The Digestive System

Overview

1. Food breakdown
   - CHO, Protein, Fat
2. Anatomy
3. Digestive process

- **Primary function**: breakdown & transport nutrients, H₂O, & electrolytes
  1. **Motility** – propulsive or mixing movements
  2. **Secretion** – energy requiring secretion of H₂O, electrolytes, & enzymes, bile salts, or mucus

![Image of digestive system]

Figure 16.1
Page 592
Primary function: breakdown & transport nutrients, H₂O, & electrolytes

3. Digestion – CHO

Table 16.1 (1) Page 593

Primary function: breakdown & transport nutrients, H₂O, & electrolytes

3. Digestion – proteins & fats

Primary function: breakdown & transport nutrients, H₂O, & electrolytes

4. Absorption – primarily in small intestines
General Digestive Anatomy

1. Digestive Tract
2. Accessory Digestive Organs

- Nasal passages
- Mouth
- Salivary glands
- Pharynx
- Trachea
- Esophagus

Liver
Stomach
Gallbladder
Pancreas
Duodenum
Descending colon
Transverse colon
Ascending colon
Jejunum
Cecum
Ileum

The Digestive Tract (inner layer to outer)

1. Mucosa
   - Mucous membrane
     - Exocrine cells (digestive juices)
     - Endocrine cells (hormones)
     - Epithelial cells (absorption)
   - Degree of folding depends on location
     - Highest in small intestine
The Digestive Tract (inner layer to outer)

2. Submucosa
   - Thick connective tissue
     ✓ Blood & nerve innervation

3. Muscularis externa
   - Inner circular layer
   - Outer longitudinal layer

4. Serosa
   - Outer connective tissue
     ✓ Prevents friction

Digestive regulation

1. Smooth-muscle function
   - Slow-wave action potentials (basal electrical rhythm)
     ✓ Interstitial cells of Cajal
     - Regulate peristalsis and segmentation

2. Intrinsic nerve plexuses (enteric nervous system) – digestive nervous system
   - Respond to local stimuli for secretion (digestive juices & GI hormones)
   - Both excitatory & inhibitory

3. Extrinsic nerves
   - Modify intrinsic activity and other various digestive organs (generally sympathetic &/or parasympathetic)

4. Gastrointestinal hormones
   - Carried throughout blood influencing other areas of digestive tract
**Sensory Receptors**

1. Chemoreceptors
   - Sense changes in chemical components within lumen
2. Mechanoreceptors
   - Respond to stretch and tension
3. Osmoreceptors
   - Changes in osmolarity

**The Digestive Process**
The Digestion Process

1. Mouth
   - Chewing
   - Saliva secretion
   - 3 major salivary glands
     - Salivary proteins
       1. Amylase (CHO breakdown)
       2. Mucus (lubrication)
       3. Lysozyme (antibacterial)

Salivary Regulation

2. Pharynx & Esophagus
   - Swallowing reflex
The Digestion Process (cont.)

2. Pharynx & Esophagus
   • Peristalsis

   Figure 16.7
   Page 603

The Digestion Process (cont.)

Stomach

   Fundus
   Esophagus
   Gastroesophageal sphincter
   Body
   Body
   Pyloric sphincter
   Duodenum
   Antrum

   Figure 16.8
   Page 604

Stomach Functions

1. Storage
2. Gastric mixing & mucous secretion
3. Production of chyme
4. Secretes hydrochloric acid (HCl)
   • Reduces large food particles
   • Kills microorganisms ingested in food
5. Initial stages of protein breakdown
   • Pepsinogen forming pepsin
Figure 16.9 (1)  Page 605

Basal electrical rhythm
~ 3 per minute

Duodenum  Pyloric sphincter

Direction of movement of peristaltic contraction

Gastric emptying

Figure 16.9 (2)  Page 605

Gastric mixing

Regulation of Gastric Emptying

- Amount of chyme
- Neural response
  - Intrinsic nerve plexus (short reflex)
  - Autonomic nerves (long reflex)  \textbf{Enterogastric Reflex}
- Hormonal
  - Enterogastrones (secretin & cholecystokinin – CCK) released from duodenal mucosa
    - Inhibit antral contractions
Regulation of Gastric Emptying

- Duodenum
  1. Fat ~ can only be processed in small intestine
  2. Acid (unneutralized)
     ✓ Excess HCl not buffered by sodium bicarbonate
  3. Hypertonicity ~ increased osmolarity due to abundance of amino acids and glucose
  4. Distension

- Emotions

Gastric Digestive Juices

~ 2 liters/day

- Responsibility of cells lining gastric mucosa

1. Oxyntic mucosa
   • Body
   • Fundus

2. Pyloric gland area (PGA)
   • Antrum

Table 16.4
Page 609
In oxyntic mucosa

- Gastric pit
- Gastric gland
- Mucosa cells
- Alkaline mucus
- Chief cells
- Pepsinogen
- Parietal cells
- HCl
- Enterochromaffin-like (ECL) cells
- Histamine

In pyloric gland area

- G cells
- Gastrin
- D cells
- Somatostatin

### Chief & Parietal Cell Regulation

- **Acetylcholine (Ach)**
  - Stimulates both
  - Also stimulates G and ECL cells

- **Histamine (paracrine)**
  - Released from ECL cells & increases HCl secretion

- **Somatostatin**
  - Released from D cells
  - Provides negative feedback

### HCl & Pepsinogen

- HCl secretion into lumen

  **Plasma**
  - Cellular metabolism
    - HCl production
      - \( CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow H^- + HCO_3^- \)
    - CT
  - Chief cell
  - Parietal cell
  - Gastric lumen
**HCl functions to:**
- Activate pepsinogen to form pepsin
- Breakdown of connective tissue
- Denatures proteins
- Kills microorganisms

**Gastric Mucosal Barrier**

**Food leaving the Stomach...**

Mixed with secretions from **pancreas** and **liver**
Pancreas

- Exocrine & endocrine tissue
  1. Exocrine: secretes enzymes capable of breaking down CHO, fat, & protein
     - Proteolytic enzymes: protein
     - Pancreatic amylase: CHO
     - Pancreatic lipase: fat
     - Regulated by secretin & cholecystokinin (CCK)
  2. Endocrine (hormones): Insulin & glucagon
Liver
➢ Digestive role: secretion of bile salts
  • Aid fat digestion & absorption

Blood flow – Hepatic Portal System

Liver
➢ Bile secretion

Gallbladder: Bile storage

Small Intestine
➢ Primary site of digestion & absorption
Segmentation of chyme
- Initiated by pacesetter cells

Small intestine – digestion & absorption
- Potential for increased surface area
  1. Extensive folding
  2. Villi & microvilli
     - Increased digestive enzyme release
- Pancreatic enzymes
  - Fat reduced to FFA (with help of bile salts)
     - Lipase
  - Proteins to AA
     - Aminopeptidases
  - CHO to di- and monosaccharides
     - Maltase, sucrase, lactase
**Small intestine – digestion & absorption**

1. Vitamin absorption (passive)
   - Water-soluble
   - Fat-soluble

2. Iron absorption – regulated
   - Absorbed into epithelial cells
     - Either used immediately for production of RBC or
     - Stored as ferritin

3. Calcium absorption – regulated
   - Active transport stimulated by Vitamin D
Biochemical Balance

Digestive tract lumen → Stomach parietal cell → Pancreatic duct cell → Intestinal epithelial cell → Blood

Large Intestine

Colon → Cecum → Rectum → Drying & storage