**Digestive System**

Small/Large Intestine
Liver

A&P Lecture Notes
Pages 98-103

Liver, Bile ducts, Pancreas and Small Intestine

Figures from: Marieb, Human Anatomy & Physiology, Pearson, 2013

Three Parts of Small Intestine

Main functions of small intestine: 1) chemical digestion 2) absorption of nutrients (90%) from chyme
Blood Supply and Drainage of Small Intestine

Wall of Small Intestine

Submucosa of duodenum contains mucus-secreting glands (Brunner’s glands) that protect the small intestine.

Intestinal Villi & Glands

Intestinal glands secrete an abundant watery fluid that helps absorb products of digestion. They also contain enteroendocrine cells (enterokinase, gastrin, secretin, CCK).
Intestinal Epithelium

Microvilli further increase the surface area available for absorption in the small intestine.

Form a ‘brush border’ on the intestine.

Digestive enzymes are embedded in the membrane of microvilli.

Main function of plicae, villi, and microvilli is to increase the surface area for absorption (from about 3.6 ft² to about 2200 ft²)

Secretions of Small Intestine

- Peptidase – breaks down peptides into amino acids
- Sucrase, maltase, lactase – break down disaccharides into monosaccharides
- Intestinal lipase – breaks down fats into fatty acids and glycerol
- Enterokinase – converts trypsinogen to trypsin
- Gastrin/somatostatin – hormones that stimulate/inhibit acid secretion by stomach
- Cholecystokinin (CCK) – hormone that inhibits gastric glands, stimulates pancreas to release enzymes in pancreatic juice, stimulates gallbladder to release bile, and relaxes hepatopancreatic sphincter (of Oddi)
- Secretin – stimulates pancreas to release bicarbonate ions in pancreatic juice; stimulates gall bladder to release bicarbonate-rich bile

See Table 23.32 in Marieb for a great summary of digestive enzymes.

Movements of the Small Intestine

Movements in local segments can occur without stimulation by parasympathetic NS. However, nervous stimulation accelerates segmentation and peristalsis.

- Peristalsis – pushing movements
- Segmentation – ringlike contractions that aid in mixing and slowing peristalsis
- Overdistended or irritated wall triggers “peristaltic rush” resulting in diarrhea

“Long distance” movements are triggered by stomach filling:
- Gastroenteric reflex (↑ motility and secretion along length of small intestine)
- Gastroileal reflex (relaxation of ileocecal sphincter)
Absorption in the Small Intestine

- monosaccharides and amino acids
  - through facilitated diffusion and active transport
  - absorbed into blood
- electrolytes and water
  - through diffusion, osmosis, and active transport
  - absorbed into blood
- vitamins
  - fat-soluble dissolve in dietary fats (vit A,D,E,K)
  - Water-soluble through diffusion, except B12 (active transport)
  - Vitamin K (large intestine) – with other lipids
  - absorbed into blood

Absorption of Fats in the Small Intestine

- fatty acids and glycerol
  - several steps
  - absorbed into lymph into blood

Chylomicrons contain TG, cholesterol, and phospholipids

Large Intestine

Figure from: Martini, Anatomy & Physiology, Prentice Hall, 2001
Histology of the Large Intestine

Walls of large intestine are much thinner than the small intestine, however, the lumen is larger

Note lack of villi and presence of numerous goblet cells (mucus)

No enzymes produced; any digestion is from previously introduced enzymes or bacteria

Functions of Large Intestine

• little or no digestive function
• absorbs water, bile salts, and electrolytes
• secretes mucus (lubrication, binding, protection, pH)
• conversion of bilirubin (uro- and stercobilinogen)
• houses intestinal flora (~800 species of bacteria) and absorbs vitamins liberated by bacterial action (K, B, and Biotin); produces intestinal gas (flatus)
• forms and stores feces
• carries out defecation

The Rectum, Anal Canal, and Anus

Temporary storage of fecal material in rectum triggers the urge to defecate

Internal anal sphincter is usually contracted but relaxes in response to distension. External sphincter must be tensed reflexively to retain feces

Procto- = anus or rectum
Movements of Large Intestine

- Slower and less frequent than those of small intestine
- Mixing movements (haustral churning every 30 min)
- Mass movements - usually follow meals (stimulated by distension of stomach and duodenum)
  - Gastrocolic reflex
  - Duodenocolic reflex
  - Peristaltic wave from transverse colon through rest of large intestine

Parasympathetic Defecation Reflex

Note that this reflex opens the internal sphincter and closes the external sphincter

Need voluntary relaxation of the external sphincter for defecation
Feces

- water (75%), solids (25%)
- electrolytes
- mucus
- bacteria (30% of solids) and sloughed epithelial cells
- bile pigments altered by bacteria provide color (mainly urobilins and stercobilins)
- odor produced by bacterial compounds (indoles and skatoles, phenols, H$_2$S, ammonia)
- indigestible materials

Major Organs of Digestive System

Organs can be divided into the:

- Digestive tract (primary) (alimentary canal); tube extending from mouth to anus (about 30 ft.)
- Accessory organs; teeth, tongue, salivary glands, liver, gallbladder, and pancreas

Liver [Hepat(o)-]

Round ligament is part of the falciform ligament that divides the lobes; remnant of fetal umbilical vein.

Note that the vena cava does not enter the liver; it passes by.
Arterial Supply and Venous Drainage of Liver

Hepatic Lobule

Paths of Blood and Bile in Hepatic Lobule
Liver Functions (over 200!)

• Three general categories of function
  1) Metabolic regulation
    • Interconversion of carbohydrates, lipids, amino acids
    • Removal of wastes
    • Vitamin and mineral metabolism
    • Drug inactivation
    • Storage of fats, glycogen, iron, vit A/B/D/E/K
  2) Hematological regulation
    • Phagocytosis and antigen presentation; ab removal
    • Synthesis of plasma proteins
    • Removal of circulating hormones
    • Removal of worn-out RBCs (Kupffer cells)
    • Removal or storage of toxins
  3) Synthesis and secretion of bile (role in digestion)

Composition of Bile (Chole-)

Yellowish-green liquid continually secreted by hepatocytes

• water

• bile salts (bile acids)
  • derived from cholesterol
  • emulsification of fats (increases surface area for digestive enzymes)
  • helps absorption of fatty acids, cholesterol, and fat-soluble vitamins
  • 80% are recycled (reabsorbed and reused) – enterohepatic circulation of bile
  • 20% excreted in feces (disposes of excess cholesterol)

• bile pigments (bilirubin and biliverdin from breakdown of RBCs)

• electrolytes

Gallbladder [Cyst(o)-]

Main function is to store and concentrate bile between meals, and release bile under the influence of CCK

Figure from: Martini, Anatomy & Physiology, Prentice Hall, 2001
fatty chyme entering duodenum stimulates the GB to release bile (via CCK)

Secretin causes the bile ducts (and pancreatic ducts) to secrete bile rich in HCO₃⁻

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Actions of Cholecystokinin (CCK) on Digestion

- Contraction of gallbladder
- Secretion of pancreatic enzymes
- Reduced emptying of stomach
- Relaxation of hepatopancreatic sphincter

Protein, CHO, lipid absorption and digestion
Matching of nutrient delivery to digestive and absorptive capability

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Pancreatic Juice

- pancreatic amylase – splits glycogen into disaccharides
- pancreatic lipases – break down triglycerides
- pancreatic nucleases – digest nucleic acids
- bicarbonate ions – make pancreatic juice alkaline (pH = 8) and neutralize acid coming from stomach
- Pancreatic proteolytic enzymes…