

# Digestion



## Chapter Outline

- I. The Digestive Process
  - A. Mechanical Digestion
  - B. Chemical Digestion
- II. The Digestive System
  - A. The Mouth
  - B. The Pharynx and Esophagus
  - C. The Stomach
  - D. The Small Intestine
  - E. The Large Intestine
- III. Problems of the Digestive System
  - A. Indigestion and Ulcers
  - B. Diarrhea and Constipation

For a chapter planning guide, teaching strategies with performance and highlighted skills objectives, and answers for activities and features, see pages T-116-T-119.

## Objectives

After you have completed this chapter, you will be able to

- 21-1 **compare** mechanical and chemical digestion.
- 21-1 **describe** the function of enzymes in chemical digestion.
- 21-2 **identify** the organs of the digestive system.
- 21-2 **state** what happens to food in the small intestine.
- 21-3 **identify** some problems of the digestive system.

## Science Process Skills

In this chapter, two science skills are highlighted. Symbols show some places where these skills are used.

- ▲ **Organizing:** When you organize information, you put the information in some kind of order.
- **Hypothesizing:** When you hypothesize, you state a suggested answer to a problem based upon known information.

Nutrients are chemical substances your body needs to function properly. You get the nutrients your body needs from food. However, the food you eat is not in a form your body can use. The large food molecules must be broken down into usable forms. The process of breaking down food into forms the body can use is called **digestion** (dy-JES-chun).

Even before you put food into your mouth, your body is getting ready for digestion. When you are hungry and smell food, your brain stimulates the production of **saliva**. You may be familiar with the expression "my mouth is watering" to describe the production of saliva. Saliva is made by the salivary glands. A cross-section of a salivary gland is shown in the photograph. The salivary glands are just one part of the digestive system.

## 21-1 The Digestive Process

### Key Points

- Mechanical digestion breaks down food into small pieces. Chemical digestion breaks down large molecules into small ones.
- Enzymes are proteins that control chemical reactions in the body.

### Study Hint

Turn to Chapter 3 to review proteins, carbohydrates, and fats.

Chemical digestion increases the surface area of food. To demonstrate how mechanical digestion increases surface area, hold two cubes, such as dice together. Tell your students to imagine that the joined cubes are a piece of food. Ask them how many sides are exposed to the air. (6) Then pull the cubes apart. Again, ask how many sides are exposed to the air. (12)

During digestion, food is broken down into forms the body can use. This breaking down process involves both physical and chemical changes in the food. A physical change is a change in the physical properties of a substance. Some examples of physical properties are shape, size, color, and odor.

Tear a sheet of paper into many small pieces. You have just caused a physical change. You have changed the paper's size and shape, but it is still paper. Unlike a physical change, a chemical change results in new substances. Think of what happens when wood burns. Wood is changed into new substances, including ash and soot.

All of your food is made up of one or more nutrients. Proteins, vitamins, and minerals are three groups of nutrients. Carbohydrates and fats are other groups of nutrients. Vitamins and minerals can pass directly from the digestive system into the body without undergoing a chemical change. However, carbohydrates, proteins, and fats must be broken down into smaller, usable forms.

### Mechanical Digestion

The physical breakdown of food into small pieces is called **mechanical digestion**. Mechanical digestion breaks large pieces of food into smaller ones. However, it does not change the substances in food.

What would happen if you tried to swallow a whole cracker? You probably would choke. What do you do with the cracker? You chew it and break the cracker into smaller and smaller pieces. Chewing and grinding are two ways that food is mechanically digested.

### Chemical Digestion

The process by which large food molecules are broken down into smaller molecules is called **chemical digestion**. For example, a cracker is made up mostly of starch. Starch is a carbohydrate that is made up of many glucose molecules joined together. Glucose is a simple sugar. It is a small molecule that is used by the body for energy. Before

your body can use the starch in crackers, the starch must be broken down into simple sugars by chemical digestion. Look at Table 21-1. What small molecules are fats broken down into during chemical digestion? fatty acids and glycerol  
(Interpreting charts)

**Table 21-1 Chemical Digestion of Nutrients**

Carbohydrates	→ change to	→ simple sugars
Proteins	→ change to	→ amino acids
Fats	→ change to	→ fatty acids and glycerol

In the digestive system, important chemicals called **enzymes** (EN-zyms) are released. Enzymes are proteins that control chemical reactions in the body, including the chemical digestion of food. How do enzymes control chemical reactions in the body? Enzymes speed up or slow down chemical reactions. They speed up chemical digestion. Enzymes combine temporarily with the large molecules in food and break them apart into smaller molecules.

Each enzyme can break down only one specific kind of food molecule. For example, enzymes that break down fats have no effect on carbohydrates and proteins. In the digestive system, enzymes are produced in liquids called digestive juices.

## Think & Discuss

1. What is the function of enzymes?
2. What is the difference between mechanical digestion and chemical digestion?
- ★ 3. Why must food undergo chemical digestion before it can be used by the body?

## 21-2 The Digestive System

Digestion is a process in which many organs work together. Some organs that make up the digestive system form a long tubelike structure called the **alimentary** <sup>7</sup> (al-uh-MEN-tuhr-ee) **canal**. Other digestive organs, such as the liver, pancreas, and gallbladder, are not part of the alimentary canal. However, these organs do help with digestion.

Enzymes speed up the hydrolysis of nutrients into simpler substances.

1. Enzymes control chemical reactions in the body.
2. During mechanical digestion, large pieces of food are broken down into smaller pieces. During chemical digestion, large food molecules are broken down into smaller ones.
3. Large molecules are too big to enter the blood. (Relating concepts)

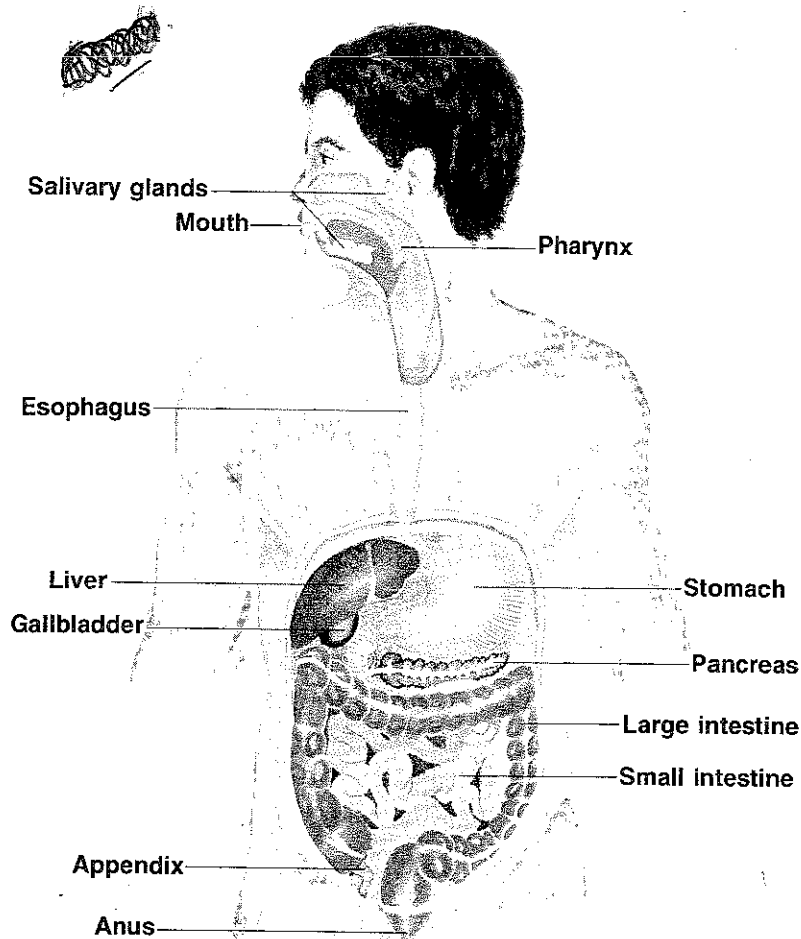
### Key Points

- The digestive system is made up of organs located in the alimentary canal and other organs that aid in digestion.
- Absorption takes place in the small intestine.

### Study Hint

After you read Section 21-2, list the digestive actions that occur in each organ of the alimentary canal.

**Figure 21-1** Food does not pass through the salivary glands, liver, gallbladder, pancreas, or appendix on its way through the digestive system. Through which organs does food pass? mouth, pharynx, esophagus, stomach, small intestine, large intestine, anus



You can see the digestive system in Figure 21-1. Notice that the digestive system begins at the mouth and ends at the anus. In Figure 21-1, you can trace the path food takes on its trip through the digestive system.

### The Mouth

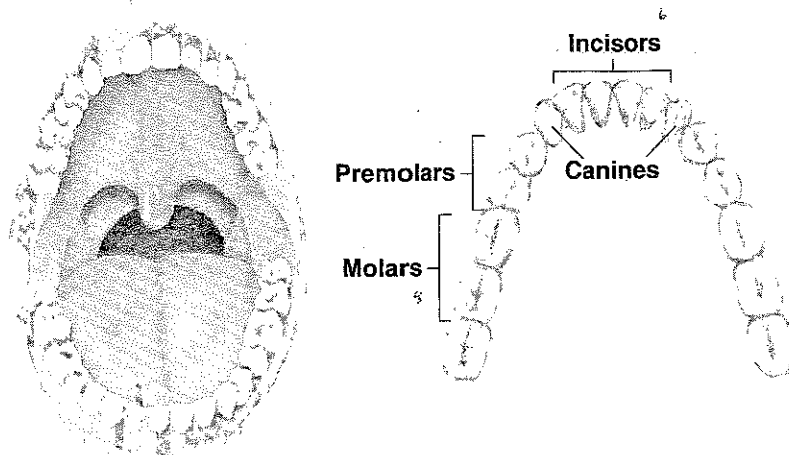
Food enters the digestive system through the mouth. In the mouth, the teeth begin the mechanical digestion of food. How do the teeth carry out mechanical digestion? The teeth cut, tear, grind, and crush large pieces of food into smaller pieces. Figure 21-2 on page 365 shows the teeth of an adult. How many teeth do adults have? 32 (Interpreting diagrams)

People have four different kinds of teeth. Each kind of tooth has a different function. The incisors and canines cut and tear food. The premolars and molars grind and crush food. Look at Figure 21-2 again. How are the shapes of the teeth adapted to their functions?

### Study Hint

You can learn more about caring for your teeth by reading the *Biology, Technology, and Society* feature at the end of the chapter.

Incisors and canines are sharp for tearing; premolars and molars have flat tops for grinding and crushing. (Interpreting diagrams)



**Figure 21-2** You probably have only 28 teeth. The third set of molars, called wisdom teeth, usually grow in during your twenties.

Do you think your tongue helps with chewing? Your tongue is used to move food around in the mouth and keep food where it can be chewed by the teeth. The tongue also helps mix food with saliva and moves food to the back of the mouth when you swallow.

What does saliva do? As food is broken down into smaller pieces by the teeth and tongue, it also is mixed with saliva. Saliva softens and moistens food. Saliva also begins the chemical digestion of food. Saliva contains an enzyme that starts to break down starch into simpler forms. Why do you think it is important for food to be softened and moistened?

Saliva is made by three pairs of salivary glands. Saliva passes from salivary glands through tiny tubes into the mouth.

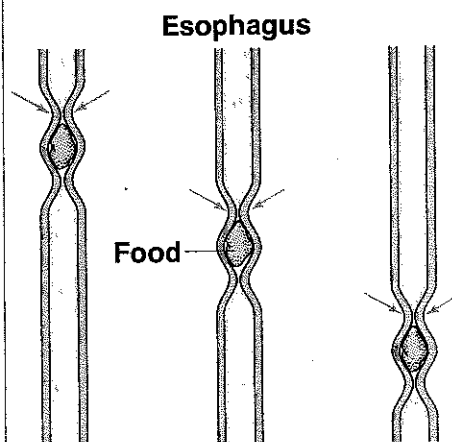
## The Pharynx and Esophagus

When food is swallowed, it enters the **pharynx** (FAR-inks), or throat. The pharynx is a passageway for both food and air. Air goes from the pharynx into the windpipe. Where does food go? It passes into the **esophagus** (i-SAF-uh-gus). The esophagus is a long, muscular tube that connects the mouth to the stomach.

The walls of the esophagus are lined with cells that secrete mucus. The esophagus walls also are made up of two layers of muscles. Mucus helps food move easily through the esophagus. A wave of contractions of the muscles forces the food downward to the stomach. The wavelike movement that moves food through the digestive system is called **peristalsis** (per-uh-STAWL-sis). Gravity

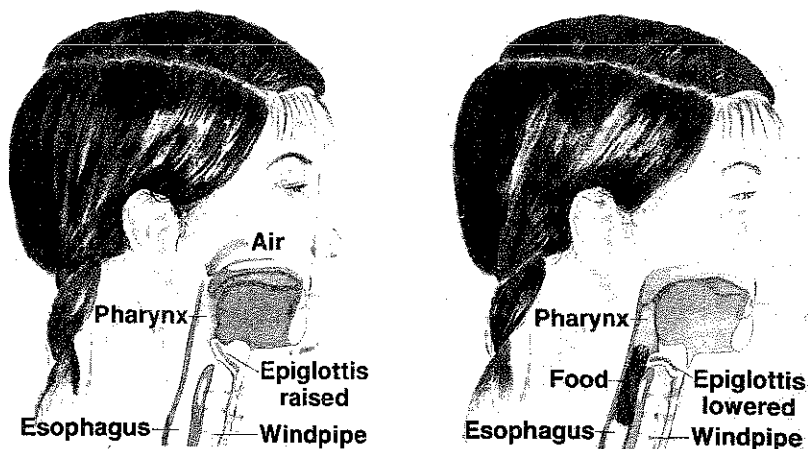
The tongue is covered with thousands of sense receptors called taste buds. There are four different kinds of taste buds, each sensitive to one of the four basic tastes—sweet, salt, sour, and bitter.

It makes food easier to swallow.  
(Relating concepts)



**Figure 21-3** Food moves through the esophagus by peristalsis.

**Figure 21-4** Does the epiglottis raise or lower when you breathe? raise



### Health and Safety Tip

*If a piece of food enters the windpipe, choking occurs. To help prevent choking, you should eat slowly, chew your food well, and avoid talking, laughing, or running with food in your mouth.*



**Figure 21-5** Dr. William Beaumont studied digestion by observing a hunter who had a gunshot wound in his stomach.

helps to move food toward the stomach, but gravity is not necessary. Even when astronauts eat in space, where there is no gravity, food reaches their stomachs.

You may be wondering what prevents food from entering the windpipe. When you swallow, a flap of tissue called the **epiglottis** (ep-uh-GLAT-is) covers the opening to the windpipe. The epiglottis blocks off the windpipe so that all your food enters the esophagus.

## The Stomach

The stomach is a large, J-shaped, baglike organ that acts as a storage place for food. The stomach also breaks down food. In fact, both mechanical and chemical digestion take place in the stomach.

How does the stomach aid in mechanical digestion? The stomach wall has three layers of muscles. Each layer contracts in a different direction, causing the stomach to twist and churn its contents. These actions help break up food into smaller pieces. The churning action of the stomach tends to begin at usual mealtimes. When you say your stomach is "growling," you are referring to contractions of the stomach muscles.

The strong churning action of the stomach also mixes food with gastric juice. Gastric juice is the digestive juice made by the stomach. Gastric juice contains three substances: mucus, **pepsin** (PEP-sin), and hydrochloric (hy-druh-KLAWR-ik) acid. Pepsin is an enzyme that begins the chemical digestion of proteins. Hydrochloric acid is a strong acid. It is needed for pepsin to work because pepsin can only work in an acid environment.



Hydrochloric acid also kills bacteria in the stomach and helps to break up food. Mucus protects the lining of the stomach from both hydrochloric acid and pepsin.

By the time food leaves the stomach, it is in the form of a thick liquid. This liquid is called **chyme** (KYM). Chyme is gradually released from the stomach, and into the small intestine.

## The Small Intestine

The small intestine is a narrow, coiled tube that is about 6.5 m long and 2.5 cm wide. The walls of the small intestine, like those of the esophagus and stomach, are muscular. Food moves through the small intestine by peristalsis.

What happens to food in the small intestine? You already know that some chemical digestion takes place in the mouth and stomach. However, most of the chemical digestion of food takes place in the small intestine.

### Digestion in the Small Intestine

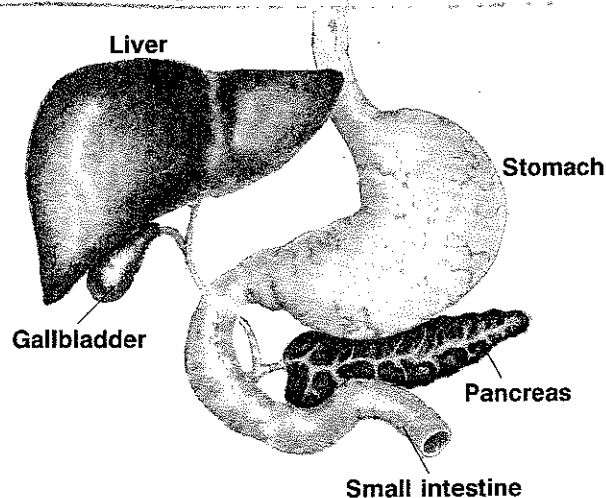
Food entering the small intestine is mixed with a variety of digestive juices. The first digestive juices that act on the food are produced by the **pancreas** (PAN-kree-us) and the **liver**. The pancreas and liver are part of the digestive system. However, they are not part of the alimentary canal.

▲ The small intestine also produces a digestive juice. The digestive juice made by the small intestine contains enzymes that complete the digestion of starches, proteins,

Some cells in the stomach produce hydrogen and chloride ions, which form hydrochloric acid. Hydrochloric acid has a pH of less than 2. You may wish to take a few minutes to review the concept of pH (discussed in Chapter 3) with students.

### Skill Builder

**Modeling** Use different colors of modeling clay and rubber tubing or pieces of garden hose to make a model of the digestive system. Use Figure 21-1 on page 364 and Figure 21-6 on page 367 as a guide. Use straight pins to attach labels on your model.



**Figure 21-6** Each of these organs is involved in the process of digestion.



Table 21-2 Summary of Digestion

NUTRIENT	DIGESTION BEGINS	DIGESTION COMPLETED
Proteins	Stomach	Small Intestine
Carbohydrates	Mouth	Small Intestine
Fats	Small Intestine	Small Intestine

and fats. You can see a summary of chemical digestion in Table 21-2. Where does the digestion of protein begin?

Where does it end? begins—stomach; ends—small intestine  
(Organizing information)

### The Job of the Pancreas

The pancreas is a small organ located below the stomach. When food first enters the small intestine, the pancreas releases digestive juices into the small intestine through a small tube. The digestive juice of the pancreas contains a variety of enzymes that change starches, proteins, and fats into simpler forms. Pancreatic juices also neutralize the acidity of the food leaving the stomach.

### The Job of the Liver

The liver is the largest organ inside the human body. What is the liver's role in digestion? The liver produces **bile**. Have you ever seen a detergent or soap breaking up grease? Detergents and soap break up grease into small drops that can be carried away in wash water. The action of bile is similar to the action of detergents and soap. Bile is a liquid that breaks down large drops of fat into very tiny droplets. This increases the surface area of fats, making it easier for pancreatic enzymes to act on them.

Bile does not pass directly from the liver to the small intestine. Instead, bile is stored in the **gallbladder**. The gallbladder is a small sac located under the liver. When food enters the small intestine, bile passes from the gallbladder into the small intestine through a small tube.

### Absorption from the Small Intestine

After food has been changed into usable forms, it is ready to be absorbed into the bloodstream. The movement of food from the digestive system to the blood takes place in the small intestine. Once inside the blood, digested food is carried to all of your body cells.

#### Study Hint

The role of the blood and the circulatory system is discussed in Chapter 22.

The absorption (ab-SAWRP-shun) of food into the bloodstream takes place through the wall of the small intestine. The inner lining of the small intestine is folded. The folds have millions of tiny fingerlike projections called **villi**. The many folds and villi give the small intestine a velvety appearance and greatly increase the surface area for absorption.

A single projection is called a villus. You can see the structure of a villus in Figure 21-7. Notice that the villus has many blood vessels. Digested food passes through the absorptive layer of the villus and into the blood vessels. How many cells thick are the villi walls?

one (Interpreting diagrams)

## The Large Intestine

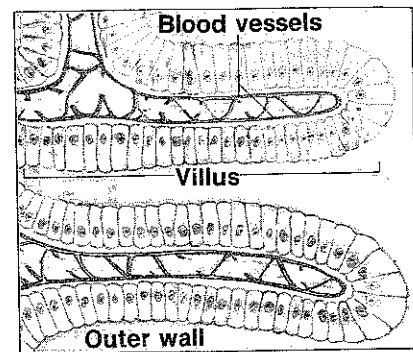
A watery mixture of undigested food moves from the small intestine into the large intestine. The large intestine is the last part of the digestive system. It is a tubelike organ about 2 m long and 7 cm wide. Why do you think it is called the large intestine?

The undigested material that enters the large intestine contains a lot of water and minerals. In the large intestine, water and minerals are absorbed into the blood. The **feces** (FEE-seez), or remaining solid waste materials, move into the lower part of the large intestine called the **rectum**. Wastes are stored temporarily in the rectum until they are eliminated from the body through the anus.

A small, thin sac called the appendix (uh-PEN-diks) is located at the place where the small intestine and large intestine join. Sometimes food gets trapped in the appendix and the appendix becomes infected with bacteria. An infection of the appendix is called appendicitis (uh-pen-duh-SY-tis).

## Think & Discuss

4. What is peristalsis?
5. What is the function of saliva?
6. Name the four different kinds of teeth and state the function of each.
7. Name the organs of the alimentary canal in order, beginning with the mouth.
- ★ 8. Is the action of bile mechanical or chemical digestion?



**Figure 21-7** When digestion is completed, nutrients are absorbed by the villi of the small intestine.

Villi also have lacteals, which are small lymph vessels. Digested fats first pass into the lacteals and then into the blood.

The large intestine also is known as the colon.

The large intestine is very wide compared to the small intestine. (Comparing)

## Study Hint

*The appendix is a vestigial organ in humans. Use an encyclopedia to find out more about the appendix and what the term "vestigial" means.*

4. wavelike movement of muscles that pushes food through the alimentary canal
5. to soften and moisten food, and digest starch
6. incisors and canines tear food; premolars and molars crush food
7. mouth, pharynx, esophagus, stomach, small intestine, large intestine (Sequencing)
8. mechanical digestion (Synthesizing ideas)

## 21-3 Problems of the Digestive System

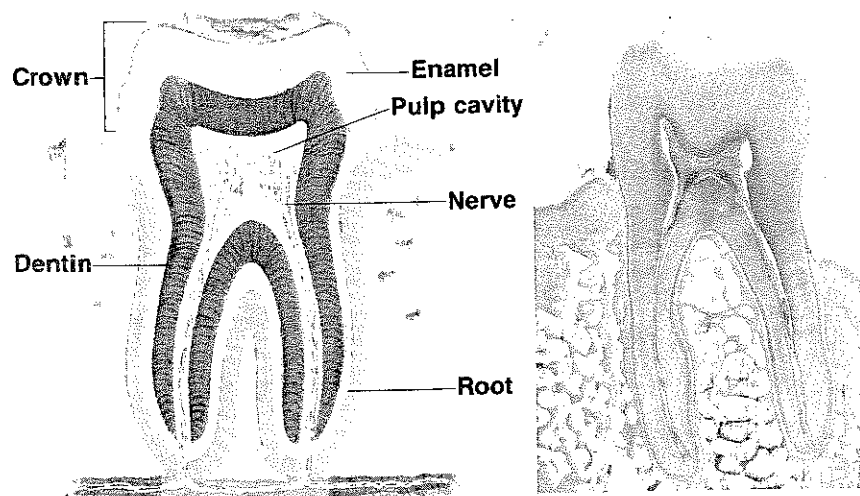
Sometimes the digestive system has problems. Some of the common problems of the digestive system are indigestion, ulcers, diarrhea (dy-uh-REE-uh), and constipation. Can you name any other problems of the digestive system?

▲ Did you name tooth decay as a problem of the digestive system? Have you ever had a cavity? A cavity is a hole in a tooth. A cavity is caused by tooth decay, which is the most common problem of the digestive system. Tooth decay is caused by bacteria that live in the mouth.

Tooth decay begins when a film called **plaque** forms on the teeth. Plaque is made up of saliva, food, and bacteria. The bacteria produce acids that break down the outer covering, or enamel, of the tooth. The structure of a tooth is shown in Figure 21-8. If the decay is left untreated, it spreads to the softer parts of a tooth. If a cavity reaches the tooth pulp, a nerve is exposed. What do you think exposure of the nerve causes? In the final stages of tooth decay, bacteria destroy the tooth pulp.

### Indigestion and Ulcers

Have you ever had indigestion? Indigestion is a general term used for pain or discomfort that occurs after eating. Most people have indigestion at one time or another. Usually indigestion is caused by poor eating habits. For example, eating too much, too little, or too fast all can cause indigestion.



### Key Point

- Tooth decay, indigestion, and ulcers are problems of the digestive system.

Answers may include hemorrhoids, food poisoning, gallstones, diverticulosis, colitis, and cancer of the organs in the digestive system. (Organizing information)

### Health and Safety Tip

*Flossing your teeth daily helps remove plaque from your teeth. Regular visits to a dentist are important to maintain healthy teeth.*

toothache (Relating concepts)

**Figure 21-8** Use the diagram of the tooth (left) to find the nerve in the X-ray of the healthy tooth (right).



**Figure 21-9** An ulcer can begin to bleed if not treated.

Ulcers in the stomach lining are called peptic ulcers. Ulcers in the large intestine are called duodenal ulcers.

### Skill Builder

**Organizing** Make a chart listing six disorders of the digestive system. Your chart should include the name of the disorder, its cause, the organ it affects, and its symptoms.

It is necessary to replace the liquids lost by the body to maintain homeostasis. (Hypothesizing)

9. bacteria
10. eating too fast, too much, or too little
11. Answers may include: some countries have unsanitary conditions; travelers are not used to microorganisms that live in the water of the other countries. (Relating cause and effect)

Sometimes eating too much causes a burning feeling commonly known as heartburn. Heartburn occurs when acidic juices from the stomach go up into the esophagus. The acid irritates the esophagus and causes a burning sensation. Because the esophagus is located behind the heart, it seems like the pain is coming from the heart.

A more serious problem occurs when stomach acids digest, or "eat" away the lining of the stomach or the small intestine. The sore, or hole, in the lining is called an **ulcer**. Ulcers develop when the mucus that coats the inside of the stomach or small intestine does not protect them from hydrochloric acid and enzymes.

Have you ever heard someone say, "I'm going to get ulcers," when the person was under a lot of stress? How and why ulcers occur is not completely understood. However, stress is known to be a contributing factor in the development of ulcers. Fortunately, most ulcers can be treated or cured with medication.

## Diarrhea and Constipation

When the walls of the large intestine fail to absorb water from food wastes, the wastes are very watery. This condition is called diarrhea. Diarrhea results when frequent, strong peristalsis moves wastes through the large intestine too quickly for water to be absorbed.

■ Diarrhea can be caused by stress and by certain viruses and bacteria. These things cause the lining of the intestine to become irritated. Why do you think it is important for a person suffering from diarrhea to drink plenty of liquids?

What happens when peristalsis in the large intestine is too slow or too weak? The wastes move slowly, and most of the water in the wastes is absorbed. The wastes become more solid than normal, and difficult to eliminate. This condition is called constipation.

## Think & Discuss

9. What part of plaque causes tooth decay?
10. What are three reasons people get indigestion?
11. Why do you think diarrhea is a common disorder among visitors to other countries?

# Chapter Review

## CHAPTER SUMMARY

### 21-1 The Digestive Process

- Mechanical digestion breaks down food into small pieces.
- Chemical digestion breaks down large molecules into smaller ones.
- Enzymes temporarily combine with the large molecules in food and break them apart into smaller molecules.
- Enzymes are specific.

### 21-2 The Digestive System

- The digestive system is made up of the mouth, pharynx, esophagus, stomach, small intestine, large intestine, pancreas, liver, and gallbladder.

- The pancreas, liver, and gallbladder are not part of the alimentary canal.
- Mechanical and chemical digestion begin in the mouth.
- The chemical digestion of food is completed in the small intestine.
- Absorption takes place through villi in the small intestine.

### 21-3 Disorders of the Digestive System

- Tooth decay is the most common problem of the digestive system.
- Indigestion, ulcers, diarrhea, and constipation are other problems of the digestive system.

## VOCABULARY LIST

alimentary canal (363)  
bile (368)  
chemical digestion (362)  
chyme (367)  
digestion (361)

enzymes (363)  
epiglottis (366)  
esophagus (365)  
feces (369)  
gallbladder (368)

mechanical digestion (362)  
pancreas (367)  
pepsin (366)  
peristalsis (365)  
pharynx (365)

plaque (371)  
rectum (369)  
saliva (361)  
ulcer (372)  
villi (369)

## VOCABULARY REVIEW

**Matching** Write the word or term from the Vocabulary List that best matches each description.

1. digests proteins pepsin
2. stores bile gallbladder
3. solid wastes feces
4. covers opening to windpipe during swallowing epiglottis
5. increases surface area of small intestine villi
6. lower portion of large intestine rectum
7. carries food from the mouth to the stomach esophagus
8. common passageway for food and air pharynx
9. wavelike motion peristalsis
10. breakdown of food into smaller pieces mechanical digestion

**Identifying Relationships** Identify the word or term in each group that does not belong. Explain why it does not belong with the group.

Accept all logical responses.

1. alimentary canal, mouth, liver
2. villi, absorption, chyme
3. enzymes, mechanical digestion, chemical digestion
4. bile, cavity, plaque
5. esophagus, peristalsis, digestion
6. pepsin, small intestine, stomach
7. pancreas, mechanical digestion, teeth
8. large intestine, rectum, pharynx
9. ulcer, villi, cavity
10. gallbladder, saliva, mouth

### 3 CONTENT REVIEW

**Completion** Write the word or words that best complete each sentence.

1. Adults have \_\_\_\_\_ different kinds of teeth. *four*
2. The \_\_\_\_\_ moves food to the back of the mouth when swallowing. *tongue*
3. The stomach wall has three layers of \_\_\_\_\_. *muscles*
4. Where the small and large intestines join, there is a small sac called the \_\_\_\_\_. *appendix*
5. Saliva, food, and bacteria build up on the teeth in the form of \_\_\_\_\_. *plaque*
6. An ulcer is a hole in the lining of the stomach or \_\_\_\_\_. *small intestine*
7. Chemical reactions in the body are controlled by \_\_\_\_\_. *enzymes*
8. The passageway for both food and air is the \_\_\_\_\_. *pharynx*
9. Gastric juice contains pepsin, hydrochloric acid, and \_\_\_\_\_. *mucus*

**Finding the Main Ideas** Use the section number to find the sentence that answers each question. Then, write the sentence.

1. What is a physical change? (21-1)
2. How does mechanical digestion help with the chemical digestion of food? (21-1)
3. What is the pharynx? (21-1)
4. What prevents food from entering the windpipe? (21-2)
5. How does the stomach aid in mechanical digestion? (21-2)
6. What is the liver's role in digestion? (21-2)
7. Where is the appendix located? (21-2)
8. What three things cause plaque to build up on the teeth? (21-3)
9. What are the usual causes of indigestion? (21-3)
10. What causes heartburn? (21-3)
11. What happens when peristalsis in the large intestine is abnormally slow? (21-3)

### CONCEPT REVIEW

For answers, see page T-119.

**Writing for Understanding** One way to find out if you understand something is to write a brief summary of the information in your own words. Reread Section 21-1, The Digestive Process, on pages 362-363 and write a brief summary of the information.

**Critical Thinking** Answer each of the following in complete sentences.

1. How would swallowing large chunks of food affect the digestive process?

2. Sometimes doctors must remove part or most of a person's stomach. How would such an operation affect the digestive process?
3. Why is absorption such an important part of the digestive process?
4. Why is the large surface area of the small intestine important?
5. Does any digestion take place in the large intestine?
6. Where does absorption take place?

### EXTENSIONS

1. Do library research to find out about Dr. William Beaumont and his patient, Alexis St. Martin. In a brief report, explain how they contributed to an understanding of the digestive system.

2. Using this book as a reference, draw a diagram of the digestive system. Label the parts in the diagram, and include a caption listing the organs through which food passes in the proper order.