

Chapter 24 Digestive System Physiology

Chemical Digestion and Absorption

Chemical digestion is the catabolism of nutrients via hydrolysis. Each nutrient must be broken down into its smallest component so that it can be utilized by the body. Once broken down, the nutrients are absorbed via active and passive transepithelia transport along the small intestine. Next, the nutrients go into the villus capillaries (and the lacteals), next to the hepatic portal vein, next to the liver and body cells...note that chyle enters the circulation via the left subclavian vein.

CARBOHYDRATE DIGESTION begins in the oral cavity via salivary amylase (amylase has an optimal pH of 6.75). Polysaccharides (such as glycogen and starch) are broken down into monosaccharides via a few steps, while cellulose is not digested at all.

- Polysaccharides (glycogen and starch)
- Oligosaccharides (limit dextrins) & disaccharides (maltose, lactose, sucrose)
- Monosaccharides (glucose, fructose, galactose)

Digestion is completed in the small intestine. The starches and glycogen are digested via pancreatic amylase, which breaks them down into maltose and limit dextrins (aka oligosaccharides). The brush border enzymes of the intestinal epithelial microvilli, digest oligosaccharides and disaccharides down into monosaccharides. This includes dextrinase, glycoamylase, maltase, sucrase and lactase.

Disorders:

- If you have a lack of lactase then you have a lactose intolerance.
- Hyperosmotic chyme goes into the small intestine, then large intestine and then it causes diarrhea.
- Bacterial metabolism causes an increase in gas, which causes bloating and pain.

Absorption:

Glucose and galactose is absorbed along the luminal membrane via secondary active transport via Na^+ cotransport. They are absorbed along the basolateral membrane via facilitated diffusion.

Fructose is absorbed via facilitated diffusion across both membranes.

PROTEIN DIGESTION begins in the stomach with HCl and the enzyme pepsin. They are broken down into small peptides which are then broken down into amino acids.

Recall that chief cells secrete pepsinogen, an inactive enzyme, and it becomes its active form (Pepsin) in the lumen. An endopeptidase breaks the interior peptide bonds between specific amino acids and proteins are digested down into polypeptides and small peptides (dipeptides, tripeptides).

Parietal cells secrete HCl and intrinsic factor.

Digestion is completed in the small intestine via pancreatic proteases and brush-border enzymes.

- The pancreatic proteases are endopeptidases (trypsin and chymotrypsin), and exopeptidase that cleaves off the last AA of the peptide, and releases AA...it is called carboxypeptidase.
- The brush-border enzymes:
 - Dipeptidase...it releases AAs
 - Exopeptidases...it releases AAs
 - Aminopeptidase (breaks peptide bond at the AA end of peptide)
 - Carboxypeptidase (breaks peptide bond at the carboxyl end of peptide)

Absorption of proteins...in the form of amino acids, and some tri/dipeptides:
Along the luminal membrane these are absorbed primarily via secondary active transport (via Na⁺ cotransport). Along the basolateral membrane they are absorbed via facilitated diffusion.

Dietary fats/lipids are digested beginning in the small intestine with the help of bile salts and pancreatic lipase. Dietary fats include triglycerides. These are broken down into fatty acids and monoglycerides.

Lipids undergo emulsion via bile salts, changing a large flat globule into smaller fat droplets. The bile salts are amphipathic, meaning they have a polar side and a non-polar side. Chemical digestion occurs via pancreatic lipases. These break down triglycerides into two fatty acids and a monoglyceride. Note that lipase is activated by colipase (a peptide in pancreatic juice).

Absorption of lipids:

Lipids go from being fat droplets to micelles. The micelles are formed in the lumen as fats and bile salts combine with their polar ends facing out, and cholesterol and fat-soluble vitamins facing the core.

- **Step 1** occurs at the luminal membrane. The lipid products leave micelle and enter epithelial cell via simple diffusion.

Steps 2-5 occur in the absorptive cell.

- **Step 2** involves the fatty acids combining with the monoglycerides to reform triglycerides.
- In **step 3**, the triglycerides, phospholipids and cholesterol are incorporated into chylomicrons (with a lipo-protein shell) within the golgi apparatus
- In **step 4**, vesicles containing chylomicrons migrate from the golgi to the basolateral membrane where they exit via exocytosis.
- In **step 5**, some fatty acids enter the capillaries. Most fats enter the lacteals via chylomicrons.

NUCLEIC ACIDS

Pancreatic nucleases...nucleotides

Brush-border enzymes: nucleotides...bases, pentose sugars and phosphate ions

ABSORPTION OF WATER, ELECTROLYTES AND WATER

Dietary vitamins:

- Fat-soluble (ADEK) are absorbed with fats
- Water-soluble are absorbed via simple diffusion
- Recall that Vitamin B-12 requires intrinsic factor from the stomach. Endocytosis of B-12 occurs with intrinsic factor in the ileum.
- Bacteria provide three vitamins absorbed along the large intestine
 - Vitamin K (about half of our dietary intake of Vit-K is produced by bacteria)
 - Biotin
 - Vit-B5

Electrolytes:

- Most are absorbed along the intestines.
- Most absorbed via secondary active transport
- Some by simple diffusion
- Iron and Ca^{2+} are actively absorbed in the duodenum, based on needs of the body.
- Ca^{2+} absorption is increased by PTH and Calcitriol in response to low ECF Ca^{2+} levels.

Water:

- Intestinal absorption occurs via osmosis.
- Water follows transport of solutes into epithelial cells, then into the IF and then into the plasma

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