Digestion, Absorption, and Transport
Chapter 3

Digestion
- Breaking down foods into nutrients
- Prepare for absorption
- Challenges of digestion
  - Accessing Nutrients
    - digestion
  - Getting nutrients through the body
    - Absorption
    - Transport
- Using nutrients
  - Metabolism (Ch. 7)

Anatomy of the Digestive Tract

General Pattern
- Central Lumen that food passes through
- Lumen surrounded by layer of epithelial cells
- Capillaries beneath epithelial cells
- Layers of muscle surrounding outside

GI Tract
"Disassembly Line"
1. Mouth
2. Pharynx (throat)
3. Esophagus
4. Stomach
5. Small intestine
6. Large intestine
7. Rectum
8. Anus
Digestion Anatomy
- Mouth
  - Process of digestion begins
  - Mastication
  - Four basic taste sensations
    - Savory
    - Aroma, texture, and temperature
  - Pharynx
  - Bolus

Anatomy of the Digestive Tract
- Esophagus
  - Two sphincters
    - Upper esophageal sphincter
    - Lower esophageal sphincter
- Stomach
  - Movement of bolus
  - Chyme
  - Pyloric sphincter

Anatomy of the Digestive Tract
- Small intestine
  - Common bile duct
    - Pancreas and gall bladder
  - Three segments
- Large intestine (colon)
  - Ileocecal valve
  - Withdrawal of water
  - Rectum and anus

Digestive System Activities
- Ingestion: intake of food (mouth)
- Propulsion: movement of food through GI tract. Swallowing, peristalsis
- Mechanical Digestion: mechanical breakdown of food (chewing) mixing (tongue, stomach, segmentation)
- Chemical Digestions: enzymatic breakdown of food (catabolism)
- Absorption: Uptake of nutrients from GI tract to blood or lymph. Occurs mostly in small intestine
- Defecation: Elimination of solid, indigestible waste (anus)
Types of Digestions

Mechanical Digestion
- Mouth: Chewing
- Stomach: Peristalsis
  - Circular and longitudinal muscles working together
  - Rate and intensity of contractions vary
  - Factors that may interfere with peristalsis
- Stomach action
  - Circular, longitudinal, and diagonal muscles
  - Timing the release of chyme

Chemical Digestion
- Digestive enzymes break big molecules into smaller molecules

Absorption
- Nutrients must cross cells of digestive tract to get into circulation

Transport
- Once in blood, nutrients circulate to cells that can:
  - Process them
  - Store them
  - Use them

Gastrointestinal Tract - Mouth
- Site of ingestion
- Beginning of both mechanical and chemical digestion
- Tongue contains taste buds, manipulates food
- Basic tastes: sweet, sour, salty, bitter, umami
- Pharynx: throat (at back of mouth)
GI tract - Salivary Glands

- Cleanses mouth
- Dissolves food chemicals for tasting
- Moistens food, helps compact into bolus
- Contains enzymes that begin chemical digestion
  - Salivary amylase breaks down starch
  - Lingual lipase begins lipid (fat) breakdown

GI tract - Esophagus

- Propels food from pharynx to stomach
- Swallowing moves food through pharynx, down esophagus
- Epiglottis: flap closes over airway (trachea) when swallowing

GI tract - Sphincters

- Gastroesophageal sphincter
- Pyloric sphincter
- Ileocecal Valve
- Anus

GI Tract - Stomach

- Can stretch from about 50mL to hold 4L of food!
  - Because of rugae, large folds when stomach is collapsed
- Muscular wall has three layers-for mixing, churning and physical breakdown in stomach
**Stomach Functions**

Holds ingested food

**Mechanical digestion:** pummeling of ingested food

**Chemical digestion:** pepsin begins protein digestion

Delivers *chyme* (creamy, partially digested paste) to small intestine

Secretion of intrinsic factor for vitamin B12 absorption

- only absolutely *essential* function of stomach!

Digestive enzymes active at low (acidic) pH

Stomach wall secretes hydrochloric acid (HCl) & mucus to protect cells of stomach

**pH Scale**

**GI tract - Small Intestine**

- Runs from pyloric sphincter to ileocecal valve

- Three regions
  - Duodenum
  - Jejunum
  - Ileum

- Longest part of alimentary canal

- Digestion nearly completed here

- Almost all absorption occurs here.

**Peristalsis**

- Waves of contraction and relaxation squeeze food through GI tract

- Occurs in: lower esophagus, stomach, small and large intestine

- Involuntary (swallowing is voluntary)
Segmentation

- Rhythmic constrictions of nonadjacent segments
- Occurs in small intestine
- Mixes food with digestive juices
- Moves food mass along intestinal wall, helping absorption

GI tract - Large Intestine

- “picture frame” around small intestine
- Runs form ileocecal valve to anus
- Reabsorbs water from feces before elimination

Bacterial Flora

- Bacteria in large intestine comes from:
  - Enter through anus
  - Surviving few from small intestine
- What do they do?
  - Help breakdown indigestible carbohydrates (like cellulose)
    - Release odorous gases (only digestion that takes place in large intestine)
  - Synthesize some vitamins (B complex, vitamin K)

Accessory Organs- Liver

- Largest gland in the body
- Contributes to digestion and nutrient processing
Liver Functions

1. Production of bile
   - Bile: fat emulsifier, breaks dietary fats into tiny particles that are accessible to digestive enzymes
2. Processing blood borne nutrients
   - Storing glucose as glycogen
   - Using amino acids to make various plasma proteins
3. Stores fat-soluble vitamins
   - A, D, K
4. Detoxification of blood
   - Converting blood ammonia to urea for excretion
   - Breaking down alcohol to harmless substances

Gall bladder

- Small greenish sac tucked against liver
- Stores and concentrates bile
- If too much cholesterol, or too few bile salts, cholesterol can crystallize here forming gallstones
- Gall bladder may be removed if necessary and bile duct will take over bile storage functions

Bile

Yellow-green, alkaline solution
Contains: bile salts, cholesterol, phospholipids, bile pigment (bilirubin), triglycerides, electrolytes

Bile salts
- cholesterol derivatives, emulsify fats (facilitates breakdown and absorption), solublize cholesterol, reabsorbed by ileum

Bilirubin
- waste product of hemoglobin breakdown, makes feces brown

Hepatic Portal Circulation
Pancreas

- Produces enzymes that break down all types of molecules
- Produces bicarbonate to neutralize stomach acid
- Released into duodenum of small intestine
- Pancreatic enzymes break down carbohydrates, proteins, fats, and nucleic acids)

Secretions of Digestion

- Five organs
  - Salivary glands, stomach, pancreas, liver, small intestine
- Secretions
  - Water
  - Enzymes
    - Protein facilitator of chemical reactions
    - Hydrolysis

Secretions of Digestion

- Saliva
  - Moisten food for easy passage
  - Protective role
  - Carbohydrate digestion
- Gastric juice
  - Protein digestion
  - Mucus
  - pH units

Secretions of Digestion

- Pancreatic juice
  - Released via ducts into duodenum
  - Enzymes act on all three energy nutrients
  - Sodium bicarbonate
  - Bile
    - Liver
    - Gallbladder
The Final Stage

- Vitamin and mineral absorption
- Undigested residues
  - Exercise intestinal muscles
  - Retention of water
- Colon
  - Intestinal bacteria
  - Recyclable materials
  - Water and dissolved salts

Absorption

- Small intestine
  - Majority of absorption
  - Ten feet long
    - Surface area
  - Absorption techniques
    - Simple diffusion
    - Facilitated diffusion
    - Active transport
Some nutrients (such as water and small lipids) are absorbed by simple diffusion. They cross into intestinal cells freely.

Some nutrients (such as the water-soluble vitamins) are absorbed by facilitated diffusion. They need a specific carrier to transport them from one side of the cell membrane to the other. (Alternatively, facilitated diffusion may occur when the carrier changes the cell membrane in such a way that the nutrients can pass through.)

Some nutrients (such as glucose and amino acids) must be absorbed actively. These nutrients move against a concentration gradient, which requires energy.

**Anatomy of the Absorptive System**
- Villi
  - Select and regulate nutrients absorbed
- Microvilli
  - Enzymes and "pumps"
- Crypts
  - Secretion of intestinal juices
- Goblet cells
  - Mucus secretion

**Preparing Nutrients for Transport**
- Transport pathways
  - Bloodstream
    - Water-soluble nutrients and smaller products of fat digestion
  - Liver
  - Lymphatic system
    - Larger fats and fat-soluble vitamins
    - Chylomicrons
    - Bypass liver at first
The Vascular System

- Closed system of vessels
  - Heart pump
- Blood
  - Delivers oxygen and nutrients
  - Removes carbon dioxide and wastes
- Blood flow
  - Special routing for digestive system
  - Liver

The Lymphatic System

- One-way route
  - No pump
  - Circulation between cells
- Entry into bloodstream
  - Subclavian vein
- Nutrients in lymphatic vessels
  - Bypass liver at first

Health and Regulation of GI Tract

- Gastrointestinal bacteria – flora
  - Most are not harmful
    - Benefits of gastrointestinal bacteria
  - Factors influencing bacteria presence
    - Diet – probiotics
    - Others
  - Digestion of fibers and complex proteins
  - Vitamin production
Health and Regulation of GI Tract

- Endocrine and nervous systems
  - Homeostatic regulation
  - Hormones and nerve pathways
  - Stimulation and inhibition of digestive secretions
  - Feedback mechanisms

The Digestive System at Its Best

- Sensitive and responsive to environment
  - Immunity against intestinal diseases
  - Defense against foreign invaders
- Health of digestive system
  - Healthy supply of blood
  - Lifestyle factors
  - Types of foods eaten
    - Balance, moderation, adequacy, and variety
Highlight 3
Common Digestive Problems

Choking
- Food slips into trachea
- Cuts off breathing
- International sign for choking
- Heimlich maneuver
- Foods commonly associated with choking
- Prevention of choking

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Vomiting and Diarrhea

- Vomiting
  - Adaptive mechanism of the body
  - Medical treatment
    - Dehydration and projectile vomiting
- Diarrhea
  - Symptom of medical conditions & treatments
    - Irritable bowel syndrome (IBS)
    - Colitis
  - Treatment

Constipation

- Not a disease
- Symptoms of constipation
- Causes
  - Lifestyle
  - Side effect of medications
- Prevention
  - Fiber and water
  - Physical activity

Belching and Gas

- Belching
  - Swallowed air
  - Prevention
- Intestinal gas
  - Consumption of certain foods
    - Individually determined
- Hiccups

Heartburn and “Acid Indigestion”

- Gastroesophageal reflux (heartburn)
  - Causes
  - Prevention
- Indigestion
  - Causes
  - Antacids and acid controllers
  - Damage to esophagus
    - Barrett’s esophagus
Ulers

- Peptic ulcers
  - Gastric ulcers
  - Duodenal ulcers
- Causes
  - Bacterial infection
  - Anti-inflammatory drugs
  - Excessive gastric acid secretion
- Ulcer treatment regimen

Recap

1. Identify organs of alimentary canal and accessory organs. What are the steps in going from ingested food to circulating nutrient?
2. What are peristalsis and segmentation? How do their functions differ?
3. Explain the difference between mechanical and chemical digestion. Identify all locations where mechanical digestion takes place. Identify all locations where chemical digestion takes place. Where are the vast majority of nutrients absorbed? Where is water reabsorbed?
4. Identify the functions of the accessory organs: salivary glands, liver, gall bladder, pancreas. Describe the function of the hepatic portal circulation.
5. Identify the regions of the small intestine. How is the structure of the small intestine specialized for nutrient absorption?
6. What is bile? What digestive function does it serve? How does it get to the small intestine?
7. Identify the regions of the large intestine. What is the major function of the large intestine? What activities do bacteria in the large intestine carry out?
8. Describe the vascular and lymphatic circulation from the GI tract.