Anatomy and Physiology: The Digestive System and Nutrient Classes

AI-Generated Study Guide

(Based on lectures delivered by Dr. Ty C.M. Hoffman)

I. Introduction to the Digestive System

- **Primary Function:** Processing of food.
- **Secondary Function:** Immune protection (due to its boundary nature with the outside world).
- **Two Major Parts:Alimentary Canal (Digestive Tract):** A continuous tube from mouth to anus through which food passes. The interior of the alimentary canal is considered "outside" the body.
- **Accessory Organs:** Organs connected to the alimentary canal, but food does not pass through them. They contribute substances essential for digestion.

II. Anatomy of the Digestive System

A. Alimentary Canal (Sequence of Structures)

- **Mouth (Oral Cavity):Structures:** Tongue, Teeth, Palate (Hard and Soft), Uvula.
- **Gingiva:** Gums surrounding the teeth.
- **Tonsils:** Part of the lymphatic system, not digestive.
- **Pharynx (Throat):**Common passageway for air, food, and drink.
- **Regions:** Nasopharynx (air only), Oropharynx (food, drink, air), Laryngopharynx (food, drink, air).
- **Epiglottis:** Cartilage flap that seals off the airway (trachea) during swallowing.
- **Esophagus (Eating Tube):**Transports food and drink from the pharynx to the stomach.
- Collapsible tube (unlike the trachea).
- **Sphincters:** Upper esophageal sphincter, Cardiac (Cardioesophageal) sphincter.
- **Stomach:**Primarily a storage device.
- Limited chemical digestion, significant mechanical digestion (churning).
- **Regions:** Cardiac region (entrance), Fundus (blind end), Body (main region), Pyloric region (exit).

- **Pyloric Sphincter:** Gatekeeper controlling the release of chyme into the small intestine.
- **Rugae:** Internal folds that allow for stomach expansion.
- **Curvatures:** Lesser and Greater curvatures.
- **Muscularis Externa:** Three layers of smooth muscle (longitudinal, circular, oblique) enabling churning.
- **Gastric Pits:** Openings in the stomach lining.
- **Cells of Gastric Pits:Mucous Neck Cells:** Produce mucus.
- **Parietal Cells:** Produce hydrochloric acid (HCl).
- **Chief Cells:** Produce pepsinogen (pro-enzyme).
- **Enteroendocrine Cells:** Produce signal molecules (hormones).
- **Small Intestine:**Site of most digestion and absorption.
- **Length:** Very long and winding.
- **Parts (in order of flow):Duodenum:** First part, hairpin loop where pancreas is located.
- **Jejunum:** Middle part.
- **Ileum:** Last part.
- **Ileocecal Valve:** Division between the ileum and cecum.
- **Surface Area Enhancements:Plicae Circularis (Circular Folds):** Macroscopic folds.
- **Villi:** Finger-like projections on plicae circularis. Contain lacteals (lymphatic vessels) and blood capillaries.
- **Microvilli (Brush Border):** Folds on the plasma membrane of individual villi cells.
- **Large Intestine:**Does not absorb nutrients but absorbs water, forming feces.
- **Parts (in order of flow):Cecum:** First part, receives material from the ileum.
- **Appendix (Vermiform Appendix):** Small projection from the cecum, believed to house beneficial bacteria.
- **Ascending Colon:** Moves superiorly.
- **Transverse Colon:** Moves transversely (right to left).
- **Descending Colon:** Moves inferiorly.
- **Sigmoid Colon:** S-shaped curve.
- **Rectum:** Straightens out.
- **Anal Canal:** Ends in the anus.
- **Haustra:** Pouch-like segments.
- **Peyer's Patches:** Lymphatic tissue important for protection.

1. **Anus:** External opening at the end of the alimentary canal.

B. Accessory Organs

- **Liver:**Largest organ of the digestive system and largest gland in the body.
- Produces bile (hepatocytes are liver cells).
- **Gallbladder:**Stores and concentrates bile produced by the liver.
- Releases bile into the small intestine (duodenum).
- **Pancreas:**Both an endocrine gland (produces insulin and glucagon) and an exocrine gland.
- **Exocrine Function:** Produces pancreatic juice, which contains bicarbonate ions (to neutralize chyme) and pancreatic enzymes for digestion.

- **Pancreatic Duct:** Carries pancreatic juice.
- **Hepatopancreatic Ampulla:** Where bile duct and pancreatic duct combine before emptying into the duodenum, guarded by a sphincter.
- **Salivary Glands:**Produce saliva.
- **Contents of Saliva:** Water, mucus, salivary amylase (begins starch digestion), antibacterial substances.
- **Types:** Parotid (next to ear), Sublingual (under tongue), Submandibular (inferior to mandible).
- **Teeth:**Perform mechanical digestion (mastication).
- **Structure:Enamel:** Hardest material in the body, superficial layer.
- **Dentin:** Similar to bone, not as hard as enamel, makes up the thickest hard layer.
- **Pulp:** Loose connective tissue with vessels and nerves.
- **Cementum:** Layer for adhesion of tooth root to periodontal ligament.
- **Dental Alveolus (Alveolus):** Tooth socket.

III. Layers of the Alimentary Canal (from Lumen Outward)

- **Mucosa:**Innermost layer, in direct contact with food/chyme/feces.
- Mucous membrane, produces mucus for lubrication.
- Includes a thin smooth muscle layer.
- **Submucosa:**Underneath the mucosa.
- Connective tissue with rich supply of arteries, veins, and lymphatic vessels (important for absorption).
- **Muscularis (Muscularis Externa):**Primarily smooth muscle.
- At least two layers: Longitudinal and Circular (stomach has an additional oblique layer).
- Responsible for propulsion (peristalsis) and mixing (segmentation).
- **Myenteric Nerve Plexus:** Network of enteric nerves controlling these muscles.
- **Serosa (or Adventitia):**Outermost layer.
- **Serosa:** A serous membrane (visceral peritoneum) found in the abdomen (e.g., small intestine, stomach).
- **Adventitia:** A connective tissue layer where the peritoneum does not surround the canal (e.g., mouth, esophagus).

Peritoneum

- A serous membrane in the abdomen with visceral and parietal layers.
- More complex than other serous membranes.
- **Lesser Omentum:** Part of peritoneum from liver to stomach.
- **Greater Omentum:** Hangs from stomach, covers small intestines, attaches to transverse colon; often accumulates fat (fatty apron).

IV. Major Functions/Processes of the Digestive System

1. **Ingestion:** Taking food into the oral cavity (eating).
2. **Mechanical Breakdown (Mechanical Digestion):** Physically breaking large chunks into smaller chunks.

- Examples: Mastication (chewing) in the mouth, churning in the stomach, segmentation in the small intestine.

1. **Propulsion:** Moving material along the alimentary canal in one direction.

- Examples: Deglutition (swallowing), Peristalsis (wave-like muscle contractions).

1. **Digestion (Chemical Digestion):** Breaking down large molecules into smaller molecules using enzymes.
2. **Absorption:** When digested, small enough particles finally enter the body from the lumen of the alimentary canal.

- Occurs primarily in the small intestine (nutrients).
- Occurs in the large intestine (water).

1. **Defecation:** Elimination of undigested residue (feces) from the body.

V. Digestion and Absorption of Specific Nutrients

A. Carbohydrates

- **Large Carbohydrates:** Polysaccharides (e.g., starch, glycogen). Too big to be absorbed.
- **Smallest Absorbable Units:** Monosaccharides (e.g., glucose, galactose, fructose).
- **Digestion Process:Mouth:** Salivary amylase begins starch digestion.
- **Stomach:** Salivary amylase inactivated by low pH.
- **Small Intestine:**Pancreatic amylase (from pancreatic juice) continues breakdown to oligosaccharides and disaccharides.
- Brush border enzymes (e.g., dextrinase, lactase, sucrase) on microvilli break down into monosaccharides.
- **Absorption:** Monosaccharides absorbed directly into blood capillaries in villi, then travel to the liver via the hepatic portal system.
- **Energy Use:** Monosaccharides (especially glucose) are major fuel for cells, used to produce ATP.
- **Storage:** Excess glucose converted to glycogen in the liver and skeletal muscles (glycogenesis). Glycogen can be broken down to glucose (glycogenolysis) when needed.

B. Proteins

- **Large Proteins:** Polymers of amino acids. Too big to be absorbed.
- **Smallest Absorbable Units:** Individual amino acids (some dipeptides and tripeptides can also be absorbed).
- **Digestion Process:Stomach:** Pepsin (from pepsinogen activated by HCl) begins protein breakdown into smaller polypeptides.

- **Small Intestine:**Pancreatic proteases (e.g., trypsin, chymotrypsin, carboxypeptidase) from pancreatic juice break polypeptides into smaller peptides.
- Brush border enzymes break small peptides into individual amino acids.
- **Absorption:** Amino acids absorbed directly into blood capillaries in villi, then travel to the liver via the hepatic portal system.
- **Energy Use:** Amino acids typically *not* used as primary fuel; primarily used for building new proteins or recycling existing ones.
- **Essential Amino Acids:** Nine amino acids that the body cannot synthesize and must be obtained from food.

C. Fats (Triglycerides)

- **Structure:** One glycerol molecule bonded to three fatty acids. Too big to be absorbed.
- **Smallest Absorbable Units:** Monoglycerides and individual fatty acids (glycerol is also absorbed separately).
- **Digestion Process:Small Intestine (primarily):Emulsification:** Bile (from liver/gallbladder) acts as a detergent, breaking large fat droplets into smaller ones, increasing surface area for enzyme action. *Note: Emulsification is not digestion.*
- **Digestion:** Pancreatic lipase (from pancreatic juice) breaks triglycerides into monoglycerides and fatty acids.
- **Absorption:Glycerol:** Absorbed into blood capillaries in villi.
- **Fatty Acids & Monoglycerides:** Absorbed into lacteals (lymphatic capillaries) in villi, making their contents appear milky. Eventually enter the bloodstream via the lymphatic system (at subclavian veins).
- **Energy Use:** Major energy source, storing more energy per gram than carbohydrates. Excess calories stored as fat.

VI. Regulation of Digestion

- **Hormonal Control:Cholecystokinin (CCK):** Released by enteroendocrine cells in the duodenum in response to chyme. Causes gallbladder contraction (bile release) and pancreas to secrete enzyme-rich pancreatic juice.
- **Secretin:** Released by enteroendocrine cells in the duodenum in response to chyme. Causes pancreas to secrete bicarbonate-rich pancreatic juice (neutralizes chyme) and may increase stomach motility.
- **Nervous Control:Enteric Nerves:** Intrinsic nervous system of the gut, arranged in plexuses (e.g., myenteric nerve plexus).
- **Vagus Nerve (Cranial Nerve X):** Extrinsic nervous input to the digestive system.
- **Swallowing Reflex:** Coordinated muscular movements triggered by food bolus at the back of the oral cavity.

VII. Glucose Homeostasis

- **Normal Blood Glucose Level:** Essential for brain function.
- **High Blood Glucose (after absorption):**Pancreas releases **insulin**.
- Insulin causes liver to perform **glycogenesis** (glucose converted to glycogen for storage), lowering blood glucose.
- **Low Blood Glucose (between meals/fasting):**Pancreas releases **glucagon**.
- Glucagon causes liver to perform **glycogenolysis** (glycogen broken down to glucose), raising blood glucose.

Quiz: Digestive System

Instructions: Answer each question in 2-3 sentences.

1. What is the primary function of the digestive system, and what secondary, protective role does it also play?
2. Explain the difference between the alimentary canal and accessory organs, providing one example of each.
3. Describe the three levels of surface area increase in the small intestine and their purpose.
4. What is the function of the epiglottis, and why is it crucial during deglutition?
5. Compare the roles of chief cells and parietal cells in the stomach lining.
6. How does the stomach contribute to both mechanical and chemical digestion, despite its primary role as a storage device?
7. Explain the process of emulsification by bile and clarify whether it is considered chemical digestion.
8. Trace the absorption pathway for fatty acids from the small intestine lumen until they enter the general bloodstream, highlighting how it differs from monosaccharides.
9. Describe peristalsis and segmentation, explaining how their functions differ in the alimentary canal.
10. How do insulin and glucagon, secreted by the pancreas, help maintain glucose homeostasis in the body?

Answer Key (Quiz)

1. The primary function of the digestive system is the processing of food, which includes digestion and absorption of nutrients. Additionally, it provides an immune function, acting as a boundary between the body and potential incoming pathogens from the outside world.
2. The alimentary canal is a continuous tube through which food passes, such as the esophagus. Accessory organs are connected to the canal but food does not pass through them; an example is the liver, which produces substances for digestion.
3. The small intestine's surface area is increased by plicae circularis (circular folds), which are further folded into villi (finger-like projections), and then individual villi cells have

microvilli (brush border). This extensive folding maximizes the surface area available for efficient nutrient absorption.

4. The epiglottis is a fold of cartilage that closes off the airway (trachea) during swallowing. This action is crucial during deglutition to prevent food and drink from entering the respiratory tract, which could lead to choking.
5. Chief cells in the stomach lining produce pepsinogen, a pro-enzyme that gets converted into active pepsin. Parietal cells, on the other hand, produce hydrochloric acid (HCl), which creates the acidic environment necessary to convert pepsinogen to pepsin and aids in protein digestion.
6. The stomach primarily acts as a storage device, but its three layers of muscle in the muscularis externa allow for vigorous churning, contributing significantly to mechanical digestion. While it performs limited chemical digestion of proteins via pepsin, its main contribution to food processing is storage and mechanical breakdown.
7. Emulsification is the process where bile, acting as a detergent, breaks large fat droplets into smaller ones. This increases the surface area for enzymes to act upon. However, emulsification is not considered chemical digestion because it only physically breaks down fats and does not involve breaking chemical bonds into smaller molecules.
8. Fatty acids absorbed in the small intestine enter lacteals, which are specialized lymphatic vessels within the villi. They travel through the lymphatic system and eventually dump their contents into the bloodstream at the subclavian veins, making their entry into general circulation indirect, unlike monosaccharides which enter blood capillaries directly.
9. Peristalsis is a wave-like contraction of muscles that propels food or chyme unidirectionally along the alimentary canal, moving it towards the anus. Segmentation, predominantly in the small intestine, involves localized, simultaneous contractions that mix chyme with digestive juices and maximize exposure to the absorptive surface, without significant forward movement.
10. When blood glucose levels rise (e.g., after a meal), the pancreas secretes insulin, which prompts the liver to take up glucose and store it as glycogen (glycogenesis), thus lowering blood glucose. Conversely, when blood glucose levels drop, the pancreas releases glucagon, signaling the liver to break down stored glycogen into glucose (glycogenolysis) and release it into the blood, raising the level back to normal.

Essay Format Questions

1. Discuss the concept of the alimentary canal being "outside the body." How does this anatomical arrangement necessitate specific protective and absorptive mechanisms within the digestive system?
2. Compare and contrast the mechanical and chemical digestion processes that occur in the mouth, stomach, and small intestine. Provide specific examples of structures and enzymes involved in each location.

3. Explain the intricate interplay between the liver, gallbladder, and pancreas in facilitating digestion in the small intestine. Detail the specific secretions from each organ and their respective roles.
4. Describe the various layers of the alimentary canal, detailing the primary function of each layer and how their specialized structures contribute to the overall process of digestion and absorption.
5. Analyze the journey of a complex meal containing carbohydrates, proteins, and fats through the digestive system. Focus on where and how each major nutrient class is chemically digested and subsequently absorbed, highlighting any unique pathways for absorption.

Glossary of Key Terms

- **Absorption:** The process by which digested nutrients and water pass from the lumen of the alimentary canal into the body's cells, and then into the blood or lymph.
- **Accessory Organs:** Organs that aid in digestion but through which food does not directly pass (e.g., liver, pancreas, salivary glands).
- **Alimentary Canal (Digestive Tract):** The continuous tube that extends from the mouth to the anus, through which food passes and is processed.
- **Amino Acids:** The monomeric building blocks of proteins.
- **Amylase:** An enzyme that breaks down starch (carbohydrates). Salivary amylase is found in saliva; pancreatic amylase is found in pancreatic juice.
- **Anus:** The terminal opening of the alimentary canal through which feces are eliminated.
- **Appendix (Vermiform Appendix):** A small, worm-shaped projection from the cecum, believed to be a reservoir for beneficial gut bacteria.
- **ATP (Adenosine Triphosphate):** The primary energy currency of cells, produced through cellular respiration.
- **Bicarbonate Ion (HCO_3^-):** A component of pancreatic juice that neutralizes the acidic chyme entering the small intestine from the stomach.
- **Bile:** A fluid produced by the liver and stored in the gallbladder, containing detergents that emulsify fats in the small intestine.
- **Bolus (Food Bolus):** A small ball of chewed food mixed with saliva and mucus, formed in the mouth before swallowing.
- **Brush Border:** The collective term for the microvilli on the surface of intestinal absorptive cells, which significantly increase surface area and house brush border enzymes.
- **Cardiac (Cardioesophageal) Sphincter:** A ring of muscle at the junction of the esophagus and stomach, regulating food entry into the stomach and preventing reflux.
- **Cecum:** The first part of the large intestine, receiving chyme from the small intestine.
- **Chief Cells:** Cells in the stomach lining that produce pepsinogen.
- **Cholecystokinin (CCK):** A hormone released by the duodenum that stimulates gallbladder contraction and pancreatic enzyme secretion.

- **Chyme:** The semi-fluid mass of partly digested food that is expelled by the stomach into the duodenum.
- **Colon:** The main part of the large intestine, including ascending, transverse, descending, and sigmoid sections.
- **Defecation:** The act of eliminating feces from the body.
- **Deglutition:** The scientific term for swallowing.
- **Dentin:** A bone-like material beneath the enamel, forming the bulk of a tooth.
- **Digestion (Chemical):** The process of breaking down complex food molecules into simpler, absorbable molecules through enzymatic reactions.
- **Duodenum:** The first and shortest section of the small intestine, receiving chyme from the stomach and secretions from the liver and pancreas.
- **Emulsification:** The process of breaking down large fat globules into smaller, dispersed fat droplets, primarily by bile, to increase surface area for enzyme action.
- **Enamel:** The hardest substance in the human body, forming the outer covering of the tooth crown.
- **Enteric Nerves:** Nerves that form an intrinsic nervous system within the walls of the alimentary canal, controlling its movements and secretions.
- **Enteroendocrine Cells:** Cells in the stomach and small intestine lining that produce hormones regulating digestive functions.
- **Epiglottis:** A leaf-shaped flap of cartilage located behind the tongue, which covers the opening of the trachea during swallowing to prevent food from entering the airway.
- **Esophagus:** The muscular tube that connects the pharynx to the stomach, transporting food via peristalsis.
- **Essential Amino Acids:** Amino acids that cannot be synthesized by the human body and must be obtained from the diet.
- **Exocrine Gland:** A gland that secretes substances into ducts, which then typically lead to a body surface or cavity (e.g., pancreas secreting pancreatic juice).
- **Feces:** Undigested and unabsorbed food residue, bacteria, and dead cells expelled from the body.
- **Fundus:** The dome-shaped, blind-ended upper part of the stomach, located superior to the cardiac region.
- **Gallbladder:** A small organ located under the liver that stores and concentrates bile.
- **Gastric Pits:** Depressions in the stomach lining that lead to gastric glands, which secrete stomach acid and enzymes.
- **Gingiva (Gums):** The soft tissue surrounding the base of the teeth.
- **Glucagon:** A hormone produced by the pancreas that raises blood glucose levels by stimulating glycogenolysis in the liver.
- **Glycogen:** A polysaccharide that serves as the primary storage form of glucose in animals, mainly in the liver and muscles.
- **Glycogenesis:** The biochemical process of synthesizing glycogen from glucose, typically in response to high blood glucose levels.
- **Glycogenolysis:** The biochemical process of breaking down glycogen into glucose, typically in response to low blood glucose levels.

- **Greater Omentum:** A large, apron-like fold of peritoneum that hangs from the greater curvature of the stomach, often storing fat.
- **Haustra:** The pouch-like segments of the large intestine, formed by contractions of its muscle layers.
- **Hepatocytes:** The main parenchymal cells of the liver, involved in bile production and many metabolic functions.
- **Hepatopancreatic Ampulla:** A dilated common duct formed by the union of the common bile duct and the pancreatic duct, emptying into the duodenum.
- **Hydrochloric Acid (HCl):** A strong acid produced by parietal cells in the stomach, crucial for activating pepsinogen and denaturing proteins.
- **Ileocecal Valve:** A sphincter muscle that separates the ileum (last part of the small intestine) from the cecum (first part of the large intestine).
- **Ileum:** The final and longest segment of the small intestine.
- **Ingestion:** The process of taking food or drink into the body through the mouth.
- **Insulin:** A hormone produced by the pancreas that lowers blood glucose levels by promoting glucose uptake by cells and glycogenesis in the liver.
- **Jejunum:** The middle section of the small intestine, where most chemical digestion and nutrient absorption occur.
- **Lactase:** A brush border enzyme that breaks down lactose into glucose and galactose.
- **Lacteal:** A specialized lymphatic capillary located within the villi of the small intestine, responsible for absorbing digested fats.
- **Lesser Omentum:** A peritoneal fold connecting the lesser curvature of the stomach and the duodenum to the liver.
- **Lipase:** An enzyme that breaks down lipids (fats) into fatty acids and glycerol. Pancreatic lipase is a key digestive enzyme.
- **Liver:** A large accessory organ involved in numerous metabolic functions, including bile production, nutrient processing, and detoxification.
- **Lumen:** The inner space or cavity within a tubular organ, such as the alimentary canal.
- **Mastication:** The scientific term for chewing.
- **Mechanical Breakdown (Mechanical Digestion):** The physical process of breaking down food into smaller pieces without chemical changes (e.g., chewing, churning).
- **Microvilli:** Microscopic folds of the plasma membrane on the apical surface of intestinal absorptive cells, forming the brush border.
- **Monosaccharides:** Simple sugars; the smallest absorbable units of carbohydrates (e.g., glucose, fructose, galactose).
- **Mucosa:** The innermost layer of the alimentary canal, composed of a mucous membrane that lines the lumen.
- **Mucous Neck Cells:** Cells in the stomach lining that produce mucus, protecting the stomach from acid.
- **Muscularis (Muscularis Externa):** The layer of smooth muscle in the alimentary canal wall, responsible for peristalsis and segmentation.
- **Myenteric Nerve Plexus:** A network of enteric nerves located between the longitudinal and circular muscle layers of the muscularis externa, controlling gut motility.
- **Oral Cavity:** The mouth; the first part of the alimentary canal.

- **Pancreas:** A glandular organ that has both endocrine (insulin, glucagon) and exocrine (pancreatic juice containing enzymes and bicarbonate) functions.
- **Pancreatic Juice:** The exocrine secretion of the pancreas, containing digestive enzymes and bicarbonate ions.
- **Parietal Cells:** Cells in the stomach lining that produce hydrochloric acid (HCl).
- **Pepsin:** An active enzyme in the stomach that initiates protein digestion by breaking peptide bonds.
- **Pepsinogen:** The inactive pro-enzyme form of pepsin, produced by chief cells, which is activated by hydrochloric acid.
- **Peristalsis:** Wave-like muscular contractions that propel food through the alimentary canal in one direction.
- **Peritoneum:** A serous membrane that lines the abdominal cavity and covers most of the abdominal organs.
- **Peyer's Patches:** Clusters of lymphatic tissue found primarily in the ileum, important for immune surveillance.
- **Pharynx (Throat):** The muscular tube posterior to the nasal and oral cavities, a common passageway for food, liquid, and air.
- **Plicae Circularis (Circular Folds):** Large, circular folds in the mucosa and submucosa of the small intestine, increasing surface area for absorption.
- **Polysaccharides:** Complex carbohydrates made up of many monosaccharide units (e.g., starch, glycogen).
- **Proteases:** A general term for enzymes that break down proteins.
- **Proteins:** Large, complex molecules made up of amino acid chains, essential for structure and function in the body.
- **Pulp:** The soft, innermost part of a tooth, containing nerves, blood vessels, and connective tissue.
- **Pyloric Region:** The lower, narrowed part of the stomach that connects to the small intestine.
- **Pyloric Sphincter:** A ring of muscle at the junction of the stomach and duodenum, controlling the release of chyme.
- **Rectum:** The straight, terminal part of the large intestine, leading to the anal canal.
- **Rugae:** Internal folds or ridges in the lining of the stomach that allow it to expand.
- **Saliva:** A watery fluid secreted by salivary glands that moistens food, aids in mechanical digestion, and contains enzymes (like amylase).
- **Salivary Glands:** Exocrine glands that produce saliva in the oral cavity (parotid, sublingual, submandibular).
- **Secretin:** A hormone released by the duodenum that stimulates the pancreas to secrete bicarbonate-rich pancreatic juice.
- **Segmentation:** Localized constrictions of the small intestine that mix chyme with digestive juices and maximize contact with the absorptive surface.
- **Serosa:** The outermost layer of the alimentary canal in regions within the peritoneal cavity; a serous membrane.
- **Small Intestine:** The primary site for chemical digestion and nutrient absorption.

- **Sphincter:** A ring of muscle that surrounds a bodily opening or passage, regulating its constriction and relaxation.
- **Stomach:** A muscular, J-shaped organ that stores food, mixes it with gastric juices, and initiates protein digestion.
- **Submucosa:** The layer of connective tissue beneath the mucosa in the alimentary canal, containing blood vessels, lymphatic vessels, and nerves.
- **Triglyceride:** The scientific term for a fat molecule, composed of one glycerol and three fatty acids.
- **Uvula:** A fleshy, grape-like projection hanging from the soft palate at the back of the throat.
- **Vagus Nerve (Cranial Nerve X):** A major cranial nerve that provides parasympathetic innervation to many organs, including those of the digestive system.
- **Villi:** Finger-like projections of the mucosa in the small intestine, greatly increasing surface area for absorption.