attributed to diets high in processed meat. In contrast, tobacco causes nearly 2 million cancer deaths per year.

I should add that I don't think it has been clearly established that meat causes cancer. Proving that foods cause or help prevent cancer is difficult for many reasons. Notably, the observational studies upon which the IARC classifications were largely based can only find associations—they cannot prove cause and effect.

That said, there are plenty of other reasons to moderate your intake of red meats and limit processed ones. There's strong evidence linking them to cardiovascular disease and a variety of other disorders, though it's not clear which compounds in them are the possible culprits. What's more, eating more plant-based foods and less meat is better for the planet, resulting in less greenhouse gas production.

And there's a far surer way to reduce the risk of colorectal cancer than tinkering with your diet: Get screened.
Gut Bacteria Involved in *Inflammation & Atherosclerosis*?

Meat & Eggs $\rightarrow$ L-Carnitine & Choline $\rightarrow$ Trimethyl Amine (TMA) $\rightarrow$ TMAO $\rightarrow$ **Inflammation & Atherosclerosis**

Dietary Choline & L-Carnitine

Gut Flora

The pathway linking diet, gut microbes and TMAO to a growing collection of disease states

TMA = Trimethyl Amine

Hepatic FMOs

TMAO

Choline

Heart Failure

Kidney Disease

Atherosclerosis

Red Meat-Derived Glycan Promotes Inflammation & Disease

Source: After AN Samraj, PNAS, 2015, 112(2), 542-7. http://m.pnas.org/content/112/2/542.long
Carbohydrate Confusion
Should you avoid carbs at all costs?

Our Planet AT RISK
The Best SPREADS
3 Veggie Dips

No, ↑ complex ↓ simple!
Emphasize a plant-based diet!
Dietary Composition & Physical Endurance

- High-fat diet: eg, Atkins!
- Normal mixed diet: ~ 1/3 endurance!
- High-carbohydrate diet: 57 min, 114 min, 167 min

Maximum endurance time:
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!!

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<td>4 Kcal/g</td>
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<tr>
<td>PRO</td>
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**NB:** Minimize not Eliminate! **Moderation** not Abstinence!!

DIETFITS (2018) + Pounds Lost Trial (2009) indicate that reducing overall calories is more important than macronutrient composition of the diet!

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

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

\[ \frac{\text{Fat}}{\text{total wt loss}} < \frac{1}{4} \]
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.

ML Pollock & JH Wilmore 1990.