Chp. 8 DIGESTIVE S. & NUTRITION
What are the steps in the digestive process?
• Ingestion – intake of food via the mouth
• Digestion – mechanically or chemically breaking down food into their subunits
• Movement – food must be moved along the GI tract in order to fulfill all functions
• Absorption – movement of nutrients across the GI tract wall to be delivered to cell via the blood
• Elimination – removal of indigestible molecules
The mouth

• 3 pairs of salivary glands secrete salivary amylase that begins carbohydrate digestion

• Tonsils at the back of the mouth and other lymphatic tissues are important in fighting disease

• Contains teeth that begin the mechanical breakdown of food

• The tongue is covered in taste buds and also assists in the mechanical breakdown and movement of food

• The tongue forms a bolus (mass of chewed food) and moves it toward the pharynx.
The pharynx and esophagus

- Pharynx is a cavity between the mouth and esophagus that serves as a passageway for food (and air)

- Esophagus is a long, muscular tube that carries food to the stomach

How do we swallow food?

Health focus: Heartburn

- Occurs when acids from the stomach pass into the esophagus (acid reflux)

- Burning sensation in the esophagus

- Chronic heartburn is called gastroesophageal reflux disease (GERD)

- Tips for decreasing heartburn:
  - Avoid high fat meals
  - Don’t overeat
  - Eat several small meals rather than the standard 3 larger meals each day
  - Exercise lightly
Anatomy of the stomach

The stomach

- Functions to store food, start digestion of proteins and controls movement of chyme into the small intestine (after 2-6 hrs.)
- There are 3 layers of muscle in the muscularis layer of the stomach wall helping in mechanical digestion and allowing it to stretch
- The mucosa layer has deep folds called rugae and gastric pits that lead into gastric glands that secrete gastric juice
- Gastric juice contains pepsin, an enzyme that breaks down proteins, and HCl and mucus
- HCl gives the stomach a pH of 2 which activates pepsin and helps kill bacteria found in food
- A bacterium, *Helicobacter pylori*, lives in the mucus and can cause gastric ulcers
8.3 The stomach and small intestine

The small intestine (about 18 ft.)

- Enzymes secreted by the pancreas into the small intestine digest carbohydrates, proteins and fats
- Bile is secreted by the gallbladder into the small intestine to emulsify fats
- Digested food is absorbed through large surface area created by numerous villi (finger-like projections) and microvilli
- Amino acids and sugars enter the capillaries while fatty acids and glycerol enter the lacteals (small lymph vessels)

8.3 The stomach and small intestine

How are nutrients digested and transported out of the small intestine?

![Image of digestive process]

8.3 The stomach and small intestine

What are the major digestive enzymes?

<table>
<thead>
<tr>
<th>Enzyme</th>
<th>Protein</th>
<th>Site of Action</th>
<th>Physiological Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trypsin</td>
<td>Neutral</td>
<td>Small intestine</td>
<td>Proteins to polypeptides</td>
</tr>
<tr>
<td>Chymotrypsin</td>
<td>Neutral</td>
<td>Small intestine</td>
<td>Polypeptides to dipeptides and tripeptides</td>
</tr>
<tr>
<td>Pancreatic Amylase</td>
<td>Neutral</td>
<td>Small intestine</td>
<td>Non-enzymatic starch to maltose, maltose to glucose</td>
</tr>
<tr>
<td>Pancreatic Lipase</td>
<td>Neutral</td>
<td>Small intestine</td>
<td>Triglycerides to fatty acids and glycerol</td>
</tr>
<tr>
<td>Pancreatic Phospholipase A2</td>
<td>Neutral</td>
<td>Small intestine</td>
<td>Phospholipids to fatty acids and lysophospholipids</td>
</tr>
<tr>
<td>Pancreatic Collagenase</td>
<td>Neutral</td>
<td>Small intestine</td>
<td>Collagen and elastin</td>
</tr>
</tbody>
</table>
The pancreas (behind stomach)

- Functions of the pancreas:
  1. Secretes enzymes into the small intestine
     - Trypsin digests proteins
     - Lipase digests fats
     - Pancreatic amylase digests carbohydrates
  2. Secretes bicarbonate into the small intestine to neutralize stomach acids
  3. Secretes insulin into the blood to keep blood sugar levels under control

The three accessory organs

- Pancreas
- Liver
- Gallbladder

The liver (LG!) and gallbladder

- Filters blood from the GI tract thus acting to remove poisons and detoxify the blood
- Removes iron, vitamins A, D, E, K and B₁₂ from the blood and stores them
- Stores glucose as glycogen and breaks it down to help retain blood glucose levels
- Makes plasma proteins and helps regulate cholesterol levels by making bile salts
- Makes bile that is then stored in the gallbladder to be secreted into the small intestine to emulsify fats
- Breaks down hemoglobin
Liver disorders

- **Hepatitis**:  
  - Inflammation of the liver  
  - Caused by Hepatitis A, B and C  
  - This can lead to liver damage, cancer and/or death

- **Cirrhosis**:  
  - The liver becomes fatty and eventually this tissue is replaced by fibrous scar tissue  
  - Seen in alcoholics and obese people  
  - This can lead to liver failure in which the liver cannot regenerate as fast as it is being damaged

How do hormones control digestive gland secretions?

The large intestine

- Larger in diameter but shorter than the small intestine (5 ft.)

- The cecum has a projection known as the appendix that may play a role in fighting infections

- Functions to:  
  - Absorb water to prevent dehydration  
  - Absorb vitamins (B complex and K) produced by intestinal flora  
  - Forms and rids the body of feces through the anus
Disorders of the colon and rectum

- Diarrhea – increased peristalsis and water is not reabsorbed due to either an infection or nervous stimulation
- Constipation – condition when feces are dry and hard that may be controlled with water and fiber
- Hemorrhoids – enlarged and inflamed blood vessels of the anus due to chronic constipation, pregnancy, aging and anal intercourse
- Diverticulosis – occurrence of pouches of mucosa from weak spots in the muscularis layer that can become infected often in the colon
- Irritable bowel syndrome (IBS) – muscularis layer contracts with power but without its normal coordination that is characterized by chronic diarrhea and abdominal pain
- Inflammatory bowel disease (IBD) – a group of inflammatory disorders such as ulcerative colitis or Crohn’s disease
- Polyps and cancer – small growths found in the epithelial lining that can be benign or cancerous

What is obesity and BMI?

- When an individual is grossly overweight and has a body mass index (BMI) ≥ 30
- BMI is a general guide to estimate how much of a person’s weight is due to adipose tissue
- It does not take into account gender, fitness or bone structure

Why should we be concerned with obesity?

- Has doubled in the US in the last 20 years
- In the US ~1/3 of adults are obese and it is now prevalent in children and adolescents
- Obesity tends to increase with an increase in income
- Is associated with an increased risk of premature death, Type 2 diabetes, hypertension, CVD, stroke, gallbladder disease, respiratory dysfunction, osteoarthritis and certain cancers
Health focus: Searching for the magic weight-loss bullet

- Trendy diet programs
  - Pritikin diet: high carbohydrate and fiber diet through whole grains and vegetables
  - Atkin’s: low-carbohydrate and high protein and fat diet
  - Zone and South beach diet: low carbohydrate with a high protein and “healthy” fat diet

- Prescription drugs

- Surgical procedures
  - Gastroplasty: stapling or partitioning of a small portion of the stomach
  - Gastric bypass: attaching the lower part of the small intestine to the stomach so most of the food bypasses the stomach and small intestine
  - Gastric banding: a constricting band is used to reduce stomach size
  - Liposuction: removal of fat cells best used for overweight people that are not obese or morbidly obese

8.6 Nutrition and weight control

Carbohydrates (Subunit=glucose)

- Sugars or polysaccharides that are digested into simple sugars that are an important energy source

- Refined grains should be minimized in the diet because fiber and vitamins are removed (i.e. white bread, cake and cookies)

- Complex carbohydrates are recommended as a good source of vitamins and minerals (i.e. beans, whole-grain products, nuts and fruits)

8.6 Nutrition and weight control

How can you reduce high-glycemic index carbohydrates?

<table>
<thead>
<tr>
<th>Table 8.3 Reducing High-Glycemic Index Carbohydrates</th>
</tr>
</thead>
<tbody>
<tr>
<td>To reduce dietary sugars:</td>
</tr>
<tr>
<td>1. Eat fewer sweets, such as candy, soft drinks, ice cream, and pastries.</td>
</tr>
<tr>
<td>2. Eat fresh fruits or fruits canned without heavy syrup.</td>
</tr>
<tr>
<td>3. Use less sugar—white, brown, or even—and less honey and syrup.</td>
</tr>
<tr>
<td>4. Avoid sweetened breakfast cereals.</td>
</tr>
<tr>
<td>5. Eat less jelly, jam, and preserves.</td>
</tr>
<tr>
<td>6. Eat fresh fruits; especially avoid artificial fruit juices.</td>
</tr>
<tr>
<td>7. When cooking, use spices, such as cinnamon, instead of sugar or flavor syrups.</td>
</tr>
<tr>
<td>8. Do not put sugar in tea or coffee.</td>
</tr>
<tr>
<td>9. Avoid potatoes and processed foods made from refined carbohydrates, such as white bread, rice, and pasta.</td>
</tr>
</tbody>
</table>
Proteins (Subunits=amino acids)

- Proteins are digested into 20 different amino acids which are used to produce cellular proteins.
- Essential amino acids are the 8 amino acids that must be attained through diet.
- Complete proteins that have all essential amino acids are usually derived from animals such as meat and dairy.
- Non-animal sources of complete proteins are tofu, soymilk and other processed food from soybeans.
- Incomplete proteins are ones that lack at least one essential amino acid (i.e. legumes, nuts, grains etc...) and need to be combined with another incomplete protein to allow all amino acids to be used in the body.
- Amino acids cannot be stored in the body thus small amounts (2 meat servings) need to be ingested on a daily basis.

Lipids (subunits=glycerol & fatty acids)

- Includes fats, oils and cholesterol.
- Saturated fats (usually of animal origin) are usually solid at room temperature while unsaturated fats are usually liquid at room temperature.
- Essential fatty acids are ones that must be ingested include linoleic acid and linolenic acid (these can only be found in polyunsaturated oils such as corn and safflower).
- Olive and canola oil contain more monounsaturated fats.
- Omega-3 fatty acids are thought to ward off heart disease are found in some fish (salmon, sardines and trout) as well as some plants (flaxseed oil).

Can lipids be harmful?

- Cardiovascular Disease (CVD) is often a result of arteries blocked by plaque made of cholesterol and saturated fats.
- Low density lipoproteins (LDL) is the “bad” cholesterol because it carries cholesterol from the liver to the cells (LDL is increased by saturated fats and decreased by unsaturated fats).
- High density lipoproteins (HDL) is the “good” cholesterol because it carries cholesterol to the liver where it is converted to bile salts.
- Trans-fatty acids are made by hydrogenation of unsaturated fatty acids for commercial products and may reduce the ability of cells to clear cholesterol from the bloodstream.
Choosing the most healthy fat and oil (eat less sat. fat and cholesterol)

<table>
<thead>
<tr>
<th>Fat</th>
<th>% Saturated Fat</th>
<th>% Monounsaturated Fat</th>
<th>% Polyunsaturated Fat</th>
<th>% Cholesterol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canola oil</td>
<td>4</td>
<td>63</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Safflower oil</td>
<td>2</td>
<td>14</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>Olive oil</td>
<td>3</td>
<td>14</td>
<td>77</td>
<td>3</td>
</tr>
<tr>
<td>Beef fat</td>
<td>51</td>
<td>44</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Butter</td>
<td>62</td>
<td>39</td>
<td>5</td>
<td>33</td>
</tr>
<tr>
<td>Coconut oil</td>
<td>82</td>
<td>11</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

Numbers in Percent

8.6 Nutrition and weight control

How can you reduce “bad” fats and cholesterol in your diet?

<table>
<thead>
<tr>
<th>Table 8.4 Reducing Saturated Fats</th>
</tr>
</thead>
<tbody>
<tr>
<td>To reduce saturated fats and trans fats in the diet:</td>
</tr>
<tr>
<td>1. Choose poultry, fish, or dry beans and peas as protein sources.</td>
</tr>
<tr>
<td>2. Remove skin from poultry and remove fatty meats before cooking, and use as much fish or fish oil as possible.</td>
</tr>
<tr>
<td>3. Use fresh,而不是 frozen, cream, milk, cheeses, and tropical oils, instead of saturated and polyunsaturated fat.</td>
</tr>
<tr>
<td>4. Use herbs and spices instead of flavoring instead of flavoring, margarine, or seasonings that contain high levels of saturated fat and cholesterol.</td>
</tr>
<tr>
<td>5. Beach or stir-fry instead of baking, frying, or roasting fish or chicken, and use less oil in cooking and dressing.</td>
</tr>
</tbody>
</table>

To reduce dietary cholesterol:

1. Avoid cheese, egg yolks, liver, and certain shellfish (oysters and clams) high in cholesterol and fat.
2. Substitute eggs yolks for egg whites in both cooking and eating.
3. Include moderate fiber in the diet. Carbohydrates, beans, seeds, and nuts, such as apples, black beans, and walnuts, are high in soluble fiber.

8.6 Nutrition and weight control

Calcium (Major Mineral=1000mg/day)

- Needed to make bone, nerve impulse conduction and muscle contraction
- 1,000mg/day are recommended to keep bones healthy early in life and 1,300mg/day after menopausal age
- Vitamin D is needed with calcium to prevent bone loss (osteoporosis)

SODIUM (500 mg/day)

- For regulating water balance (X hypertension)
8.6 Nutrition and weight control

How can you reduce your sodium intake?

Table 8.6 Reducing Dietary Sodium

To reduce dietary sodium:
1. Use spices instead of salt to flavor foods.
2. Add little or no salt to foods at the table, and add only small amounts of salt when you cook.
3. Eat unseasoned crackers, pretzels, potato chips, nuts, and popcorn.
4. Avoid hot dogs, ham, bacon, luncheon meats, smoked salmon, sardines, and anchovies.
5. Avoid processed cheese and canned or dehydrated soups.
6. Avoid brine-soaked foods, such as pickles or olives.
7. Read nutrition labels to avoid high-salt products.

8.6 Nutrition and weight control

A summary of minerals
(eat a balanced diet—varied complete)

8.6 Nutrition and weight control

VITAMINS: organic compounds we need (often enzyme-helpers)
13 in 2 groups: Fat-soluble vitamins

Table 8.7 Fat-soluble vitamins

Vitamin  Function  Food Sources  Conditions with

Vitamin A: Antioxidants, vision, immune system, growth, reproduction, and development of bones and teeth.
- Deep yellow, orange, green, red, blue, white, white, and purple fruits and vegetables.
- Carotenoids: beta-carotene, lutein, zeaxanthin.

Vitamin D: Immune system, bone health, muscle function.
- High in dairy, eggs, liver, fatty fish, fortified foods.

Vitamin E: Antioxidant, immune system, skin, hair, vision.
- Nuts, seeds, oils, vegetables, berries, legumes.

Vitamin K: Blood clotting.
- Leafy greens, broccoli, cauliflower, Brussels sprouts, and milk.

Table 8.7 Fat-soluble vitamins

Vitamin  Function  Food Sources  Conditions with

Vitamin A: Antioxidants, vision, immune system, growth, reproduction, and development of bones and teeth.
- High in red, orange, yellow, and green fruits and vegetables.
- Carotenoids: beta-carotene, lutein, zeaxanthin.

Vitamin D: Immune system, bone health, muscle function.
- High in fatty fish, eggs, liver, fortified foods.

Vitamin E: Antioxidant, immune system, skin, hair, vision.
- Nuts, seeds, oils, vegetables, berries, legumes.

Vitamin K: Blood clotting.
- Leafy greens, broccoli, cauliflower, Brussels sprouts, and milk.
Water-soluble vitamins

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Functions</th>
<th>Food Sources</th>
<th>Deficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin C</td>
<td>Antioxidant, immune support, collagen formation</td>
<td>Citrus fruits, leafy greens, berries</td>
<td>Scurvy</td>
</tr>
<tr>
<td>Thiamin (B1)</td>
<td>Energy metabolism</td>
<td>Whole grains, legumes, salmon</td>
<td>Beriberi</td>
</tr>
<tr>
<td>Riboflavin (B2)</td>
<td>Energy metabolism, cell growth and function</td>
<td>Milk, eggs, green vegetables</td>
<td>Severe deficiency causes Keshan disease</td>
</tr>
<tr>
<td>Niacin (B3)</td>
<td>Energy metabolism, skin health</td>
<td>Whole grains, legumes, nuts</td>
<td>Pellagra</td>
</tr>
<tr>
<td>Pantothenic Acid (B5)</td>
<td>Energy metabolism</td>
<td>Meat, eggs, legumes</td>
<td></td>
</tr>
<tr>
<td>Biotin (B7)</td>
<td>Energy metabolism</td>
<td>Eggs, legumes, whole grains</td>
<td></td>
</tr>
<tr>
<td>Folate (B9)</td>
<td>DNA synthesis, early fetal development</td>
<td>Leafy greens, legumes, fortified cereals</td>
<td>Neural tube defects</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>DNA synthesis, nervous system function</td>
<td>Meat, dairy, fortified cereals</td>
<td>Pernicious anemia</td>
</tr>
</tbody>
</table>

Antioxidants

- Are chemicals that decrease the rate of oxidation or transfer of electrons

- Vitamin A, C, and E are considered antioxidants because they are thought to defend the body against free radicals that can transfer electrons and damage cells and DNA

- These vitamins are common in fruits and vegetables

A guide to daily food recommendations

- Grains: 6 oz. every day
- Vegetables: 2 1/2 cups every day
- Fruits: 2 cups every day
- Milk: 3 cups every day, age 2-8; 2 cups every day, age 9-12
- Meat & Beans: 5 1/2 oz. every day

Source: US Dept of Agriculture

Data from the US Department of Agriculture
8.6 Nutrition and weight control

An example of a healthy day of eating

<table>
<thead>
<tr>
<th>Time</th>
<th>Breakfast</th>
<th>Snack</th>
<th>Lunch</th>
<th>Snack</th>
<th>Dinner</th>
<th>Dessert</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 AM</td>
<td>Oatmeal</td>
<td>White bread</td>
<td>Tomato soup</td>
<td>Cheese</td>
<td>Grilled chicken</td>
<td>Blueberry mousse</td>
</tr>
<tr>
<td>10:00 AM</td>
<td>Banana</td>
<td>Greek yogurt</td>
<td>Apple slices</td>
<td>Yogurt</td>
<td>Grilled salmon</td>
<td>Chocolate cake</td>
</tr>
<tr>
<td>12:00 PM</td>
<td>Peanut butter and jelly</td>
<td>Tuna sandwich</td>
<td>Sweet potato</td>
<td>Avocado</td>
<td>Grilled fish</td>
<td>Chocolate mousse</td>
</tr>
<tr>
<td>5:00 PM</td>
<td>Grilled chicken</td>
<td>Greek yogurt</td>
<td>Grilled salmon</td>
<td>Kefir</td>
<td>Chocolate mousse</td>
<td>Blueberry mousse</td>
</tr>
</tbody>
</table>

8.6 Nutrition and weight control

Eating disorders

- Anorexia nervosa - psychological disorder due to fear of getting fat and usually results in self-induced starvation, high physical activity and may include purging

- Bulimia nervosa - disorder in which people eat large amounts of high-calorie food (binge-eating) followed by purging to avoid weight gain often more than once a day

- Binge-eating disorder - obese people are afflicted in which overeating is not followed by purging that can lead to depression, anger, anxiety and more binges

- Muscle dysmorphia – characterized by people that think their bodies are underdeveloped and are often preoccupied with body-building activities and diet

Eating disorders are associated with body image