Functions of digestive system

• Digestion
  • Breakdown of food (chemically) using enzymes, acid, and water

• Absorption
  • Nutrients, Ions, Water

• Secretion
  • Mucus, digestive enzymes, acid, bicarb, electrolytes

• Motility
  • Peristalsis (moves stuff forward)
  • Segmentation (mixes stuff up)

• ***regional specialization ("assembly line"):
  • ingestion → mechanical breakdown → chemical digestion → absorption → waste processing
Structure/ Function of GI Tract

• GI Tract is a 4 layered tubule
  • Mucosa- epithelium + lamina propria + muscularis mucosae
  • Submucosa- connective and vascular tissue
  • Muscularis externa- smooth muscle- inner circular, outer longitudinal
  • Serosa- thin covering membrane
Mouth, Pharynx, Esophagus

• Functions: ingestion, mastication (chewing), deglutition (swallowing)

• Salivary glands: secrete saliva which contains amylase and lipase
  • Amylase begins digestion of starches into disaccharides
  • Lipase begins to digest lipids

• Esophagus: swallowing (upper), peristalsis (lower)
  • Lower esophageal sphincter control entry to stomach
Stomach

• Functions: storage, mechanical breakdown of food (chime), chemical digestion (HCl and pepsin)

• Structure: mucosa: simple columnar epithelium, *gastric glands*
  • - secrete acidic gastric juice (pH 1-2), 1-3 L/day
  • - mucous cells secrete alkaline mucus to protect stomach epithelium
  • muscularis: 3 layers thick
  • - *pyloric sphincter* controls passage of chyme from stomach to duodenum
Acid secretion in stomach

• *parietal cells* secrete hydrochloric acid (*HCl*)

• \( \text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3 \rightleftharpoons \text{H}^+ + \text{HCO}_3^- \)

• \( \text{H}^+ \) is active transported into the lumen, \( \text{Cl}^- \) follows via diffusion through channels

• \( \text{HCO}_3^- \) is transported back into ECF (countertransport with \( \text{Cl}^- \))
Enzyme secretion in stomach

• *chief cells* secrete *pepsinogen* (inactive), activated at low pH to form *pepsin*
• pepsin digests proteins into smaller peptides
Small Intestine, Liver, and Pancreas

• functions: chemical digestion and absorption

• SI regions: duodenum, jejenum, ileum
  • a. Digestion
  • - duodenum receives chyme from stomach, secretions from liver and pancreas

• Liver - processes absorbed nutrients (delivered via hepatic portal vein)
  - secretes bile, stored in gallbladder
  • bile salts - derived from cholesterol, function to emulsify fats → micelles
  • bile pigments (bilirubin, biliverdin) - waste products from hemoglobin breakdown

• Pancreas - acinar cells secrete digestive enzymes:
  • trypsin, chymotrypsin, carboxypeptidase, amylase, lipase
  • many enzymes are secreted in inactive form (zymogens), activated by trypsin in lumen
  • - duct cells secrete bicarbonate (NaHCO3) to neutralize acid (pH → 8)

• SI (brush border) enzymes complete digestion
Absorption in SI

• Absorption
  • - small intestine has huge **surface area**, specialized for absorption
• (1) length > 3 meters
• (2) circular folds
• (3) **villi** - epithelium (enterocytes and goblet cells) + lamina propria (capillaries and lacteals)
• (4) **microvilli** - “brush border” membrane

  • - Na+, Cl-, K+ absorbed via active transport and diffusion through channels
  • - glucose & amino acids - cotransport with Na+ (secondary active transport)
  • - H2O - via osmosis, follows solute transport
  • water-soluble nutrients are absorbed into intestinal capillaries → liver (via HPV)
  • lipids are formed into **chylomicrons** and absorbed into lymphatic vessels (lacteals)
Large Intestine

- functions: fluid absorption, waste packaging and elimination
  - LI absorbs most remaining water and ions from chyme
  - intestinal microflora - bacteria in colon, produce some vitamins (K, B12)
  - defecation reflex
Neural Control

1. Enteric Nervous System - submucosal and myenteric plexuses
   - local control within the GI tract (short reflex)

2. Autonomic Nervous System
   - parasympathetic: vagus nerve - stimulates GI tract motility and secretion (long reflex)
   - sympathetic division mostly inhibits GI tract
Enteric Nervous System (ENS)

- Primary neural mechanism that controls GI function
- Neurons mostly found in: Submucosal (Meisner’s) plexus and Myenteric (Auerbach’s) plexus
SM Action Potentials

- SM can have different types of action potentials: spike, spike followed by a plateau, spikes on slow waves
• In the small intestine the **interstitial cells of Cajal** have pacemaker activity and create slow wave Aps (BER)-normal is 12 cycles per minute

• Neural stimulation can modify contraction rate and strength but is not necessary to initiate contraction

Voltage-gated Ca channels that are active at resting membrane potentials open -> influx of Ca depolarizes the cell and opens more voltage gated Ca channels -> increase in Ca activates Ca-dependent K channels that open and repolarize the cell; voltage gated Ca channels also inactivate
Parasympathetic Innervation

- Parasympathetic neurons travel along the vagus nerve and synapse with the ENS or directly to the GI tract
- Release ACh as the neurotransmitter on effector cells
- ACh release will result in an increase in baseline tension, but does not change the frequency of contraction
Sympathetic Innervation

- Sympathetic neurons travel through the splanchnic nerve and can synapse to the ENS or directly to effector cells
- Release Norepinephrine as neurotransmitter on effector cells
- Results in a decrease in tension, but does not change contraction frequency
Hormonal Control

• **gastrin** - secreted by G cells in the gastric glands
  • - stimulates gastric acid secretion; stimulates gastric motility and mucosal growth
  • (- acid secretion is also stimulated by *histamine* secreted by ECL cells in gastric glands)

• **CCK** (cholecystokinin) - secreted by endocrine cells in intestinal crypts
  • - stimulates bile release from gallbladder and pancreatic enzyme secretion

• **secretin** - stimulates bicarbonate secretion by pancreas

• **GIP** (gastric inhibitory peptide) - stimulates insulin secretion by pancreas;
  - GIP, CCK and secretin all inhibit gastric acid secretion