Chapter 08
Lecture Outline

See separate PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes.

Points to ponder

- What are the digestive system structures and their functions?
- Where does carbohydrate, protein, and fat digestion and absorption occur?
- What are proteins, lipids, carbohydrates, minerals and vitamins needed for?
- What is an essential vs. a nonessential nutrient?
- What are the 3 accessory organs of digestion?
- What is obesity and why is it a problem?
- What is LDL and HDL?
- What are the components of a healthy diet?
- Name and explain 4 eating disorders.

What are the main steps in the digestive process?

- Ingestion – intake of food via the mouth
- Digestion – mechanically or chemically breaking down foods 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 cells via the blood
- Elimination – removal of indigestible molecules

What are the 4 major layers that make up the wall of the GI tract?

- Mucosa – innermost layer that produces mucus to protect the lining and also produces digestive enzymes
- Submucosa – 2nd layer of loose connective tissue that contains blood vessels, lymphatic vessels, and nerves
- Muscularis – 3rd layer made of 2 layers of smooth muscle that move food along the GI tract
- Serosa – outer lining that is part of the peritoneum

Visualizing the layers of the GI tract

Figure 8.2 The layers of the gastrointestinal tract wall.
An overview of the digestive system

8.1 Overview of Digestion

What is the pathway that food follows?

mouth
pharynx
esophagus
stomach
small intestine
large intestine
rectum
anus

8.1 Overview of Digestion

Anatomy of the mouth

hard palate
soft palate
uvula
tonsil
incisors (2)
canine (1)
premolars (2)
molars (3)
incisors (2)

8.2 The Mouth, Pharynx, and Esophagus

The mouth

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

• Tonsils at the back of the mouth are lymphatic tissues, important in fighting disease.

• The mouth 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.

8.2 The Mouth, Pharynx, and Esophagus

Teeth

• There are 32 teeth in adults (20 deciduous teeth in babies).

• Teeth are used for mechanical breakdown of food.

• Each tooth is made of a crown and a root.

• A hard covering of enamel and dentin covers the crown.

8.2 The Mouth, Pharynx, and Esophagus

Teeth

• An inner pulp area has nerves and blood vessels.

• Dental caries (cavities) occurs when bacteria metabolize sugars and produce acids; limiting sugar intake and brushing teeth reduces tooth decay.
How do we swallow food?

- Voluntary phase
  - In the beginning, when food is being swallowed from the mouth into the pharynx, it is a voluntary act.

How do we swallow food?

- Involuntary phase
  - Once the food is in the pharynx, swallowing becomes a reflex.
  - The epiglottis covers the voice box to make sure food is routed into the esophagus.
  - Food moves down the esophagus through peristalsis (rhythmic contraction).

Heartburn

- This occurs when acids from the stomach pass into the esophagus (acid reflux).
- There is a burning sensation in the esophagus.
- Chronic heartburn is called gastroesophageal reflux disease (GERD).
Heartburn

The following are tips for decreasing heartburn.
- Avoid high fat meals.
- Do not overeat.
- Eat several small meals rather than the standard 3 larger meals each day.
- Exercise lightly.

The stomach

- It functions to store food, start digestion of proteins, and control movement of chyme into the small intestine.
- The stomach is a J-shaped organ with a thick wall.
- There are 3 layers of muscle in the muscularis layer of the stomach wall to help in mechanical digestion and allow it to stretch.
- The mucosa layer has deep folds called rugae, and gastric pits that lead into gastric glands that secrete gastric juice.

The small intestine

- The small intestine averages 6 m (18 ft) in length.
- 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.
8.3 The Stomach and Small Intestine

Anatomy of the small intestine

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

What are the major digestive enzymes?

The 3 accessory organs

The pancreas

Fish-shaped spongy organ behind the 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 liver and gallbladder

- The liver is a large metabolic organ that lies under the diaphragm and is made of 100,000 lobules.
- It filters blood from the GI tract, thus acting to remove poisons and detoxify the blood.
- The liver removes iron, vitamins A, D, E, K, and B<sub>12</sub> from the blood and stores them.
- It stores glucose as glycogen and breaks it down to help retain blood glucose levels.
The liver and gallbladder

- The liver makes plasma proteins and helps regulate cholesterol levels by making bile salts.
- It makes bile that is then stored in the gallbladder to be secreted into the small intestine to emulsify fats.
- The liver also breaks down hemoglobin.

Liver disorders

- Hepatitis
  - Hepatitis is inflammation of the liver.
  - It is caused by Hepatitis A, B, and C.
  - This disease can lead to liver damage, cancer, and/or death.

Liver disorders

- Cirrhosis
  - The liver becomes fatty and eventually the liver tissue is replaced by fibrous scar tissue.
  - It is seen in alcoholics and obese people.
  - Cirrhosis 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

- The large intestine includes the cecum, colon, rectum, and anal canal.
- It is larger in diameter but shorter than the small intestine.
- The cecum has a projection known as the appendix that may play a role in fighting infections.
The large intestine

Disorders of the colon and rectum

- **Diarrhea** — increased peristalsis and failure to reabsorb water, due to either an infection or nervous stimulation
- **Constipation** — feces are dry and hard; condition may be controlled with water and fiber
- **Hemorrhoids** — enlarged and inflamed blood vessels of the anus due to chronic constipation, pregnancy, aging, or anal intercourse
- **Diverticulosis** — occurrence of pouches of mucosa from weak spots in the muscularis layer that can become infected; often occur in the descending colon

Disorders of the colon and rectum

- **Irritable bowel syndrome (IBS)** — muscularis layer contracts with power, but without its normal coordination; characterized by chronic diarrhea and abdominal pain
- **Inflammatory bowel disease/collitis (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? What is BMI?

- When an individual is grossly overweight and has a body mass index (BMI) $\geq 30$, he or she is obese.
- 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?

- 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.
Why should we be concerned with obesity?

- It is associated with an increased risk of premature death, type 2 diabetes, hypertension, CVD, stroke, gallbladder disease, respiratory dysfunction, osteoarthritis, and certain cancers.

Searching for the magic weight-loss bullet

- Trendy diet programs
  - Pritikin diet: high carbohydrate and fiber diet through whole grains and vegetables
  - Atkins: low-carbohydrate, and high protein and fat diet
  - Zone and South beach diets: low carbohydrate diets that are high in protein and “healthy” fats

- Prescription drugs

To understand weight and nutrition, we first have to understand nutrients

- Nutrients are components of food that are needed to perform physiological body functions.

  - Nutrients include
    - carbohydrates.
    - proteins.
    - lipids.
    - minerals.
    - vitamins.

Carbohydrates

- Carbohydrates are sugars or polysaccharides that are digested into the simple sugars which 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).

Can carbohydrates be harmful?

- Refined sugars and fructose sweeteners may contribute to obesity.

- These foods may cause the pancreas to secrete large amounts of insulin which can lead to insulin resistance seen in type 2 diabetes and increased fat metabolism.

- An increase in fat deposition may increase the risk of coronary heart disease, liver diseases, and certain cancers.
How can you reduce high-glycemic index carbohydrates?

<table>
<thead>
<tr>
<th>To Reduce Dietary Sugar</th>
</tr>
</thead>
<tbody>
<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 raw—and less honey and syrups.</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 fruit; especially avoid artificial fruit juices.</td>
</tr>
<tr>
<td>7. When cooking, use spices, such as cinnamon, instead of sugar to flavor foods.</td>
</tr>
<tr>
<td>8. Do not put sugar in tea or coffee.</td>
</tr>
<tr>
<td>9. Avoid processed foods made from refined carbohydrates, such as white bread, rice, and pasta, and limit potato intake.</td>
</tr>
</tbody>
</table>

Proteins

- 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.
- Nonanimal sources of complete proteins are tofu, soymilk, and other processed food from soybeans.

Can proteins be harmful?

- An overabundance of protein can result in dehydration during exercise and sweating.
- An overabundance of proteins can lead to calcium loss in urine which can lead to kidney stones.
- Eating red meat as a source of protein is high in saturated fats that can lead to CVD.

Lipids

- Lipids include 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; they include linoleic acid and linolenic acid (these can only be found in polyunsaturated oils such as corn and safflower).
Choosing the most healthy fat and oil

<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>6</td>
<td>62</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>safflower oil</td>
<td>9</td>
<td>12</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>olive oil</td>
<td>14</td>
<td>77</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>beef fat</td>
<td>51</td>
<td>44</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>butter</td>
<td>62</td>
<td>33</td>
<td>5</td>
<td>33</td>
</tr>
<tr>
<td>coconut oil</td>
<td>62</td>
<td>11</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

Can lipids be harmful?

- CVD is often a result of arteries blocked by plaque made of cholesterol and saturated fats.
- Low density lipoprotein (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.

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

<table>
<thead>
<tr>
<th>Table 8.4 Reducing Certain Lipids</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 shellfish and pass on processed products.</td>
</tr>
<tr>
<td>2. Remove skin from poultry and trim fat from red meats before cooking; place on a rack so that fats drain off.</td>
</tr>
<tr>
<td>3. Broil, grill, or bake rather than fry.</td>
</tr>
<tr>
<td>4. Limit your intake of butter, cream, cheeses, shortenings, and tropical oil in sauces and salad oils.</td>
</tr>
<tr>
<td>5. Use tasters and spices to season vegetables instead of butter, margarine, or cream. Use herbes just instead of salted dressings.</td>
</tr>
<tr>
<td>6. Drink skim milk instead of whole milk, and use skim milk in cooking and baking.</td>
</tr>
</tbody>
</table>

To Reduce Dietary Cholesterol

1. Avoid cheese, egg yolks, liver, and certain shellfish (shrimp and lobster). Substitute fat-free or low-fat dairy products.
2. Substitute skim milk for full-fat milk and cheese.
3. Include edibles fiber in the diet. Eat beans, oatmeal, brown rice, and nuts, including avocados, cheese, and nuts, as high in unsaturated fats.

Can lipids be harmful?

- High density lipoprotein (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.

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

Minerals

- The body contains > 5g of each major mineral and < 5g of each trace mineral.
- Major minerals make up components of cells, body fluids, and tissues (i.e., calcium).
- Minor minerals are components of larger molecules (i.e., iron in hemoglobin).
- A varied and complete diet usually provides necessary minerals.

Calcium

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

- Sodium is needed for regulating water balance.
- 500 mg/day is the recommended amount (on average each American takes in 4,000 – 4,700 mg/day).
- Sodium can increase hypertension in people who already have it.

Vitamins

- Organic compounds (not including proteins, fats, or carbohydrates) are used for metabolism but not produced in high enough quantities by the body.
- Vitamins are often enzyme helpers (coenzymes).
- There is a total of 13 vitamins in 2 groups: fat-soluble and water-soluble.

Antioxidants

- Antioxidants are chemicals that decrease the rate of oxidation or transfer of electrons.
- Vitamin C, E, and A are considered antioxidants because they are thought to defend the body against free radicals that can transfer electrons and damage cells and DNA.
- The vitamins are common in fruits and vegetables.
Eating disorders

- **Anorexia nervosa** – psychological disorder due to fear of getting fat; 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; overeating is not followed by purging, and this 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

Figure 8.16. The characteristics of different eating disorders.