I. **Announcements** Quiz 2 Tuesday covers GI Physiol + Nutrition ≡ Lectures 4, 5 + 6 (1st ½). Discussion then wbc differential lab! Please read p 5-2 + articles sent by e-mail! By 5 pm Tuesday send nutrition reports to Anna [alakuni3@uoregon.edu](mailto:alakuni3@uoregon.edu) or Conor [conoro@uoregon.edu](mailto:conoro@uoregon.edu). Outline update? Q?

II. **Nutrition Connections** -Sodium-Sugar, +Plants+Fish+Exercise?

III. **Blood + Body Resistance to Infection I**

G&H ch 32, 33, LS, Stuart Fox, Daniel Chiras (DC), Basiro Davey

A. Blood: cell + fragments vs liquid (plasma vs serum) LS
B. Red blood cells, white blood cells, platelets, Demo? LS, DC
C. Red blood cell production, hemoglobin G&H pp 413-9
   G&H fig 32-1 thru 32-6 +..., Fox
D. Pathogen? Microbe that causes disease, Davey pp 5-6
E. Barriers to infection Davey fig 2.1 p 12, fig 2.2 p 13
F. *National Geographic*, The Wars Within, Lennart Nilsson
G. WBC effectors: Innate & adaptive immunity G&H pp 433-7
   G&H fig 34-1 + Davey fig 2.2 p 13, fig 3.4 p 24, fig 3.12 p 36
H. *Medical Physiology News* Handwasing to prevent infection!
US Centers for Disease Control
Health Valley Organic

NUTRITION SCORECARD (PER SERVING)

- SODIUM: 50 mg
- FAT: 2.5 g
- FIBER: 4 g
- ANTIOXIDANT: 45% RDI* (VITAMIN A)

NO SALT ADDED

Vegetable SOUP

NET WT 15 OZ (425g)

American Heart Association CERTIFIED
Meets Criteria For Heart Healthy Food

USDA ORGANIC
If whole can x2!

Vit A 90%
Vit C 40%
Ca²⁺ 8%
Fe²⁺ 16%

Leading brands ≥ 860 mg per serving!

Na+ Na+ Na+...Help!
Why Lower Sodium?
Sodium Reduction as a Means to Prevent Cardiovascular Disease and Stroke

1. Approximately 90% of Americans will develop high blood pressure or hypertension over their lifetime.

2. BP-related diseases: stroke, CHD, heart failure & kidney disease are leading causes of morbidity & mortality in the US & throughout the world.

3. Independent of its effects on BP, excess sodium intake adversely affects the heart, kidneys & blood vessels.

4. Reducing sodium intake to < 1500 mg/d should reduce American deaths from CVD & stroke by 20%.

http://sodiumbreakup.heart.org/
Sodium (Na) Intakes of U.S. Adults

- Intakes of U.S. Adults: < 1500 mg BP
- Body requirement = 1 tsp of Salt (NaCl ≅ 40% Na)

- < 2400 mg ↓ BP
- = 1 tsp of Salt
- (NaCl ≅ 40% Na)

- < 1500 mg ↓ BP
- < ¼ tsp Salt/d!

Body requirement
More Reasons to Shake the Salt Habit

Stop me!

①↓blood vessel vasodilation w/in 30 min by ingesting 1500 mg Na+!

②↑Ca$^{2+}$ excretion ↑bone loss, risk of osteoporosis & fractures.

③May directly impair kidney function & ↑risk of kidney stones.

④GI cancer risk, inflammation?

UCB WellnessLetter Jun 2011, Jan 2012

Mayo Clinic How to tame your salt habit!
Dietary Approaches to Stop Hypertension (DASH)

Fruits & vegetables + low-fat dairy products

http://www.nhlbi.nih.gov/health/health-topics/topics/dash
Why Lower Simple Sugars?
Each person in the US ingests ~ ¾ cup or 31 tsp of refined sugars added to foods & beverages each day ≡ > 140 lb per year!
Sugar in processed foods?

- ½ cup canned corn = 1 tsp sugar
- 1 Tbs ketchup = 1 tsp sugar
- 12 oz cola ≥ 10 tsp sugar
- 1 Tbs creamer = 2 tsp sugar
- 8 oz sweetened yogurt = 8 tsp sugar
- 2 oz chocolate = 8 tsp sugar

Sizer & Whitney 2011 fig 4-17 p 139
Added Sugars: Average US Supply per Person

S&W 2011 fig C4-4 p 145

USDA

Suggested upper limit (men)\textsuperscript{a}

Suggested upper limit (women)\textsuperscript{a}

AHA suggested upper limits!
Number of people with diabetes increases to 24 million," announced the Centers for Disease Control and Prevention in June.

One out of four Americans aged 60 or older now has the disease. Another 57 million people—40 percent of those aged 40 to 70—have pre-diabetes. Diabetes has even started to show up in teenagers.

"We've seen strong and sustained increases in the incidence of diabetes since 1990, and they show no signs of slowing down," notes Linda Geiss, chief of diabetes surveillance at the CDC. "It's like a runaway train."

Is there any good news about an epidemic that's out of control?

"Diabetes is an almost totally avoidable disease," says Walter Willett of the Harvard School of Public Health in Boston. "We estimate that more than 92 percent of the cases could be avoided by diet and lifestyle."
1994 Diabetes Prevalence in the US by State

2010 Diabetes Prevalence in the US by State

Source: Centers for Disease Control, Division of Diabetes Translation, [http://www.cdc.gov/diabetes/statistics](http://www.cdc.gov/diabetes/statistics), S&W 2014 fig 4-15 p139B.
Why More Fruits, Vegetables, Whole Grains & Beans?
Phytochemicals ≡ Plant chemicals

1. Anti-oxidants
   - protect DNA from oxidative damage

2. Protein synthesis
   - regulation/control

3. Hormone-like action
   - endocrine mimicry

4. Blood effects
   - modify blood chemistry

Potential regulators of health!

10s of thousands!

Phytochemicals ≡ Plant chemicals

aroma, color, taste
Recommendations for CANCER PREVENTION

1. Be as lean as possible without becoming underweight.
2. Be physically active for at least 30 minutes every day.
3. Avoid sugary drinks. Limit the consumption of energy-dense foods particularly processed foods high in added sugar, or low in fiber, or high in fat.
4. Eat more of a variety of vegetables, fruits, whole grains & legumes such as beans.
5. Limit consumption of red meats (such as beef, pork & lamb) & avoid processed meats.
6. If consumed at all, limit alcoholic drinks to 2 for men & 1 for women a day.
7. Limit consumption of salty foods & foods processed with salt (sodium).
8. Don't use supplements to protect against cancer.
American Institute for Cancer Research
Foods that Fight Cancer

**Beans**  fiber, saponins, protease inhibitors, phytic acid.

**Berries**  fiber, vitamin C, ellagic acid, flavonoids

**Cruciferous Vegetables**  glucosinolates: glucoraphin → sulphoraphane, crambene, indole-3-carbinol & isothiocyanates

**Dark Green Leafy Vegetables**  fiber, folate, carotenoids: 10 lutein & zeaxanthin; saponins, flavonoids

**Flaxseed**  lignans (a phyto-E), α-linolenic acid (an Ω-3)

**Garlic**  organosulfurs: allicin, alliin, allyl sulfides; quercetin,...

**Grapes and Grape Juice**  resveratrol (a polyphenol)

**Green Tea**  catechins (class of flavonoids), polyphenols

**Soy**  isoflavones, saponins, phenolic acids, phytic acid, phytosterols, protein kinase inhibitors

**Tomatoes**  lycopene

**Whole Grain**  fiber, vitamins, minerals, 100s of phytochemicals: antioxidants, phenols, lignans (a phyto-E), saponins

http://www.aicr.org/site/PageServer?pagename=foodsthatfightcancer_home
# Common Foods Ranked by Antioxidant Content

<table>
<thead>
<tr>
<th>Rank</th>
<th>Food Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Blackberries</td>
</tr>
<tr>
<td>2</td>
<td>Walnuts</td>
</tr>
<tr>
<td>3</td>
<td>Strawberries</td>
</tr>
<tr>
<td>4</td>
<td>Spinach</td>
</tr>
<tr>
<td>5</td>
<td>Artichokes, prepared</td>
</tr>
<tr>
<td>6</td>
<td>Cranberries</td>
</tr>
<tr>
<td>7</td>
<td>Coffee</td>
</tr>
<tr>
<td>8</td>
<td>Raspberries</td>
</tr>
<tr>
<td>9</td>
<td>Pecans</td>
</tr>
<tr>
<td>10</td>
<td>Blueberries</td>
</tr>
<tr>
<td>11</td>
<td>Cloves, ground</td>
</tr>
<tr>
<td>12</td>
<td>Grape juice, cranberry juice, pomegranate juice</td>
</tr>
<tr>
<td>13</td>
<td>Chocolate, dark, unsweetened</td>
</tr>
<tr>
<td>14</td>
<td>Cherries, sour</td>
</tr>
<tr>
<td>15</td>
<td>Wine, red</td>
</tr>
</tbody>
</table>

Sizer & Whitney 2011 Table C2-3 p 64
Antioxidant Capacity Depends Upon Seasons, Storage, Testing Methods, Variety...

- 1 sm Apple, Red Delicious, w/skin
- 1 oz Chocolate, dark
- ½ c Plums, dried
- 5 fl oz Wine, red
- ½ med Artichokes, boiled
- 1 oz Pecans
- ½ c Blueberries, fresh
- 1 oz Walnuts, English
- ½ c Strawberries, sliced
- 1 med Sweet potato, baked

*Measured in micromole TE (Trolox equivalents), a laboratory-derived value used to measure the antioxidant activity of foods. Other laboratory methods yield other results.*

Broccoli sprouts may contain ~ 10,000 unique phytochemicals!
A Wealth of Phytochemicals

All cruciferous vegetables contain powerful cancer-fighting phytochemicals, including: diindolylmethane (DIM), one of many indoles found in these vegetables, has been shown to inhibit proteins associated with breast and ovarian cancers. crambene, plentiful in Brussels sprouts, may offer the most preventive benefits when combined with indole-3-carbinol (I3C). glucosinolates, which turn into powerful protective agents called isothiocyanates when a cruciferous vegetable is chewed or chopped. May reduce inflammation, a factor in cancer development.
≥ 5 tomato-containing meals per week may protect from cancers of the esophagus, stomach & prostate!
...but, the phytochemical candidate, lycopene with anti-oxidant activity is also in guava, papaya, pink grapefruit & watermelon!
The Mayo Clinic Diet Emphasizes Vegetables, Fruits & Whole Grains, Too!

Mayo Clinic Healthy Weight Pyramid

- SWEETS: Up to 75 calories daily
- FATS: 3 to 5 daily servings
- PROTEIN/DAIRY: 3 to 7 daily servings
- CARBOHYDRATES: 4 to 8 daily servings
- FRUITS: Unlimited (minimum 3)
- VEGETABLES: Unlimited (minimum 4)

© Mayo Foundation for Medical Education and Research. See your doctor before you begin any healthy weight plan.

Vegetarian Food Pyramid? **Yes, but be a scientist!**

- **Oils:** 2–3 teaspoons
- **Nuts and Seeds:** 1–2 servings
- **Dairy:** Vegan: fortified non-dairy substitutes (3 servings)
- **Vegetables:** 2–4 servings
- **Green Leafy Vegetables:** 2–3 servings
- **Beans and Protein Foods:** 2–3 servings
- **Fruits:** 1–2 servings
- **Dried Fruit:** 1–2 servings
- **Bread, Pasta, Rice, Fortified Cereals:** 6–10 servings

**Vegans need these supplements:**
- Vitamin B₁₂: 2.4 μg/d
- Vitamin D: 200 IU/d
- Calcium: 600 mg/d

**Vegetarian Food Pyramid**

**Water:** 8 cups daily - Needs increase with activity

**Sources:**
- Sizer & Whitney 2006 *Nutrition: Concepts & Controversies*
Environmental Working Group Suggestions

12 Most Contaminated
Buy These Organic
• Apples
• Bell Peppers
• Celery
• Cherries
• Imported Grapes
• Nectarines
• Peaches
• Pears
• Potatoes
• Red Raspberries
• Spinach
• Strawberries

12 Least Contaminated
Not as Much Concern
• Asparagus
• Avocados
• Bananas
• Broccoli
• Cauliflower
• Corn (sweet)
• Kiwi
• Mangos
• Onions
• Papaya
• Pineapples
• Peas (sweet)

...Now Clean 15!!
+Cabbage, Eggplant, Grapefruit

http://www.ewg.org/foodnews/
Why Fish & Healthy Oils?
AHA Statistical Fact Sheet 2013 Update
What do Americans* eat per day?

**Whole grains**: 0.5-0.8 servings/d  
Only 3-5% consume ≥ 3 servings/d

**Vegetables**: 1.3-2.2 servings/d  
Only 3-7% consume ≥ 5 servings/d

**Fruits**: 1.1-1.8 servings/d  
Only 6-11% consume ≥ 4 servings/d

**Fish & Shellfish**: 1.2-1.7 servings/wk  
75%-80% or more consume < 2 servings/wk

Fish Oil Intakes & Cardiovascular Death Rates

Cardiovascular Deaths per 100,000 Population

- Ireland: 0.09%
- USA: 0.13%
- France: 0.14%
- Japan: 0.37%

Sizer & Whitney 2011  
fig 5-12 p 167
Deep cold water fish are fabulous sources of \(\Omega-3\) fatty acids!
NB: Minimize trans fats!
Healthy Oils to Minimize Atherosclerosis

HAPOC?
Essential Fatty Acids: Ω-6 Linoleic & Ω-3 Linolenic Acids

Linoleic → Arachadonic Acid → Inflammatory Cascade

Linolenic → EPA, DHA → Anti-inflammatory
Emphasize good fats from plant sources like avocados!
1. Don't smoke or use any tobacco product.
2. Keep the weight off.
3. Get off the couch.
4. Eat a healthy diet.
5. Drink less alcohol.
7. Limit sun exposure.
8. Limit radiation from medical imaging tests.
9. Test your home for radon.
10. Test your water for arsenic.
11. Decrease workplace exposure to carcinogens.
12. Limit your exposure to air pollution (outdoors & indoors).
1. Use up at least as many calories as you take in!

2. Eat a variety of nutritious foods from all food groups.

3. Eat less of the nutrient-poor foods.

4. Don’t smoke tobacco — and stay away from tobacco smoke.

http://www.heart.org/HEARTORG/GettingHealthy/NutritionCenter/HealthyDietGoals/Dictionary-of-Nutrition_UCM_305855_Article.jsp
1. Choose lean meats & poultry without skin & prepare them without added saturated & trans fat.
2. Select fat-free, 1 percent fat & low-fat dairy products.
3. Cut back on foods containing partially hydrogenated vegetable oils to reduce trans fat.
4. Cut back on foods high in dietary cholesterol. Aim to eat less than 300 milligrams of cholesterol each day.
5. Cut back on beverages and foods with added sugars.
6. Choose and prepare foods with little or no salt. Aim to eat less than 1,500 milligrams of sodium per day.
7. If you drink alcohol, drink in moderation. 1 drink/day if you’re a woman & 2 drinks/day if you’re a man.
8. Follow AHA recommendations when you eat out & keep an eye on portion sizes.
Why exercise?
THE REWARD OF FITNESS: LONGEVITY

DEATH RATES
10,000 person yr

WOMEN (3120)

FITNESS LEVEL
Low 1 2 3 4 5 High

39.5
20.5
12.2
6.5
8.5

Exercise is a must based on its insulin-like effect!
100s of other reasons! Exercise –

↑ lean body mass, ↑ cardiac output,
↑ myocardial contractility, ↑ central & peripheral blood flow, ↑ fibrinolytic activity,
↑ HDL cholesterol, ↑ work capacity,
↑ sleep quality, ↓ % body fat,
↓ TOT & LDL cholesterol, ↓ triglycerides, ↓ platelet aggregation, ↓ blood pressure,
↓ CVD risk,…
Guidelines: Healthy Adults < 65 yr

Do moderately intense aerobic exercise
30 min/d, 5 d/wk

OR

Do vigorously intense aerobic exercise
20 min/d, 3 d/wk

AND

Do 8-10 strength-training exercises
8-12 repetitions/each exercise, 2 d/wk

http://www.acsm.org/access-public-information/position-stands
http://www.acsm.org/access-public-information/brochures-fact-sheets/fact-sheets
Federal exercise guidelines include strength training for all:

**Adults**: Moderate to Vigorous Exercise
- At least 30 min, 5 d/wk

**Children**: Moderate to Vigorous Exercise
- At least 60 min, 5 d/wk

[Visit CDC guidelines](http://www.cdc.gov/physicalactivity/everyone/guidelines/index.html)
[Visit Health guidelines](http://www.health.gov/paguidelines/)

[NEW Physical Activity Guidelines for Americans](http://www.health.gov/paguidelines/)
What's in Blood? Plasma & Blood Cells

- **Plasma** (55% of whole blood)
- **Buffy coat**: platelets and leukocytes (<1% of whole blood)
- **Erythrocytes** (45% of whole blood)
- **Platelets**
- **Leukocytes** (white blood cells)
- **Erythrocytes** (red blood cells)
Dermal bone production of red blood cells

Cellularity (percent) vs. Age (years)
- Vertebral bone
- Sternum
- Rib
- Tibia (shaft)
- Femur (shaft)

G&H 2011 fig 32-1 p 414
**Pluripotent Hematopoietic Stem Cell Lines**

- **PHSC** (Pluripotent hematopoietic stem cell)
  - CFU-S (Colony-forming unit–spleen)
  - LSC (Lymphoid stem cell)

- **CFU-B** (Colony-forming unit–blast)
  - Erythrocytes

- **CFU-E** (Colony-forming unit–erythrocytes)
  - Granulocytes (Neutrophils, Eosinophils, Basophils)
  - Monocytes
  - Macrophages
  - Megakaryocytes
  - Platelets
  - T lymphocytes
  - B lymphocytes
Red Blood Cell Genesis

Proerythroblast → Basophil erythroblast → Polychromatophil erythroblast → Orthochromatohchromatophil erythroblast → Reticulocyte → Erythrocytes

Microcytic, hypochromic anemia

Sickle cell anemia

Megaloblastic anemia

Erythroblastosis fetalis

G&H 2011 fig 32-3 p 415
Erythropoietin Regulates RBC Production

Hematopoietic Stem Cells

Kidney

Erythropoietin

Decreases

Proerythroblasts

Red Blood Cells

Tissue Oxygenation

Decreases

Factors that decrease oxygenation
1. Low blood volume
2. Anemia
3. Low hemoglobin
4. Poor blood flow
5. Pulmonary disease

G&H 2011 fig 32-4 p 416
Hemoglobin Formation

Citric Acid Cycle

I. 2 succinyl-CoA + 2 glycine → Protoporphyrin IX

II. 4 pyrrole → Protoporphyrin IX

III. Protoporphyrin IX + Fe^{2+} → Heme

IV. Heme + Polypeptide → Hemoglobin chain (α or β)

V. 2 α chains + 2 β chains → Hemoglobin A
Heme Structure

NB: CO carbon monoxide binds with ~200-fold greater affinity than O₂
What a difference one amino acid can make!

Amino acid sequence of normal hemoglobin:
Val – His – Leu – Thr – Pro – Glu – Glu

Amino acid sequence of sickle-cell hemoglobin:
Val – His – Leu – Thr – Pro – Val – Glu
Immune Response

1. Detect invader or ID toxic product.
2. Communicate to network.
3. Recruit coordinated, multi-pronged attack.
4. Amplify & if yes to success, then –
5. Suppress

Davey 1990 p 6
Pathogen?

Microbes that cause disease!

- Bacteria
- Viruses
- Protozoa
- Fungi
- Multicellular Parasites, e.g., ticks & lice

Davey 1990 p 5
Pathogens & Parasites Cause:

1. 70-80% of deaths in less developed countries

2. Tens of millions of deaths due to infectious diseases

3. > 20 million childhood deaths per year in Asia, Africa & Latin America due to diarrheal infections alone

4. Yet < 2% deaths in modern, industrialized countries!

World Health Organization 2011 Statistics +
http://www.who.int/bulletin/volumes/86/9/07-050054.pdf

Davey 1990 p 5
Why such striking differences across the world?

1. Poor sanitation
2. Contaminated water supply
3. Contaminated food supply
4. Malnutrition
5. Existing infections
6. Patchy, inadequately-funded vaccinations
7. AIDS superimposed on top of 1-6!

Davey 1990 p 5
FIGURE 2.1 Summary of the main physical, chemical and mechanical barriers to infection entering the human body.
Good phagocytes!

Davey 1990 p 13
Figure 33-2 Movement of neutrophils by *diapedesis* through capillary pores and by *chemotaxis* toward an area of tissue damage. G&H 2011
Hand-washing

The right way to wash your hands:

Thoroughly wash with soap and warm running water — rubbing your hands together for at least 10 seconds.

Hand-washing is the single most effective thing you can do to reduce the spread of colds and other infectious disease.

It’s not necessary to use anti-bacterial soaps when washing up. Regular soap and water do the job just fine.

Also, using germicidal soaps too often may produce antibiotic-resistant bacteria.

*Source: Hospital Infections Program, U.S. Centers for Disease Control and Prevention*

**NB:** Happy Birthday Song 20-30 sec!!!