

## 9.5 Digestion in the Small and Large Intestines

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### Structure of the Small Intestine

- Most digestion and \_\_\_\_\_ of nutrients occurs in the SI
- 2.5 cm in diameter and up to 7m long
- Made up of three sections: duodenum, \_\_\_\_\_ and ileum

### Sections of the Small Intestine

- \_\_\_\_\_: The duodenum is the first 25-30 cm and is where most enzymes are added and where digestion in the small intestine begins
- \_\_\_\_\_: In the jejunum, digestion continues and some nutrients are absorbed
- \_\_\_\_\_: The majority of nutrients are absorbed in the ileum

### Maximizing Nutrient Absorption in the Small Intestine

- The inner layer of the small intestine is folded into ridges containing fingerlike projections (\_\_\_\_\_) to maximize surface area for nutrient \_\_\_\_\_
  - 10X increase in SA
- Furthermore, each of the single layered epithelial cells that make up the villi (singular: villus) has even smaller, microscopic projections of the cell membrane called \_\_\_\_\_ (singular: microvillus)
  - The combined effect of the villi and microvilli is estimated to increase the surface area by a factor of 500.

### Nutrient Absorption in the Small Intestine

- Within each villus is a network of tiny blood vessels called \_\_\_\_\_.
  - All \_\_\_\_\_, except digested fats, enter the bloodstream through the capillaries
- Digested \_\_\_\_\_ are transported through small vessels called \_\_\_\_\_.
  - The digested fats are transported into the \_\_\_\_\_ system, and from there into the bloodstream

### From Stomach to Duodenum

- The \_\_\_\_\_ sphincter controls the movement of chyme from the stomach to the duodenum
- Muscle relaxes \_\_\_\_\_ to allow small increments of chyme to enter so overflow is avoided

### Digestive Vs. Accessory Organs

- **Digestive Organs:** The alimentary canal is made of digestive organs that form a hollow tube (mouth to anus). Food \_\_\_\_\_ through these organs.

- **Accessory Organs:** The accessory organs \_\_\_\_\_ fluids into the tract that aid in digestion. Food \_\_\_\_\_ pass through the accessory organs.
  - Include the pancreas, liver and \_\_\_\_\_

## The Pancreas

- **The structure:**
  - Connects to the duodenum via the \_\_\_\_\_ duct
  - Spongy, \_\_\_\_\_ and tapered
  - Sits behind stomach
  - Head sits in C-part of duodenum
  - \_\_\_\_\_ produce and secrete substances into the body
- There are two main functions of the pancreas
  1. To secrete pancreatic juice (1L/day) into the tract to aid digestion. Pancreatic juice includes:
    - Water
    - Digestive \_\_\_\_\_
    - Bicarbonate
    - \_\_\_\_\_
  2. To regulate blood \_\_\_\_\_ by producing and releasing the hormones insulin and glucagon

## What controls the release of pancreatic juices into the small intestine?

- Hormones cholecystokinin (CCK) and secretin when chyme enters duodenum
- **Controlling Pancreas: Hormone CCK**
  - When \_\_\_\_\_ chyme enters the duodenum, cholecystokinin (CCK) is secreted by special cells in the duodenum and released into the bloodstream.
    - CCK signals the pancreas to secrete a variety of substances, including \_\_\_\_\_ that are needed for lipid, carbohydrate, and protein digestion.
    - CCK also signals the stomach to \_\_\_\_\_ the movement of chyme into the small intestine so that fats can be properly digested.
- **Controlling Pancreas: Secretin**
  - The low pH (about 2.5) of chyme triggers a chemical called prosecretin that is present in the epithelial cells of the small intestine to be converted into its active form, \_\_\_\_\_
    - Secretin stimulates the pancreas to release \_\_\_\_\_ ions to neutralize the acidic chyme and raise the pH from about pH 2.5 to pH 9.0.
    - Thus, secretin \_\_\_\_\_ the small intestine from stomach acids. Unlike the stomach, the small intestine does not have a thick mucous layer for protection against acid.

## Digestive Enzymes: Protease Trypsin

- Recall that pepsin (protein digestive enzyme in stomach) is only active in acidic conditions
  - Therefore, not active in the small intestine
- The pancreas releases trypsinogen, which is an inactive form of a protein-digesting enzyme called \_\_\_\_\_. The trypsinogen travels from the pancreas to the duodenum
  - Once it reaches the duodenum, an enzyme called \_\_\_\_\_ converts it into active trypsin
  - Trypsin further breaks down any partially digested proteins that remain and converts other proenzymes into their active forms

## Digestive Enzymes: Lipases

- Fats that enter the duodenum are subjected to the action of \_\_\_\_\_
- Lipases are enzymes secreted by the pancreas that break down \_\_\_\_\_ into fatty acid molecules.
- However, fats in chyme are present as \_\_\_\_\_ globules.
  - Lipases cannot penetrate beyond the surface of the fat globules. The liver and its secretions (bile) must become involved.

## The liver & Gallbladder

- The liver produces and secretes \_\_\_\_\_, a substance that emulsifies fats, breaking them into tiny droplets called micelles
  - This gives the lipases (enzyme) a much greater \_\_\_\_\_ on which to act, and the rate of lipid digestion increases
- Bile is continuously produced in the liver, but it is \_\_\_\_\_ in the gallbladder
  - Bile travels to the gallbladder: Liver → hepatic ducts (L & R) → common hepatic duct → cystic duct → gallbladder
  - When lipids are present in the small intestine, bile is squeezed out of the gallbladder: Gallbladder → cystic duct → common bile duct → duodenum
- Other Roles of the Liver
  - The removal and breakdown of \_\_\_\_\_ (e.g. alcohol) occurs in the liver.
  - The liver is also involved in producing and storing \_\_\_\_\_ and fat soluble vitamins.

## Control of Bile Secretion

- **Secretin**
  - Secretin stimulates the flow of bile from the \_\_\_\_\_ to the \_\_\_\_\_
- **CCK Cholecystinin**
  - CCK stimulates the gallbladder to contract, causing bile to be secreted into the \_\_\_\_\_

## The Need for Transport Mechanisms

- In order for all cells in the body to receive the broken down nutrients from the tract, substances must cross several cell membranes.
- **Mechanisms for moving substances across cell membranes**
  - **Passive Transport:**
    - Movement of **small** particles \_\_\_\_\_ their concentration gradient
      - Particles move from area of ↑concentration → area of ↓concentration
    - \_\_\_\_\_ required!
    - **Diffusion:** Small \_\_\_\_\_ diffuse on their own
    - **Osmosis:** Term for diffusion of water specifically
    - **Facilitated diffusion:** Large particles require membrane proteins to facilitate their diffusion (e.g. protein channels A and B)
  - **Active transport:**
    - Movement of **large** particles \_\_\_\_\_ their concentration gradient
      - From area of ↓concentration → area of ↑concentration
    - Energy is \_\_\_\_\_
    - Transport proteins move materials across membrane
    - Molecule examples: calcium ions, amino acids, carbohydrates, and vitamins.

## Structure of the Large Intestine (LI)

- Approximately 1.5 m in length
- Approximately 7.6 cm in diameter
- 2-3 times larger in diameter than the small intestine
- The large intestine consists of the cecum, appendix, colon, rectum, and anus
  - The \_\_\_\_\_ is separated into four parts: ascending, transverse, descending and sigmoid

## Functions of the Large Intestine

- Digestion is complete and most of the nutrients, including ~90% of water, have been absorbed by the time the digested material reaches the large intestine
- As \_\_\_\_\_ material, such as cellulose, passes through the colon, water (~10%) is absorbed through the process of osmosis
  - It may take 4 to 72 hrs for the undigested material to pass through the large intestine, depending on the types and volume of food eaten.
- Approximately 20 L of fluids pass through the large intestine daily, and most of this is reabsorbed back into the body.
- \_\_\_\_\_ B and K, and \_\_\_\_\_, sodium (Na+) and chloride (Cl-) ions, are also absorbed in the LI

## Bacteria in the Colon

- 500+ species of bacteria normally inhabit the LI
- \_\_\_\_\_ is the most common species
- They exist in a \_\_\_\_\_: Bacteria live in a suitable environment and have access to a plentiful food supply. In return, they produce essential \_\_\_\_\_ (e.g. vit K and B)

- Another byproduct of bacterial action is gas— some is absorbed in the large intestine and some is released as \_\_\_\_\_
- Although these bacteria are needed, some strains can create serious or even fatal problems if they enter and reproduce in the stomach or small intestine

**Egestion**

- Indigestible food such as \_\_\_\_\_ and other fibers are important
  - Add \_\_\_\_\_ and provides full feeling
  - Retains water in large intestine to help in egestion
  - The absorption of water in the large intestine results in a soft solid (feces)
    - If too much was absorbed → \_\_\_\_\_
    - If too little was absorbed → \_\_\_\_\_
- \_\_\_\_\_ in wall of large intestine detects movement of feces in rectum→ defecation reflex activated
- Defecation is controlled by two \_\_\_\_\_ muscles in the anus
  - Internal sphincter - smooth, \_\_\_\_\_
  - External sphincter - skeletal, \_\_\_\_\_
  - Feces is eliminated when both sphincters are \_\_\_\_\_

**Endoscope**

- Designed to look inside the body
- \_\_\_\_\_: any procedure that uses an endoscope to look inside the body
- Narrow \_\_\_\_\_ with a light source, lens, and camera for imaging
- Enters body through mouth anus, or an \_\_\_\_\_
- Different attachments can be inserted to perform different procedures including:
  - \_\_\_\_\_: taking a sample of tissue for examination
  - Surgery: such as. gallbladder removal
- \_\_\_\_\_ endoscopes look like a pill and can be swallowed. The capsule takes thousands of images as it makes its way down the entire tract.