Outline – Digestive System

I. Function
II. Layers of the GI tract
III. Major parts: mouth, pharynx, esophagus, stomach, small intestine, large intestine, pancreas, liver, gall bladder.
IV. Digestive enzymes

The Digestive System

- The digestive system consists of a long tube, called the gastrointestinal (GI) tract that extends from the mouth to the anus, along with accessory organs.
- The digestive system is divided into specialized compartments for food processing.
- Nerves and hormones control digestive activities.

Function of the Digestive System

- The function of the digestive system is to:
  1. bring food into the body
  2. digest it into nutrients that are absorbed by the body
  3. eliminate wastes out of the body.

Terminology

- Digestion: The process of breaking complex molecules into simpler molecules which can be absorbed in the GI tract.
- Absorption: The process of transporting molecules across the wall of the GI tract into vessels to be transported to the liver.

Digestion

- Mechanical digestion - chewing of food, churning action of the stomach, and segmentation of the small intestine.
- Chemical digestion - action of enzymes and chemicals on foods.

What type of epithelial tissue lines the GI tract?

1. Simple cuboidal
2. Simple squamous
3. Simple columnar
4. Stratified squamous
Wall of the Digestive Tract
- Along most of its length, the wall of the digestive system has four basic layers
  1. Mucosa
  2. Submucosa
  3. Muscularis
  4. Serosa

Wall of the Digestive Tract - Mucosa
- Mucosa - Mucus membrane layer lines the GI tract
  - The open area inside the GI tract is the lumen.
  - Glandular epithelial cells secrete digestive enzymes.
  - Goblet cells secrete mucus, which lubricates.
  - Simple columnar epithelial cells line the lumen.

Wall of the Digestive Tract - Submucosa
- Submucosa – layer of connective tissue with nerves, blood supply, lymph vessels.
  - Protect us from disease, nerves stimulate muscles, transport of nutrients.

Wall of the Digestive Tract - Muscularis
- Muscularis – Layer of smooth muscles.
  - Has two layers of muscle, one circular and one longitudinal
  - Functions to mix and moves food.

Wall of the Digestive Tract - Serosa
- Serosa – a layer covering the GI tract that secretes serous fluid.
  - The fluid functions to reduce friction between moving layers of tissue.

Components of the GI Tract
- The major GI Tract (Alimentary Canal) components
  - Mouth
  - Esophagus
  - Stomach
  - Small intestine
  - Large intestine

Accessory Organs
- The digestive organs are aided by several accessory organs
  - Salivary glands
  - Pancreas
  - Gallbladder
  - Liver

The Digestive System Has Specialized Compartments

Table 15.1 - Structure of Tissues of the Digestive System
<table>
<thead>
<tr>
<th>Tissues</th>
<th>Description/Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mucosa</td>
<td>Simple columnar epithelial cells line lumen</td>
</tr>
<tr>
<td>Submucosa</td>
<td>Layer of connective tissue with nerves, blood supply, lymph vessels</td>
</tr>
<tr>
<td>Muscularis</td>
<td>Layer of smooth muscles</td>
</tr>
<tr>
<td>Serosa</td>
<td>A covering layer that secretes serous fluid</td>
</tr>
</tbody>
</table>

Note: Additional information on the digestive system and its components is available in the text.
Parts of the Digestive Tract - Mouth

1. Mouth: specialized for tasting, speech, moistening food, and mechanical and enzymatic digestion.

Parts of the Digestive Tract - Mouth

- The mouth contains:
  1. Salivary glands - secretes salivary amylase that begins the process of digesting starch.
  2. Tongue - mixes chewed food with saliva.
  3. Teeth - break food into smaller pieces
  4. Tonsils - protects against infections
  5. Uvula - working with the soft palate, closes off the nasopharynx during swallowing

Mouth - Salivary glands

- Saliva:
  - Moistens food
  - Dissolves the chemicals in the food
  - Contains the enzyme, salivary amylase
    - Begins digestion of carbohydrates
  - Produced by 3 major pairs of glands
    - Parotid salivary glands
    - Sublingual salivary glands
    - Submandibular salivary glands

Salivary glands

![Salivary glands diagram]

Mouth - Tongue

- The tongue
  - A large skeletal muscle with taste buds
  - Important in speech
  - Helps form food into a bolus
  - A soft mass of food, suitable for swallowing

Mouth - Pharynx

2. Pharynx: behind the uvula where the nasal and oral cavities join. Common passageway for air, liquids, and food.

- Swallowing reflex begins here.
- Epiglottis covers opening in the larynx that leads to the trachea when swallowing.

Esophagus

3. Esophagus – passage that connects the pharynx to the stomach.

- No digestive processes occur here

Esophagus

- Food is pushed through our digestive system by a series of muscular contractions called peristalsis

![Teeth diagram]

Teeth

(a) The structure of the human tooth is suited for its function of breaking food into smaller pieces.
Sphincters - circular muscles that control the entrance and exit of materials to and from the stomach.

Acid reflux - heartburn occurs when partially digested food comes back up into the esophagus and produces a burning sensation. This is also called, “GERD” gastro-esophageal reflux disease.

The stomach breaks up food through muscular contractions. There are three layers of smooth muscle.

The food that leaves the stomach is only partially digested.

The functions of the stomach include:
1. Responsible for the storage of food
2. Turns food into a soupy mixture called **chyme**
3. Adds digestive enzymes and acids that begin chemical digestion of proteins

The stomach expands to accommodate amounts of food:
- When empty the stomach can hold about 50 ml (1/4 cup)
- When full, can hold several liters of food

Very little nutrition is actually absorbed into the bloodstream from the stomach.
- Exceptions include alcohol and some drugs including aspirin

Gastric glands secrete:
1. The digestive enzyme, **pepsin**, that begins the digestion of proteins.
2. Hydrochloric acid (HCl) - strong acid that kills bacteria, aids in the digestion of proteins, begins to break down connective tissues, and activates pepsin.

The wall of the stomach is protected by a thick layer of mucus secreted by goblet cells.

The thick soupy acidic liquid that leaves the stomach is called:
1. chylomicrons
2. bolus
3. chyme
4. feces

Stomach – Secretions

Stomach – Storage of Food

Esophagus

Esophagus

Stomach

Stomach

The thick soupy acidic liquid that leaves the stomach is called:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>chylomicrons</td>
<td>25%</td>
</tr>
<tr>
<td>bolus</td>
<td>25%</td>
</tr>
<tr>
<td>chyme</td>
<td>25%</td>
</tr>
<tr>
<td>feces</td>
<td>25%</td>
</tr>
</tbody>
</table>
Layers of the Stomach

- Surface epithelium
- Mucosa
- Submucosa
- Muscularis
- Serosa

Gastric Pits

- Gastric glands in the wall of the stomach produce gastric juice, a mixture of hydrochloric acid and pepsin.

How many layers of smooth muscle are in the wall of the stomach?
1. One
2. Two
3. Three
4. Four

What is the muscular tube that passes foodstuffs from the pharynx to the stomach?
1. Trachea
2. Larynx
3. Esophagus
4. Small intestine

The primary function of the stomach is:
1. to break down fats
2. to store food, liquefy, begin digestion
3. to absorb major nutrients
4. package feces

Parts of the Small Intestine

- The small intestine has three regions:
  1. Duodenum
  2. Jejunum
  3. Ileum

Function of the Small Intestine

1. This is the primary site of digestion (mainly chemical, but also mechanical)
2. Where most (80%) of the nutrients are absorbed into the body.

5. The Small Intestine

- Small intestine – thin long tube (2.5 cm in diameter and about 6 meters long.
- Secretions from the pancreas, liver and gall bladder enter the small intestine
- Smooth muscles surround the intestine to push the food through the digestive tract.
Digestion in the Small Intestine

- The digestion of complex molecules (carbohydrates, proteins, fats, and nucleic acids) in the small intestine is aided by:
  1. enzymes in the wall of the small intestine and released from the pancreas
  2. and by bile from the gall bladder

Small Intestine Structure

- The lining of the small intestine is
  - Pleated (has folds) (circular folds)
  - The pleats have numerous finger-like projections called villi to increase surface area

Small Intestine - Villi

- Villi (villus, singular) - greatly increase the absorption area of the small intestine.
- Villi contain blood capillaries and lymphatic vessels called lacteals
  - Lacteals — absorb fatty acids.
  - Blood capillaries — absorb nutrients including glucose and amino acids.

Microvilli

- Each villus is covered with microvilli
- Gives the small intestine a velvety appearance, increases the surface area
- Called the brush border

Small Intestine Structure - Villi

- Absorption – once complex molecules are broken down into smaller molecules, they are transported across the intestine wall.
- Each villus contains a network of capillaries and a lacteal

Enzymes of the Small Intestine

- Found in the walls of the cells lining the small intestine (in the brush border)
- CHO enzymes that breaks down di, tri and polysaccharides into monosaccharides
- Peptidases that peptides into amino acids
6. Large Intestine

- By the time the food enters the large intestine most of the nutrients have been removed.

Large Intestine - Functions

1. Water, salts, & vitamins are absorbed from the large intestine, adjusting the consistency of the waste material, to form feces
2. Stores feces
3. Eliminates feces from the body

Components of the Large Intestine

- Cecum - lies below the junction with the small intestine.
- Appendix – slender pouch extending from cecum, may play a role in fighting infections but may become inflamed.

Components of the Large Intestine

- Colon – largest portion of the large intestine
  - absorbs much of the remaining water, and sodium and potassium ions
  - Contains beneficial bacteria which act on indigestible material (causing gas), produce B complex vitamins, and most of the vitamin K needed for clotting of blood.
  - The undigested food residue that leaves the colon is called feces

Nutrients are primarily absorbed in the:

1. Stomach
2. Small Intestine
3. Large Intestine

Accessory Organs of the Digestive System

- The pancreas releases secretions into the small intestine to aid in digestion
- The pancreas is also a gland that releases hormones
Pancreas - Functions
1. Produces the hormones into the bloodstream which regulate glucose levels.
2. Secretes digestive enzymes into the small intestine.
3. Secretes bicarbonate ions into the small intestine to neutralize the acid in the chyme.

Pancreas - Hormones
- The pancreas secretes two hormones into the blood to regulate glucose levels:
  1. Insulin - decreases blood glucose levels.
  2. Glucagon - increases blood glucose levels.

Pancreas – Digestive Enzymes
- The pancreas produce and release four types of enzymes into the small intestine:
  1. amylase - digests starch
  2. proteases - digest proteins
  3. lipase - digests fats
  4. nuclease – digest nucleic acids

Liver
- Blood from capillaries of the intestine, carrying nutrients, goes to the liver through the hepatic portal veins.
- The liver has 2 blood supplies:
  - Nutrient rich, oxygen poor blood from the intestines via the hepatic portal veins
  - Nutrient poor, oxygen rich blood from the hepatic artery

Hepatic Portal System

Liver functions - digestion
1. Produces Bile
2. Processes (metabolizes) nutrients from the GI tract.
3. Metabolizes drugs and toxins
   - The liver has many enzymes that help the body metabolize.

More Liver Functions
4. Produces plasma proteins.
5. Breaks old blood cells down, producing bilirubin
6. Breaks down amino acids, forming urea
7. Stores iron and fat soluble vitamins A, D, E, K, and B12.
8. Stores glucose as glycogen.
9. Regulates the quantity of cholesterol in the blood

Liver - Bile
- The liver produces bile which helps to break down fats.

Accessory Organs - Gallbladder
- Gall bladder - stores excess bile. Bile emulsifies fat.
**Digestive Enzymes**

- **Digestive enzymes** - break down macromolecules into smaller molecules.

- See page 292, Table 15.2

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**Digestive Enzymes**

<table>
<thead>
<tr>
<th>Enzymes</th>
<th>Produced by</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amylase</td>
<td>salivary glands, pancreas</td>
<td>breaks down starch to maltose</td>
</tr>
<tr>
<td>CHG enzymes</td>
<td>small intestine</td>
<td>breaks down di and trisaccharides to monosaccharides</td>
</tr>
<tr>
<td>Pepsin</td>
<td>stomach</td>
<td>breaks proteins into smaller pieces</td>
</tr>
<tr>
<td>Peptidases</td>
<td>small intestine and pancreas</td>
<td>breaks proteins and polypeptides into amino acids</td>
</tr>
<tr>
<td>Nucleases</td>
<td>pancreas</td>
<td>breaks nucleic acids into nucleotides</td>
</tr>
<tr>
<td>Lipase</td>
<td>pancreas</td>
<td>digests fat molecules into monoglyceride and fatty acids</td>
</tr>
<tr>
<td>Bile</td>
<td>Liver</td>
<td>Emulsification of fats</td>
</tr>
</tbody>
</table>

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**What is the monomer unit of starch?**

1. Amino acids  
2. Fatty acids  
3. Glucose  
4. Glycerol

---

**What is the monomer unit of proteins?**

1. Amino acids  
2. Fatty acids  
3. Glucose  
4. Glycerol

---

**What is the monomer unit of DNA and RNA?**

1. Amino acids  
2. Fatty acids  
3. Glucose  
4. Nucleotides

---

**Bile is produced by:**

1. Pancreas  
2. Gall Bladder  
3. Liver  
4. Small Intestine

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**The digestive enzyme responsible for fat digestion is:**

1. Pepsin  
2. Pepsidase  
3. Lipase  
4. Bile

---

**Lipase is secreted from**

1. Small intestine  
2. Stomach  
3. Pancreas  
4. Large intestine

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### Important Concepts

- What is the purpose of the digestive system?
- What are the layers of the GI tract and be able to describe the layers and what are the functions of the layers?
- What are the parts of the mouth and their functions?
- What are the major parts of the digestive system and their functions? Be able to describe the parts of the digestive system (mouth, pharynx, esophagus, stomach, small intestine, large intestine, pancreas, liver, gall bladder)
- What are the parts of the mouth and their functions?
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