Chapter 14
The Digestive System and Body Metabolism

Slides 14.1 – 14.14

Lecture Slides in PowerPoint by Jerry L. Cook
The Digestive System and Body

Metabolism

- Digestion
  - Breakdown of ingested food
  - Absorption of nutrients into the blood
- Metabolism
  - Production of cellular energy (ATP)
  - Constructive and degradative cellular activities
Organs of the Digestive System

- Two main groups
  - Alimentary canal – continuous coiled hollow tube
  - Accessory digestive organs
Organs of the Alimentary Canal

- Mouth
- Pharynx
- Esophagus
- Stomach
- Small intestine
- Large intestine
- Anus
Mouth (Oral Cavity) Anatomy

- Lips (labia) – protect the anterior opening
- Cheeks – form the lateral walls
- Hard palate – forms the anterior roof
- Soft palate – forms the posterior roof
- Uvula – fleshy projection of the soft palate

Figure 14.2a
Mouth (Oral Cavity) Anatomy

- **Vestibule** – space between lips externally and teeth and gums internally
- **Oral cavity** – area contained by the teeth
- **Tongue** – attached at hyoid and styloid processes of the skull, and by the lingual frenulum

Figure 14.2a
Mouth (Oral Cavity) Anatomy

- Tonsils
  - Palatine tonsils
  - Lingual tonsil

Figure 14.2a
Processes of the Mouth

- Mastication (chewing) of food
- Mixing masticated food with saliva
- Initiation of swallowing by the tongue
- Allowing for the sense of taste
• Nasopharynx – not part of the digestive system

• Oropharynx – posterior to oral cavity

• Laryngopharynx – below the oropharynx and connected to the esophagus
Pharynx Function

- Serves as a passageway for air and food
- Food is propelled to the esophagus by two muscle layers
  - Longitudinal inner layer
  - Circular outer layer
- Food movement is by alternating contractions of the muscle layers (peristalsis)
Esophagus

- Runs from pharynx to stomach through the diaphragm
- Conducts food by peristalsis (slow rhythmic squeezing)
- Passageway for food only (respiratory system branches off after the pharynx)
Layers of Alimentary Canal Organs

- Mucosa
  - Innermost layer
  - Moist membrane
    - Surface epithelium
    - Small amount of connective tissue (lamina propria)
    - Small smooth muscle layer
• **Submucosa**
  - Just beneath the mucosa
  - Soft connective tissue with blood vessels, nerve endings, and lymphatics
• **Muscularis externa – smooth muscle**
  - Inner circular layer
  - Outer longitudinal layer
• **Serosa**
  - Outermost layer – visceral peritoneum
  - Layer of serous fluid-producing cells
Layers of Alimentary Canal Organs

- Visceral peritoneum
- Intrinsic nerve plexuses:
  - Myenteric nerve plexus
  - Submucosal nerve plexus
- Submucosal glands

**Mucosa:**
- Surface epithelium
- Lamina propria
- Muscle layer

**Submucosa**
- Longitudinal muscle layer
- Circular muscle layer

**Muscularis externa:**
- Lamina propria
- Muscle layer

**Serosa:**
- (visceral peritoneum)

- Nerve
- Artery
- Vein
- Gland in mucosa
- Duct of gland outside alimentary canal
- Lumen
- Lymph nodule

Figure 14.3

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Alimentary Canal Nerve Plexuses

- All are part of the autonomic nervous system
- Three separate networks of nerve fibers
  - Submucosal nerve plexus
  - Myenteric nerve plexus
  - Subserous plexus
Stomach Anatomy

• Located on the left side of the abdominal cavity
• Food enters at the cardioesophageal sphincter
• Regions of the stomach
  • Cardiac region – near the heart
  • Fundus
  • Body
  • Pylorus – funnel-shaped terminal end
• Food empties into the small intestine at the pyloric sphincter
Stomach Anatomy

- **Rugae** – internal folds of the mucosa
- **External regions**
  - Lesser curvature
  - Greater curvature

![Stomach Anatomy Diagram](image)
Stomach Anatomy

- Layers of peritoneum attached to the stomach
  - Lesser omentum – attaches the liver to the lesser curvature
  - Greater omentum – attaches the greater curvature to the posterior body wall
  - Contains fat to insulate, cushion, and protect abdominal organs
Stomach Functions

- Acts as a storage tank for food
- Site of food breakdown
- Chemical breakdown of protein begins
- Delivers chyme (processed food) to the small intestine
Specialized Mucosa of the Stomach

- Simple columnar epithelium
  - Mucous neck cells – produce a sticky alkaline mucus
  - Gastric glands – secrete gastric juice
  - Chief cells – produce protein-digesting enzymes (pepsinogens)
  - Parietal cells – produce hydrochloric acid
  - Endocrine cells – produce gastrin
Structure of the Stomach Mucosa

- Gastric pits formed by folded mucosa
- Glands and specialized cells are in the gastric gland region
Small Intestine

- The body’s major digestive organ
- Site of nutrient absorption into the blood
- Muscular tube extending from the pyloric sphincter to the ileocecal valve
- Suspended from the posterior abdominal wall by the mesentery
Subdivisions of the Small Intestine

- Duodenum
  - Attached to the stomach
  - Curves around the head of the pancreas
- Jejunum
  - Attaches anteriorly to the duodenum
- Ileum
  - Extends from jejunum to large intestine
Chemical Digestion in the Small Intestine

- Source of enzymes that are mixed with chyme
  - Intestinal cells
  - Pancreas
- Bile enters from the gall bladder
Projections of the Small Intestine

- **Villi**
  - Fingerlike structures formed by the mucosa
  - Give the small intestine more surface area

- **Microvilli**
  - Small projections of the plasma membrane
  - Found on absorptive cells
Structures Involved in Absorption of Nutrients

- Absorptive cells
- Blood capillaries
- Lacteals (specialized lymphatic capillaries)
Folds of the Small Intestine

- Called circular folds or *plicae circulares*
- Deep folds of the mucosa & submucosa
- Do not disappear when filled with food
- The submucosa has Peyer’s patches (collections of lymphatic tissue like tonsils)
Large Intestine

- Larger in diameter, but shorter than the small intestine
- Frames the internal abdomen
Functions of the Large Intestine

- Absorption of water
- Eliminates indigestible food from the body as feces
- Does not participate in digestion of food
- Goblet cells produce mucus to act as a lubricant
Structures of the Large Intestine

- Cecum – saclike first part of the large intestine

- Appendix
  - Accumulation of lymphatic tissue that sometimes becomes inflamed (appendicitis)
  - Hangs from the cecum
  - Scientists believe it used to help filter soil and excess bacteria from food
Structures of the Large Intestine

- Colon
  - Ascending
  - Transverse
  - Descending
  - S-shaped sigmoidal
- Rectum
- Anus – external body opening
Accessory Digestive Organs

- **Salivary Glands**
  - Produce saliva
    - Mixture of mucus and serous fluids
    - Helps to form a food bolus
    - Contains salivary amylase to begin starch digestion
    - Dissolves chemicals so they can be tasted
  - Parotid glands – located anterior to ears
  - Submandibular glands
  - Sublingual glands
Teeth

• The role is to masticate (chew) food

• Humans have two sets of teeth
  • Deciduous (baby or milk) teeth
    • 20 teeth are fully formed by age two
  • Permanent teeth
    • Replace deciduous teeth beginning between the ages of 6 to 12
    • A full set is 32 teeth, but some people do not have wisdom teeth
Classification of Teeth

- Incisors – to cut
- Canines – to pierce
- Premolars & Molars – to grind
Regions of a Tooth

- **Crown** – exposed part
  - Outer: enamel
  - Middle: Dentin
  - Inner: Pulp cavity

- **Neck**
  - Region in contact with the gum
  - Connects crown to root

- **Root**
  - Periodontal membrane attached to the bone
  - Root canal carrying blood vessels and nerves
Pancreas

- Produces a wide spectrum of digestive enzymes that break down all categories of food
- Enzymes are secreted into the duodenum
- Alkaline fluid introduced with enzymes neutralizes acidic chyme
- Endocrine products of pancreas
  - Insulin
  - Glucagons
Liver

- Largest gland in the body
- Located on the right side of the body under the diaphragm
- Consists of four lobes suspended from the diaphragm and abdominal wall by the falciform ligament
- Connected to the gall bladder via the common hepatic duct
Bile

- Produced by cells in the liver

Composition

- Bile salts
- Bile pigment (mostly bilirubin from the breakdown of hemoglobin)
- Cholesterol
- Phospholipids
- Electrolytes
Gall Bladder

- Sac found in hollow fossa of liver
- Stores bile from the liver by way of the cystic duct
- Bile is introduced into the duodenum in the presence of fatty food
- Gallstones can cause blockages
Processes of the Digestive System

- Ingestion – getting food into the mouth
- Propulsion – moving foods from one region of the digestive system to another
- Peristalsis – alternating waves of contraction
- Segmentation – moving materials back and forth to aid in mixing
- Mechanical digestion
  - Mixing of food in the mouth by the tongue
  - Churning of food in the stomach
  - Segmentation in the small intestine
Processes of the Digestive System

- Chemical Digestion
  - Enzymes break down food molecules into their building blocks
  - Each major food group uses different enzymes
    - Carbohydrates are broken to simple sugars
    - Proteins are broken to amino acids
    - Fats are broken to fatty acids and alcohols
Absorption

- End products of digestion are absorbed in the blood or lymph
- Food must enter mucosal cells and then into blood or lymph capillaries

Defecation

- Elimination of indigestible substances as feces
Control of Digestive Activity

- Mostly controlled by reflexes via the parasympathetic division

- Chemical and mechanical receptors are located in organ walls that trigger reflexes

- Stimuli include:
  - Stretch of the organ
  - pH of the contents
  - Presence of breakdown products

- Reflexes include:
  - Activation or inhibition of glandular secretions
  - Smooth muscle activity
Nutrition

• Nutrient – substance used by the body for growth, maintenance, and repair

• Categories of nutrients
  • Carbohydrates
  • Lipids
  • Proteins
  • Vitamins
  • Mineral
  • Water
Dietary Sources of Major Nutrients

• Carbohydrates
  • Most are derived from plants
  • Exceptions: lactose from milk and small amounts of glycogens from meats

• Lipids
  • Saturated fats from animal products
  • Unsaturated fats from nuts, seeds, and vegetable oils
  • Cholesterol from egg yolk, meats, and milk products
Dietary Sources of Major Nutrients

- **Proteins**
  - Complete proteins – contain all essential amino acids
    - Most are from animal products
  - Legumes and beans also have proteins, but are incomplete

- **Vitamins**
  - Most vitamins are used as cofactors and act with enzymes
  - Found in all major food groups
Dietary Sources of Major Nutrients

- Minerals
  - Play many roles in the body
  - Most mineral-rich foods are vegetables, legumes, milk, and some meats
Metabolism

- Chemical reactions necessary to maintain life
  - Catabolism – substances are broken down to simpler substances
  - Anabolism – larger molecules are built from smaller ones
  - Energy is released during catabolism
Carbohydrate Metabolism

- The body’s preferred source to produce cellular energy (ATP)
- Glucose (blood sugar) is the major breakdown product and fuel to make ATP

Figure 14.16
Fat Metabolism

- Handled mostly by the liver
  - Use some fats to make ATP
  - Synthesize lipoproteins, thromboplastin, and cholesterol
  - Release breakdown products to the blood
- Body cells remove fat and cholesterol to build membranes and steroid hormones
Protein Metabolism

- Proteins are conserved by body cells because they are used for most cellular structures.
- Ingested proteins are broken down to amino acids.
- Cells remove amino acids to build proteins.
- Synthesized proteins are actively transported across cell membranes.
- Amino acids are used to make ATP only when proteins are overabundant or there is a shortage of other sources.
Role of the Liver in Metabolism

• Several roles in digestion
• Detoxifies drugs and alcohol
• Degrades hormones
• Produce cholesterol, blood proteins (albumin and clotting proteins)
• Plays a central role in metabolism
Metabolic Functions of the Liver

- **Glycogenesis**
  - Glucose molecules are converted to glycogen
  - Glycogen molecules are stored in the liver

- **Glycogenolysis**
  - Glucose is released from the liver after conversion from glycogen

- **Gluconeogenesis**
  - Glucose is produced from fats and proteins
Cholesterol Metabolism

- Functions of cholesterol
  - Serves as a structural basis of steroid hormones and vitamin D
  - Is a major building block of plasma membranes
  - Most cholesterol is produced in the liver and is not from diet
Cholesterol Transport

- Cholesterol and fatty acids cannot freely circulate in the bloodstream
- They are transported by lipoproteins (lipid-protein complexes)
  - Low-density lipoproteins (LDLs) transport to body cells
  - High-density lipoproteins (HDLs) transport from body cells to the liver
Energy intake = total energy output (heat + work + energy storage)

Energy intake is liberated during food oxidation

Energy output

Heat is usually about 60%

Storage energy is in the form of fat or glycogen
Regulation of Food Intake

• Body weight is usually relatively stable
  • Energy intake and output remain about equal

• Mechanisms that may regulate food intake
  • Levels of nutrients in the blood
  • Hormones
  • Body temperature
  • Psychological factors
Metabolic Rate and Body Heat Production

• Basic metabolic rate (BMR) – amount of heat produced by the body per unit of time at rest

• Factors that influence BMR
  • Surface area – small body usually has higher BMR
  • Gender – males tend to have higher BMR
Factors that influence BMR (continued)

- Age – children and adolescents have a higher BMR
- The amount of thyroxine produced is the most important control factor
  - More thyroxine means higher metabolic rate
Total Metabolic Rate (TMR)

• Total amount of kilocalories the body must consume to fuel ongoing activities

• TMR increases with an increase in body activity

• TMR must equal calories consumed to maintain homeostasis and maintain a constant weight
Body Temperature Regulation

- Most energy is released as foods are oxidized
- Most energy escapes as heat
- The body has a narrow range of homeostatic temperature
  - Must remain between 35.6°C to 37.8°C (96° to 100° F)
- The body’s thermostat is in the hypothalamus
- Initiates heat-loss or heat-promoting mechanisms
Developmental Aspects of the Digestive System

- The alimentary canal is a continuous tube by the 5th week of development.
- Digestive glands bud from the mucosa of the alimentary tube.
- The developing fetus receives ALL nutrients through the placenta.
- In newborns:
  - feeding must be frequent
  - peristalsis is inefficient
  - vomiting is common
Developmental Aspects of the Digestive System

- Teething begins at around six months
- Metabolism decreases with age
- Middle age digestive problems
  - Ulcers
  - Gall bladder problems
- Activity of digestive tract in old age
  - Fewer digestive juices
  - Peristalsis slows
  - Diverticulosis and cancer are more common