I. **Announcements** Outline & Quiz 1 update? Quiz Key will be posted in the glass box near 112 HUE. MU Quiz? Next T
Nutritional Analyses; Record your diet ≥ 1 d on DLN p 4-8.

II. **Addiction Medicine Follow-up** CB1 & CB2 receptors & immunity? ETOH dependence-endocannabinoids? Anxiety?


IV. **Metabolic Lab Research cf: Dietary Intake Estimation**

V. **Gastrointestinal Physiology** G&H ch 62, 63, 64, 65 + LS2

A. Digestion overview + alimentary tract fig 62-1 p 753-4
B. Gut cross section, histology + plexi fig 62-2 pp 754-9
C. Secretions+phases tab 64-1, fig 64-1,64-2,64-7 pp 775-87
D. **Hydrolysis**: Central theme of digestion  ch 65 p 789-93
   1. Carbohydrate fig 65-1 p 790
   2. Fat fig 65-3 p 791, fig 65-4 p 792
   3. Protein fig 65-2 p 791
WOW!  SUPER  😊
~ TOP 5 - 10 ~

EXCELLENT!!
~ TOP 15 ~

GREAT EFFORT
~ TOP 20 - 25 ~
**Endocannabinoid Receptors**

**CB-1**
- Brain Structures
- Controlling Energy Intake
  - (e.g., Hypothalamic Hunger-Satiety Center)

**CB-2**
- Leukocytes/WBCs/Brain
- Immune & Inflammatory Reactions
  - (e.g., Lymphocytes & Macrophages)

Endocannabinoid hyperactivity

Metabolic & Eating Disorders
1. Abdominal Obesity
2. Dyslipidemia
3. Hyperglycemia

http://www.jimmunol.org/content/165/1/373.full?ijkey=YriEsKcvAs2z
ETOH Dependence + Link to Endocannabinoids?

**Suspect Genes?**
Dopaminergic Receptor DA D2  
ETOH Dehydrogenase  
Aldehyde Dehydrogenase  
Fatty Acid Amide Hydrolase (FAAH)  
G- vs A-allele μ-Opioid Receptor (OPRM 1)  
Cation Transport & Synaptic Transmission

*Metabolizes Anandamide + Δ9-THC*  
Anandamide Deficient → Anxiety

*e.g., Delete Gene for FAAH or Block*  
*FAAH Action by URB597 (KDS4103)*

1. ↑ Preference for ETOH  
2. ↑ Sensitivity to ETOH Sedation  
3. ↑ Recovery from ETOH Motor Incoordination

*e.g., G- vs A-Allele for OPRM 1*  
1. ↑ Feelings of Intoxication/Sedation  
2. ↑ Happiness/Euphoria  
3. Naltrexone more effective in patients with G-allele?

http://www.ncbi.nlm.nih.gov/pubmed/26756798  
Ask people what they ate yesterday or even today, and the odds are that they’ll underestimate the amount. This discrepancy is called the eye-mouth gap.

One study found that some obese people actually ate twice as much as they reported. Research has shown that perhaps 80% of us – even lean and athletic people – underestimate our food intake.
Adults underestimate, on average, their daily intakes by 800 calories. > 1 ½ lb per wk!!

They overestimate intakes of fruit & dairy products, but underestimate amounts of sweets, refined grains, oils, and other fats they eat.

Misreporting is seldom a deliberate deception – it’s likely an unconscious response perhaps to social & family pressure, combined with wishful thinking.

People don’t know how much food they put on their plates.
The Eye-Mouth Gap Bottom Line

If you’re trying to lose weight or improve your diet, don’t trust your eyes.

Weigh or measure the food you eat to get a good sense of how much you’re really eating.

Lombo editorial comments:

1. Train yourself to make good guesses/estimates rather than weigh everything.

2. Train yourself...that is... **Exercise! Exercise!! Exercise!!!**

NB: Each group 500 kcal deficit/day, 16 weeks
Compared to dieting, exercise is superior in inducing % body fat reduction & preserving lean body mass!
Dietary Composition & Physical Endurance

- eg, Atkins!

- High-fat diet
  - ~ 1/3 endurance!

- Normal mixed diet
  - Maximum endurance time: 57 min

- High-carbohydrate diet
  - Maximum endurance time: 114 min and 167 min
Discussion 4: Nutritional Analyses via 2 Programs

ChooseMyPlate.gov

Diet Analysis+ Version 8.0

- The Most Extensive Database Ever provides over 20,000 easy-to-find foods, including most common foods, popular brands, regional favorites, international foods, and vegetarian options.
- “How Big Is a Serving” Tips, based on the MyPyramid recommendations, are linked on the screen where students need help.
- Trans fats include the most up-to-date information available, and are displayed in all reports.
- MyPyramid values include the latest USDA updates, and show actual intake in all categories, including Discretionary calories.
- The 3-Day Average Wizard lets you print the most common assignment in one step.
Digestion Steps

1. Ingestion
2. Mechanical Digestion
3. Chemical Digestion
4. Peristalsis
5. Absorption
6. Storage
7. Defecation

GI-Doughnut Analogy

GI Lumen

Body

Me?
GI Regulation

1. Local/Intrinsic
2. Nervous
3. Hormonal

- rapid
- Slower, but longer lasting!

autoregulation
extrinsic
Muscularis Externa
Glands

Serosa
Epithelium
Submucosa
Lumen
Lamina Propria

Longitudinal Muscle
Circular Muscle

Myenteric motor plexus!

Meissner’s sensory & secretory plexus!

H Howard 1990

cf: G&H fig 62-2
Parasympathetic Branch Activates the Gut!

NERVOUS

G&H 2011 fig 60-3 p 731
Cholecystokinin $\rightarrow$ Gallbladder contraction + Pancreatic enzymes

↓ Motility $\leftarrow$ GIP

↑ Insulin

↓ Motility $\leftarrow$ GLP-1

↑ Insulin

↓ Cl$^-$ $\leftarrow$ Guanylin

↑ NaCl + H$_2$O in feces

Gastrin $\rightarrow$ HCl, Pepsinogen by stomach

Motilin $\rightarrow$ ↑ Motility

Secretin $\rightarrow$ HCO$_3^-$, H$_2$O by pancreas

Cholecystokinin $\rightarrow$ Gallbladder contraction + Pancreatic enzymes

What about feedback for hunger-satiety?
Ghrelin (stomach fundus, pancreas,...)
Leptin (adipocytes)

Suspense – until next time!
FIGURE 15-6

Peristalsis in the esophagus. As the wave of peristaltic contraction sweeps down the esophagus, it pushes the bolus ahead of it toward the stomach.

For an animation of this figure, click the Gastrointestinal Motility tab in the Gastrointestinal Physiology tutorial on the CD-ROM.

Ringlike peristaltic contraction sweeping down the esophagus
# Gut Secretions

<table>
<thead>
<tr>
<th>Secretion</th>
<th>Release Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mucus</td>
<td>into GI Lumen</td>
</tr>
<tr>
<td>2. Enzymes</td>
<td>into GI Lumen</td>
</tr>
<tr>
<td>3. H₂O, acids, bases+</td>
<td>into GI Lumen</td>
</tr>
<tr>
<td>4. Hormones</td>
<td>into Blood</td>
</tr>
<tr>
<td>Secretion Type</td>
<td>Daily Volume (ml)</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Saliva</td>
<td>1000</td>
</tr>
<tr>
<td>Gastric secretion</td>
<td>1500</td>
</tr>
<tr>
<td>Pancreatic secretion</td>
<td>1000</td>
</tr>
<tr>
<td>Bile</td>
<td>1000</td>
</tr>
<tr>
<td>Small intestine secretion</td>
<td>1800</td>
</tr>
<tr>
<td>Brunner’s gland secretion</td>
<td>200</td>
</tr>
<tr>
<td>Large intestinal secretion</td>
<td>200</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6700</strong></td>
</tr>
</tbody>
</table>
Figure 64-1 Typical function of a glandular cell for formation and secretion of enzymes and other secretory substances.
Primary secretion:
1. Ptyalin
2. Mucus
3. Extracellular fluid

Na\(^+\) active absorption
Cl\(^-\) passive absorption
K\(^+\) active secretion
HCO\(_3^-\) secretion

Figure 64-2 Formation and secretion of saliva by a submandibular salivary gland.
Figure 64-7 Phases of gastric secretion & their regulation. G&H 2011 p 780.
Hi gang!!
You need me for digestion!!

Hydrolysis of Energy Nutrients

...Central-linking theme!!

H₂O + Enzyme

The ENZYME data bank

Help!
Me too!
Polymer to Monomer (Many to One)

Carbohydrate

Protein + Fat

Glucose

Amino Acids

Fatty Acids + Glycerol
Carbohydrates in foods

Sizer & Whitney 2011 p 136
Carbohydrate Digestion $= 1^0$ Energy Nutrient

- Starches
  - Ptyalin (saliva) - 20-40%
  - Pancreatic amylase - 50-80%

- Maltose and 3 to 9 glucose polymers
  - Maltase and $\alpha$-dextrinase (intestine)

- Glucose
  - Lactase (intestine)
  - Sucrase (intestine)

- Lactose
- Galactose

- Fructose
  - Sucrose

G&H 2011 fig 65-1 p 790
Why Do Some People Have Trouble Digesting Milk?

- Ability to digest milk carbohydrates varies
  - Lactase
    - Made by small intestine
- Symptoms of intolerance
  - Gas, diarrhea, pain, nausea?
- Milk allergy?
- Nutritional consequences
- Milk tolerance and strategies
HIGH FAT FOODS

An LDL to HDL ratio greater than 5 to 1 in men or 4.5 to 1 in women

Increased risk of heart disease
Fat Digestion = $2^0$ Energy Nutrient

Fat $\xrightarrow{(Bile + Agitation)}$ Emulsified fat

Emulsified fat $\xrightarrow{Pancreatic lipase}$ Fatty acids and 2-monoglycerides

G&H 2011 fig 65-4 p 792
HIGH PROTEIN (FAT?) FOODS?
Where does enzymatic digestion of protein begin?
Zymogen = inactive precursor
Protein Digestion = \(3^0\) Energy Nutrient

Proteins → *Pepsin* → [Proteoses, Peptones, Polypeptides]

Trypsin, chymotrypsin, carboxyphosphopeptidase, procollagenase

Polypeptides + Amino acids → *Peptidases* → Amino acids

G&H 2011 fig 65-2 p 791
What is the **major** function of the small intestine?

Absorption!!
Brush border

Pinocytic vesicles

Endoplasmic reticulum

Mitochondria

G&H 2011 fig 65-7
A. Central lacteal, Blood capillaries, Vein, Artery

B. Brush border, Basement membrane, Venules, Arteriole, Capillaries, Central lacteal
Why is the pancreas so unique?
Enzymes specific for all 3 energy nutrients!

Duct cells secrete aqueous NaHCO₃ solution
Acinar cells secrete digestive enzymes

Endocrine portion of pancreas (Islets of Langerhans)

Exocrine portion of pancreas (Acinar and duct cells)

Hormones (insulin, glucagon)

Blood

Stomach

Duodenum

Bile duct from liver

The glandular portions of the pancreas are grossly exaggerated.
Poor motility causes greater absorption, and hard feces in transverse colon causes constipation.

Excess motility causes less absorption and diarrhea or loose feces.
Questions
Discussion?