SECTION 1

The Digestive System

It's your last class before lunch, and you're starving! Finally, the bell rings, and you get to eat!

You feel hungry because your brain receives signals that your cells need energy to maintain homeostasis. Eating is just the beginning. Your body must change food into substances that your cells can use. Your **digestive system,** shown in **Figure 1,** is a group of organs that work together to break down food so that it can be used by the body.

READING WARM-UP

Objectives

- Compare mechanical digestion with chemical digestion.
- Describe the parts and functions of the digestive system.

Terms to Learn

digestive system
esophagus
stomach
pancreas
small intestine
liver
gallbladder
large intestine

READING STRATEGY

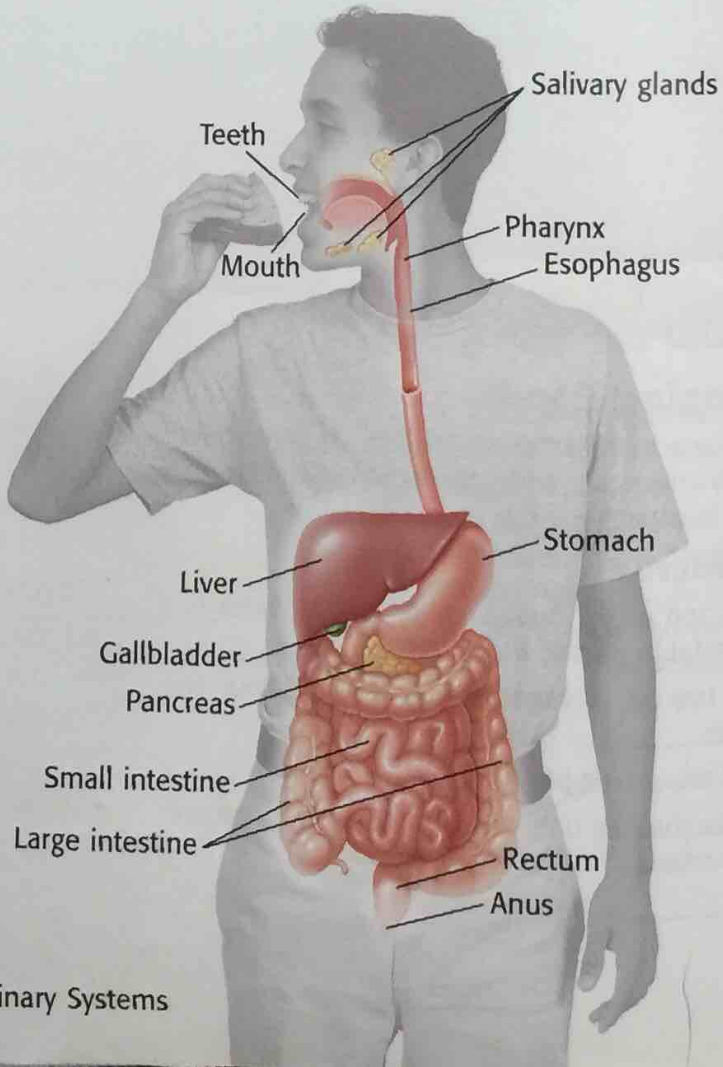
Prediction Guide Before reading this section, write the title of each heading in this section. Next, under each heading, write what you think you will learn.

digestive system the organs that break down food so that it can be used by the body

Digestive System at a Glance

The most obvious part of your digestive system is a series of tubelike organs called the *digestive tract.* Food passes through the digestive tract. The digestive tract includes your mouth, pharynx, esophagus, stomach, small intestine, large intestine, rectum, and anus. The liver, gallbladder, pancreas, and salivary glands are also part of the digestive system. But food does not pass through these organs.

Figure 1 The Digestive System



Breaking Down Food

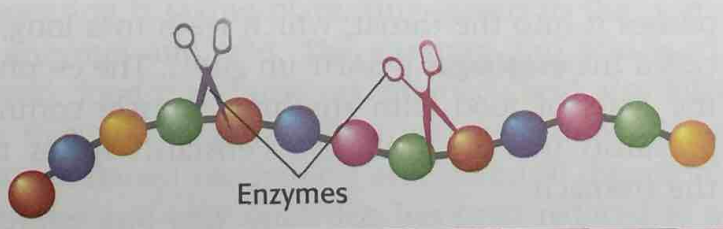
The digestive system works with the circulatory system, which includes the heart, blood vessels, and blood, to deliver the materials cells need to function. Digestion is the process of breaking down food into a form that can pass from the digestive tract into the bloodstream. There are two types of digestion. The breaking, crushing, and mashing of food is called *mechanical digestion*. In *chemical digestion,* large molecules are broken down into nutrients. Nutrients are substances that the body needs for energy and for growth, maintenance, and repair.

Three major types of nutrients—carbohydrates, proteins, and fats—make up most of the food you eat. Substances called *enzymes* break some nutrients into smaller particles that the body can use. For example, proteins are chains of smaller molecules called *amino acids*. Proteins are too large to be absorbed into the bloodstream. So, enzymes cut up the chain of amino acids. The amino acids are small enough to pass into the bloodstream. This process is shown in **Figure 2.**

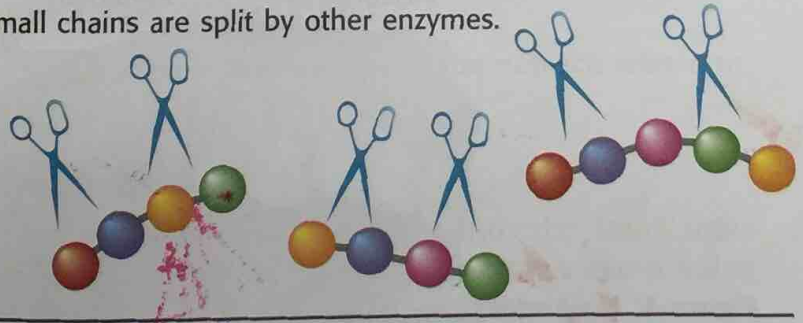
Reading Check **How do the digestive and circulatory systems work together?** (*See the Appendix for answers to Reading Checks.*)

Figure 2 **The Role of Enzymes in Protein Digestion**

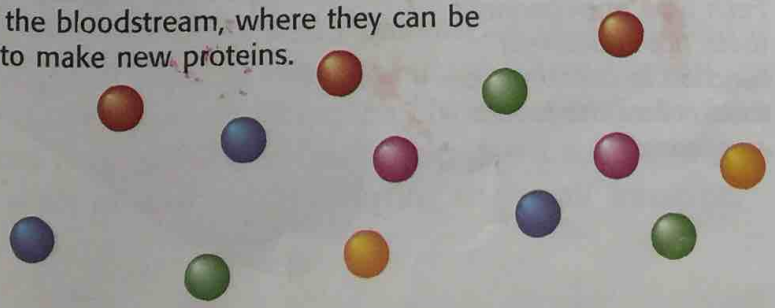
1 Enzymes act as chemical scissors to cut the long chains of amino acids into small chains.



2 The small chains are split by other enzymes.



3 Individual amino acids are small enough to enter the bloodstream, where they can be used to make new proteins.



QUICK LAB

Break It Up!

1. Drop **one piece of hard candy** into a **clear plastic cup of water.**
2. Wrap an **identical candy** in a **towel,** and crush the candy with a **hammer.** Drop the candy into a **second clear cup of water.**
3. The next day, examine both cups. What is different about the two candies?
4. What type of digestion is represented by breaking the hard candy?
5. How does chewing your food help the process of digestion?

Digestion Begins in the Mouth

Chewing is important for two reasons. First, chewing creates small, slippery pieces of food that are easier to swallow than big, dry pieces are. Second, small pieces of food are easier to digest.

Teeth

Teeth are very important organs for mechanical digestion. With the help of strong jaw muscles, teeth break and grind food. The outermost layer of a tooth, the *enamel,* is the hardest material in the body. Enamel protects nerves and softer material inside the tooth. **Figure 3** shows a cross section of a tooth.

Have you ever noticed that your teeth have different shapes? Look at **Figure 4** to locate the different kinds of teeth. The molars are well suited for grinding food. The *premolars* are perfect for mashing food. The sharp teeth at the front of your mouth, the *incisors* and *canines,* are for shredding food.

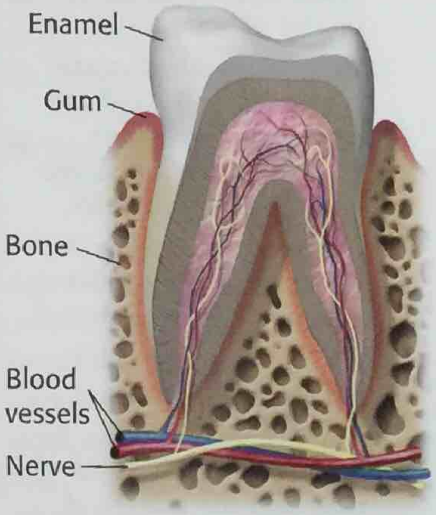


Figure 3 *A tooth, such as this molar, is made of many kinds of tissue.*

Saliva

As you chew, the food mixes with a liquid called *saliva*. Saliva is made in salivary glands located in the mouth. Saliva contains an enzyme that begins the chemical digestion of carbohydrates. Saliva changes complex carbohydrates into simple sugars.

Leaving the Mouth

Once the food has been reduced to a soft mush, the tongue pushes it into the throat, which leads to a long, straight tube called the **esophagus** (i SAHF uh guhs). The esophagus squeezes the mass of food with rhythmic muscle contractions called *peristalsis* (PER uh STAL sis). Peristalsis forces the food into the stomach.

esophagus a long, straight tube that connects the pharynx to the stomach

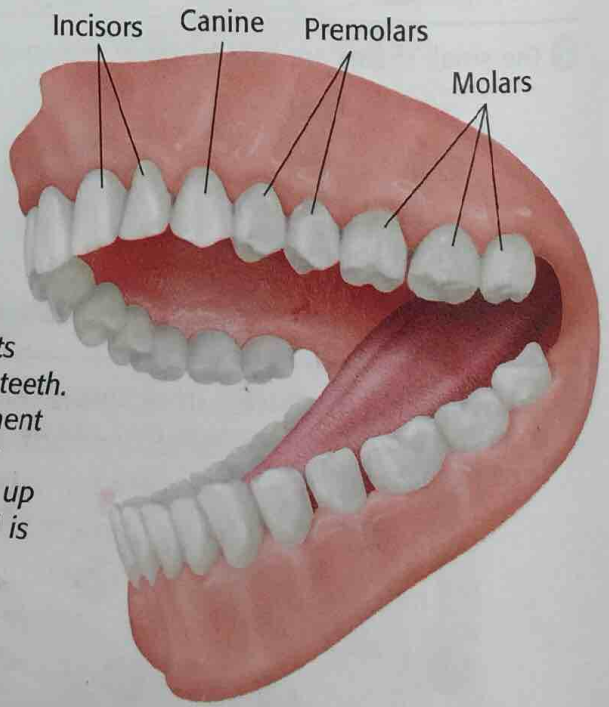
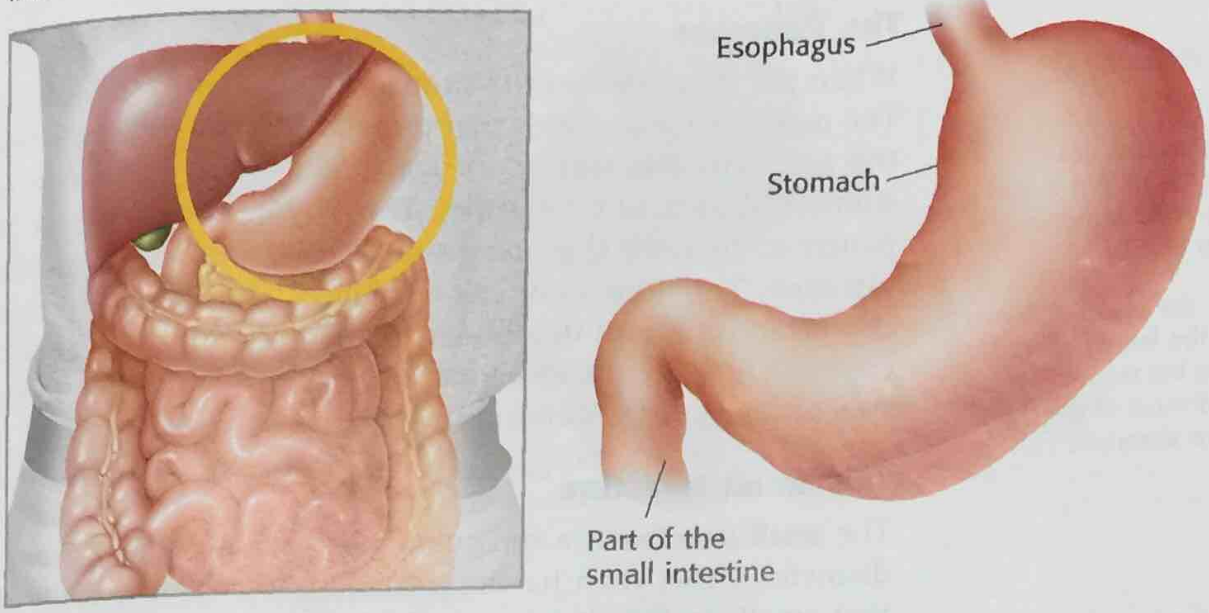


Figure 4 *Most adults have 32 permanent teeth. Each type of permanent tooth has a different function in breaking up food before the food is swallowed.*

Figure 5 The Stomach

The stomach squeezes and mixes food for hours before it releases the mixture into the small intestine.



The Harsh Environment of the Stomach

The **stomach** is a muscular, saclike, digestive organ attached to the lower end of the esophagus. The stomach is shown in **Figure 5.** The stomach continues the mechanical digestion of your meal by squeezing the food with muscular contractions. While this squeezing is taking place, tiny glands in the stomach produce enzymes and acid. The enzymes and acid work together to break food into nutrients. Stomach acid also kills most bacteria that you might swallow with your food. After a few hours of combined mechanical and chemical digestion, your peanut butter and jelly sandwich has been reduced to a soupy mixture called *chyme* (KIEM).

stomach the saclike, digestive organ between the esophagus and the small intestine that breaks down food into a liquid by the action of muscles, enzymes, and acids

Reading Check **How is the structure of the stomach related to its function?**

Leaving the Stomach

The stomach slowly releases the chyme into the small intestine through a small ring of muscle that works like a valve. This valve keeps food in the stomach until the food has been thoroughly mixed with digestive fluids. Each time the valve opens and closes, it lets a small amount of chyme into the small intestine. Because the stomach releases chyme slowly, the intestine has more time to mix the chyme with fluids from the liver and pancreas. These fluids help digest food and stop the harsh acids in chyme from hurting the small intestine.

MATH PRACTICE

Tooth Truth

Young children get a first set of 20 teeth called *baby teeth*. These teeth usually fall out and are replaced by 32 permanent teeth. How many more permanent teeth than baby teeth does a person have? What is the ratio of baby teeth to permanent teeth? Be sure to express the ratio in its most reduced form.

The Pancreas and Small Intestine

Most chemical digestion takes place after food leaves the stomach. Proteins, carbohydrates, and fats in the chyme are digested by the small intestine and fluids from the pancreas.

The Pancreas

When the chyme leaves the stomach, the chyme is very acidic. The pancreas makes fluids that protect the small intestine from the acid. The **pancreas** is an oval organ located between the stomach and small intestine. The chyme never enters the pancreas. Instead, the pancreatic fluid flows into the small intestine. This fluid contains enzymes that chemically digest chyme and contains bicarbonate, which neutralizes the acid in chyme. The pancreas also functions as a part of the endocrine system by making hormones that regulate blood sugar.

pancreas the organ that lies behind the stomach and that makes digestive enzymes and hormones that regulate sugar levels

small intestine the organ between the stomach and the large intestine where most of the breakdown of food happens and most of the nutrients from food are absorbed

The Small Intestine

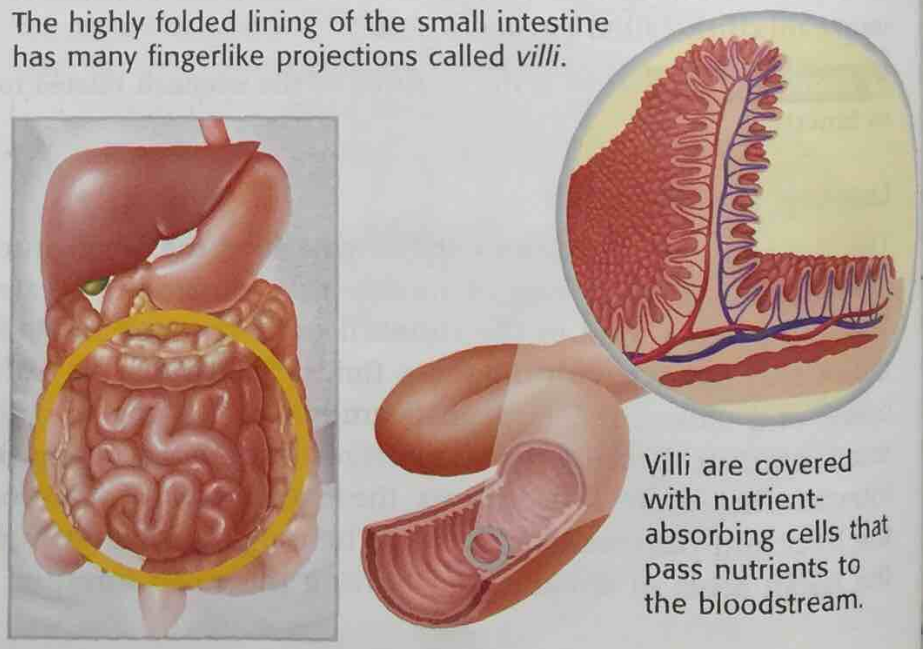
The **small intestine** is a muscular tube that is about 2.5 cm in diameter. Other than having a small diameter, it is really not that small. In fact, if you stretched the small intestine out, it would be longer than you are tall—about 6 m! If you flattened out the surface of the small intestine, it would be larger than a tennis court! How is this possible? The inside wall of the small intestine is covered with fingerlike projections called *villi*, shown in **Figure 6.** The surface area of the small intestine is very large because of the villi. The villi are covered with tiny, nutrient-absorbing cells. Once the nutrients are absorbed, they enter the bloodstream.

CONNECTION TO Social Studies

WRITING SKILL **Parasites** Intestinal parasites are organisms, such as roundworms and hookworms, that infect people and live in their digestive tract. Worldwide, intestinal parasites infect more than 1 billion people. Some parasites can be deadly. Research intestinal parasites in a library or on the Internet. Then, write a report on a parasite, including how it spreads, what problems it causes, how many people have it, and what can be done to stop it.

Figure 6 **The Small Intestine and Villi**

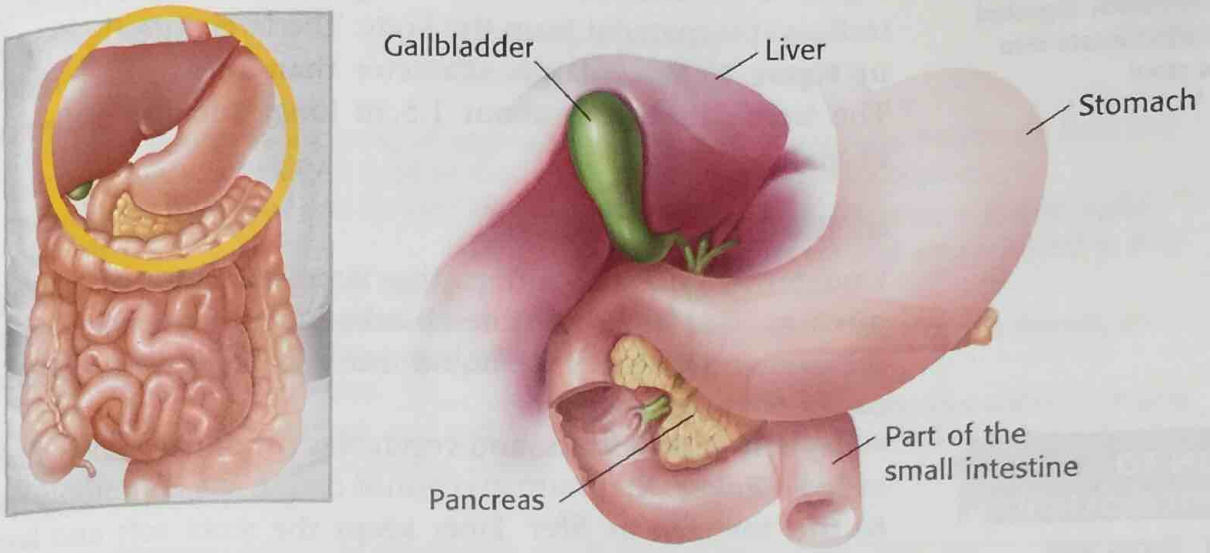
The highly folded lining of the small intestine has many fingerlike projections called *villi*.



Villi are covered with nutrient-absorbing cells that pass nutrients to the bloodstream.

Figure 7 The Liver and the Gallbladder

Food does not move through the liver, gallbladder, and pancreas even though these organs are linked to the small intestine.



The Liver and Gallbladder

The **liver** is a large, reddish brown organ that helps with digestion. A human liver can be as large as a football. Your liver is located toward your right side, slightly higher than your stomach, as shown in **Figure 7.** The liver helps with digestion in the following ways:

- It makes bile to break up fat.
- It stores nutrients.
- It breaks down toxins.

liver the largest organ in the body; it makes bile, stores and filters blood, and stores excess sugars as glycogen

gallbladder a sac-shaped organ that stores bile produced by the liver

Breaking Up Fat

Although bile is made by the liver, bile is temporarily stored in a small, saclike organ called the **gallbladder,** shown in **Figure 7.** Bile is squeezed from the gallbladder into the small intestine, where the bile breaks large fat droplets into very small droplets. This mechanical process allows more fat molecules to be exposed to digestive enzymes.

Reading Check **How does bile help digest fat?**

Storing Nutrients and Protecting the Body

After nutrients are broken down, they are absorbed into the bloodstream and carried through the body. Nutrients that are not needed right away are stored in the liver. The liver then releases the stored nutrients into the bloodstream as needed. The liver also captures and detoxifies many chemicals in the body. For instance, the liver produces enzymes that break down alcohol and many other drugs.

SCHOOL to HOME

Bile Model

You can model the way bile breaks down fat and oil. With a parent, put a small amount of water in a small jar. Then, add a few drops of vegetable oil to the water. Notice that the two liquids separate. Next, add a few drops of liquid dishwashing soap to the water, tighten the lid securely onto the jar, and shake the jar. What happened to the three liquids in the jar? Finally, make a model of the liver and investigate how its structure and functions are related.

ACTIVITY

large intestine the wider and shorter portion of the intestine that removes water from mostly digested food and that turns the waste into semisolid feces, or stool

The End of the Line

Material that can't be absorbed into the blood is pushed into the large intestine. The **large intestine** is the organ of the digestive system that stores, compacts, and then eliminates indigestible material from the body. The large intestine, shown in **Figure 8,** has a larger diameter than the small intestine. The large intestine is about 1.5 m long, and has a diameter of about 7.5 cm.

In the Large Intestine

Undigested material enters the large intestine as a soupy mixture. The large intestine absorbs most of the water in the mixture and changes the liquid into semisolid waste materials called *feces,* or *stool.*

Whole grains, fruits, and vegetables contain a carbohydrate, called *cellulose,* that humans cannot digest. We commonly refer to this material as *fiber.* Fiber keeps the stool soft and keeps material moving through the large intestine.

Reading Check **How does eating fiber help digestion?**

Leaving the Body

The *rectum* is the last part of the large intestine. The rectum stores feces until they can be expelled. Feces pass to the outside of the body through an opening called the *anus.* It has taken each of your meals about 24 hours to make this journey through your digestive system.

CONNECTION TO Environmental Science

Waste Away Feces and other human wastes contain microorganisms and other substances that can contaminate drinking water. Every time you flush a toilet, the water and wastes go through the sewer to a wastewater treatment plant. At the wastewater treatment plant, the disease-causing microorganisms are removed, and the clean water is released back to rivers, lakes, and streams. Find out where the wastewater treatment plants are in your area. Report to your class where their wastewater goes.

ACTIVITY

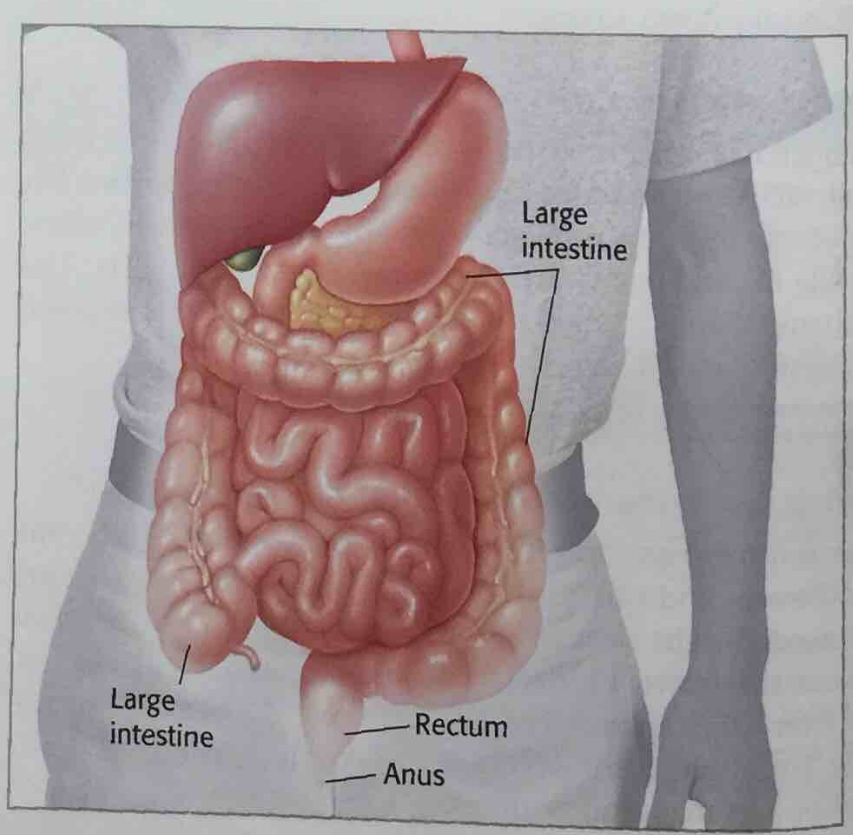


Figure 8 *The large intestine is the final organ of digestion.*

SECTION Review

Summary

- Your digestive system is a group of organs that work together to digest food so that the nutrients from food can be used by the body.
- The breaking and mashing of food is called *mechanical digestion*. Chemical digestion is the process that breaks large food molecules into simpler molecules.
- The stomach mixes food with acid and enzymes that break down nutrients. The mixture is called *chyme*.
- In the small intestine, pancreatic fluid and bile are mixed with chyme.
- From the small intestine, nutrients enter the bloodstream and are circulated to the body's cells.
- The liver makes bile, stores nutrients, and breaks down toxins.
- The large intestine absorbs water, changing liquid waste into semisolid stool, or feces.

Using Key Terms

1. Use each of the following terms in a separate sentence: *digestive system*, *large intestine*, and *small intestine*.

Understanding Key Ideas

2. Which of the following is NOT a function of the liver?
   - **a.** to secrete bile
   - **b.** to store nutrients
   - **c.** to detoxify chemicals
   - **d.** to compact wastes
3. What is the difference between mechanical digestion and chemical digestion?
4. What happens to the food that you eat when it gets to your stomach?
5. Describe the role of the liver, gallbladder, and pancreas in digestion.
6. Put the following steps of digestion in order.
   - **a.** Food is chewed by the teeth in the mouth.
   - **b.** Water is absorbed by the large intestine.
   - **c.** Food is reduced to chyme in the stomach.
   - **d.** Food moves down the esophagus.
   - **e.** Nutrients are absorbed by the small intestine.
   - **f.** The pancreas releases enzymes.

Critical Thinking

7. **Evaluating Conclusions** Explain the following statement: "Digestion begins in the mouth."
8. **Identifying Relationships** How would the inability to make saliva affect digestion?

Interpreting Graphics

9. Label and describe the function of each of the organs in the diagram below.