Advanced Nutrition and Human Metabolism 7th edition Gropper Solutions Manual

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Instructor's Manual
Advanced Nutrition and Human Metabolism, Gropper, 7e
Chapter 2 – The Digestive System: Mechanism for Nourishing the Body

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Chapter Outline

I. Introduction
   1. This chapter covers the organs and processes involved in digestion and absorption of the nutrients consumed and needed. The body needs six classes of nutrients: carbohydrates, lipids, proteins, vitamins, minerals, and water

II. The Structures of the Digestive Tract and the Digestive and Absorptive Processes
   1. The digestive tract consist of organs digestive, absorbing, and assisting in the digestion and absorption process
   2. Key Terms
      a. Endocrine – all the body's hormone-secreting glands
      b. Zymogens – an inactive form of an enzyme
   3. Figures and Tables
      a. Figure 2.1 – the digestive tract and its accessory organs
      b. Figure 2.2 – the sublayers of the small intestine
      c. Table 2.1 – digestive enzymes and their actions

   A. Oral Cavity
      1. Consists of the mouth and pharynx; entryway to the digestive tract
      2. Key Terms
         a. Lingual lipase – pertains to the tongue and digestion of lipids
      3. Figures and Tables
         a. Figure 2.3 – secretions of the oral cavity

   B. Esophagus
      1. Receives the bolus from the oral cavity and passes it to the stomach
      2. Key Terms
         a. Reflex – an involuntary response to a stimulus
         b. Nervous system – the system of nervous tissue made up of neurons and glial cells

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3. Selected disorders of the esophagus – gastroesophageal reflex disease

C. Stomach
   1. Receives the bolus of food from the esophagus and further digests. Consists of four main regions: cardia, fundus, body, and antrum/pyloric portion
   2. Key Terms
      a. Chyme – partially digested food
      b. Mucin – glycoproteins found in some body secretions, such as saliva
      c. Prostaglandins – biologically active compounds derived from linoleic or α-linolenic acids
      d. Antral – pertaining to the antrum; the lower or distal portion of the stomach
      e. Osmolarity – a measure of the solute particle numbers expressed as osmoles of solute particles in 1 L of solution (osm/L); in dilute aqueous solutions as found in the human body, only a small numerical difference exists between osmolarity and osmolality
      f. Bile – a body fluid made in the liver and stored in the gallbladder that participates in emulsifying fat and forming micelles for fat absorption
      g. Insulin – hormone secreted by the pancreas in response to rising blood glucose derived from food; promotes glycose uptake into muscles and adipose tissue, thus normalizing blood glucose concentration
   3. Gastric juice – contains hydrochloric acid that is composed of hydrogen ions and chloride ions from parietal cells in the lumen of the stomach
   4. Regulation of gastric secretions – three phases: before food reaches the stomach, once the food reaches the stomach, and after food has left the stomach
   5. Regulation of gastric motility and gastric emptying – use of peristalsis still occurs in the stomach; the stomach also uses electrical rhythm
   6. Selected disorders of the stomach – peptic ulcer disease
   7. Figures and Tables
      a. Figure 2.4 – structure of the stomach including a gastric gland and its secretions
      b. Figure 2.5 – mechanism of HCl secretion
      c. Figure 2.6 – approximate pHs of selected body fluids, compounds, and beverages
      d. Figure 2.7 – effects of selected gastrointestinal hormones/peptides on gastrointestinal tract secretions and motility

D. Small Intestine
   1. Chyme enters the small intestine and digestion continues with absorption of nutrients. There are three sections of the small intestine – duodenum, jejunum, and ileum
   2. Key Terms
      a. Enterocytes – an intestinal cell
      b. Microvilli – extensions of intestinal epithelial cells designed to present a large surface area for absorbing dietary nutrients
      c. Apical – at or near the apex; pertaining to the intestinal lumen side of an enterocyte
      d. Glycocalyx – the layer of glycoprotein and polysaccharide that surrounds many cells

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3. Structural aspects, secretions, and digestive processes of the small intestine – consists of folds of mucosa, villi, and microvilli
4. Regulation of intestinal motility and secretions – chyme is propelled by contractions that are influenced by the nervous system as well as various hormones and peptides
5. Figures and Tables
    a. Figure 2.8 – the small intestine
    b. Figure 2.9 – the structure of the small intestine
    c. Figure 2.10 – structure of the absorptive cell of the small intestine
    d. Figure 2.11 – movement of chyme in the gastrointestinal tract

E. Accessory Organs
1. Pancreas – found behind the greater curvature of the stomach; contains both endocrine and exocrine cells
2. Key Terms
    a. Exocytosis – a process by which compounds may be released from cells
    b. Proteases – enzymes that digest proteins
    c. Serum – the pale yellowish, clear fluid portion of blood from which the clotting factors have been removed
    d. Acute – having a rapid or sudden onset
    e. Steatorrhea – the presence of an excessive amount of fat in the feces
    f. Enterohepatic circulation – movement of a substance, such as bile, from the liver to the intestine and then back to the liver
    g. Resins – compound that is usually solid or semisolid and usually exists as a polymer
    h. Plasma – liquid portion of blood that has been separated from the particulate portion
3. Liver – two lobes, right and left, each containing hepatocytes. Makes bile
4. Gallbladder – located on the surface of the liver; stores concentrated bile
5. Figures and Tables
    a. Figure 2.12 – ducts of the gallbladder, liver, and pancreas, also exocrine and endocrine portions of the pancreas
    b. Figure 2.13 – the anatomy of the liver
    c. Figure 2.14 – enterohepatic circulation of bile
    d. Figure 2.15 – synthesis of secondary bile acids by intestinal bacteria

F. Absorptive Process
1. Absorption of most nutrients begins in the duodenum and continues throughout the jejunum and ileum. Most absorption occurs in the proximal portion of the small intestine
2. Key Terms
    a. Pinocytosis – process by which the plasma membrane of a cell folds inwards to ingest material
    b. Endocytosis – form of endocytosis in which material enters a cell through its membrane and is incorporated in vesicles for digestion
    c. Macronutrient – dietary nutrients that supply energy, including fats, carbohydrates, and proteins
3. Figures and Tables
    a. Figure 2.16 – primary sites of nutrient absorption in the gastrointestinal tract
    b. Figure 2.17 – primary mechanisms for nutrient absorption

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G. Colon (Large Intestine)
    1. Materials enter through the ileocecal sphincter into the cecum then through the ascending, transverse, descending, and sigmoid sections
    2. Key Terms
        a. Microflora – bacteria adapted to living in a specific environment, such as intestines
        b. Fermentation – an anaerobic breakdown of carbohydrates and proteins by bacteria
        c. Short-chain fatty acids – fatty acids typically containing two to four carbons
        d. Splanchnic – pertaining to the internal organs. The splanchnic organs or portal-drained viscera include the liver, stomach, intestines, and spleen
        e. In vitro – in a test tube or culture
        f. Fermented – anaerobically broken down substrates that yield reduced products and energy
        g. Probiotics – products that contain specific strains of microorganisms in sufficient numbers to alter the microflora of the gastrointestinal tract, ideally to exert beneficial health effects
        h. Prebiotics – nondigestible food ingredients that serve as substrates to promote the colonic growth and/or activity of selected health-promoting species of bacteria
    3. Colonic secretions and motility and their regulation – goblet cells secrete mucus
    4. Colonic bacteria – trillions of microorganisms make up the gut microbiota
    5. Figures and Tables
        a. Figure 2.18 – the colon
        b. Figure 2.19 – some benefits from the presence of bacteria in the large intestine

III. Coordination and Regulation of the Digestive Process
A. Neural Regulation
    1. Autonomic division communicates with digestive organs directly and with the digestive tract's own, local, nervous system
B. Regulatory Peptides
    1. Consists of regulatory peptides, more specifically gastrointestinal hormones and neuropeptides, that influence digestion and absorption
    2. Key Terms
        a. Ghrelin – a hormone secreted by the stomach and duodenum that signals hunger
        b. Leptin – polypeptide hormone secreted by adipose tissue that reduces hunger through hypothalamic mechanisms
    3. Figures and Tables
        a. Table 2.2 – selected regulatory hormones/peptides of the gastrointestinal tract, their main production sites, and selected digestive tract functions

IV. Summary
    1. The mechanisms in the gastrointestinal tract that allow food to be ingested, digested, and absorbed, are necessary for a person's adequate nourishment and health

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Resources

In-Text Web Sites

The Visible Human Project

In-Text Suggested Readings

- Dykstra MA, Switzer NJ, Sherman V, Karmali S, Birch DW. Roux-en-Y gastric bypass: How and why it fails? Surgery Curr Res. 2014; 4:165–8.
- Handzlik-Orlik G, Holecki M, Orlik B, Wylezol M, Dulawa J. Nutrition management of the post-bariatric surgery patient. Nutr Clin Prac. 2014; 29:718–39.
- Mohammad AE, Elrazek AA, Elbanna AEM, Bilasy SE. Medical management of patients after bariatric surgery: Principles and guidelines. World J Gastrointest Surg. 2014; 6:220–8.
- Soenen S, Rayner CK, Jones KL, Morowitz M. The ageing gastrointestinal tract. Curr Opin Clin Nutr Metab Care. 2016; 19:12–8.
- Stein J, Stier C, Raab H, Weiner R. The nutritional and pharmacological consequences of obesity surgery. Aliment Pharmacol Ther. 2014; 40:582–609.
- Thompson KL. Nutrition support for the critically ill, postbariatric surgery patient. Top Clin Nutr. 2014; 29:98–112.

Additional Resource

- Saboor, M., Zehra, A., Qamar, K., & Moinuddin. (2015). Disorders associated with malabsorption of iron: A critical review. *Pakistan Journal of Medical Sciences*, *31*(6), 1549–1553.
  Disorders Associated with Malabsorption of Iron: A Critical Review

Perspectives – Classroom Discussion

You may pose these questions to your students when discussing the perspectives section of this chapter.

- Gastric bypass has become more prevalent as a treatment for obesity. However, there are many nutritional risks with the lasting effects of the procedure. What are some of these long-term effects that should be considered when making the decision to proceed or not?
  - Macronutrient and micronutrient deficiencies, as well as reduction/loss of intrinsic factor.
- Discuss the pH levels of the gastrointestinal tract and the relevance of the pH being at that level for that organ.
  - Most of the gastrointestinal tract is slightly alkaline, a pH around 7.8. This is to protect the organs from acidic conditions, as well as enzyme mechanisms. The stomach is at a pH of around 2.0–3.0 to aid in digestion and enzyme mechanisms but is well protected by mucus.

Assignment – Individual Project

- Digestion and absorption are processes many do not even consider when going for the first meal of the day or the delicious dinner that's been simmering all day. There are many organs involved and many more enzymes required. Create a

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diagram or process map showing how dinner enters the oral cavity and ends the digestion process in the colon. Once the organs involved are identified, add the enzymes that are being utilized within each organ and their function.

- Oral Cavity
  - Salivary alpha-amylase – carbohydrate digestion
  - Lingual lipase – lipid digestion
- Esophagus
- Stomach
  - Pepsinogen – protein digestion
  - Gastric lipase – lipid digestion
- Small Intestine
  - Peptidases – protein digestion
  - Nucleotidase – nucleotide digestion
  - Pancreatic alpha-amylase – protein digestion
  - Pancreatic lipase – lipid digestion
  - Disaccharidases – carbohydrate digestion

Answer Keys

Case Study – Post-Surgery Nourishment

1. d
2. a
3. b
4. e
5. d
6. a

Worksheet 1: Responding to Research – Malabsorption Disorders

1. a
2. a
3. cystic fibrosis; malignant lymphoma
4. Parasite infection, nutritional and/or absorption disorder, blood disorder, surgical resection.

Worksheet 2: Labeling It – Transport

1. Active transport, identified by ATP being present and transport going against concentration gradient.
2. Diffusion via channel, identified by following concentration gradient (low concentration to high concentration).
3. Diffusion, identified by following concentration gradient.
4. Secondary active transport, identified by the opposite flow of Cl^- and HCO_3^- and not the use of ATP.
5. Diffusion via channel, identified by following concentration gradient.

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Worksheet 1: Responding to Research – Malabsorption Disorders

Digestion is the key mechanism to your body in being able to absorb the nutrients you consume. There are many organs and processes involved in digestion, each playing a key role to the system functioning properly. If one of these key elements is altered, the entire digestion and absorption process may be altered.

Read the following article and then respond to the questions.

- Saboor, M., Zehra, A., Qamar, K., & Moinuddin. (2015). Disorders associated with malabsorption of iron: A critical review. *Pakistan Journal of Medical Sciences*, *31*(6), 1549–1553.
  Disorders Associated with Malabsorption of Iron: A Critical Review

1. Cystic fibrosis causes the mucous to be thicker in the lungs, as well as the liver, pancreas, and small intestine.
a. True
b. False

_____

2. Bridget has recently been suffering with severe diarrhea and pain throughout her body, especially in her knees. She is concerned if she has a disorder related to malabsorption because she has an unexpected drop in weight. Which malabsorption disorder best matches her description?

a. Whipple's disease
b. Helicobacter pylori infection
c. Giardiasis
d. Zollinger-Ellison syndrome

_____

3. An example of a disease premucosal is _____ and postmucosal is _____.

a. giardiasis; malignant lymphoma
b. cystic fibrosis; malignant lymphoma
c. giardiasis; macroglobulinemia

_____

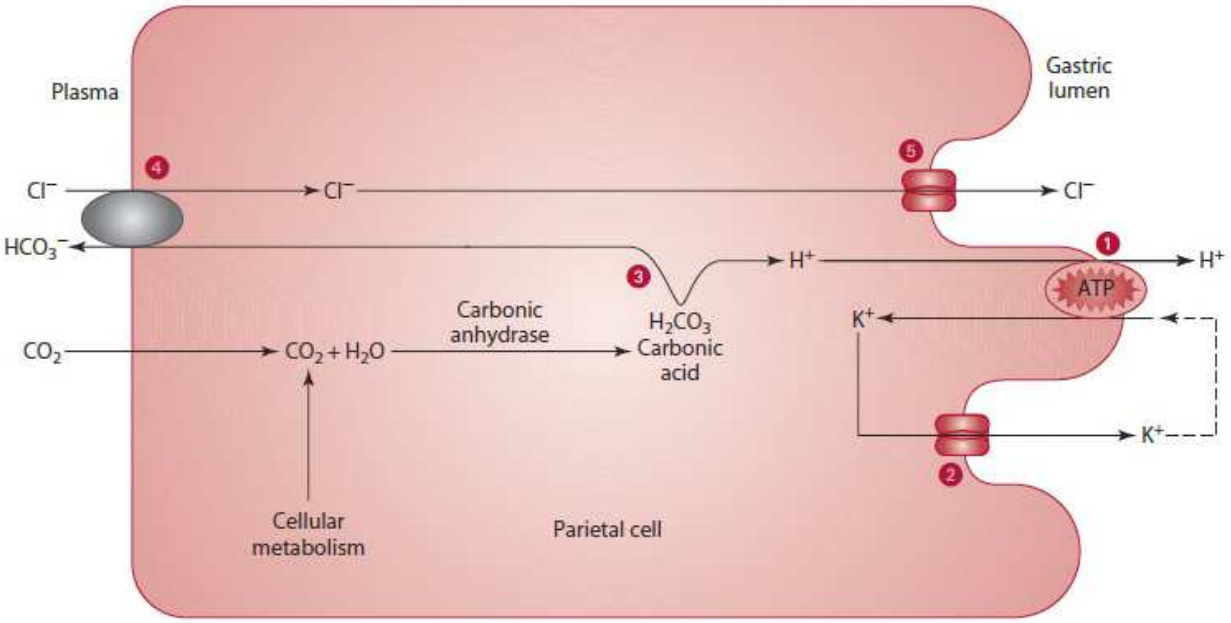
4. Iron-deficiency anemia is usually not seen without a cause. What are a few potential causes?

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Worksheet 2: Labeling It – Transport

Using the figure below, label the transport that is occurring and identify how this is determined based on information provided in the figure.



1.

2.

3.

4.

5.

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