Nutrition for Health and Healthcare 6th edition DeBruyne Solutions Manual

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Chapter 2 – Digestion and Absorption

Objectives

2.1 Describe the path followed that food takes during digestion and associated muscular actions.
2.2 Describe the actions and origins of digestive secretions.
2.3 Describe the anatomical details of the GI tract and the features and activities of intestinal cells involved in nutrient absorption.
2.4 Describe the three types of lipoproteins and the process of nutrient delivery from the GI tract to body cells by the vascular system.
2.5 Explain the causes and effects of foodborne illnesses in humans and methods of insuring food safety.

Chapter Outline **Instructor Resources**

I. Anatomy of the Digestive Tract — Teaching Suggestion 2-1
   A. Introduction
      1. GI tract is a flexible, muscular tube
      2. It extends from the mouth to the anus
   B. The Digestive Organs — Worksheet 2-1; Teaching Suggestions 2-2 and 2-3
      1. Mouth to the Esophagus
         a. Food is chewed and softened in the mouth
         b. Bolus is formed
         c. Bolus passes epiglottis, which closes off the trachea to prevent choking
         d. Food passes through the pharynx and across the epiglottis into the esophagus
      2. Esophagus to the Stomach
         a. Bolus slides down the esophagus, through the esophageal sphincter to the stomach
         b. Stomach adds gastric juices
         c. Grinds the bolus to semi-liquid mass called chyme
         d. Chyme is released through the pyloric sphincter to small intestine
      3. The Small Intestine
         a. Passes by the opening to the common bile duct
         b. Fluids enter from gallbladder
         c. Fluids enter from pancreas
         d. Travels through the duodenum, jejunum, and ileum
      4. The Large Intestine (Colon)
         a. Chyme passes through the ileocecal valve into the colon
         b. Travels through the colon, past the appendix, to the rectum
         c. Colon withdraws water from the chyme
      5. The Rectum
         a. Chyme is now a semi-solid waste
         b. When it is time to defecate, the anal sphincter opens to allow the wastes to pass
   C. The Involuntary Muscles and the Glands
      1. Gastrointestinal Motility - movement of material through the tract
      2. Peristalsis
         a. Begins in the esophagus
         b. Wavelike contractions propel or push chyme forward
         c. Involves longitudinal and circular muscles

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3. Segmentation
    a. Occurs in the intestines
    b. Mixes the chyme with more gradual pushing
    c. Periodic squeezing occurs, forcing the contents back a few inches
    d. Helps to mix with digestive juices
    e. Provides access to absorbing surface
4. Liquefying Process
    a. Begins in the mouth
        (i) Chewing
        (ii) Adding saliva
        (iii) Stirring with the tongue
    b. Stomach further mixes and kneads the food
    c. Intestinal muscles promote further breakdown and give further access to the digestive juices
5. Stomach Action
    a. Has three sets of muscles
        (i) Longitudinal
        (ii) Circular
        (iii) Diagonal
    b. Gastric glands secrete juices
    c. Pyloric sphincter opens briefly, about three times per minute, to let portions of the liquefied chyme into the intestine

II. The Process of Digestion
A. Digestive juices come from:
    1. Salivary glands
    2. Stomach
    3. Small intestine
    4. Liver (via gallbladder)
    5. Pancreas
B. Digestion in the Mouth
    1. Salivary glands secrete saliva, which contains:
        a. Water
        b. Salts
        c. Enzymes (including salivary amylase)
    2. Initial breakdown of starches
    3. Other nutrients aren't affected
C. Digestion in the Stomach
    1. Gastric juice = water, enzymes (pepsin), and hydrochloric acid
    2. Acid prevents bacterial growth
    3. Mucus protects the stomach from acid
    4. Initial breakdown of protein occurs
    5. Salivary amylase is digested
    6. Minor events
        a. Digestion of fat by gastric lipase
        b. Digestion of sucrose by stomach acid
        c. Attachment of protein carrier to vitamin B_{12}

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D. Digestion in the Small and Large Intestines Internet Activity 2-1
   1. Pancreatic juice contains digestive enzymes and bicarbonate
   2. Digestive Enzymes - enzymes to digest carbohydrates, fats, and protein
   3. Bicarbonate - sodium bicarbonate to neutralize acidic chyme
   4. Bile
      a. Secreted by liver and stored in gallbladder
      b. Emulsifies fat so that enzymes can work on it
      c. Emulsifiers are substances that disperse fat in water
   5. The Rate of Digestion
      a. Depends on the contents of the meal
      b. More rapid digestion with simple sugars
      c. Slower digestion with fats
   6. Protective Factors
      a. GI bacteria protect against infectious bacteria
      b. GI tract and small intestine have cells that confer specific immunity against intestinal disease
   7. The Final Stage Crossword 2, Internet Activity 2-2
      a. Energy-yielding nutrients are disassembled to basic building blocks and then absorbed
      b. Vitamins, minerals, and water are absorbed as they are
      c. Undigested residues such as fibers enter the colon and are excreted
      d. Adequate ingestion of fiber and water relieves constipation

III. The Absorptive System
   A. The Small Intestine
      1. Villi and Microvilli
         a. Most absorption occurs in the small intestine
         b. Intestinal surface contains villi (fingerlike projections) and microvilli (microscopic "hairs"), which absorb nutrients
      2. Specialization in the Intestinal Tract - the cells of successive portions of the GI tract are specialized to absorb different nutrients
      3. The Myth of "Food Combining"
         a. Eating different foods at the same time (such as fruit and meat) does not cause problems for the digestive system
         b. Some combinations are beneficial: vitamin C from citrus fruits aids in the absorption of iron from meats
   B. Absorption of Nutrients
      1. Water-soluble nutrients and small fat molecules are released into the blood
      2. Larger fats and fat-soluble vitamins are released into the lymphatic system
      3. Fats need packaging for transport
      4. Combine with special proteins to form chylomicrons, a type of lipoprotein

Worksheet 2-2

IV. Transport of Nutrients
   A. The Vascular System
      1. Circulatory system: heart → arteries → capillaries → veins → heart
      2. Digestive vascular system: heart → arteries → capillaries in intestines → hepatic portal vein → liver → sinusoid →vein → heart
   B. The Lymphatic System - a one-way route for fluids to travel from tissue spaces to the blood

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C. Transport of Lipids: Lipoproteins
    1. Lipids travel within the circulatory system bundled with a protein
    2. Chylomicrons, a type of lipoprotein, transport newly absorbed dietary lipids from the intestinal cells to the rest of the body
    3. VLDL, LDL, and HDL - very low-density lipoprotein, low-density lipoprotein, and high-density lipoprotein
        a. As chylomicrons circulate, their lipid contents are removed by cells, so they become smaller and smaller
        b. Liver picks up chylomicron remnants and makes VLDL
        c. Triglycerides are removed and they become cholesterol-rich LDL
        d. Cholesterol returning to liver is packaged as HDL
    4. Health Implications of LDL and HDL
        a. Elevated concentrations of LDL are associated with risk of heart disease
        b. Elevated concentrations of HDL are associated with low risk of heart disease
        c. Ways to improve HDL/LDL ratio
            (i) Weight management
            (ii) Intake of poly- or monounsaturated fat instead of saturated fat
            (iii) Intake of soluble fibers
    5. Physical activity
D. The System at Its Best - the GI tract is sensitive and responsive to environmental conditions

V. Nutrition in Practice - Food Safety
A. The FDA lists foodborne illness as the leading food safety concern in the US
B. What is foodborne illness? - illness caused by food infection or intoxication
C. What is the difference between foodborne infections and food intoxications?
    1. Infection is caused by eating food contaminated by infectious microbes
    2. Intoxication is caused by eating food containing natural toxins or microbes that produce toxins
D. How do people get foodborne illness?
    1. Errors in food handling by individuals
    2. Errors made by food manufacturers or chefs
E. What kinds of programs are in place to help keep food safe?
    1. FDA working with other countries to help them adopt safe food-handling practices
    2. HACCP
F. Are foods bought in grocery stores and foods eaten in restaurants safe?
    1. "Sell by" dates
    2. Safety seals
    3. Package wrappers
    4. Government-provided guidelines on cleanliness and safe food preparation
    5. Consumer actions to help prevent foodborne illness when dining out
        a. Hand washing
        b. Expect cleanliness
        c. Expect food served at appropriate temperatures
        d. Refrigerate take-home food within two hours

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G. What can people do to protect themselves from foodborne illness?
    1. Keep a clean, safe kitchen
    2. Avoid cross-contamination
    3. Keep hot foods hot
    4. Keep cold foods cold
H. What precautions need to be taken when preparing meat and poultry? - cook to proper temperatures
I. How can a person enjoy seafood safely?
    1. Cook fish until opaque
    2. Choose pasteurized oysters
    3. Keep seafood cold and clean before cooking
J. Do foods that are unsafe to eat smell bad?
    1. Some bacterial waste produces off-odors
    2. Not all do
    3. Health Departments and USDA Extension Service offices can provide guidelines
K. How can a person defend against foodborne illness when traveling to foreign countries?
    1. Wash hands frequently and/or properly use hand sanitizers
    2. Eat only well-cooked and hot or canned foods
    3. Wash produce to be eaten raw with purified water
    4. Use only water that has been purified
    5. Refuse unpasteurized and improperly refrigerated milk products
    6. Travel with antidiarrheal medications

Answers to Global Nutrition Watch Activities

1. b
2. c
3. wash fresh vegetables with warm water and a scrub brush

Answers to Text "Clinical Applications" Questions

1. The nutrients that are ready for absorption early are absorbed near the top of the gastrointestinal tract, and those that take longer to be digested are absorbed further down. Although much of the digestion of carbohydrates and proteins begins to take place in the mouth and stomach, respectively, the major enzymes that promote fat digestion are not present until fat reaches the small intestine. Fat absorption into the vascular system and cells is more complex than that of either carbohydrates or protein. The water-soluble nutrients from carbohydrate and protein digestion (and the smaller products of fat digestion) are released directly into the blood. However, the larger fats and fat-soluble vitamins are insoluble in water and need to be packaged for transport into the vascular system. Whereas water-soluble nutrients are absorbed directly into the bloodstream, fat-soluble nutrients are absorbed into the lymph. This lymph eventually returns to the bloodstream in an area near the heart. Because fat digestion and absorption are complex and rely on many different body tissues and processes, there is ample opportunity for something to go wrong. Thus, fat is not absorbed normally in most malabsorption disorders.

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2. The following information on fiber could be given to a client who frequently experiences constipation:

   Some fibers are not absorbed by the digestive tract, but continue through and are excreted in the stool. They promote the wavelike contractions that keep food moving through the intestine. Fiber also absorbs many times its weight in water, which causes a large, soft, bulky stool that passes through the bowel easily and quickly. A softer, larger stool helps prevent constipation and straining. Drinking plenty of water, in addition to eating foods high in fiber, supplies fluids for the fiber to absorb. This is why it is recommended to drink plenty of fluids when eating high-fiber foods to relieve constipation.

Answer Keys for Assignments

The following assignment/review worksheets are provided for duplication at the end of this instructor's manual section:

- Worksheet 2-1: Digestive Organs Matching Exercise
- Worksheet 2-2: Digestion and Absorption Review
- Crossword 2-1: The Glands and Fluids of Digestion

Answer Key: Worksheet 2-1

1.	G	3.	A	5.	F	7.	D	9.	B	11.	C
2.	D	4.	C	6.	H	8.	E	10.	D	12.	D

Answer Key: Worksheet 2-2

1. The tongue moves the food around the mouth, facilitating chewing and swallowing. The teeth crush and soften food and moisten it for swallowing. The salivary glands in the mouth excrete saliva, which dissolves foods. Enzymes known as amylases begin to break down carbohydrates.
2. The muscular actions of peristalsis, segmentation, and sphincter contraction help to propel food through the gastrointestinal tract.
3. The cells of the stomach wall secrete mucus that coats and protects the stomach's lining.
4. Choosing monounsaturated and polyunsaturated fats instead of saturated fats, choosing foods high in soluble fibers, maintaining a healthy weight, and being physically active can improve the LDL-to-HDL ratio.
5. Nutrients are trapped among the villi and microvilli of the intestinal wall, and, with the help of enzymes, are completely digested and absorbed into the cells beneath them. Water-soluble nutrients and small lipids will move from the microvilli into the blood. Larger lipids, cholesterol, and fat-soluble vitamins will move into the lymph vessels.
6. The enzyme pepsin works with the stomach acids to help break down proteins.
7. The pancreas secretes pancreatic juices, which contribute enzymes that help to digest fats, protein, and carbohydrates.
8. Bile is produced by the liver and stored in the gallbladder. It helps emulsify fats so that enzymes can break them down for absorption.
9. The nutrient content of meals can influence the rate of digestion. High-fat meals remain in the stomach longer than high-carbohydrate meals.
10. Adequate fiber and fluids in the diet contribute to regularity and prevent constipation.

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11. HCl (hydrochloric acid) kills some of the bacteria on food that may cause foodborne illness.
12. Large lipids, cholesterol, and fat-soluble vitamins are packaged with protein into chylomicrons (a type of lipoprotein) for absorption into the lymph vessels.

Answer Key: Crossword 2

1. bicarbonate
2. intestinal juice
3. mucus
4. saliva
5. hydrochloric acid
6. salivary glands

7A. pancreatic juice

7D. pepsin

8. amylase
9. emulsifier
10. bile
11. gastric juice
12. gastric glands

Teaching Suggestions

2-1 Demonstration of the Digestive System

Coil a 23′ rope or dialysis hose in a bag. Begin the demonstration by pulling the rope out of the bag without disclosing its length. Expand on the concept of the size of the small intestine and large intestine by discussing the surface area. Another adaptation would be to depict the whole length of the digestive system, including the mouth, esophagus, stomach, small intestine, large intestine, and rectum by using the same rope.[1]

2-2 Digestion and Absorption

The study of digestion and absorption requires learning an immense number of new terms. With beginning students, it helps to introduce the GI tract systematically, using a chart or a film, and naming each part in sequence; then, use all the names with the chart while explaining the processes of digestion and absorption. Warn students frankly that the task of learning the digestive system parts and their functions is unglamorous but essential. To bring the subject to life, digress at intervals to share related knowledge they find intrinsically interesting about choking, ulcers, and other topics.[2]

2-3 Learning Game

The popularity of the game "Trivial Pursuit" inspired the construction of a similar game for use with students. The game, of course, was called "Nutritional Pursuit," and it was used for a nutrition and disease course, although it could be used for almost any course if the questions were modified. The students enjoyed it and it really helped to reinforce what they learned in class.[3]

Internet Activities

2-1 Analysis of Internet Sites

Have students go to the following websites to look for information.

- American College of Gastroenterology: http://gi.org//
  Click on Patients and then GI Health & Disease. Have each student find information on a different disease of the GI tract and how that disease affects normal digestion or absorption.

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[1] L. Fishman, *Instructor's Manual to Accompany Nutrition: Concepts and Controversies, Fourth Edition* (St. Paul, MN: West, 1988) p. 7.

[2] L.W. Turner, *Instructor's Manual for Understanding Nutrition, Eighth Edition* (Belmont, CA: West/Wadsworth, 1999).

[3] Thanks to Gail Kauwell, University of Florida.

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- Three Rivers Endoscopy Center: http://www.gihealth.com/
  Click on Patient Education, then on Patient Pamphlets, and then on How Your Digestive System Works. Students can find a user-friendly description of digestion and pictures of the GI tract.

2-2 Research on Products for Digestive Problems

Have students search the Internet to learn about over-the-counter products designed to treat common digestive problems such as heartburn, constipation, diarrhea, and hemorrhoids. Have them write a brief paper which describes the appropriate and inappropriate uses of these medications and adverse health implications associated with misuse and overuse of certain medications.

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Worksheet 2-1: Digestive Organs Matching Exercise

Instructions: Match the letter for the organ on the right to its function(s) in digestion or absorption on the left. You may use an organ more than once.

Function in the Body

_____ 1. Bile is stored

_____ 2. The pancreatic duct delivers digestive enzymes here

_____ 3. Carbohydrate digestion begins

_____ 4. Pepsin is produced for protein digestion

_____ 5. Bicarbonate is produced here to neutralize stomach acid

_____ 6. Bile is produced

_____ 7. Large lipids are packaged in chylomicrons for absorption

_____ 8. Bacteria degrade some of the fiber from food

_____ 9. Using peristalsis, food is transported from the mouth to the lower esophageal sphincter

_____ 10. Most digestion of carbohydrates, fats, and proteins occurs here

_____ 11. Starch digestion stops because of the acidic conditions

_____ 12. Bile emulsifies fat so enzymes can penetrate and digest it

Organ

A. Mouth

B. Esophagus

C. Stomach

D. Small intestine

E. Large intestine (colon)

F. Pancreas

G. Gallbladder

H. Liver

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Worksheet 2-2: Digestion and Absorption Review

1. What factors contribute to digestion in the mouth?

2. What muscular actions help to propel food through the gastrointestinal tract?

3. Why doesn't gastric fluid cause harm to the stomach?

4. What diet and lifestyle factors can improve a person's LDL-to-HDL ratio?

5. How are nutrients absorbed into the circulatory system through the small intestine?

6. What is the role of pepsin in digestion?

7. What does the pancreas secrete, and how does it contribute to digestion?

8. Where is bile produced, and what is its purpose in digestion?

9. What factors can alter the rate of digestion?

10. What role do fiber and fluids play in the process of digestion?

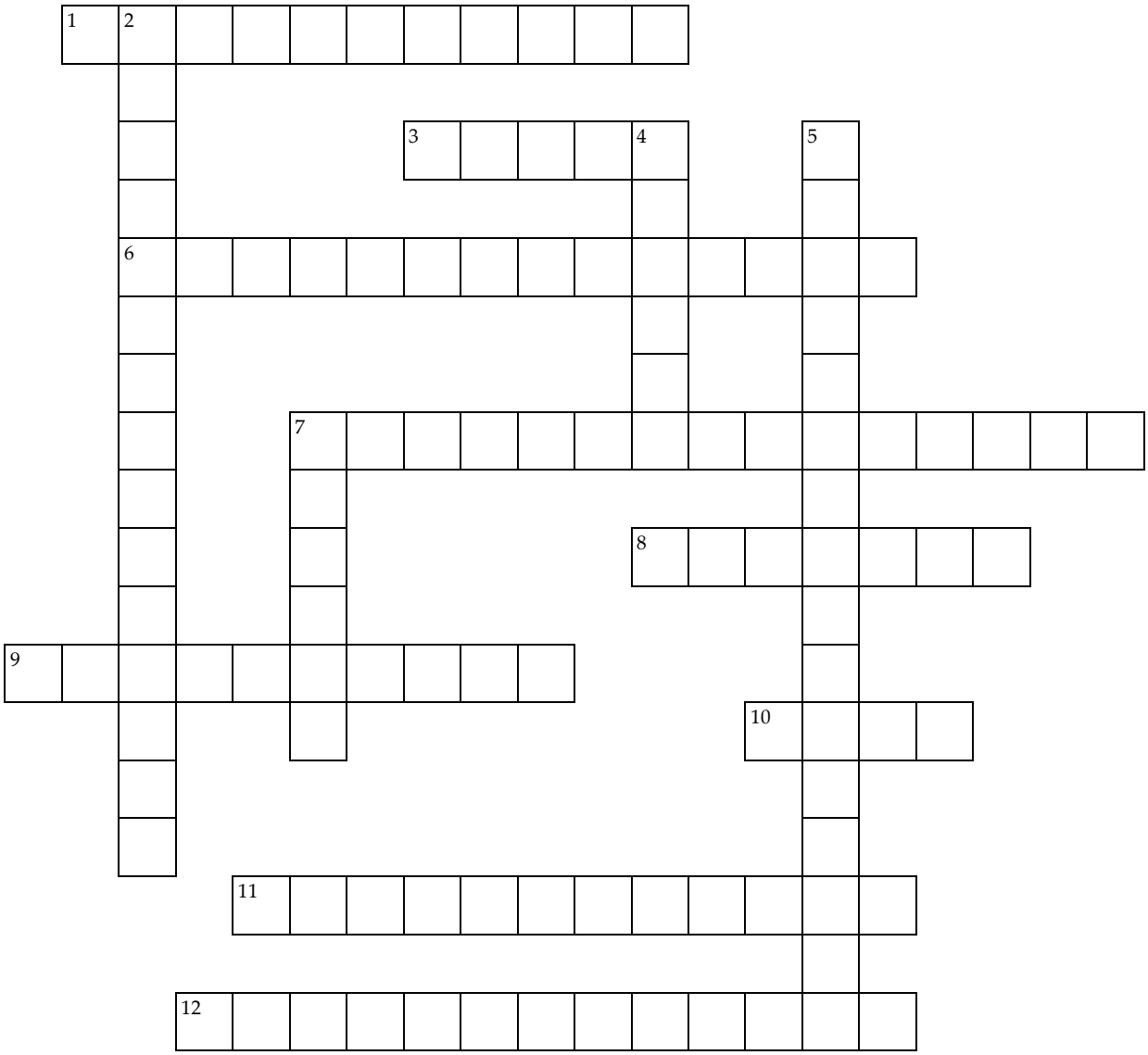
11. What substance produced in the stomach can kill bacteria and lower the risk of foodborne illness?

12. What role do chylomicrons play in absorption?

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Crossword 2: The Glands and Fluids of Digestion



Across	Down
1. An alkaline secretion of the pancreas; part of the pancreatic juice 3. A mucopolysaccharide secreted by cells of the stomach wall that protects the cells from exposure to digestive juices 6. Exocrine glands that secrete saliva into the mouth 7. The exocrine secretion of the pancreas, containing enzymes 8. An enzyme that splits amylose (a form of starch) 9. A substance that mixes with both fat and water and that disperses the fat in the water, forming an emulsion 10. An emulsifier that prepares fats and oils for digestion; made by the liver, stored in the gallbladder, and released into the small intestine when needed 11. The digestive secretion of the gastric glands containing a mixture of water, hydrochloric acid, and enzymes 12. Exocrine glands in the stomach wall that secrete gastric juice into the stomach	2. The secretion of the intestinal glands 4. The secretion of the salivary glands 5. An acid composed of hydrogen and chloride atoms 7. A protein-digesting enzyme (gastric protease) in the stomach

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