Chapter 23 – The Digestive System

Functions of Digestive System
1. Take in food
2. Break it down into food molecules
3. Absorb molecules into the bloodstream
4. Rid body of any indigestible remains

Organs of the digestive system fall into two groups:
1. **Alimentary canal** (gastrointestinal or GI tract or gut)
   - Continuous muscular tube that runs from the mouth to anus (about 30 feet)
   - Digests food by breaking down into smaller fragments
   - Absorbs fragments through lining into blood
   - Organs (food passes through): mouth, pharynx, esophagus, stomach, small intestine, large intestine, and anus

2. **Accessory digestive organs** (aids in digestion, food does not pass through)
   - Teeth
   - Tongue
   - Gallbladder
   - Digestive glands: produce secretions that help break down foodstuffs
     - Salivary glands (parotid, sublingual and submandibular)
     - Liver
     - Pancreas

### DIAGRAM 1: (p. 857) Digestive System
1. Label diagram
2. Highlight organs food passes through
3. Circle all accessory organs

### 23.1 Digestive Processes-6 Essential Activities
1. **Ingestion**: eating
2. **Propulsion**: movement of food through the alimentary canal, which includes:
   - Swallowing
   - **Peristalsis**: major means of propulsion of food that involves alternating waves of contraction and relaxation
3. **Mechanical Digestion**: includes chewing, mixing food with saliva, churning food in stomach, and segmentation (local constriction of intestine that mixes food with digestive juices). This process increases efficiency of absorption by repeatedly moving different parts of food mass over the intestinal wall.
4. **Chemical Digestion**: series of catabolic steps (set of metabolic pathways that breaks down molecules into smaller units, then oxidized to release energy) that involves enzymes that break down complex food molecules into chemical building blocks. Begins in mouth and completed in the small intestine.
5. **Absorption**: passage of digested fragments from lumen (inside wall of GI tract) into blood or lymph (a colorless fluid containing white blood cells)
6. **Defecation**: elimination of indigestible substances via anus in form of feces (poo)

### DIAGRAM 2: (p. 858)
1. Label all 6 Essential Digestive Activities of the GI Tract
23.2 Peritoneum: what is it?

- The **peritoneum** is the largest serous membrane in the body. A complex, two-layered membrane, it produces a fluid that reduces friction between organs in the abdominal and pelvic cavities.
- The **parietal** peritoneum lines the abdominal wall.
- The fused, sling-like layers of the **visceral** peritoneum, known as **mesenteries**:
  - suspend organs within the abdomen
  - carry nerves and blood vessels to them
- The great **omentum** is a specialized double-fold of fatty peritoneum hanging from the stomach

### DIAGRAM 3:

1. Take a gander and label the missing areas:
   - Visceral (mesenteries) peritoneum
   - Greater omentum
   - Parietal peritoneum

23.3 Control of Digestive System: Enteric Nervous System

- GI tract has its own **nervous** system, referred to as **enteric nervous system** (in-house nerve supply of GI tract; enter = gut)
  - Also called the **gut brain**
  - Contains more neurons than spinal cord
- Gut brain is made up of **enteric neurons** that communicate extensively with each other
  - Major nerve supply to GI tract wall that controls **motility**
  - Enteric neurons make up bulk of two main interconnecting **intrinsic nerve plexuses**:
    1. **Submucosal nerve plexus** (Regulates glands and smooth muscle in mucosa)
    2. **Myenteric nerve plexus** (controls GI tract motility)
- **Parasympathetic system** enhances (activates) digestive process
- **Sympathetic system** inhibits (prevents) digestion

Basic Concepts of Regulating Digestive Activity

1. **Digestive activity** is provoked by a range of mechanical and chemical stimuli
   - Receptors located in **walls** of GI tract organs
   - Respond to stretch, changes in **osmolarity** (number of solute particles per liter) and pH, and presence of substrate and end products of digestion
2. **Effectors of digestive activity** are smooth muscle and glands
   - When stimulated, receptors initiate **reflexes** that stimulate smooth muscle to mix and move lumen (cavity) contents
   - Reflexes can also activate or inhibit digestive glands that secrete digestive juices or hormones
3. **Neurons (intrinsic and extrinsic) and hormones control digestive activity**
   - Nervous system control: Read Page 862, short and long reflexes together
   - **Intrinsic controls**: involve short reflexes (enteric nervous system)
   - **Extrinsic controls**: involve long reflexes (autonomic nervous system)
     - Hormonal controls:
       - Hormones from cells in stomach and small intestine stimulate **target** cells in same or different organs to secrete or contract
Part 2 – Functional Anatomy of the Digestive System

Let’s first remind ourselves of the **main organs** of the digestive system. List them in order below:

1. mouth
2. pharynx
3. esophagus
4. stomach
5. small intestine
6. large intestine
7. anus

Now, list the **associated organs** of the digestive system below:

1. teeth
2. tongue
3. gallbladder
4. Digestive glands: salivary glands, pancreas and liver

Let’s take the same journey through our GI tract that our food takes: (oh my goodness, SO FUN!!!)

**Mouth:** Also called the **oral** (buccal) **cavity**
- Hard and soft palate, teeth, tongue, tonsils, uvula and salivary glands etc.
- Walls of mouth lined with stratified squamous epithelium (remember that stuff? Ha!)
- Tough cells that resist abrasion
- Cells of gums, hard palate, and part of tongue are keratinized for extra protection

**Teeth:** (p. 867)
- *Mastication:* process of chewing that tears and grinds food into smaller fragments
  - Twenty **deciduous teeth,** or milk or baby teeth, that erupt between 6 and 24 months of age
  - 32 deep-lying **permanent teeth** enlarge and develop while roots of milk teeth are resorbed from below, causing them to loosen and fall out (occurs around 6–12 years of age)

  In an adult, 32 teeth arranged in two arcades (each jaw) of 16 teeth each:
  - four **incisors** for cutting (front center on top and bottom)
  - two **canines**- tear or pierce (on either side of incisors on top and bottom)
  - four **premolars/bicuspids**- grind/crush (next two on either side of two canines on top and bottom)
  - six **molars**- best grinders (last three on top and bottom- the third molars = wisdom teeth)

**Tongue:** occupies floor of mouth
- Composed of interlacing bundles of skeletal muscle
- Functions include:
  - Gripping, repositioning, and mixing of food during chewing
  - Formation of **bolus,** mixture of food and saliva
  - Initiation of swallowing, speech, and taste
- Intrinsic muscles change shape of tongue
- Extrinsic muscles alter tongue’s position
- **Lingual frenulum:** attachment to floor of mouth
- Superior surface bears papillae (peglike projections of underlying mucosa) 3 types:
  1. **Filiform papillae:** gives tongue roughness to provide friction; only one that does not contain taste buds; gives tongue a whitish appearance
  2. **Fungiform papillae:** mushroom shaped, scattered widely over tongue; vascular core causes reddish appearance of tongue
  3. **Vallate (circumvallate) papillae:** 8–12 form V-shaped row in back of tongue
- **Terminal sulcus:** groove located posterior to vallate papillae
Salivary Glands:
- Functions of saliva
  - Cleanses mouth
  - Dissolves food chemicals for taste
  - Moistens food; compacts into bolus (wad of food)
  - Begins breakdown of starch with enzyme amylase
- Composition of saliva
  - Mostly water (97–99.5%), so hypo-osmotic
  - Slightly acidic (pH 6.75 to 7.00)
  - Electrolytes
  - Salivary amylase and lingual lipase
  - Proteins: mucin, lysozyme, and IgA
- Most saliva produced by major (extrinsic) salivary glands located outside oral cavity

Three pairs of salivary glands:
1. Parotid: anterior to ear and external to masseter muscle
2. Submandibular: medial to body of mandible
3. Sublingual: anterior to submandibular gland under tongue

Digestion occuring in the Mouth:

Chemical Digestion:

<table>
<thead>
<tr>
<th>Macromolecule:</th>
<th>Organ/Accessory Organ:</th>
<th>Enzyme:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrates</td>
<td>Mouth</td>
<td>Salivary Amylase</td>
</tr>
<tr>
<td>- monosaccharides</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mechanical Digestion:

<table>
<thead>
<tr>
<th>Location:</th>
<th>Type of Action:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouth</td>
<td>Teeth chewing and grinding</td>
</tr>
</tbody>
</table>

Carbohydrates get reduced into the simple sugar glucose, the energy source used by the body cells to power their life processes. Any surplus of glucose is converted into glycogen and stockpiled in the liver and muscle cells.

In the mouth, the teeth cut and grind up food (mechanical digestion) and the salivary glands secrete saliva (chemical digestion). Salivary amylase breaks down carbohydrates-monosaccharides (basic form of a carb [glucose, galactose, fructose]-exits the epithelial cells and enters the blood stream via facilitated diffusion. The tongue manipulates the food and pushes it up against the hard palate. Meanwhile, the airway is sealed off and the muscular pharynx contracts in a wave to push the bolus of food down into the esophagus (peristalsis). Salivary amylase will eventually be inactivated by the stomach.
From the mouth food passes into the **pharynx**....

- Food passes into **oropharynx** and then into **laryngopharynx**
- Allows passage of food, fluids, and air
  - Stratified squamous epithelium lining with mucus-producing glands
  - External muscle layers consists of two skeletal muscle layers
    1. **Inner** layer of muscles runs longitudinally
    2. **Outer** pharyngeal constrictors encircle wall of pharynx

From the pharynx, food passes into the **esophagus**....

- Flat muscular tube that runs from laryngopharynx to stomach
  - Is collapsed when not involved in food propulsion
- **Gastroesophageal (cardiac) sphincter** surrounds cardial orifice (where it joins stomach)
  - Keeps orifice closed when food is not being swallowed
  - Mucus cells on both sides of sphincter help protect esophagus from acid reflux
- Pharynx and esophagus are conduits to pass food from mouth to stomach
- Major function of both organs is **propulsion** that starts with **deglutition** (swallowing)

From the esophagus, food passes into the **stomach**....

- **Stomach** is a J-shaped muscular bag linking the esophagus to the first section of the small intestine called the duodenum.
- The stomach acts as a temporary storage tank where **chemical breakdown** of protein digestion starts:
  - Gastric glands secrete:
    - **Hydrochloric acid** (HCl) -destroys harmful microorganisms
    - Enzyme **pepsin** -initiates breakdown of protein in food
  - Converts bolus of food to paste-like **chyme** (food in a liquefied state)
- Stomach wall contains muscle layers that help aid in **mechanical digestion**:
  - Inner oblique layer allows stomach not only to churn, mix, and move chyme, but also to pummel it, which increases physical breakdown ramming it into the small intestine
- **Pyloric valve** (sphincter) controlling stomach emptying into the small intestine

**DIAGRAM 8: (p. 872 & 873) Stomach**
Look over the diagram of the stomach. Draw in and label the valve that keeps food moving into the stomach from the esophagus.

**Digestion occurring in the Stomach:**

**Chemical Digestion:**

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<thead>
<tr>
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<th>Enzyme:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrates -monosaccharides</td>
<td>Stomach</td>
<td>Salivary Amylase is <strong>inactivated</strong> by HCl</td>
</tr>
<tr>
<td><strong>Proteins</strong> -Amino acids</td>
<td>Stomach</td>
<td>HCl and <strong>pepsin</strong> break protein into peptide chains</td>
</tr>
<tr>
<td><strong>Lipids (fats)</strong> -Fatty Acids</td>
<td>Stomach</td>
<td><strong>Gastric lipase</strong> splits lipids into fatty acids and monoglycerides</td>
</tr>
</tbody>
</table>
**Mechanical Digestion:**

<table>
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<th>Type of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stomach wall</td>
<td>Churn, mix, pummel, breakdown and ram chyme into the small intestine</td>
</tr>
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</table>

Proteins are cut into polypeptide chains, peptides and finally into single amino acids (basic unit of protein). All body cells are maintained using amino acids and are necessary for a variety of reasons such as in growth and repair. Your body will use proteins for energy as a final resort.

**In Summary:** Processes carried out by stomach
1. Carries out breakdown of food
2. Serves as holding area for food
3. Delivers chyme to small intestine
4. Denatures (stops from working) proteins by HCl
5. Pepsin carries out enzymatic digestion of proteins
   - Milk protein (casein) is broken down by rennin in infants (results in curdy subs.)
6. Only stomach function essential to life is secretion of intrinsic factor for vitamin B₁₂ absorption
   - B₁₂ needed for red blood cells to mature
   - Lack of intrinsic factor causes pernicious anemia
   - Treated with B₁₂ injections

From the stomach, food passes into the **small intestine**...

**Accessory Organs- Liver, Gallbladder and Pancreas- play an Important Role in the Small Intestine:**

1. **Liver:** digestive function is **production** of bile (fat emulsifier)
   - Weighs up to 6lbs (largest internal organ)
   - Located in the upper right abdomen below diaphragm
   - Receives nutrients from the gut via the hepatic (hepat= liver) portal vein
   - Detoxifies substance (ex: drugs and alcohol)
   - Regulates glucose levels
   - Stores vitamins and minerals
   - Recycles RBC’s

2. **Gallbladder:** chief function is **storage** of bile
   - Bile passes along the left and right hepatic ducts from the liver’s two lobes into a common hepatic duct, common bile duct, cystic duct and then into the gallbladder.
   - Bile is released after a meal, when it passes along the cystic duct and bile duct to enter the duodenum-the first section of the small intestine.

3. **Pancreas:** supplies most of the enzymes needed to digest chyme, and to neutralize stomach acid
   - Endocrine function: secretion of **insulin** (regulates blood glucose levels) and **glucagon**
   - High pH of pancreatic juice helps neutralize acidic chyme before entering duodenum
   - Pancreatic enzymes
     - Proteases (for proteins): secreted in inactive form to prevent self-digestion
     - Amylase (for carbohydrates)
     - Lipases (for lipids)
     - Nucleases (for nucleic acids)

**DIAGRAM 9:** (p. 888) Liver, Gallbladder and Pancreas
Label the gallbladder, right & left hepatic ducts, common hepatic duct, bile and sphincter duct, duodenum, jejunum, pancreas and liver.

Body cannot make enough healthy RBCs
Small Intestine:
- About 17 feet long (small in diameter—reason it’s referred to as the small and not large)
- Small intestine is the major organ of digestion and nutrient absorption (huge surface area)
- 90% of all nutrient absorption occurs here
- Consists of three sections: (DJ I)
  1. Duodenum—specialized for digestion
  2. Jejunum—specialized for absorption
  3. Ileum—specialized for absorption
- Modifications include:
  1. Circular folds—forces chyme to slowly spiral through lumen, allowing more time for nutrient absorption
  2. Villi—finger-like projections aiding in absorption
  3. Microvilli—brush border of cytoplasmic extensions (fuzzy appearance) used to digest carbs and proteins
- Digestive Processes in the Small Intestine
  - Chyme from stomach contains partially digested carbohydrates and proteins and undigested fats
  - Chyme has to be mixed with bile and pancreatic juice to continue digestion
  - Takes 3–6 hours in small intestine to absorb all nutrients and most water

Digestion occurring in the Small Intestine:

Chemical Digestion:

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From the small intestine, food passes into the Large Intestine...

Large Intestine (colon):
- About 5 feet long (twice the diameter of the small intestine—hence its name)
- Produces vitamin K and draws out water from the liquid chyme turning it into semisolid feces (poo)
- Subdivisions of large intestine:
  1. Cecum: first part of large intestine, short pouch connecting small intestine to colon
  2. Appendix: masses of lymphoid tissue
    - Bacterial storehouse capable of recolonizing gut when necessary
    - Twisted shape of appendix makes it susceptible to blockages
  3. Colon: four regions
    - Ascending colon: travels up right side of abdominal cavity until right-angle turn
    - Transverse colon: travels across abdominal cavity ends in another right-angle turn
    - Descending colon: travels down left side of abdominal cavity
    - Sigmoid colon: S-shaped portion that travels through pelvis
  4. Rectum: three rectal valves stop feces from being passed with gas (flatus)
  5. Anal canal: last segment of large intestine that opens to body exterior at anus surrounded by two anal sphincters: internal (smooth muscle) & external (skeletal muscle)

**DIAGRAM 10: (p. 895) Large Intestine**
Label the cecum, sigmoid, anal canal, transverse, ascending, descending, rectum, external anal sphincter, appendix, and anal canal.