Emesis

Emesis, or vomiting, is elimination of food by forceful expulsion through the mouth. It is often in response to an irritant that affects the digestive tract, including but not limited to viruses, bacteria, emotions, sights, and food poisoning. This forceful expulsion of the food is due to the strong contractions produced by the stomach muscles. The process of emesis is regulated by the medulla.

34.4 Digestive System Regulation

By the end of this section, you will be able to do the following:

- Discuss the role of neural regulation in digestive processes
- Explain how hormones regulate digestion

The brain is the control center for the sensation of hunger and satiety. The functions of the digestive system are regulated through neural and hormonal responses.

Neural Responses to Food

In reaction to the smell, sight, or thought of food, like that shown in Figure 34.20, the first response is that of salivation. The salivary glands secrete more saliva in response to stimulation by the autonomic nervous system triggered by food in preparation for digestion. Simultaneously, the stomach begins to produce hydrochloric acid to digest the food. Recall that the peristaltic movements of the esophagus and other organs of the digestive tract are under the control of the brain. The brain prepares these muscles for movement as well. When the stomach is full, the part of the brain that detects satiety signals fullness. There are three overlapping phases of gastric control—the cephalic phase, the gastric phase, and the intestinal phase—each requires many enzymes and is under neural control as well.

Figure 34.20 Seeing a plate of food triggers the secretion of saliva in the mouth and the production of HCL in the stomach. (credit: Kelly Bailey)

Digestive Phases

The response to food begins even before food enters the mouth. The first phase of ingestion, called the **cephalic phase**, is controlled by the neural response to the stimulus provided by food. All aspects—such as sight, sense, and smell—trigger the neural responses resulting in salivation and secretion of gastric juices. The gastric and salivary secretion in the cephalic phase can also take place due to the thought of food. Right now, if you think about a piece of chocolate or a crispy potato chip, the increase in salivation is a cephalic phase response to the thought. The central nervous system prepares the stomach to receive food.

The **gastric phase** begins once the food arrives in the stomach. It builds on the stimulation provided during the cephalic phase. Gastric acids and enzymes process the ingested materials. The gastric phase is stimulated by (1) distension of the stomach, (2) a decrease in the pH of the gastric contents, and (3) the presence of undigested material. This phase consists of local, hormonal, and neural responses. These responses stimulate secretions and powerful contractions.

The **intestinal phase** begins when chyme enters the small intestine triggering digestive secretions. This phase controls the rate of gastric emptying. In addition to gastrin emptying, when chyme enters the small intestine, it triggers other hormonal and neural events that coordinate the activities of the intestinal tract, pancreas, liver, and gallbladder.

Hormonal Responses to Food

The **endocrine system** controls the response of the various glands in the body and the release of hormones at the appropriate times.

One of the important factors under hormonal control is the stomach acid environment. During the gastric phase, the hormone **gastrin** is secreted by G cells in the stomach in response to the presence of proteins. Gastrin stimulates the release of stomach acid, or hydrochloric acid (HCl) which aids in the digestion of the proteins. However, when the stomach is emptied, the acidic environment need not be maintained and a hormone called **somatostatin** stops the release of hydrochloric acid. This is controlled by a negative feedback mechanism.

In the duodenum, digestive secretions from the liver, pancreas, and gallbladder play an important role in digesting chyme during the intestinal phase. In order to neutralize the acidic chyme, a hormone called **secretin** stimulates the pancreas to produce alkaline bicarbonate solution and deliver it to the duodenum. Secretin acts in tandem with another hormone called **cholecystokinin** (CCK). Not only does CCK stimulate the pancreas to produce the requisite pancreatic juices, it also stimulates the gallbladder to release bile into the duodenum.

LINK TO LEARNING

Visit this website (http://openstax.org/l/enteric_endo) to learn more about the endocrine system. Review the text and watch the animation of how control is implemented in the endocrine system.

Another level of hormonal control occurs in response to the composition of food. Foods high in lipids take a long time to digest. A hormone called **gastric inhibitory peptide** is secreted by the small intestine to slow down the peristaltic movements of the intestine to allow fatty foods more time to be digested and absorbed.

Understanding the hormonal control of the digestive system is an important area of ongoing research. Scientists are exploring the role of each hormone in the digestive process and developing ways to target these hormones. Advances could lead to knowledge that may help to battle the obesity epidemic.

KEY TERMS

alimentary canal tubular digestive system with a mouth and anus
aminopeptidase protease that breaks down peptides to single amino acids; secreted by the brush border of small intestine
anus exit point for waste material
bile digestive juice produced by the liver; important for digestion of lipids
bolus mass of food resulting from chewing action and wetting by saliva
carboxypeptidase protease that breaks down peptides to single amino acids; secreted by the brush border of the small intestine
carnivore animal that consumes animal flesh
cephalic phase first phase of digestion, controlled by the neural response to the stimulus provided by food
cholecystokinin hormone that stimulates the contraction of the gallbladder to release bile
chylomicron small lipid globule
chyme mixture of partially digested food and stomach juices
chymotrypsin pancreatic protease
digestion mechanical and chemical breakdown of food into small organic fragments
dipeptidase protease that breaks down peptides to single amino acids; secreted by the brush border of small intestine
duodenum first part of the small intestine where a large part of digestion of carbohydrates and fats occurs
elastase pancreatic protease
endocrine system system that controls the response of the various glands in the body and the release of hormones at the appropriate times
esophagus tubular organ that connects the mouth to the stomach
essential nutrient nutrient that cannot be synthesized by the body; it must be obtained from food
gallbladder organ that stores and concentrates bile
gastric inhibitory peptide hormone secreted by the small intestine in the presence of fatty acids and sugars; it also inhibits acid production and peristalsis in order to slow down the rate at which food enters the small intestine
gastric phase digestive phase beginning once food enters the stomach; gastric acids and enzymes process the ingested materials
gastrin hormone which stimulates hydrochloric acid secretion in the stomach
gastrovascular cavity digestive system consisting of a single opening
gizzard muscular organ that grinds food
herbivore animal that consumes a strictly plant diet
ileum last part of the small intestine; connects the small intestine to the large intestine; important for absorption of B-12
ingestion act of taking in food
intestinal phase third digestive phase; begins when chyme enters the small intestine triggering digestive secretions and controlling the rate of gastric emptying
jejunum second part of the small intestine
lactase enzyme that breaks down lactose into glucose and galactose
large intestine digestive system organ that reabsorbs water from undigested material and processes waste matter
lipase enzyme that chemically breaks down lipids
liver organ that produces bile for digestion and processes vitamins and lipids
maltase enzyme that breaks down maltose into glucose
mineral inorganic, elemental molecule that carries out important roles in the body
monogastric digestive system that consists of a single-chambered stomach
omnivore animal that consumes both plants and animals
pancreas gland that secretes digestive juices
pepsin enzyme found in the stomach whose main role is protein digestion
pepsinogen inactive form of pepsin
peristalsis wave-like movements of muscle tissue
proventriculus glandular part of a bird's stomach
rectum area of the body where feces is stored until elimination
roughage component of food that is low in energy and high in fiber
ruminant animal with a stomach divided into four compartments
salivary amylase enzyme found in saliva, which converts carbohydrates to maltose
secretin hormone which stimulates sodium bicarbonate secretion in the small intestine
small intestine organ where digestion of protein, fats, and carbohydrates is completed
somatostatin hormone released to stop acid secretion when the stomach is empty
sphincter band of muscle that controls movement of materials throughout the digestive tract
stomach saclike organ containing acidic digestive juices
sucrase enzyme that breaks down sucrose into glucose and fructose
trypsin pancreatic protease that breaks down protein
villi folds on the inner surface of the small intestine whose role is to increase absorption area
vitamin organic substance necessary in small amounts to sustain life

CHAPTER SUMMARY

34.1 Digestive Systems

Different animals have evolved different types of digestive systems specialized to meet their dietary needs. Humans and many other animals have monogastric digestive systems with a single-chambered stomach. Birds have evolved a digestive system that includes a gizzard where the food is crushed into smaller pieces. This compensates for their inability to masticate. Ruminants that consume large amounts of plant material have a multi-chambered stomach that digests roughage. Pseudo-ruminants have similar digestive processes as ruminants but do not have the four-compartment stomach. Processing food involves ingestion (eating), digestion (mechanical and enzymatic breakdown of large molecules), absorption (cellular uptake of nutrients), and elimination (removal of undigested waste as feces).

Many organs work together to digest food and absorb nutrients. The mouth is the point of ingestion and the location where both mechanical and chemical breakdown of food begins. Saliva contains an enzyme called amylase that breaks down carbohydrates. The food bolus travels through the esophagus by peristaltic movements to the stomach. The stomach has an extremely acidic environment. An enzyme called pepsin digests protein in the stomach. Further digestion and absorption take place in the small intestine. The large intestine reabsorbs water from the undigested food and stores waste until elimination.

34.2 Nutrition and Energy Production

Animal diet should be balanced and meet the needs of the body. Carbohydrates, proteins, and fats are the primary components of food. Some essential nutrients are required for cellular function but cannot be produced by the animal body. These include vitamins, minerals, some fatty acids, and some amino acids. Food intake in more than necessary amounts is stored as glycogen in the liver and muscle cells, and in fat cells. Excess adipose storage can lead to obesity and serious health problems. ATP is the energy currency of the cell and is obtained from the metabolic pathways. Excess carbohydrates and energy are stored as glycogen in the body.

34.3 Digestive System Processes

Digestion begins with ingestion, where the food is taken in the mouth. Digestion and absorption take place in a series of steps with special enzymes playing important roles in digesting carbohydrates, proteins, and lipids. Elimination describes removal of undigested food contents and waste products from the body. While most absorption occurs in the small intestines, the large intestine is responsible for the final removal of water that remains after the absorptive process of the small intestines. The cells that line the large intestine absorb some vitamins as well as any leftover salts and water. The large intestine (colon) is also where feces is formed.

34.4 Digestive System Regulation

The brain and the endocrine system control digestive processes. The brain controls the responses of hunger and satiety. The endocrine system controls the release of hormones and enzymes required for digestion of food in the digestive tract.

VISUAL CONNECTION QUESTIONS

1. Figure 34.11 Which of the following statements about the digestive system is false?
   a. Chyme is a mixture of food and digestive juices that is produced in the stomach.
   b. Food enters the large intestine before the small intestine.
   c. In the small intestine, chyme mixes with bile, which emulsifies fats.
   d. The stomach is separated from the small intestine by the pyloric sphincter.

2. Figure 34.12 Which of the following statements about the small intestine is false?
   a. Absorptive cells that line the small intestine have microvilli, small projections that increase surface area and aid in the absorption of food.
   b. The inside of the small intestine has many folds, called villi.
   c. Microvilli are lined with blood vessels as well as lymphatic vessels.
   d. The inside of the small intestine is called the lumen.

3. Figure 34.19 Which of the following statements about digestive processes is true?
   a. Amylase, maltase, and lactase in the mouth digest carbohydrates.
   b. Trypsin and lipase in the stomach digest protein.
   c. Bile emulsifies lipids in the small intestine.
   d. No food is absorbed until the small intestine.

REVIEW QUESTIONS

4. Which of the following is a pseudo-ruminant?
   a. cow
   b. pig
   c. crow
   d. horse

5. Which of the following statements is untrue?
   a. Roughage takes a long time to digest.
   b. Birds eat large quantities at one time so that they can fly long distances.
   c. Cows do not have upper teeth.
   d. In pseudo-ruminants, roughage is digested in the cecum.

6. The acidic nature of chyme is neutralized by _____.
   a. potassium hydroxide
   b. sodium hydroxide
   c. bicarbonates
   d. vinegar

7. The digestive juices from the liver are delivered to the _____.
   a. stomach
   b. liver
   c. duodenum
   d. colon

8. A scientist dissects a new species of animal. If the animal's digestive system has a single stomach with an extended small intestine, to which animal could the dissected specimen be closely related?
   a. lion
   b. snowshoe hare
   c. earthworm
   d. eagle

9. Which of the following statements is not true?
   a. Essential nutrients can be synthesized by the body.
   b. Vitamins are required in small quantities for bodily function.
   c. Some amino acids can be synthesized by the body, while others need to be obtained from diet.
   d. Vitamins come in two categories: fat-soluble and water-soluble.

10. Which of the following is a water-soluble vitamin?
    a. vitamin A
    b. vitamin E
    c. vitamin K
    d. vitamin C

11. What is the primary fuel for the body?
    a. carbohydrates
    b. lipids
    c. protein
    d. glycogen

12. Excess glucose is stored as _____.
    a. fat
    b. glucagon
    c. glycogen
    d. it is not stored in the body

13. Many distance runners "carb load" the day before a big race. How does this eating strategy provide an advantage to the runner?
    a. The carbohydrates cause the release of insulin.
    b. The excess carbohydrates are converted to fats, which have a higher calorie density.
    c. The glucose from the carbohydrates lets the muscles make excess ATP overnight.
    d. The excess carbohydrates can be stored in the muscles as glycogen.

14. Where does the majority of protein digestion take place?
    a. stomach
    b. duodenum
    c. mouth
    d. jejunum

15. Lipases are enzymes that breakdown _____.
    a. disaccharides
    b. lipids
    c. proteins
    d. cellulose

16. Which of the following conditions is most likely to cause constipation?
    a. bacterial infection
    b. dehydration
    c. ulcer
    d. excessive cellulose consumption

17. Which hormone controls the release of bile from the gallbladder
    a. pepsin
    b. amylase
    c. CCK
    d. gastrin

18. Which hormone stops acid secretion in the stomach?
    a. gastrin
    b. somatostatin
    c. gastric inhibitory peptide
    d. CCK

19. In the famous conditioning experiment, Pavlov demonstrated that his dogs started drooling in response to a bell sounding. What part of the digestive process did he stimulate?
    a. cephalic phase
    b. gastric phase
    c. intestinal phase
    d. elimination phase

CRITICAL THINKING QUESTIONS

20. How does the polygastric digestive system aid in digesting roughage?
21. How do birds digest their food in the absence of teeth?
22. What is the role of the accessory organs in digestion?
23. Explain how the villi and microvilli aid in absorption.
24. Name two components of the digestive system that perform mechanical digestion. Describe how mechanical digestion contributes to acquiring nutrients from food.
25. What are essential nutrients?
26. What is the role of minerals in maintaining good health?
27. Discuss why obesity is a growing epidemic.
28. There are several nations where malnourishment is a common occurrence. What may be some of the health challenges posed by malnutrition?
29. Generally describe how a piece of bread can power your legs as you walk up a flight of stairs.
30. In the 1990s fat-free foods became popular among people trying to lose weight. However, many dieticians now conclude that the fat-free trend made people less healthy and heavier. Describe how this could occur.
31. Explain why some dietary lipid is a necessary part of a balanced diet.
32. The gut microbiome (the bacterial colonies in the intestines) have become a popular area of study in biomedical research. How could varying gut microbiomes impact a person's nutrition?
33. Many mammals become ill if they drink milk as adults even though they could consume it as babies. What causes this digestive issue?
34. Describe how hormones regulate digestion.
35. Describe one or more scenarios where loss of hormonal regulation of digestion can lead to diseases.
36. A scientist is studying a model that has a mutation in the receptor for somatostatin that prevents hormone binding. How would this mutation affect the structure and function of the digestive system?