CHAPTER 24
DIGESTIVE SYSTEM

CHAPTER OVERVIEW: This chapter describes the location, structure and functions of the organs of the digestive system. The neuronal, hormonal and local controls of smooth muscle motility and digestive gland secretion are described and explained for each major region of the digestive tract. The functions of the digestive secretions from each organ are considered in detail. The roles of the digestive system in the maintenance of homeostasis are reviewed. How the major nutrients are digested, absorbed, and transported, is reviewed.

OUTLINE (two to four fifty-minute lectures):
Seeley, A&P, 5/e

### Topic Outline, Chapter 24

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<th>Chapter 1: General Overview</th>
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<td>A. Digestive Tract; Alimentary Tract; Alimentary Canal = Mouth to Anus (G.I. Tract = Stomach &amp; Intestines only)</td>
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<td>B. Accessory Organs</td>
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<td>B. Mastication - Chewing, Mechanical Digestion</td>
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<td>C. Propulsion - Movement Through Tract; Peristalsis</td>
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<td>D. Mixing - Mechanical digestion, Aids Chemical Digestion</td>
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<td>E. Secretion - Lubricate, Liquify and Chemically digest</td>
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<td>F. Digestion - Breakdown into Components by Mechanical and Chemical Means</td>
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<td>G. Absorption - Transport (From Tract to Blood, Lymph) by simple Diffusion, Facilitated Diffusion, Active Transport, and Cotransport</td>
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<td>H. Transportation - Distribution Throughout Body</td>
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### Figures & Tables

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Defecation

J. Regulation - Coordination of Activities by Nerves (Vagus Nerve) and Hormones

V. Anatomy and Histology of the Digestive Tract, p. 786

A. Oral Cavity

1. Boundaries
   a. Anterior – Lips
   b. Posterior – Fauces
   c. Lateral – Cheeks
   d. Superior – Palate (Hard & Soft)
   e. Inferior – Tongue and Muscular Floor
   f. Regions
      1). Vestibule = Between Lips/Cheeks and Alveolar Processes
      2). Oral Cavity Proper = Medial to Alveolar Processes

2. Lips and Cheeks
   a. Buccinator Muscle and Buccal Fat Pad
   b. Important in Mastication and Speech

3. Tongue
   a. Frenulum
   b. Intrinsic and Extrinsic Muscles
   c. Papillae
   d. Functions in Speech, Taste, Mastication, Swallowing

4. Teeth
   a. Deciduous and Permanent
   b. Tooth Structure
      1). Root, Neck, Crown
      2). Pulp with Vessels and Nerves
      3). Dentin, Enamel, Periodontal Ligaments

5. Muscles of Mastication
   a. Mandible to Skull - Masseter, Temporal
   b. Floor to Roof of Mouth - Medial and Lateral Pterygoids

6. Palate and Palatine Tonsils

7. Salivary Glands
   a. Parotid Glands
   b. Submandibular Glands
   c. Sublingual Glands

B. Pharynx Nasopharynx, Oropharynx, and Laryngopharynx

C. Esophagus
   1. Length - 25 cm

3. Upper and Lower Esophageal Sphincters

4. Mucosal Lining = Moist Stratified Squamous Epithelium with Mucous Glands in Submucosa

D. Stomach

1. Stomach Anatomy
   a. Gastropharyngeal Opening and Cardiac Sphincter
   b. Greater and Lesser Curvatures
   c. Pyloric Region, Opening and Sphincter

2. Stomach Histology
   a. Serosa = Visceral Peritoneum
   b. Muscularis has Three Layers
   c. Rugae
   d. Gastric Pits and Glands
      1). Surface Mucous Cells
      2). Mucous Neck Cells
      3). Parietal Cells, Produce Hydrochloric Acid and Intrinsic Factor
      4). Chief Cells, Produce Pepsinogen
      5). Endocrine Cells, Produce Regulatory Hormones
   e. Simple Columnar Epithelium

E. Small Intestine

1. Length = 4.6 to 9 m

2. Duodenum
   a. 180° Arc
   b. Papillae
      1). Greater Duodenal Papilla and Hepatopancreatic Ampulla
      2). Lesser Duodenal Papiolla and Accessory Pancretic Duct
   c. Modifications that Increase Surface Area
      1). Plica Circularis
      2). Villi
      3). Brush Borders and Microvilli
   d. Mucosa = Simple Columnar Epithelium
      1). Absorptive Cells
      2). Goblet Cells
      3). Granular Cells
      4). Endocrine Cells
   e. Intestinal Glands

3. Jejunum and Ileum

F. Liver

1. Liver Anatomy
   a. Largest Internal Organ - 1.36 Kg
   b. Four Lobes - Right, Left, Caudate and Quadrate
   c. Porta - Inferior Surface
1. Blood Vessels
   a). Hepatic Portal Vein
   b). Hepatic Artery
2. Lymphatic Vessels
3. Nerves
4. Ducts
   a). Two Hepatic Ducts Combine to Form
      Common Hepatic Duct
   b). Join with Cystic Duct to Form
      Common Bile Duct

2. Liver Histology
   a. Connective Tissue Capsule and Bare Area
   b. Lobule Structure - Hexagonal
      1). Central Veins - Blood Leaving Liver
      2). Portal Triads at Corners
         a). Hepatic Duct - Bile Leaving Liver
         b). Hepatic Portal Vein - Blood Entering Liver
         c). Hepatic Artery - Blood Entering Liver
      3). Hepatic Cords of Hepatocytes Between
      4). Hepatic Sinusoids - Mixing of Venous and
         Arterial Blood
         a). Endothelial Cells
         b). Hepatic Phagocytic Cells (Kupffer Cells)

G. Gallbladder
   1. Size - 8 cm. X 4 cm.
   2. Wall Structure
      a. Mucosa with Rugae
      b. Muscularis of Smooth Muscle
      c. Outer Serosa

H. Pancreas
   1. Structure - Head, Body, Tail
   2. Endocrine Portion - Pancreatic Islets
   3. Exocrine Portion - Acini
      a. Interlobular Ducts
      b. Pancreatic Duct to Hepatopancreatic Ampulla

I. Large Intestine
   1. Cecum and Vermiform Appendix
   2. Colon
      a. Size = 1.5 - 1.8 m.
      b. Parts
         1). Ascending Colon
         2). Descending Colon
         3). Transverse Colon
         4). Sigmoid Colon
      c. Incomplete Longitudinal Muscle Layer
         1). Teniae Coli
         2). Haustra
      d. Epiploic Appendages
e. Crypts = Tubular Glands

3. Rectum


J. Peritoneum

1. Serous Membranes Clinical Note, p.800

2. Visceral Peritoneum and Parietal Peritoneum

3. Mesenteries
   a. Retroperitoneal Organs
   b. Greater Omentum
   c. Lesser Omentum
   d. Omental Bursa
   e. Coronary and Falciform Ligaments
   f. Mesentery Proper
      1). Transverse Mesocolon
      2). Sigmoid Mesocolon
      3). Mesoappendix

VI. Functions of the Digestive System, p. 801

1. Movement, Secretion, and Absorption
2. Regulation is Neural and Hormonal

13 A. Functions of the Oral Cavity

1. Secretions of the Oral Cavity, 1-1.5 L / Day
   a. Serous Saliva
   b. Salivary Amylase
   c. Lysozyme
   d. Mucin
   e. Primarily Parasympathetic Control

14 B. Deglutition
   a. Swallowing = Deglutition
   b. Voluntary Phase
   c. Pharyngeal Phase (1-2 sec.)
      1). Reflex Stimulus = Tactile Receptors in Oropharynx
      2). Afferent – Cranial Nerves V, IX
      3). Swallowing Center in Medulla Oblongata
      4). Efferent – Cranial Nerves V, IX, X, XI
      5). Effectors are Pharyngeal Constrictor Muscles
   d. Esophageal Phase (5-8 sec.)
      1). Peristaltic Waves
      2). Stimulus = Bolus in Upper Esophagus
      3). Intramural Nerve Plexus

15 C. Stomach Functions

1. Secretions of the Stomach (2 -3 L/ Day)

Table 24.3, p.802

Systemic Interactions, p.826
a. Mucus - Surface Mucous Cells and Mucous Neck Cells
b. Hydrochloric Acid – Parietal Cells  
Predict Quest. 5

c. Gastrin - Endocrine Cells
d. Intrinsic Factor - Parietal Cells
e. Pepsinogen - Chief Cells

2. Regulation of Stomach Secretion  
Clinical Focus, p.809

a. Neural Mechanisms
b. Hormonal Influences  
Table 24.4, p.807
Clinical Note, p.806

c. Phases
   1). Cephalic Phase  
Fig. 24.19a, p.808  TA-506
   2). Gastric Phase  
Fig. 24.19b, p.808  TA-507
   3). Intestinal Phase  
Fig. 24.19c, p.808  TA-508

3. Stomach Filling
4. Mixing of Stomach Contents - Formation of Chyme
   a. Mixing Waves (80%)
   b. Peristaltic Waves (20%)

5. Stomach Emptying
   a. Time
      1). Liquids = 1.5-2.5 hrs.
      2). Meal = 3-4 hrs.
   b. Pyloric Pump

6. Regulation of Stomach Movements  
Clinical Note, p.810

   a. Coordinated with Control of Secretion
   b. Too Fast or Slow Impairs Normal Absorption

D. Functions of the Small Intestine

1. Secretions of the Small Intestine  
Table 24.3, p.802
Table 24.4, p.807
Clinical Note, p.812

   a. Primarily Mucus, Electrolytes, and Water from Intestinal Mucosa
   b. Hormones - Secretin and Cholecystokinin
   c. Digestive Enzymes Bound to Microvilli – Disaccharidases, Peptidases and Nucleases

2. Movement in the Small Intestine - 3-5 hr. from Pylorus to Ileocecal Valve
   a. Segmental Mixing Contractions  
Fig. 24.3b, p.786
   b. Peristaltic Propulsive Contractions  
Fig. 24.3a, p.786
   c. Local Neural and Chemical Signals

3. Absorption from the Small Intestine
   a. Nutrients
   b. Water from Food and from Digestive Secretions

E. Liver Functions - Most by Hepatocytes  
Clinical Note, p.813

1. Bile Production
   a. 600-1000 ml / Day
   b. Functions
      1). Bile Salts - Emulsify Fats
      2). Contains Bilirubin and Other Excretory Products
   c. Control  
Fig. 24.21, p.811  TA-509

2. Nutrient Storage - Glycogen, Fat Soluble Vit., Fat,
Iron, and Copper
3. Nutrient Interconversion - Hepatocytes
4. Detoxification - Hepatocytes
5. Phagocytosis – Kupffer Cells

19 F. Functions of the Gallbladder
1. Temporary Bile Storage (40 -70 ml.)
2. Control
3. Gallstones

19 G. Functions of the Pancreas
1. Formation of Pancreatic Juice
   a. Aqueous Component with High Bicarbonate Ion Concentration
   b. Pancreatic Enzymes
      1). Proteolytic Enzymes
      2). Pancreatic Amylase
      3). Lipases
      4). Deoxyribozymes and Ribozymes
   2. Control of Pancreatic Secretion
      a. Neural Controls – Parasympathetic and Sympathetic
      b. Secretin and Cholecystokinin

20 H. Functions of the Large Intestine
1. Transit Time = 18 -24 hr.
2. Secretions of the Large Intestine
   a. Primarily Mucus
   b. Bicarbonate/Chloride Exchange
3. Water Reabsorption with Na⁺ /Cl⁻ Gradient
4. Symbiotic Bacteria
   a. 30% of Dry Weight Feces
   b. Vit. K Production
   c. Flatus
5. Movement in the Large Intestine
   a. Mass Movements
   b. Gastrocolic Reflexes
   c. Duodenal Reflexes
   d. Defecation Reflex Aided by Voluntary Movements

21 VII. Digestion, Absorption, and Transport, p. 817
   Table 24.5, p.818
   Clinical Focus, p.824

   A. Carbohydrates
   1. Digestion
      a. Amylases
      b. Disaccharidases in Intestinal Epithelium
   2. Absorption and Transport
      a. Sodium Cotransport Mechanism
      b. Role of Insulin
B. Lipids
1. Emulsification by Bile Salts
2. Digestion by Pancreatic Lipases
3. Absorption
   a. Micelle Formation
   b. Simple Diffusion Across Intestinal Epithelium
   c. Formation of Chylomicrons = 85% Triacylglycerol,
   7% Cholesterol, 7% Phospholipid, and 1% Protein
4. Lipid Transport - in Lacteals
   a. Lipoproteins
      1). Very Low Density Lipoproteins (VLDL)
      2). Low-Density Lipoprotein (LDL) to Cells
          Receptor-Mediated Endocytosis
      3). High-Density Lipoproteins (HDL) Back to Liver
          for Recycling or Disposal

C. Proteins
1. Digestion
   a. Pepsin
   b. Pancreatic Peptidases to Small Peptides
   c. Tripeptides, Dipeptides and Amino Acids by
      Peptidases on Intestinal Epithelium
2. Absorption
   a. Separate Sodium Cotransport Mechanisms for
      Acidic, Basic and Neutral Amino Acids
   b. Most Enter as Di- and Tri-peptides
   c. Final Digestion to Single Amino Acids is
      Intracellular to Hepatic Portal System
3. Uptake by Other Cells = Active Transport under
   Hormonal Control

D. Water
1. 92% Absorbed in Small Intestine, 6-7% Absorbed in
   Large Intestine
2. Direction of Diffusion Determined by Osmotic
   Gradients

E. Ions
1. Active Transport of Sodium, Potassium, Magnesium,
   and Phosphate
2. Passive Diffusion of Chloride Following Sodium;
   Active Transport of Chloride in Ileum
3. Active Transport of Calcium Requires Vit. D and is
   Under Hormonal control

VIII. Systems Pathology: Diarrhea, p. 825

IMPORTANT CONSIDERATIONS: If there are only two lectures available for the discussion of the digestive tract, the details of the anatomy should be left for the laboratory and the lectures should concentrate on the functions and controls of the parts of the tract, followed by discussion of the specific digestion and absorption of the major nutrients. If there are four lecture sessions available, then more discussion of the overall structure and function of the digestive system is possible as well as more in-depth coverage of the regulatory mechanisms.
SEE INSTRUCTOR'S MANUAL AND COURSE SOLUTIONS MANUAL FOR ADDITIONAL RESOURCES.