After you have finished reading this chapter, you should be able to:

**Understand** the importance of proper nutrition for good health.

**Outline** the process of digestion in different types of organisms.

**Describe** the structures and functions of the human digestive system.

*For some animals, obtaining food is a relatively simple task. Tapeworms, for example, have no mouth or digestive tract; they simply attach to the wall of an animal's intestine and absorb digested nutrients across their outer body surface. For these animals, eating is not necessary. Unfortunately, as humans, we can't enjoy the same advantage. We can't recline in a bathtub of oatmeal for breakfast and chicken soup for lunch and simply soak up the nutrients.***

Gil Brum

**Introduction**

A nutritionist once said, “You are what you eat.” This seems a simple phrase. In this chapter, you will examine this statement to learn how it is true. In addition, you will examine ways your body uses the food you eat.

An adolescent’s body is growing rapidly. The food you eat provides the matter your body uses to build cells, tissues, and organs. The atoms in a carrot you eat will take their place in the new cells you are building. The carrot’s atoms may become part of skin cells, muscle cells, or blood cells. However, is it only growing adolescents who need to eat? Or does a person who is no longer growing also need to eat?

The answer is pretty obvious. You need to eat for as long as you live; our bodies are in constant need of repair even if we are no longer growing. Every day of our lives, some old cells and tissues are replaced by new
ones. Atoms in the carrot may be used in the process of replacing cells and tissues. In addition to using food to build cells and tissues, food provides the energy an organism needs to remain alive. Food provides our matter (what we are made of) and our energy (what keeps us alive). In effect, we really are what we eat. (See Figure 8-1.)

**KNOW YOUR FOOD: PROPER NUTRITION**

In the 1880s, a nerve disease called *beriberi* affected many soldiers being cared for at a military hospital in the Dutch East Indies. The patients who developed beriberi were extremely tired. In time, their muscles became weak, and some even became paralyzed. Scientists studying this disease spent years searching for the microorganisms they assumed must be the cause of beriberi. They were unsuccessful.

Then in 1896, one scientist, Christian Eijkman, noticed that some of the chickens that lived near the hospital also showed symptoms of beriberi. Within four months, many but not all of the sick chickens died. Eijkman studied the chickens that survived. He learned that a new worker in the hospital had stopped feeding the surviving chickens food that was left over from feeding the hospital patients. Most of the hospital leftovers consisted of white polished rice, in which the outer shells (hulls) of the rice seeds (kernels) have been removed. Eijkman learned that the new hospital worker was feeding the chickens whole rice that still had outer hulls. Later, Eijkman found that whole rice reversed beriberi in both chickens.
and humans. Something present in the outer hulls of rice kernels had cured the disease. (See Figure 8-2.)

This discovery, made over a century ago, provided the first clue that something missing from a diet can produce a specific disease. Years later, researchers discovered that rice hulls contain vitamin B$_1$, also called thiamin. Thiamin is a coenzyme needed by an enzyme in one of the chemical reactions that occurs in cellular respiration. Without vitamin B$_1$, the enzyme does not work and a basic function of cell metabolism is disrupted.

Useful, often essential, molecules in food are known as nutrients. The six main groups of nutrients are carbohydrates, lipids, proteins, vitamins, minerals, and water. The first three types—carbohydrates, lipids, and proteins—can be used by the body as sources of energy. These organic compounds can be broken down and used in chemical reactions that eventually produce ATP. The breaking down of more complex substances into simpler substances is called catabolism. The chemical pathways of cellular respiration that produce energy from nutrients are catabolic pathways. Chemical reactions that break down substances are a major part of metabolism.

Organisms also combine simpler molecules to make more complex substances. This building-up part of metabolism is called anabolism. For example, proteins are broken down into amino acids. These amino acids are then used in anabolic pathways to build other proteins an organism needs. Lipids are also broken down and reassembled into new lipids. It is through anabolic pathways that nutrients provide the matter that living organisms need.

Amino acids are the building blocks of proteins. Humans can make only 12 of the 20 types of amino acids the body needs. The eight amino acids that cannot be made by humans, called the essential amino acids, must be obtained from food. Rice and beans are a popular combination of foods. You might be surprised to learn that there is a sound nutritional reason for eating rice and beans together. Neither rice nor beans alone provide all eight of the essential amino acids. To get all eight amino acids, you must eat both rice and beans together!

What nutrient makes up most of what we eat? Most of our food consists of water. For example, almost 95 percent of a tomato is water. (See Figure
While we need about 50 grams of protein a day, we need 2 liters or 2000 grams of water a day. We also need vitamins and minerals—simple chemical elements such as calcium, magnesium, iron, sodium, potassium, and chlorine—in our food to allow for the proper functioning of a wide variety of chemical reactions that occur in cellular metabolism.

It is also recommended that a person’s diet include foods high in fiber, also called roughage. Fiber is the part of plants that cannot be broken down by our digestive system. Fiber consists mostly of the complex carbohydrate cellulose. Cellulose is what makes up the tough wall that surrounds plant cells. If fiber cannot be digested, why do we need to include it in our diet? In fact, it is now believed that a high-fiber diet reduces the risk of developing certain kinds of cancer. Dietary fiber works in this way: Because it cannot be digested, fiber must be eliminated by the body. Having significant amounts of dietary fiber to eliminate keeps food and other ingested materials moving through the body. Organs that make up the digestive system have many muscles. Like the muscles in our arms and legs, muscles in the organs of our digestive system must be kept in good shape. Fiber makes the muscles work by forcing them to move it through the body. As a result, fiber helps prevent constipation, a condition that occurs when food moves too slowly through the digestive system. In addition, fiber helps remove dangerous substances, or toxins, that may be present in food. For all of these reasons, eating food with sufficient amounts of fiber will help maintain good health.

\[\text{LET’S EAT RIGHT, BUT HOW?}\]

In 1977, the United States government published a set of dietary guidelines, recommending what people should eat. There was great concern that the incidence of heart disease was increasing, and something had to be done. The best-known form of these guidelines is found in the Food Guide Pyramid that was developed by nutritionists at the United States Department of Agriculture in 1991. It groups together foods of certain types and shows how many servings of each type of food the average person should eat each day. The pyramid is designed to be a clear and simple way to help people select the correct foods to eat, that is, foods that contain the proper nutrients. (See Figure 8-4 on page 166.)

There are six types of food in the food pyramid. The food types you should eat the most of according to the USDA are at the broad base of the
The foods that you should eat the least of are at the narrow top of the pyramid. Notice that the grain group is in the bottom level of the pyramid. The next layer up contains the fruit and vegetable groups. In the next higher layer are the foods in the milk group and the meat, poultry, fish, eggs, beans, and nuts group. Finally, at the top of the pyramid are fats, oils, and sweets. According to these guidelines, these foods should be consumed in limited amounts. The food pyramid is meant to be a visual representation of a healthful diet. Foods in a healthful diet should be selected in the same way the food pyramid is constructed, with more servings of foods at the bottom and fewer servings of foods at the top.

However, a great deal of controversy surrounds these guidelines. What is troubling to many prominent scientists and nutritionists is that, in spite of all the attention given to healthy eating (especially for low-fat, high-carbohydrate diets, as recommended by the Food Guide Pyramid and encouraged by the food industry), the levels of obesity and diabetes have increased significantly in the United States in the last 25 years. In addi-
tion, heart disease has not decreased. The head of the department of nutrition at the Harvard School of Public Health declared in 2001 that the food pyramid is not at all accurate. The food pyramid says that all fats are bad and all complex carbohydrates are good. In a major article in *The New York Times* in July 2002, this nutritionist and a variety of other researchers stated that such thinking may, in fact, be all wrong. They state that it is necessary to understand the hormone insulin and how it works in relation to carbohydrates, levels of sugar in the blood, and the conversion of stored sugar into fat. Also, we must learn what determines whether the body uses stored fat or carbohydrates for energy, and what determines the feelings of hunger and fullness in a person. More scientists and nutritionists are beginning to suggest that fat in our diet may be good and that too many carbohydrates, like white bread and pasta, may be bad for your health. Intensive scientific research is just beginning to get answers to the question: How do we eat right? One thing is certain—it will be careful scientific investigation and not just government policy makers that will give us reliable answers to such important questions.

### THE NEED FOR DIGESTION

Food comes in many different forms. For a single-celled ameba, food may be a bacterial cell one-tenth the ameba’s size. For an earthworm, food may be a piece of a leaf that fell to the ground. A fish may eat a small crayfish; a bird may eat an earthworm. For us, food may be a hamburger or a piece of celery. For all organisms, food must be digested. Why?

Every organism is a single cell or a collection of cells. The cell theory states that cells are the basic units of structure and function of all organisms. In other words, what an organism needs is what its cells need. An organism needs food because its cells need food. You may be 1.5 meters tall and weigh 60 kilograms, but, from a biological point of view, a human—or a cat, a tree, or any other organism—is simply a collection of a very large number of cells. Each and every one of the 40 trillion (12 zeros!) or so cells in your body needs food to survive. So in order to nourish you, the food you eat must get into each of your cells.

That is why digestion is necessary. The foods mentioned—a piece of leaf, a crayfish, an earthworm, a hamburger, or a piece of celery—are all too large, their molecules too complex, to get inside of a single cell. For substances to get inside the cells, they must be broken down into relatively simple molecules. **Digestion** is the process of breaking down food particles into molecules small enough to be absorbed by cells.
DIFFERENT ORGANISMS: DIFFERENT METHODS OF DIGESTING FOOD

Usually, before food can be digested, it must be taken into an organism. The process of taking in food is appropriately called ingestion. For most organisms, the food starts to be broken down right after ingestion. Often this begins with food being made into smaller pieces by mechanical digestion. In humans and many other animals, this is accomplished by chewing. Teeth break the food into smaller pieces. Mechanical breakdown is followed by chemical digestion. During chemical digestion, enzymes break large molecules into small, simpler molecules. These small molecules can then get into the cells by absorption. Finally, elimination occurs as indigestible material, such as fiber, passes out of the organism.

The ameba ingests its food by surrounding it. In a flowing motion, called phagocytosis, an ameba engulfs a food particle such as a bacterium. Once inside the ameba, the bacterium is contained within a food vacuole. Lysosomes, organelles that contain enzymes, join with the food vacuole to deliver the enzymes that digest the food. This process that occurs in the cell is intracellular (chemical) digestion. (See Figure 8-5a.)

Have you ever seen a stump of a dead tree covered with mushrooms? The mushrooms survive by feeding on the nutrients contained in the dead wood cells. To take the complex molecules of wood into its cells, the mushroom secretes enzymes into the tree stump. Wood molecules are broken down outside the fungus and then absorbed. The work done by the digestive enzymes outside the mushroom’s cells is called extracellular digestion. (See Figure 8-5b.) Organisms in the fungus kingdom are an important exception to the usual order of things. Chemical digestion occurs outside these organisms before food gets taken in. The matter that once made up the bodies of most organisms gets broken down by fungi after the organism’s cells have died. This process, which we call rotting, or decomposition, may happen in your refrigerator if food is left there too long; but it is happening in the natural world all the time. By the process of decomposition, fungi, along with many types of bacteria, make it possible for the organic compounds in dead organisms to get recycled and reused by living organisms.
Another very different digestive system is found in the Planaria, a type of flatworm often found living under rocks in streams and ponds. A planarian’s mouth is on its underside, or ventral surface. Extending from the mouth is a muscular tube, the pharynx, which the planaria can push into its prey to release digestive enzymes there. Partially digested food then gets sucked into a pouch, or sac, inside the planaria, called the digestive cavity. Further digestion and absorption into cells occur here; undigested materials leave the flatworm through its mouth. (See Figure 8-6.)

Crayfish eat plants, dead organisms, and even other crayfish. They grab food with their claws and tear it into smaller pieces. Next,
mandibles crush the food before it gets passed into the crayfish’s mouth. Then the food passes into the **esophagus**, the tube located at the beginning of the animal’s digestive system. The crayfish’s digestive system consists of a pathway beginning with one opening, a mouth, and ending with another, the anus. As food travels through the pathway, the process of digestion occurs in a series of steps. The pathway of digestion is similar to an assembly line in a factory, except that the reverse process is occurring. Instead of putting parts together in a specific series of steps, we are now taking particles of food apart, one step at a time. This **one-way digestive system** is found in many animal species, including humans.

So, in crayfish, the digestive pathway or tube begins with the mouth and esophagus. Leaving the esophagus, the food is moved into the stomach. Here, hard teethlike structures grind up the food. Chemical digestion then occurs, and the food is transported by the blood for absorption into the cells of the crayfish. Undigested food material passes into the intestine to be eliminated through the anus. (See Figure 8-7.)

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**Figure 8-7** The crayfish has a one-way digestive system: food enters the mouth and waste exits the anus.

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**THE HUMAN DIGESTIVE SYSTEM**

The digestive system in humans has exactly the same purpose as the digestive system in any other organism: to get nutrients from food into cells. When does food enter your body? Not when you put it in your mouth; not even when it enters your stomach or your intestine. These locations are actually spaces directly connected to the outside world. Food does not really enter “you” until it is absorbed across the membranes of cells that line your digestive system. Only then is the food truly inside of you. (See Figure 8-8.)

Think about what happens to a hamburger as it travels through the human digestive system. To begin, of course, the hamburger must enter the mouth. Teeth in the mouth provide mechanical digestion. The meat and bun get broken up into smaller and smaller pieces. This chewing process increases the surface area of the food. Smaller pieces of food provide more surface area for the body’s enzymes to work on. When in the
mouth, the hamburger is mixed with **saliva**, a fluid produced by salivary glands in the mouth. Chemical digestion begins as the enzyme amylase in the saliva starts the digestion of starch in the hamburger bun. The large polysaccharide molecules begin to be broken down into simpler molecules, eventually to the monosaccharide sugars. (See Figure 8-9.)

Swallowing occurs in two steps. The tongue pushes the food to the back of the mouth where it enters the esophagus, a muscular tube that carries the mouthfuls of hamburger down to the stomach. As the food starts its 10-second journey through the esophagus, an involuntary action begins. Waves of muscle contractions, called **peristalsis**, occur. As the process of peristalsis is initiated, the pathways up to the nose and down to the lungs are closed off. The epiglottis is a small flap of tissue that is pushed down by the food being swallowed to close off the trachea.

Figure 8-9  Food does not really enter you until it is absorbed across the membranes of the cells that line the digestive system.
The trachea is the pathway for air to the lungs; if food enters it by mistake, uncontrollable coughing and difficult breathing occur. (See Figure 8-10.)

When the waves of contraction along the esophagus arrive at the stomach, a muscular valve quickly opens and closes. The valve allows the food to enter the stomach, without letting out the acidic contents of the stomach. Occasionally, acid backs up through the valve, causing a pain commonly called “heartburn.” This pain has nothing to do with the heart. Heartburn occurs when stomach acid reaches the lining of the esophagus, causing a painful feeling in the chest.

The stomach is a large muscular organ on the left side of the abdomen, just below a muscular sheet called the diaphragm. Having many folds in its wall, the stomach can stretch from its normal 1-liter size to hold 4 liters of food. The stomach evolved long ago in animals because it was an advantage to store food. With this ability, an animal could eat less frequently. Eating is often a dangerous time for many animals. A grazing animal, for example, has to lower its head to eat grasses. In that position, it is more difficult for the animal to notice a predator. Therefore the ability to eat quickly, and store food in the stomach for digestion later, was an adaptation that contributed to an animal’s survival. It is interesting to note that some people survive quite well without a stomach. In some
cases the stomach, or part of the stomach, is surgically removed in order to fight stomach cancer. A person without a stomach has a digestive system that is basically one long tube. These people eat small amounts of food many times during the day.

The muscular movement of the stomach churns the food and continues the process of mechanical digestion. As muscles in the stomach wall contract and relax, food gets mixed with gastric juice. Gastric juice, made and released by cells in the stomach wall, contains hydrochloric acid, pepsinogen, and water. The hydrochloric acid kills many bacteria that may be present in the food, some of which could cause illness. The acid also turns the pepsinogen into the protein-digesting enzyme pepsin. Therefore, a second step in the chemical digestion of the hamburger begins in the stomach with the breaking down of the protein in the meat by pepsin.

Muscular contractions of the stomach walls occur in waves of peristalsis, pushing the contents of the stomach into the small intestine about 3 or 4 hours after your meal. The small intestine, which is a muscular tube like the esophagus, is about 6 to 7 meters in length. (The small intestine takes its name from the small size of its diameter, only about 2.5 centimeters. It is actually longer than the large intestine, which is about 1.5 meters long.) Again, peristalsis moves food material along the length of the small intestine. Most of the chemical digestion of food occurs in the small intestine, not in the stomach. Large quantities of different enzymes are used to accomplish this task. These enzymes come from two major sources—the lining of the small intestine itself and the pancreas. Enzymes that break down all four major types of organic compounds come from the pancreas. These include the enzyme trypsin that breaks down proteins, nuclease for nucleic acid, carbohydrase for carbohydrates, and lipase for lipids.

Of the nutrients in the hamburger, the fat—usually a substantial amount—causes the most problems. Fat particles remain stuck together, making it difficult for the lipase enzymes to break them down. (Remember that enzymes work only on the surface of a food particle.) The liver, the largest organ in the abdomen, helps the body digest fat by producing bile. Bile is stored in the gallbladder until it is needed. Then bile is emptied into the small intestine through a small duct. When it comes in contact with fat, bile acts like the detergent in dish soap and breaks up the fat into smaller droplets. This process is called emulsification. Bile emulsifies fats into tiny droplets, allowing them to be more effectively digested by enzymes.

By now, the hamburger is very much changed. The starch that was in the bun has been changed into monosaccharide sugar molecules. The
meat protein exists as amino acids, and the fat as fatty acid molecules and glycerol. Remember, all of this food is still outside of you! Now, these small molecules are able to pass through the wall of the small intestine into your blood vessels. In the blood, the food is carried to your cells. Finally, your food is really inside of you!

In order to make this absorption of food molecules more efficient, the inside of the small intestine has many folds covered by large numbers of fingerlike projections called villi. These projections, and even smaller projections on each of them, greatly increase the surface area inside the small intestine. The surface area of all the villi is equal to the size of an entire tennis court. This huge surface area is all wrapped up inside your small intestine! (See Figure 8-11.)

Almost all of the useful nutrients get absorbed in the small intestine. Anything that passes on from there into the large intestine is primarily indigestible material, such as the cellulose in the lettuce that was on the hamburger. Compared to the small intestine, the large intestine is large
quickly refill their reserves. On again, off again, or “yo-yo,” dieting may result. The fluctuating weight loss and gain can be dangerous.

Most researchers now realize that the best way to avoid becoming overweight is to reduce the amount you eat somewhat and to increase physical activity. Exercise increases the amount of energy used by the body. It also increases the amount of muscle tissue, which even when resting burns more calories than other types of body tissues.

There are other serious health risks involved in severe weight loss that is caused by a refusal to eat. The disorder called anorexia nervosa is most common in young women. Abnormal fears of being overweight, as well as other fears, may lead to anorexia nervosa. An anorexic person appears unhealthy. This disorder can be fatal.

Bulimia is another eating disorder. Unlike most anorexics, a person with bulimia might appear healthy. However, this person swings between overeating and getting rid of the food, often by taking laxatives or inducing vomiting. Some studies show that as many as 20 percent of college-age women suffer from some form of bulimia. This disorder can be dangerous. It can damage the heart, kidneys, or digestive system. Counseling to help a person understand the reasons behind these eating disorders is important. It is also important to learn how to make wise choices about what one eats. In some severe cases, hospital treatment may be necessary.

in diameter, about 6 centimeters, but it is short in length. In the large intestine, water from the remaining material is reabsorbed into the body. Feces, the solids that remain, are pushed along by peristalsis and forced by muscles of the rectum out through the anus.

Figure 8-11 Villi increase the surface area of the small intestine, which makes absorption of food molecules more efficient.
Before concluding this tour of the digestive system, credit must be given to some helpers. Throughout the intestines, huge numbers of bacteria help break down food, producing certain gases as by-products. In fact, almost half the mass of feces, other than the water in them, is made up of bacterial cells. In addition to helping the process of digestion, these intestinal bacteria make several important vitamins. They also help rid the body of harmful bacteria. Fortunately for us, useful “friendly” bacteria keep us company and give important assistance to us in our intestines.

**WHEN THINGS GO WRONG: DISEASES OF THE DIGESTIVE SYSTEM**

In the stomach, gastric juice begins to digest protein in the foods we eat. However, the stomach itself is made of protein. To prevent the stomach from digesting itself, cells in the wall of the stomach produce a thick layer of mucus. This mucous lining protects stomach tissue from the acid and the pepsin it produces in the gastric juice. However, sometimes the layer of mucus protection fails. Gastric juice reaches the wall of the stomach and begins to break it down. The results are painful and serious. The eating away of tissue produces an ulcer. When this happens in the stomach, it is called a *peptic ulcer*.

For many years, it was thought that ulcers should be treated by reducing the amount of acid in the stomach. People who had ulcers were given antacids, chemicals to neutralize the acidity. Although the people often felt better, the ulcers almost always returned. Recently, researchers have shown that an infection by the acid-resistant bacteria *Helicobacter pylori* is really the main factor in causing ulcers. Treatment with antibiotics to kill the bacteria is much more effective for eliminating ulcers than the use of antacids.

A related but rare disease occurs when the duct that carries enzymes from the pancreas to the small intestine becomes blocked. The enzymes build up in the pancreas, and it rapidly digests itself. This condition, called *pancreatitis*, is very serious.

Another place where problems can occur is at the beginning of the large intestine. A small pouch extends from the beginning of the large intestine where it joins the small intestine. This pouch, the appendix, is a vestigial organ. The appendix has no function in humans now, but, in our ancestors, it probably helped in the digestion of plant material. Inflammation of the appendix causes appendicitis, with symptoms that include pain in the abdomen, nausea, and fever. If left untreated or treated incorrectly, the appendix may burst, producing a life-threatening bac-
terial infection in the abdomen. (See Figure 8-12.)

The main job of the large intestine is allowing water to be reabsorbed from the feces. If too much water is reabsorbed, the feces cannot move easily through the large intestine, and constipation occurs. If too little water is reabsorbed, the feces are too liquid, and diarrhea is the result. This can happen if a viral or bacterial infection irritates the lining of the large intestine. Diarrhea can cause the body to lose a great deal of water. Dehydration due to diarrhea is the main cause of infant death in many countries of the world.

One of the most common types of cancer in North America is colon cancer. The large intestine is made up of the colon and the very end of the intestine, the rectum. The typical North American diet contains low levels of fiber. As a result, the feces move too slowly through the colon. This is directly related to colon cancer. Physicians also suggest that there may be a strong hereditary predisposition to colon cancer.

Refer to the table below to review the main types and functions of digestive organs, glands, and enzymes in humans.

**DIGESTIVE ORGANS: THEIR GLANDS, ENZYMES, AND FUNCTIONS**

<table>
<thead>
<tr>
<th>Organ</th>
<th>Gland</th>
<th>Enzyme</th>
<th>Digestive Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouth</td>
<td>Salivary</td>
<td>Ptyalin (amylase)</td>
<td>Starches into sugars</td>
</tr>
<tr>
<td>Stomach</td>
<td>Gastric</td>
<td>Pepsin (protease)</td>
<td>Large proteins into small proteins</td>
</tr>
<tr>
<td>Small intestine</td>
<td>Pancreas</td>
<td>Lipase, trypsin, carboxydrase, nuclease</td>
<td>Fats, proteins, starches, nucleic acids</td>
</tr>
<tr>
<td>Small intestine</td>
<td>Liver</td>
<td>Bile</td>
<td>Digest and absorb fats (fatty acids)</td>
</tr>
<tr>
<td>Small intestine</td>
<td>Intestinal</td>
<td>Intestinal</td>
<td>Sugars; proteins to amino acids</td>
</tr>
</tbody>
</table>
INTRODUCTION

All organisms that consume food need to obtain certain nutrients from the foods. Among the most important of these nutrients are carbohydrates (sugars and starches) and fats. In order to eat a balanced diet, it is important to know which nutrients are found in which foods. A variety of tests are used to detect the presence of certain nutrients in foods. In this investigation, you will test for the presence of glucose (a sugar), starch, fats, water, and protein in a variety of foods.

MATERIALS

Food samples, test tubes, test-tube rack, graduated cylinder, scapula, Lugol iodine solution, Benedict solution, alcohol burner or other source of heat, test-tube clamp, biuret solution, brown paper or a brown-paper supermarket bag, safety goggles

PROCEDURE

Try to predict which nutrients will be found in the food samples before you actually test them. After each test, record your results in a data table.

Note: Wear safety goggles and follow all other safety precautions.

1. To test a food sample for the presence of starch:
   In a test tube, add a drop of Lugol iodine solution to the food sample. A blue-black color indicates the presence of starch.

2. To test for the presence of a sugar:
   In a test tube, cover a food sample with Benedict solution. Place the test tube in a test-tube clamp and heat the test tube until the contents boil. An orange color indicates that sugar is present.

3. To test for the presence of protein:
   In a test tube, cover a food sample with colorless biuret solution. Observe. A pink or purple color in the biuret solution indicates the presence of protein.
4. To test for the presence of fat:
   Gently rub the food sample on a piece of brown paper or a brown paper bag from a supermarket. A translucent grease spot shows that fat is present.

5. To test for the presence of water:
   Gently heat a food sample in a test tube. Place the test tube in a rack and observe the top of the test tube when it cools. Droplets from steam show that water is present.

INTERPRETIVE QUESTIONS

1. How did your predictions compare with the results of your tests on the food samples?
2. List some foods that are good sources of the nutrients you tested for.
3. Why is water considered an important nutrient?
4. Research: What is the importance of, and some uses for, the following nutrients?
   a. carbohydrates
   b. fats
   c. proteins
   d. water
   e. minerals
   f. vitamins


**CHAPTER 8 REVIEW**

*Answer these questions on a separate sheet of paper.*

**VOCABULARY**

*The following list contains all of the boldfaced terms in this chapter. Define each of these terms in your own words.*

absorption, bile, digestion, digestive cavity, elimination, esophagus, extracellular digestion, gastric juice, ingestion, intracellular digestion, lysosomes, mechanical digestion, peristalsis, phagocytosis, saliva, villi

**PART A—MULTIPLE CHOICE**

*Choose the response that best completes the sentence or answers the question.*

1. Which of the following are groups of nutrients?  
   a. vitamins, minerals, water, and carbon dioxide  
   b. carbohydrates, lipids, proteins, and nucleic acids  
   c. carbohydrates, proteins, water, and minerals  
   d. carbohydrates, vitamins, water, and oxygen

2. Starch is broken down by enzymes in saliva. This is an example of  
   a. catabolism  
   b. peristalsis  
   c. anabolism  
   d. mechanical digestion.

3. Amino acids are assembled together to build protein molecules. This is an example of  
   a. catabolism  
   b. peristalsis  
   c. anabolism  
   d. mechanical digestion.

4. Most of the food you eat consists of  
   a. proteins  
   b. carbohydrates  
   c. lipids  
   d. water.

5. Plant-eating dinosaurs had a muscular organ that contained stones that helped to grind up food. This organ was primarily involved in  
   a. chemical digestion  
   b. mechanical digestion  
   c. intracellular digestion  
   d. nutrient absorption.

6. Beriberi is a type of  
   a. bacteria that live in the human digestive system  
   b. disease caused by a vitamin deficiency  
   c. enzyme found in gastric juice  
   d. microorganism involved in decomposition.

7. Amino acids from the proteins you eat are used to make the proteins that make up your body. This is an example of  
   a. absorption  
   b. catabolism  
   c. anabolism  
   d. phagocytosis.

8. Fiber is important to your body because it  
   a. helps keep food moving through the body  
   b. is rich in vitamins  
   c. is an important source of protein  
   d. contains essential amino acids.
9. A spider injects enzymes into its prey, then sucks up the liquefied tissues. This is an example of  
   a. phagocytosis  b. absorption  
   c. extracellular digestion  d. intracellular digestion.

10. Which of these organisms has a one-way digestive system with two openings?  
   a. planarian  b. jellyfish  c. mushroom  d. crayfish

11. Swallowed food is pushed to the stomach through the process of  
   a. phagocytosis  b. peristalsis  c. ingestion  d. mechanical digestion.

12. The food types you should eat most frequently are in the  
   a. top of the food pyramid  b. fruit and vegetable group  
   c. meat, eggs, beans, and nuts group  d. grains group.

13. The process of breaking down food particles into molecules small enough to be absorbed by cells is called  
   a. digestion  b. ingestion  c. phagocytosis  d. exocytosis.

14. Most of the chemical digestion of food takes place in the  
   a. esophagus  b. pancreas  c. stomach  d. small intestine.

15. Villi  
   a. emulsify fats  b. increase the surface area for absorption  
   c. play an important role in mechanical digestion  d. increase the chances of colon cancer.

**PART B—CONSTRUCTED RESPONSE**

*Use the information in the chapter to respond to these items.*

16. Identify structures A through I in the diagram on the next page.

17. At what time does:  
   a. most of the digestive action of bile and pancreatic juice occur?  
   b. the digestion of the starch in a whole-wheat bun begin?  
   c. the digestion of the meat protein in a hamburger patty occur?

18. Explain why a two-opening digestive system is more effective than a one-opening digestive system. Name an animal that has each type of digestive system.

19. Describe how products from the salivary glands, stomach, pancreas, and liver aid in the process of digestion in humans.

20. When people are treated with antibiotics for long periods of time, they may begin to have digestive problems. Explain why this is so.
Eating Right Early Might Reduce Premature Births

A new study of sheep suggests that malnutrition around the time of conception may promote early delivery of offspring.

In the April 25 Science, Frank H. Bloomfield of the University of Auckland in New Zealand and his colleagues followed the pregnancies of 8 ewes that were consistently well fed and 10 ewes that were undernourished from 60 days before conception to 30 days after. Sheep in the latter group, whose weights fell to about 15 percent below normal, had an average pregnancy of 139 days, while the well-fed ewes were pregnant an average of 146 days.

The investigators found that modest undernutrition altered a crucial surge of the hormone cortisol that normally occurs in a mammalian fetus as birth approaches. This surge triggers maturation of organ systems and also seems to provide a signal to the mother that it’s time to give birth. In half of the undernourished ewes, this cortisol spike came early.

“If these findings are applicable to human pregnancy, then a focus on events around the time of conception may hold the key to prevention of one of the major causes of preterm birth,” Bloomfield and his colleagues conclude.

21. Explain the difference in how the two groups of female sheep in the study were treated.
22. State the finding that resulted from this study of the two groups of sheep.
23. Explain why this research could be important to knowledge about human birth.