

32.2 Digestive System

VOCABULARY

digestion
digestive system
sphincter
esophagus
peristalsis
stomach
chyme
small intestine
bile

KEY CONCEPT The digestive system breaks down food into simpler molecules.

MAIN IDEAS

- ▶ Several digestive organs work together to break down food.
- ▶ Digestion begins in the mouth and continues in the stomach.
- ▶ Digestion is completed in part of the small intestine.

Connect to Your World

What would you do to help advance scientific understanding? In June 1822, Alexis St. Martin was shot in the stomach and treated by William Beaumont, an Army surgeon. The 19-year-old St. Martin recovered, but the bullet wound left a small hole in his stomach. Beaumont covered the hole and persuaded St. Martin to let him observe the digestive process by tying foods to a string, dropping them into the stomach hole, and retrieving them at different times to see how quickly different foods were digested. Over ten years, the experiments yielded a wealth of information about the digestive process. St. Martin married, had children, and lived to the age of 76.

▶ MAIN IDEA

Several digestive organs work together to break down food.

Digestion is the process by which the large complex molecules in food are broken down into smaller molecules that can be used by the body. The **digestive system** is a collection of organs that breaks down food into energy that can be used in cells. It is like a factory that takes things apart instead of putting them together. The major organs of this “disassembly line” include the mouth, esophagus, stomach, pancreas, liver, gallbladder, large and small intestines, rectum, and anus, as shown in **FIGURE 2.1**. Rings of muscle, called **sphincters** (SFIHNGK-tuhrs), separate one section from another. The opening and closing of these sphincters and the contractions of smooth muscle in the walls of the organs keep food moving in one direction.

Digestion takes place through the interactions of enzymes, stomach acid, hormones, bile from the liver, and a network of nerves and muscles throughout the digestive system. Each organ contributes to breaking food down. For instance, in the mouth, salivary glands secrete an enzyme that helps to digest starches. The stomach releases enzymes that break down proteins.

Once digestion is complete, nutrients are absorbed by the body and transported by the circulatory system and lymphatic system to all the cells. Finally, undigested materials are eliminated as liquid and solid wastes. The entire process—from food entering the mouth to wastes leaving the body—takes about 24 to 33 hours per meal.

Predict What might happen if the digestive sections were not divided by sphincters?

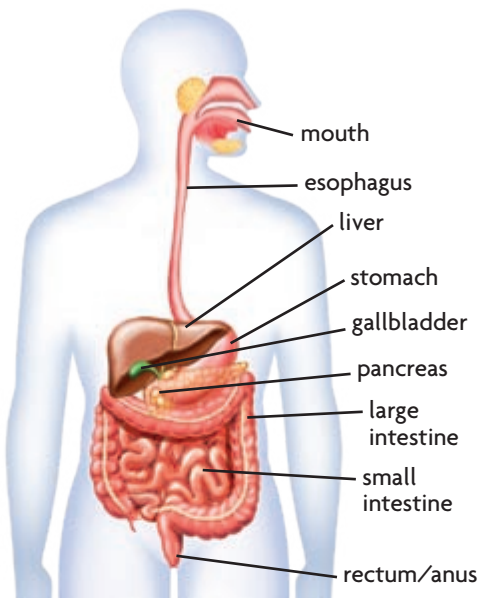


FIGURE 2.1 The major digestive organs are separated by sphincters, which help keep food moving in one direction.

▶ MAIN IDEA

Digestion begins in the mouth and continues in the stomach.

You may have heard someone telling their children, “Chew your food—don’t just gulp it!” This is actually good advice, because the first step in breaking down food is mechanical and chemical digestion in the mouth.

Digestion in the Mouth

You unwrap the sandwich you brought for lunch and bring it up to your mouth. Mechanical digestion begins the moment you bite into the sandwich and start chewing. Your teeth shred and grind the food into smaller pieces. Your tongue keeps the pieces positioned between your teeth. Chemical digestion, on the other hand, involves the action of enzymes. As you chew your food, the salivary glands release saliva that moistens the food and contains an enzyme called amylase (AM-uh-LAYS). Amylase begins the breakdown of complex starch molecules into sugars.

Once food has been chewed and mixed with saliva, the tongue pushes it to the back of the mouth. As you swallow, the food moves into the **esophagus** (ih-SAHF-uh-guhs), a tube that connects the mouth to the stomach. Food is kept moving down the esophagus by the action of peristalsis, as **FIGURE 2.2** shows. **Peristalsis** (PEHR-ih-STAWL-sihs) is the rhythmic, involuntary contraction of the smooth muscles in the walls of digestive organs.

Digestion in the Stomach

The next stop for your thoroughly chewed sandwich is the stomach. The **stomach** is a muscular sac that can stretch to nearly twice its original size and holds up to 2 liters (2 qt) of food. The stomach continues the digestion that began in the mouth. Proteins are digested in the stomach and small intestine, but fats and sugars are digested only in the small intestine. Major enzymes and their functions in the digestive system are listed in **FIGURE 2.3**.

The walls of the stomach contain three layers of smooth muscle that contract about every 20 seconds. This churning action breaks food into even smaller pieces and mixes the food with the stomach’s digestive juices.

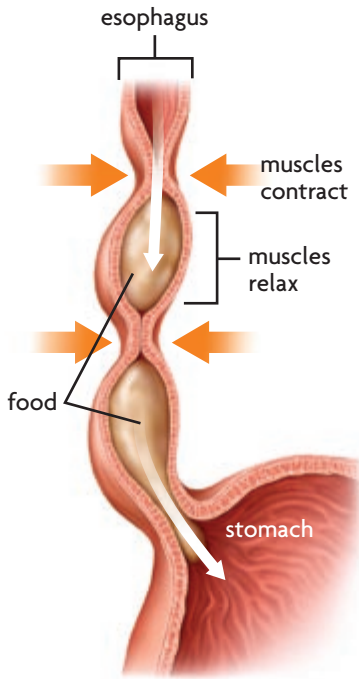


FIGURE 2.2 As food enters the esophagus, muscles behind the food contract, pushing it forward, while the muscles in front of the food relax. This rhythmic squeezing, called peristalsis, keeps food moving in one direction.

FIGURE 2.3 Major Digestive Enzymes

ENZYME	DIGESTIVE ORGAN	FUNCTION
Salivary amylase	mouth	breaks down starches into simpler sugars
Pepsin	stomach	breaks down proteins
Maltase, lactase, sucrase	small intestine	breaks down sugars into simpler molecules
Peptidase		breaks down proteins into amino acids
Trypsin	small intestine, pancreas	continues breakdown of proteins
Amylase		continues breakdown of starches
Lipase		aids in breaking down fats

As **FIGURE 2.4** summarizes, chemical digestion occurs along with the churning of mechanical digestion. The stomach lining secretes gastric juice containing hydrochloric acid (HCl) and the digestive enzyme pepsin. Gastric juice is acidic enough to kill most bacteria found on food and to break the bonds between protein molecules. Pepsin also breaks some chemical bonds between the amino acids in proteins. Digestive juices and enzymes turn your partly digested sandwich into a semi-liquid mixture called **chyme** (kym).

The stomach empties as peristaltic actions push the chyme against the sphincter that separates the stomach from the small intestine. With each contraction, the sphincter opens slightly, and chyme squirts into the small intestine, where digestion continues. It takes from two to six hours to empty the stomach after a meal.

Once the stomach is empty, the production of gastric juice stops. What keeps the stomach from digesting itself? First, pepsin is active only when there is food to digest. Second, the stomach secretes a layer of mucus to protect itself from its own acidic environment. Even so, cells in the stomach lining are replaced every few days to maintain the protective layer of mucus.

Apply If you ate a meal of spaghetti and meatballs, where would digestion of the pasta and meat begin?

CONNECT TO

CHEMISTRY

Hydrochloric acid (HCl) is so strong that it can dissolve an iron nail in a matter of hours. To protect your stomach lining, specialized epithelial cells secrete bicarbonate, a base substance. Bicarbonate neutralizes the acid to keep it from burning through your stomach lining.

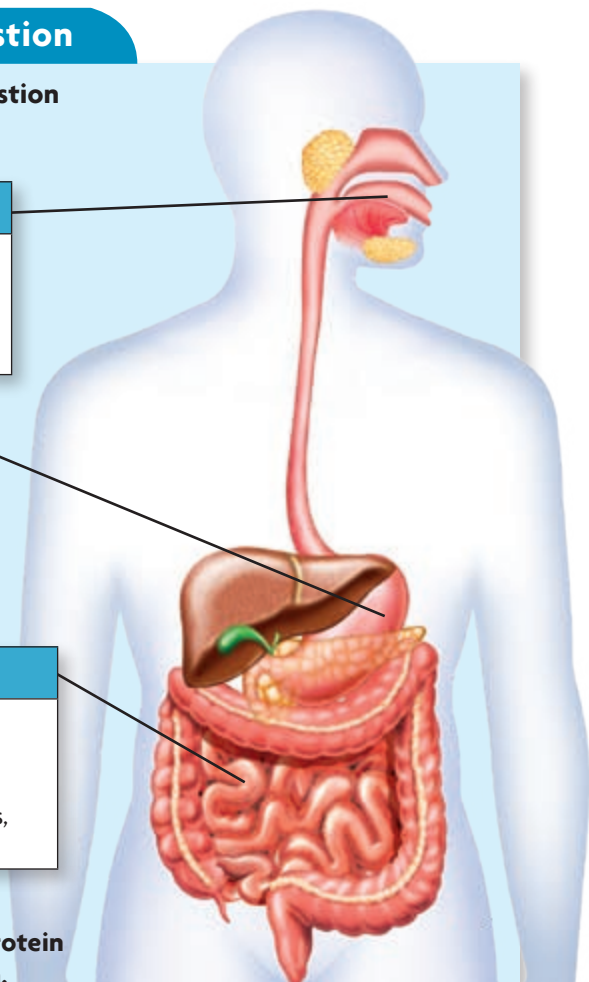
FIGURE 2.4 Mechanical and Chemical Digestion

The digestive organs use mechanical and chemical digestion to break food down into simple molecules.

MOUTH	
Mechanical Chewing shreds and grinds food into smaller particles.	Chemical Salivary amylase breaks down starches into simple sugars.

STOMACH	
Mechanical Smooth muscle contractions churn food to break it down and mix it with digestive juices.	Chemical HCl and pepsin break down proteins.

SMALL INTESTINE	
Mechanical Muscular contractions break down and mix food with digestive enzymes, bile, and hormones.	Chemical Enzymes, bile, and hormones finish digestion of proteins, sugars, and fats.

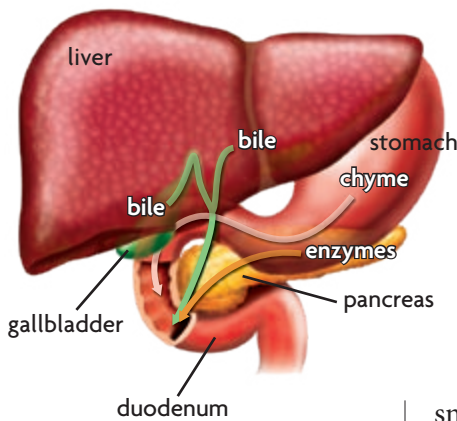


CRITICAL VIEWING Do you think a high-carbohydrate or a high-protein meal would be digested more quickly? Explain.

▶ MAIN IDEA

Digestion is completed in part of the small intestine.

FIGURE 2.5 The liver and pancreas help digest fats, carbohydrates, and proteins in the small intestine. The liver secretes bile through the gallbladder, and the pancreas secretes an alkaline fluid and digestive enzymes.



The remaining carbohydrates, proteins, and fats from your sandwich are digested in the duodenum (DOO-uh-DEE-nuhm), the section of small intestine closest to the stomach. The **small intestine** is a long, narrow tube in which most digestion takes place. Smooth muscle contractions churn the food, and chemical digestion further breaks down the complex molecules. As shown in **FIGURE 2.5**, enzymes and hormones from the pancreas, liver, and gallbladder flow through ducts into the duodenum to help complete the digestive process.

The pancreas is a small gland located behind the stomach. When chyme first enters the small intestine, the pancreas releases an alkaline fluid to help neutralize the acid and stop the action of pepsin. The pancreas also releases enzymes to break down starches further into simple sugars. For example, lactase is an intestinal enzyme that breaks down lactose, a sugar found in milk. The pancreas also produces an enzyme, lipase, that splits fat into fatty acids and smaller molecules.

The liver, which filters blood, is also a digestive organ. It produces a chemical substance, **bile**, that helps to digest fats. Bile is stored in a smaller organ, the gallbladder. When bile is needed to digest fats, it is released through ducts that empty into the duodenum. The bile breaks down large globules of fat into smaller droplets for further digestion.

Proteins entering the small intestine have already been broken down by the action of pepsin and gastric juice into smaller chains of amino acids. In the duodenum, enzymes finish the process by breaking these chains into individual amino acids. By the time chyme has passed through the duodenum, food has been broken down into small molecules. Section 3 describes how these molecules are absorbed by the body.

Apply How would the pancreas and liver help to digest ice cream?

32.2 Formative Assessment

REVIEWING ▶ MAIN IDEAS

1. What is the main function of the **digestive system**?
2. Give an example of mechanical and chemical **digestion** in the mouth and in the **stomach**.
3. What organs help to continue digestion in the **small intestine**?

CRITICAL THINKING

4. **Predict** One person eats a beef steak in a few bites, while another chews the same amount of beef well. If all other conditions are equal, will both people digest their beef at the same rate? Explain.
5. **Predict** If a person has his or her gallbladder removed, what changes in diet should be made? Why?



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PREMIUM CONTENT

CONNECT TO

CELL STRUCTURE

6. The cells of the stomach lining produce a great deal of mucus. If you were to view such a cell under a microscope, what type of organelle would you expect to see in abundance?