CHAPTER

32 Digestive and Excretory Systems

KEY CONCEPTS

32.1 Nutrients and Homeostasis

Cells require many different nutrients.

32.2 Digestive System

The digestive system breaks down food into simpler molecules.

32.3 Absorption of Nutrients

Nutrients are absorbed and solid wastes eliminated after digestion.

32.4 Excretory System

The excretory system removes wastes and helps to maintain homeostasis.

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STANDARDS-BASED ASSESSMENT

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1. In the 1850s, Louis Pasteur conducted many experiments and based on his results, proposed that specific microorganisms cause disease. This proposal is an example of a scientific

A hypothesis.

B guess.

C theory.

D experiment.

2.

Set Up for Chicken Pox Experiment		
Volunteer	Injected with Dead Chicken Pox Virus	Injected with Distilled Water
A	X	
B		X
C	X	X

A scientist studies three volunteers who never had chicken pox by injecting each with a dead virus, distilled water, or a combination of the two. The experimental design is described in the table above. After the injection, whose blood stream would *most* likely contain antibodies for the chicken pox virus?

A volunteer A only

B volunteer B only

C volunteers A and B

D volunteers A and C

3. A person infected with HIV is more likely to become sick with other diseases because

A people infected with HIV must take drugs to suppress the immune system.

B pathogens can enter the bodies of people infected with HIV during surgery.

C HIV mutates quickly into other diseases that affect the immune system.

D HIV attacks the cells that produce immune responses.

4. Mucous membranes and the skin are nonspecific defenses against infection. The functions of the skin in immunity are to block the entry of pathogens and to

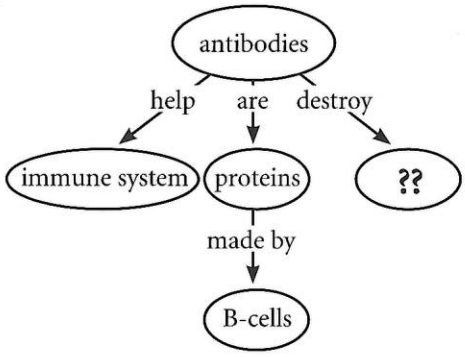
A release white blood cells.

B produce antibodies.

C secrete sweat and oil.

D activate active immunity.

5.



Which word *best* completes this concept map?

A white blood cells

B red blood cells

C pathogens

D vectors

6. Some interferons stimulate noninfected cells to produce thick coats that prevent viruses from infecting the cells. Which statement *best* explains why interferons are effective against viruses but not bacteria?

A Bacteria are living microorganisms, but viruses are not.

B Interferons affect viral DNA, but do not affect bacterial DNA.

C Bacteria have a cell wall, but viruses only have a protein coat.

D Viruses need to enter a cell to reproduce, but bacteria do not.

THINK THROUGH THE QUESTION

To answer this question, think about how bacteria and viruses are different. Which of these differences is related to the way interferons act?

What is that gut feeling inside you?

SEM; magnification 5000×

Connecting CONCEPTS

A lot is going on in your stomach when you eat. For instance, epithelial cells, shown in the close-up above, secrete four types of substances: stomach acid; a protective mucus that keeps the stomach from digesting itself; enzymes that break down many types of food; and hormones that control the process.

Organ Systems This colored CT scan is a cross-section of the digestive system as seen from above. The vertebrae and rib bones (white) help to protect the liver, stomach, and pancreas. The small and large intestines (not shown) are below these organs. The whole system breaks down food into simpler molecules that the body can absorb and use.

32.1 Nutrients and Homeostasis

KEY CONCEPT Cells require many different nutrients.

MAIN IDEAS

- Six types of nutrients help to maintain homeostasis.
- Meeting nutritional needs supports good health.

VOCABULARY

mineral, p. 973
vitamin, p. 974
Calorie, p. 975

Review
carbohydrate, protein, fat

REVIEW AT CLASSZONE.COM

Connect Until the 1740s, British sailors on long voyages were crippled by scurvy, an illness that produced weakness, bruising, bleeding gums, and painful joints. British physician James Lind learned that Dutch sailors who ate oranges at sea never got scurvy. He hypothesized that citrus fruits might not only cure the illness but prevent it as well. To test his ideas, Lind divided the crew of one ship into six groups and gave each group different foods. Only the sailors eating oranges and lemons remained healthy. By simply adding vitamin C to the sailors' diets, Lind had shown the British navy how to wipe out scurvy at sea.

MAIN IDEA

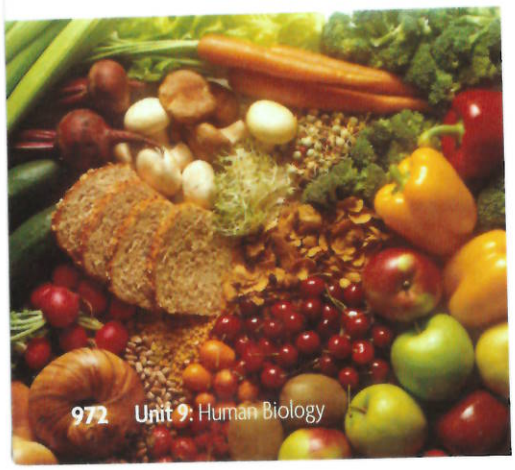
Six types of nutrients help to maintain homeostasis.

Today, scientists and health experts know a great deal more about how important nutrients are to maintain homeostasis in your body. You need to consume six types of nutrients every day to keep your body in good health: water, carbohydrates, proteins, fats, minerals, and vitamins. If any one of these nutrients is missing for too long, your body's cells will stop working properly, which also affects your organs.

Water

Your body is made up of 55 to 60 percent water. As a natural solvent, water is involved in nearly every chemical reaction in every cell of your body. It also helps you to digest food and eliminate waste products, maintain your blood volume, regulate your body temperature, and keep your skin moist. To maintain your fluid balance, you need to drink about 2 liters (8 cups) of water a day to replace the amount you lose through sweat, urine, and respiration.

FIGURE 32.1 Complex carbohydrates (whole grains, potatoes, vegetables) must be broken down into sugars to be used as fuel. Simple carbohydrates, such as those found in fruits, do not need to be broken down as much.



Carbohydrates

Carbohydrates, shown in **FIGURE 32.1**, are the main source of energy for your body. Simple carbohydrates are sugars found in sugar cane, honey, and fruits. Complex carbohydrates are starches found in vegetables, grains, and potatoes. To be absorbed by your body, starches must be broken down during digestion into simple sugars, such as glucose. Excess supplies of glucose are converted to glycogen and are stored in the liver and muscle tissues for future use. Many grains, fruits, and vegetables also contain cellulose, a dietary fiber. Fiber cannot be digested, but it helps move food through your digestive system.

Proteins

Proteins are the raw materials used for the growth and repair of the body's cells and tissues. In addition, proteins make up all enzymes and many hormones that are vital for cell metabolism. Proteins are composed of chains of amino acids. Your body can make only 12 of the 20 amino acids it needs to build proteins. The other 8, called essential amino acids, must come from the foods you eat. Foods such as meat, cheese, and eggs contain all eight essential amino acids. However, most plant proteins lack at least one essential amino acid. Vegans—people who do not eat meat, dairy products, or eggs—must eat plant foods in combination to obtain all the amino acids they need. For example, red beans and rice together contain all 20 amino acids.

Fats

Fats provide energy and key components in cell membranes, myelin sheaths for neurons, and certain hormones. Fats consist of long chains of fatty acids hooked to glycerol molecules. Your body can make some fatty acids, but you must obtain all of the essential fatty acids from the foods you eat. Fats are classified as either saturated or unsaturated, depending on the structure of their fatty acid chains. Saturated fats are solid at room temperature and are found in animal products. Most unsaturated fats are liquid at room temperature and are found in plant oils, such as corn or olive oils, and in some fish, such as cod or salmon. In general, unsaturated fats are considered more beneficial to people's health than are saturated fats.

FIGURE 32.2 Proteins and fats are often found in the same foods. Beef, chicken, and eggs contain protein and saturated fats. Fish, nuts, beans, and seeds contain protein and unsaturated fats.

Minerals

Small amounts of minerals and vitamins are also needed to maintain homeostasis. **Minerals** are inorganic materials the body uses to carry out processes in cells and to build or repair tissues. Some of the more common minerals are listed in **FIGURE 32.3.** Calcium, for example, is essential for bone and tooth formation, muscle contraction, and nerve transmission. Sodium and potassium help to maintain the body's fluid homeostasis. You are constantly losing minerals in sweat, urine, and other waste products. You can replace them by eating a variety of plant foods or by combining plant and animal foods.

TAKING NOTES

Use a two-column chart to organize your notes about different nutrients and their functions.

Water	- makes up 55 to 60% of body - maintains blood volume

FIGURE 32.3 Important Minerals

MINERALS	SOURCES	IMPORTANT FOR
Calcium	dairy products, salmon, sardines, dark leafy greens	blood clotting, bone/tooth formation; muscle/nerve function
Iron	liver, dark leafy greens, whole grains	component in hemoglobin
Iodine	iodized salt, seafoods, sea vegetables	component in thyroid hormones
Magnesium	nuts, whole grains, leafy green vegetables	bone/tooth formation; coenzyme in protein synthesis
Phosphorus	meats, dairy products, nuts, dried peas and beans	bone/tooth formation; active in many metabolic processes
Potassium	meats, dairy products, many fruits and vegetables	regulation of pH, fluid balance, and muscle/nerve function
Sodium	table salt, seafoods, processed foods	regulation of pH, fluid balance, and muscle/nerve function
Zinc	meats, seafoods, grains	activation of many enzymes in metabolic processes

Vitamins

Vitamins are organic molecules that work with enzymes to regulate cell functions, growth, and development. As shown in **FIGURE 32.4**, these nutrients are divided into fat-soluble vitamins and water-soluble vitamins. Fat-soluble vitamins dissolve in fatty acids. The fat-soluble vitamins A, D, E, and K can be stored in the body's fatty tissues for future use. For this reason, taking high doses of these vitamins can actually create harmful, or toxic, levels in the body.

Water-soluble vitamins dissolve in water. The water-soluble vitamin C and the B vitamins cannot be stored and are excreted in urine and feces. As a result, you need to eat foods rich in these nutrients to keep replenishing them. The National Academy of Sciences publishes recommended daily amounts of minerals and vitamins based on your age, gender, and level of activity.

Apply Would a diet higher in protein or in complex carbohydrates give you more energy? Explain your answer.

FIGURE 32.4 Essential Vitamins

VITAMIN	SOURCES	IMPORTANT FOR
Fat-Soluble (Dissolves in Fat)		
A (retinol)	dark green, yellow, and orange vegetables, fortified milk, fish and liver oils	healthy skin, mucous membranes, vision
D (calciferol)	fortified dairy and whole grain products, egg yolks, fish and liver oils	bone and tooth formation, increase in calcium and phosphorus absorption
E (tocopherol)	vegetable oils, nuts, fish oils, meats, leafy green vegetables	prevention of cell damage
K	leafy green vegetables, egg yolks, liver; also made by intestinal bacteria	blood clotting and synthesis of clotting factors
Water-Soluble (Dissolves in Water)		
B_1 (thiamine)	pork and red meats, whole grains, dried beans and peas, eggs	metabolism of carbohydrates
B_2 (riboflavin)	dairy products, liver and organ meats, enriched whole grains	metabolism of carbohydrates and proteins, normal growth in skin, lips, and mucous membranes
B_3 (niacin)	meats, dried peas and beans, whole grains	metabolism of glucose, fats, and proteins
B_6 (pyridoxine)	meats, fish, peanuts, eggs, bran cereal	metabolism of amino acids
B_{12}	liver, meats, eggs, dairy products	protein synthesis and red blood cell production
C (ascorbic acid)	citrus fruits, berries, tomatoes, broccoli, cabbage, potatoes, melons	antioxidant, maintenance of cartilage and bone, iron absorption, tissue repair, wound healing, healthy gums
Pantothenic acid	meats, dairy products, whole grains	metabolism of glucose, fats, and proteins
Folic acid	leafy green vegetables, liver, nuts, oranges, broccoli, peas, fortified cereals	amino acid synthesis and metabolism, prevention of neural tube defects in fetuses
Biotin	egg yolks, liver, soybeans	metabolism of carbohydrates, proteins, and fats
Choline	egg yolks, liver, whole grains	production of phospholipids and neurotransmitters

MAIN IDEA

Meeting nutritional needs supports good health.

A balanced diet is important throughout your life, but particularly during pre-teen and early teen years. During these years, you are growing and developing faster than at any other time since the first two years of your life. Your bone mass is increasing nearly 40 percent, you are gaining most of your adult body mass, and you are developing sexual characteristics.

To fuel this growth spurt, your body requires considerably more nutrients and more energy in the form of Calories consumed, as shown in **FIGURE 32.5.** A calorie, with a small *c*, is the amount of energy required to raise one gram of water one degree Celsius. One **Calorie** (capital *C*) from food equals one kilocalorie, or 1000 calories. Different foods contain different amounts of energy. One gram of protein or carbohydrate yields four Calories, while one gram of fat yields nine Calories.

Calories alone are not the whole story, however. The rapid changes in your body require adequate amounts of all six nutrients. Dietary experts recommend that most of your Calories come from eating whole grains, fruits, and vegetables, which are rich in fiber, vitamins, and minerals. Also, experts suggest drinking more low-fat milk or soy drinks and water, and fewer high-sugar soft drinks and juices. High-sugar foods provide Calories but very little nutritional value. Dietary experts also recommend eating more lean meats and fish, while cutting down on foods high in saturated fat.

It is also important to find a balance between food and physical activity so that you use about as many Calories as you consume. The U.S. Department of Agriculture (USDA) Web site provides information on how to develop a balanced diet.

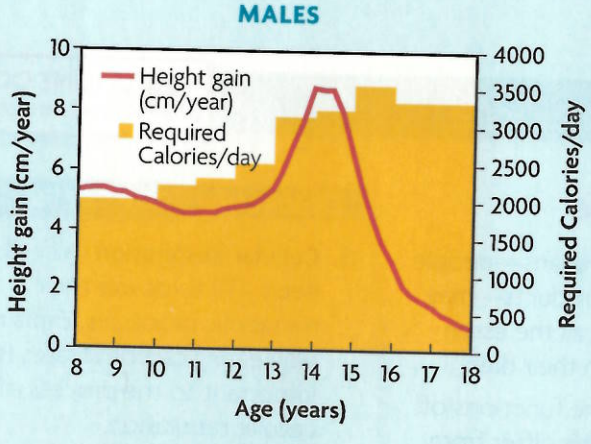
Connecting CONCEPTS

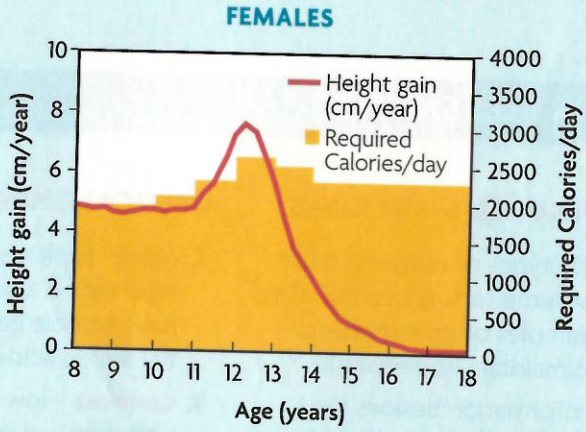
Cellular Respiration You read in **Chapter 4** about the different ways that plant and animal cells obtain energy. In nearly all plant and animal cells, mitochondria use molecules broken down by digestion to build ATP, the main power source for cells.

FIGURE 32.6 Your food choices can help you consume high-quality energy and nutrients at a time when your body needs them the most.

FIGURE 32.5 Growth and Energy Needs

During rapid growth, the body requires significantly more energy.

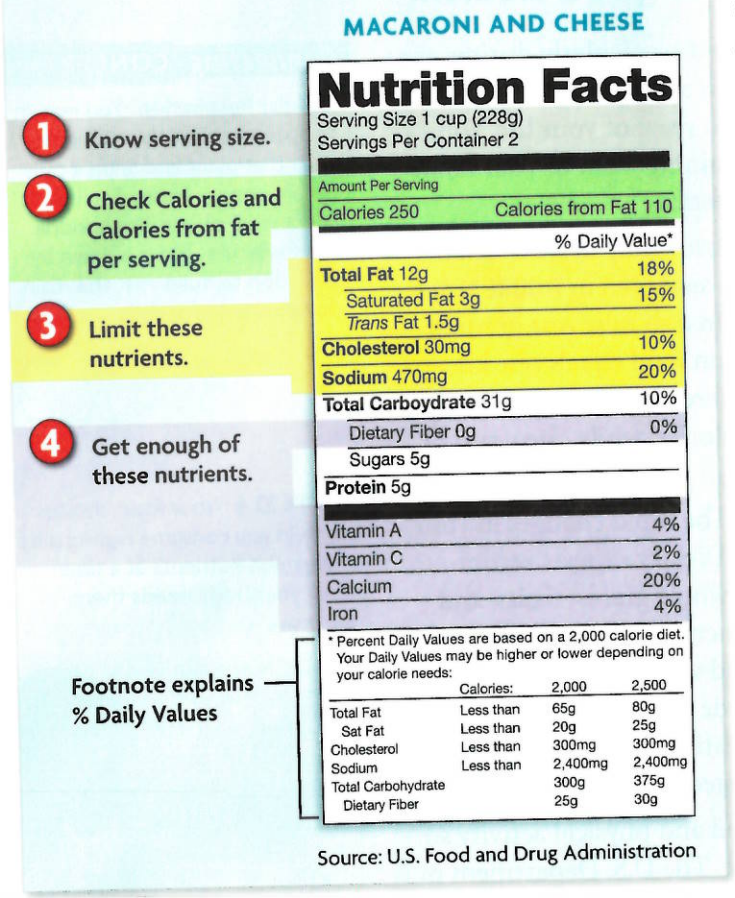




Contrast **What differences do you notice between the two charts?**

Sources: Adapted from JM Tanner: *Growth at adolescence,* ed.2, Oxford; Food and Nutrition Board: *Recommended dietary allowances,* ed. 10, National Academy Press; Institute of Medicine, Food and Nutrition Board, *Dietary reference,* National Academies Press.

FIGURE 32.7 READING A FOOD LABEL



Source: U.S. Food and Drug Administration

The information on a food label, such as the one in **FIGURE 32.7**, can help you make good choices and compare the values of different foods. The label shown here is from a box of macaroni and cheese.

1. **Serving size and number** This measurement varies from one product to another. In this case, one serving equals one cup. Notice that this container holds *two* servings.
2. **Calories and Calories from fat** The numbers listed on the label are for *one serving only.* If you eat both servings, you are actually getting 500 Calories, nearly half from fat.
3. **Nutrients to limit** Americans usually consume too much saturated fat, trans fat, cholesterol, and sodium. Trans fat is a type of fat that can cause cell damage. A diet high in these nutrients is linked to obesity, which affects more and more Americans of all ages. Too much sodium can raise blood pressure by causing the body to retain water.
4. **Nutrients to target** Americans need to consume enough of these nutrients each day. Notice that this product is low in vitamins and minerals, except for calcium, and has no dietary fiber. The wheat used in the macaroni has been processed until there is no fiber left.

As the label shows, if you eat this product, you will also need to eat whole grains, vegetables, and fruits during the day to obtain the nutrients that are missing from this food.

Analyze What nutritional advantages do unprocessed foods offer over processed foods?

32.1 ASSESSMENT

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REVIEWING MAIN IDEAS

1. What six types of nutrients must you consume to stay healthy? Give two examples of how nutrients help to maintain homeostasis.
2. What information besides the number of **Calories** can help you make good food choices?

CRITICAL THINKING

3. **Apply** Explain why vegans—people who eat no animal products—may have trouble getting all the essential amino acids from their diet.
4. **Contrast** How do the functions of **vitamins** and **minerals** differ from the functions of proteins and carbohydrates?

Connecting CONCEPTS

5. **Cellular Respiration** All cells need ATP to power their metabolic processes. Explain why eating carbohydrates is so important to the process of cellular respiration.

32.2 Digestive System

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.

VOCABULARY

digestion, p. 977
digestive system, p. 977
sphincter, p. 977
esophagus, p. 978
peristalsis, p. 978
stomach, p. 978
chyme, p. 979
small intestine, p. 980
bile, p. 980

REVIEW AT CLASSZONE.COM

Connect In June 1822, Alexis St. Martin was shot in the stomach and treated by William Beaumont, an Army surgeon. The 28-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 86.

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 32.8.** 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.

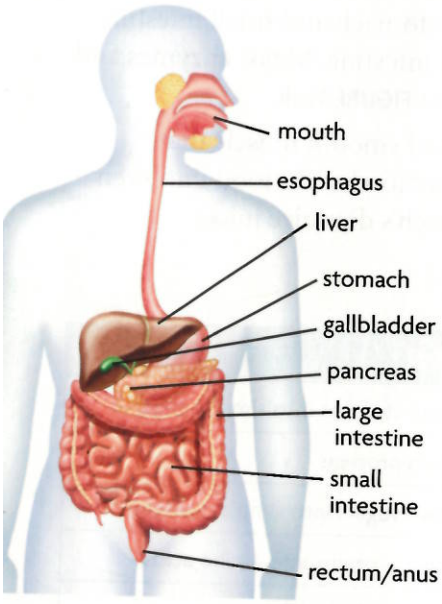


FIGURE 32.8 The major digestive organs are separated by sphincters, which help keep food moving in one direction.

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

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.

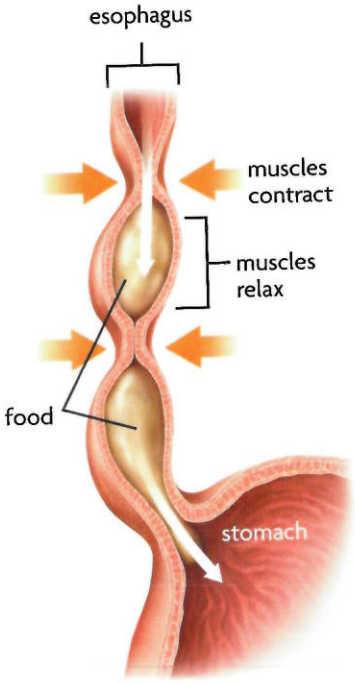


FIGURE 32.9 As food enters the esophagus, muscles behind the food contract, pushing it forward, while the muscles in front of the food relax. This rhythmic squeezing, called peristalsis, keeps food moving in one direction.

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 32.9** 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 32.10**.

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 32.10 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 32.11** 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?**

Connecting CONCEPTS

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.

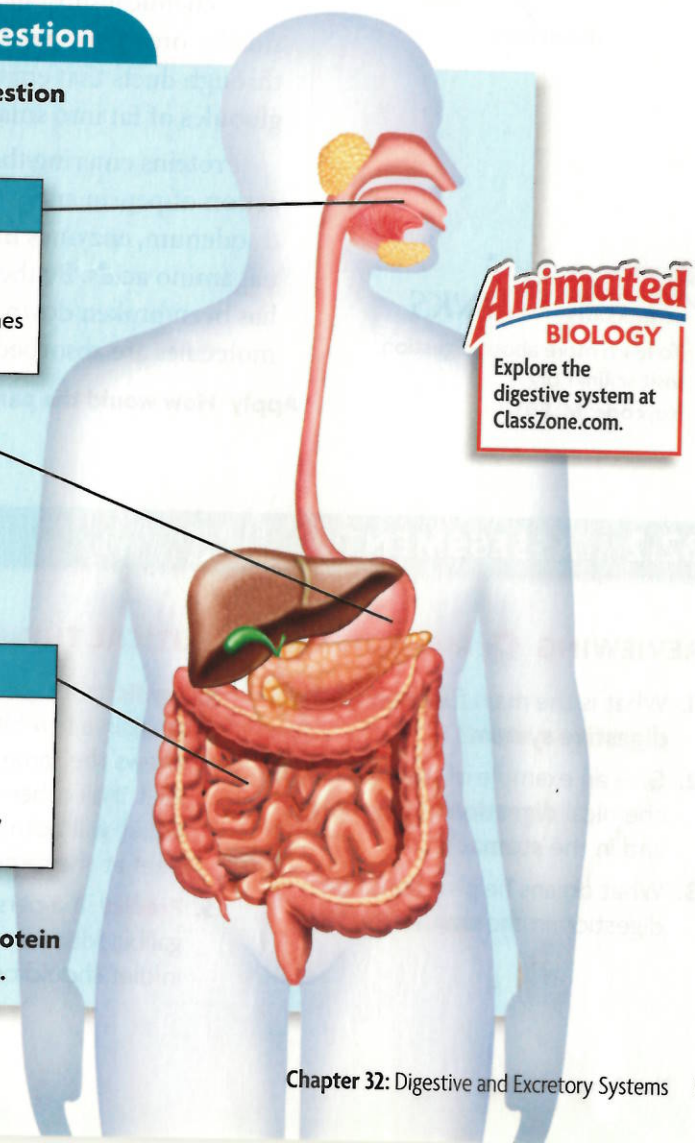
FIGURE 32.11 Mechanical and Chemical Digestion

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.



Animated BIOLOGY
Explore the digestive system at ClassZone.com.

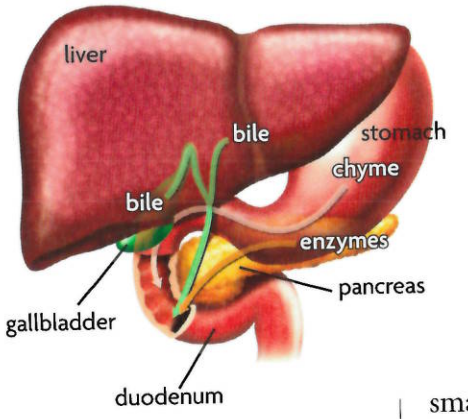
CRITICAL VIEWING **Do you think a high-carbohydrate or a high-protein meal would be digested more quickly? Explain.**

MAIN IDEA

Digestion is completed in part of the small intestine.

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 32.12,** enzymes and hormones from the pancreas, liver, and gallbladder flow through ducts into the duodenum to help complete the digestive process.

FIGURE 32.12 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 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 32.3 describes how these molecules are absorbed by the body.

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

NSTA SCILINKS
scilinks.org
To learn more about digestion, visit scilinks.org.
Keycode: MLB032

32.2 ASSESSMENT

ONLINE QUIZ
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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?

Connecting CONCEPTS

6. **Cell Structure** 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?

Testing a Digestive Enzyme

In this lab, you will test the effectiveness of the digestive enzyme pepsin under different conditions. You will also determine whether pepsin acts on carbohydrates, fats, or proteins.

PROBLEM Under which conditions is pepsin most effective?

MATERIALS

- 4 100-mL beakers
- 10 cm tape
- marker
- 2 100-mL graduated cylinders
- 160 mL water
- 80 mL 1% hydrochloric acid solution
- 80 mL pepsin
- 4 pecans
- balance
- 4 pieces of potato
- 4 pieces of beef jerky
- warm water bath
- clock

PROCESS SKILL
Analyzing Data

PROCEDURE

1. Label the beakers A, B, C, and D. Add 80 mL of water to beaker A.
2. Add 40 mL of water and 40 mL of the hydrochloric acid solution to beaker B.
3. Add 40 mL of water and 40 mL of pepsin to beaker C.
4. Add 40 mL of the hydrochloric acid solution and 40 mL of pepsin to beaker D.
5. Measure and record the mass of four pecans. Find the average of the four masses. Obtain four pieces each of potato and beef jerky that are about the same mass as the average mass of the pecans.
6. Place one of each piece of food in beaker A. Repeat this step with beakers B, C, and D.
7. Place the beakers in a warm water bath at a temperature of about 37°C.
8. Observe and record the condition of the food in each beaker after 15 minutes, 30 minutes, 45 minutes, and 24 hours. Create a data table like the one below for each beaker. Use the following phrases to describe your observations of the condition of each piece of food: "not dissolving," "beginning to dissolve," "partly dissolved," "mostly dissolved," "completely dissolved." If the condition does not change at all, write "nothing happened."

TABLE 1. CONDITIONS OF FOOD PIECES

Beaker A	Potato	Pecan	Beef Jerky
15 min			
30 min			
45 min			
24 hr			

ANALYZE AND CONCLUDE

1. **Experimental Design** What were the independent and dependent variables in this experiment? Which beaker was the control? Why were the beakers placed in the warm water bath?
2. **Analyze** Compare the condition of each of the same pieces of food in each beaker. Which piece of food in which beaker was the most digested?
3. **Analyze** Hydrochloric acid has a low pH. What conclusion can you draw about the relationship between the effectiveness of pepsin and pH?
4. **Infer** Potatoes are about 90 percent carbohydrate and 10 percent protein. Pecans are about 87 percent fat, 5 percent protein, and 8 percent carbohydrate. Beef jerky is about 80 percent protein and 20 percent carbohydrate. On which molecule does pepsin act?
5. **Predict** If you were to repeat this experiment, replacing the pepsin with salivary amylase, which breaks down carbohydrates, how would you expect your results to change? The pH of saliva is about 7.4.

32.3 Absorption of Nutrients

KEY CONCEPT Nutrients are absorbed and solid wastes eliminated after digestion.

MAIN IDEAS

- Most absorption of nutrients occurs in the small intestine.
- Water is absorbed and solid wastes are eliminated from the large intestine.

VOCABULARY

absorption, p. 982
villi, p. 983
microvilli, p. 983

REVIEW AT CLASSZONE.COM

Connect Suppose you tried to wipe up spilled water with a "sponge" made of solid plastic. Without the ability to absorb water, your sponge is useless. People with celiac disease face a similar, but more life-threatening, problem. Celiac disease is an autoimmune disorder that makes people unable to tolerate the protein gluten found in wheat, rye, and barley. Their immune systems produce antibodies to destroy it. The antibodies also damage the surfaces of cells lining the small intestine. This means that no matter how much a person eats, the body cannot absorb the food and becomes malnourished. The only treatment is to eliminate all gluten from the diet to protect the lining of the small intestine.

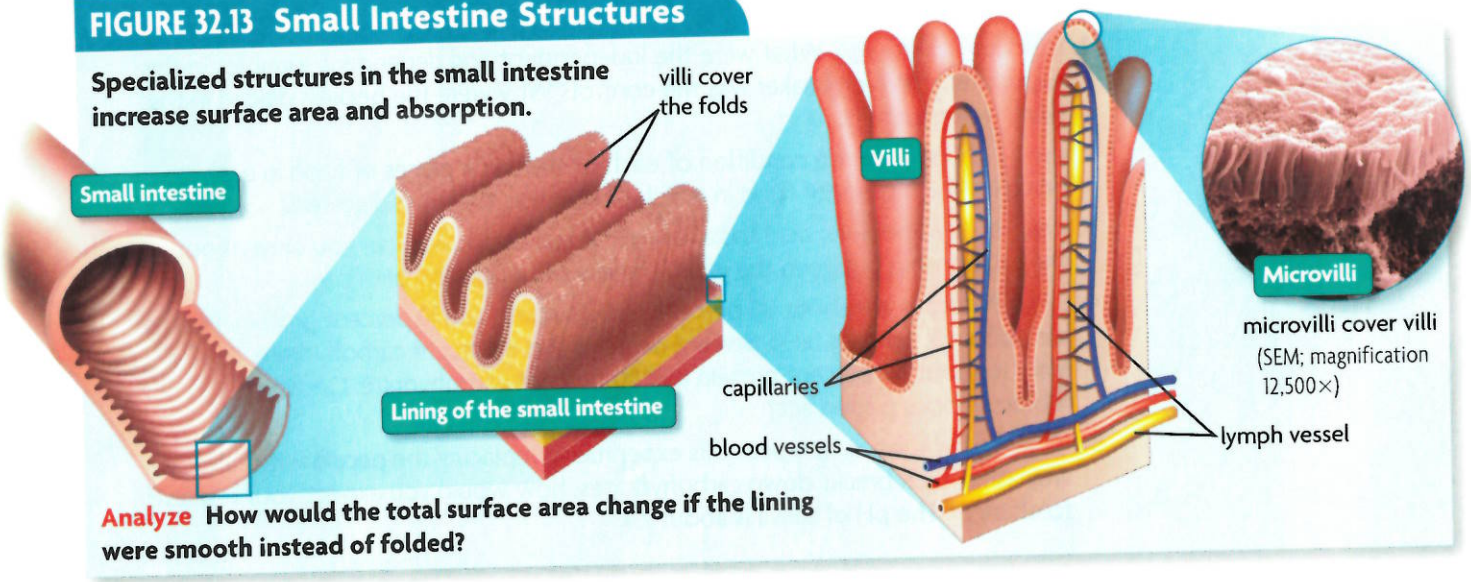
MAIN IDEA

Most absorption of nutrients occurs in the small intestine.

Food moving through the "disassembly line" of the digestive system is only part of the process. Your body must absorb the nutrients in order for the food you digest to do you any good. **Absorption** is the process by which nutrients move out of the digestive organs into the circulatory and lymphatic systems. As shown in **FIGURE 32.13**, the small intestine has three main structures—the lining, villi, and microvilli—that absorb most of the nutrients from chyme.

FIGURE 32.13 Small Intestine Structures

Specialized structures in the small intestine increase surface area and absorption.



Analyze **How would the total surface area change if the lining were smooth instead of folded?**

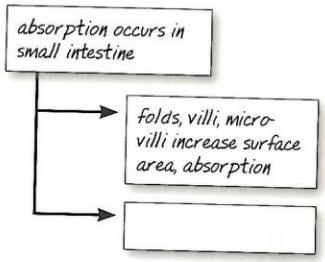
Specialized Structures for Absorption

As you look over the diagram in **FIGURE 32.13,** notice that the lining of the small intestine is ridged and folded. These structures increase the surface area and slow the passage of material through the intestine. Slower motion allows more time for nutrients to be absorbed. The folds of the lining are covered with villi. **Villi** (VIHL-eye) are small fingerlike projections, covered with epithelial cells, that absorb nutrients.

In turn, every epithelial cell on the villi has thousands of tiny projections called **microvilli** that add even more surface area to absorb nutrients. Each microvillus is smaller than the period at the end of this sentence. The photograph in the diagram shows microvilli covering the epithelial cells like a dense carpet.

TAKING NOTES

Use a main idea and supporting detail diagram to help you remember the facts about absorption.



Absorption of Different Nutrients

As digestion is completed, nutrients are absorbed in each of the three parts of the small intestine: the duodenum, the jejunum, and the ileum. Together, these parts measure about 6 meters (about 20 ft) long. Villi in each of the three sections absorb different nutrients.

Duodenum Most simple sugars, amino acids, and minerals such as calcium and iron are absorbed by villi in the duodenum. These nutrients diffuse into the circulatory system and are carried to the liver.

Jejunum The villi in the jejunum (juh-JOO-nuhm) absorb glucose along with some amino acids, vitamin C, most B vitamins, and some water. These nutrients diffuse into the circulatory system to be distributed throughout the body.

Ileum The villi in the ileum (IHL-ee-uhm) absorb fat-soluble vitamins and vitamin B_{12}, fatty acids, cholesterol, and some water. The nutrients empty into lymph and blood vessels and are distributed to the cells.

Connecting CONCEPTS

Cell Structure As you read in **Chapter 3,** plant cell walls are made of cellulose, or fiber. These tough cell walls cannot be broken down or absorbed in the small intestine. Instead, fiber moves through the small intestine to the large intestine.

QUICK LAB DESIGNING EXPERIMENTS

Villi in the Small Intestine

In this lab, you will design a model of the villi in the lining of the small intestine.

PROBLEM How can you model the function of villi in the small intestine?

MATERIALS

- 4 large paper cups
- water
- 8 paper towels
- timer

PROCEDURE

1. Use a paper cup, water, and paper towel to make a model of the villi in the lining of the small intestine.
2. Make three new models that are different. To do this, change one material to determine which model most effectively shows the action of the villi.
3. Determine which of your models most effectively models the villi.

ANALYZE AND CONCLUDE

1. **Summarize** Explain how this experiment models the action of the villi in the small intestine.
2. **Apply** Write a definition to describe how you measured each model's effectiveness.
3. **Analyze** Which model was most effective? How do you know?

Absorbed Nutrients and the Liver

Nutrient-rich blood leaves the small intestine and enters the liver. Enzymes in the liver use some nutrients to build more complex molecules that are needed by cells. The liver also stores some nutrients in liver tissues. For example, excess glucose is turned into glycogen and stored for future use. When you need large amounts of energy, glycogen can be converted back into glucose to keep the glucose levels in your blood relatively stable.

Analyze **Explain how the microvilli add more surface area to the small intestine to absorb nutrients.**

MAIN IDEA

Water is absorbed and solid wastes are eliminated from the large intestine.

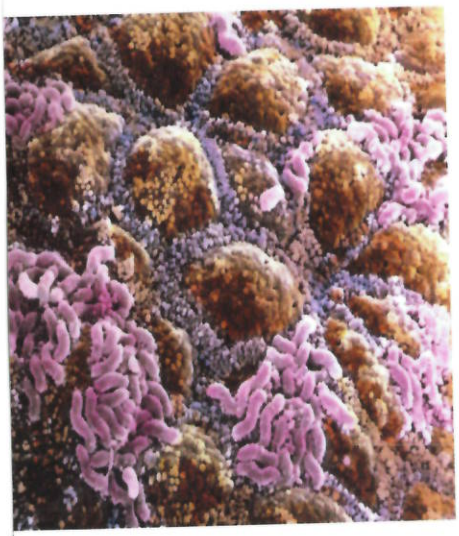


FIGURE 32.14 This micrograph shows the surface of the large intestine colonized by normally harmless bacteria, such as *Escherichia coli* (shown in pink clusters). (colored SEM: magnification 2500×)

The large intestine, or colon, is 1.5 meters (5 ft) long and about twice the diameter of the small intestine. The large intestine absorbs about 1 liter of water a day, along with some salts, which helps to maintain the body's fluid balance. The remaining undigested material forms into a solid mass, called feces. This material is partly composed of undigested fiber from plant foods, dead bacteria, and traces of undigested fat and protein. Bile pigments from the liver give feces its brownish color. The feces is stored in the rectum, a tube that connects the large intestine to the anus. Feces is then eliminated through the anus.

The large intestine also contains many types of bacteria. Some synthesize a few B vitamins and vitamin K (a blood-clotting factor). Other bacteria, such as *Escherichia coli*, shown in **FIGURE 32.14**, live harmlessly in the colon until some disturbance, such as an illness, allows them to overgrow other bacteria. An overgrowth of *E. coli* can reduce water absorption and cause severe diarrhea.

Your sandwich has taken roughly 24 to 33 hours to move through your digestive system. Now some of the water absorbed by the large intestine must be filtered through the kidneys and excreted, as described in Section 32.4.

Infer **A diet high in which types of foods might help the colon to function well?**

32.3 ASSESSMENT

ONLINE QUIZ ClassZone.com

REVIEWING MAIN IDEAS

1. Explain the purposes of the lining, **villi**, and **microvilli** in the small intestine.
2. What are the main functions of the large intestine?

CRITICAL THINKING

3. **Contrast** Explain the difference between digestion and **absorption**. What role does each process play in maintaining homeostasis?
4. **Apply** Which nutrients would take longer to digest and absorb: sugars, proteins, or fats? Explain.

Connecting CONCEPTS

5. **Animals** The desert kangaroo rat in Arizona eats plants but doesn't drink water. Yet even in summer, it doesn't suffer from dehydration. How do you think the rat's digestive system helps it to obtain water to maintain homeostasis?

DATA ANALYSIS ClassZone.com

Outliers in Data Sets

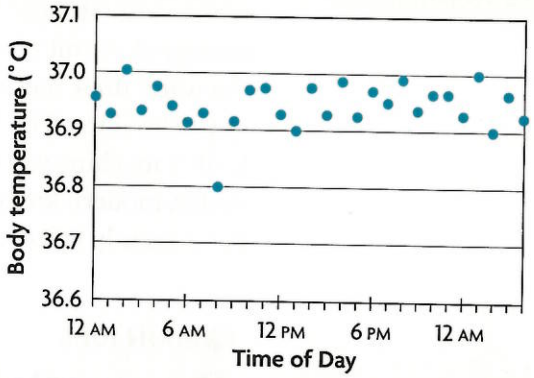
Sometimes in a scientific investigation, one or more unusual data points are recorded. A data point that is outside of the pattern of data is called an **outlier.** Outliers can result from human error in reading or recording data, from equipment failure, or from rare events such as a 31°C (70°F) day in Wisconsin in January.

To rule out the possibility that the outlier is a valid data point, scientists check their equipment, the laboratory set-up, and the recording process. If the outlier seems to be valid, further research may be needed. Simply ignoring or deleting outliers are not appropriate ways of handling these data.

EXAMPLE

A scientist measured the body temperatures of 1 person over time. As shown in the scatterplot at the right, nearly every temperature was between 36.9°C (98.4°F) and 37.8°C (98.6°F). Notice, however, that one temperature was recorded at 36.8°C (98.2°F). This outlier could be the result of equipment failure or human error. In cases of outliers, scientists must always ask, "What other explanations could there be for the data point? Do these data warrant further investigation?" Investigating the outlier further might lead to new discoveries.

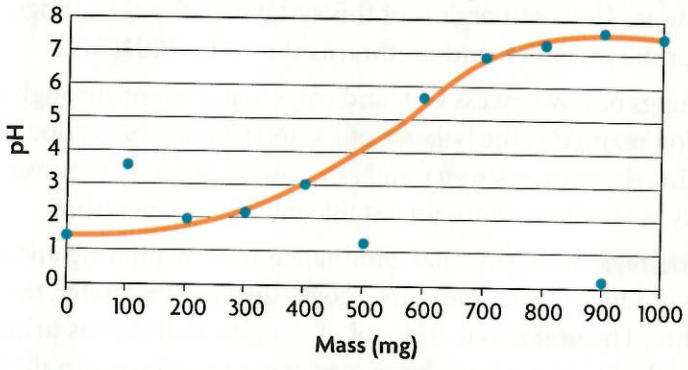
GRAPH 1. BODY TEMPERATURES



IDENTIFY OUTLIERS

Scientists investigated how the mass of an antacid affects its ability to raise the pH of gastric juices in the stomach. They recorded their data in the graph below. Examine the graph, and answer the questions that follow.

GRAPH 2. EFFECTIVENESS OF ANTACID



1. **Analyze** What is the trend in the data? Which points might be the outliers?
2. **Evaluate** What are some possible explanations for these outliers? How should the scientists proceed?

32.4 Excretory System

KEY CONCEPT The excretory system removes wastes and helps maintain homeostasis.

MAIN IDEAS

- The excretory system eliminates nonsolid wastes from the body.
- The kidneys help to maintain homeostasis by filtering the blood.
- Nephrons clean the blood and produce urine.
- Injury and disease can damage kidney functions.

VOCABULARY

excretory system, p. 986
kidney, p. 986
ureter, p. 986
urinary bladder, p. 986
nephron, p. 987
glomerulus, p. 988
dialysis, p. 991

REVIEW AT CLASSZONE.COM

Connect In 1943, Dutch physician Willem Kolff, who treated kidney patients, constructed the first machine to filter the blood of patients whose kidneys had temporarily stopped functioning. Kolff circulated their blood through synthetic sausage skins submerged in a saltwater bath. The high concentration of salt in the water drew metabolic wastes out of the blood through tiny pores in the synthetic skins. The filtered blood was then returned to the patients. However, Kolff's machine worked well only for people with temporary kidney failure. Today, modern kidney machines can help people even when their kidneys have permanently failed.

MAIN IDEA

The excretory system eliminates nonsolid wastes from the body.

If the digestive system is like a disassembly and distribution line, the excretory system is a like a group of waste treatment and disposal facilities. The **excretory system** is the body system that eliminates nonsolid wastes through sweat, urine, and exhalation to help maintain homeostasis in the body. The waste products include toxic materials, excess water, salts, CO_2, urea, minerals, and vitamins. The main organs of this system are the skin, lungs, kidneys, ureters, urinary bladder, and urethra, as shown in **FIGURE 32.15.**

The lungs remove excess CO_2 and some water vapor through exhalation. This action maintains the balance of O_2 and CO_2 in your blood. Sweat glands in the skin release excess water and salts. Sweat not only removes wastes but also cools the body to maintain a stable internal temperature.

The **kidneys** are organs that eliminate wastes by filtering and cleaning the blood to produce urine. The urine moves through the ureter, the bladder, and the urethra. The **ureter** (yu-REE-tuhr) is a tube that carries urine from each kidney to the bladder. The **urinary bladder** is a saclike organ that can store up to half a liter (over 2 cups) of urine at one time. The urine is released through a single tube, the urethra, into the outside environment.

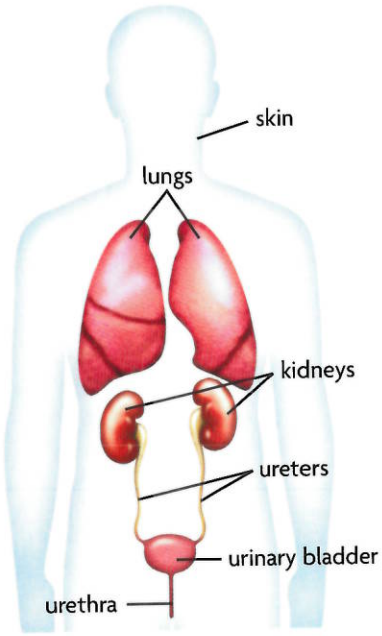


FIGURE 32.15 The excretory system not only excretes nonsolid wastes but also maintains the body's homeostasis.

Connect When you are exercising, what organs of the excretory system are eliminating wastes?

MAIN IDEA

The kidneys help to maintain homeostasis by filtering the blood.

The kidneys are among the main organs responsible for maintaining fluid and chemical balances in your body within the limits that support life. One quarter of your blood supply passes through your kidneys every minute. Once the blood is filtered, cleaned, and chemically balanced by the kidneys, it is returned to the circulatory system.

Structure of the Kidneys

Your kidneys are a pair of bean-shaped organs, each about the size of your fist. They are located on the right and left sides of the lower back. Each kidney weighs about as much as a baseball. Most people are born with two kidneys. However, if one is damaged or must be removed, you can still live comfortably with only one kidney.

The main parts of the kidney are illustrated in **FIGURE 32.16.** Each kidney has an inner layer, called the medulla, and an outer layer, called the cortex. The cortex is packed with nephrons, which extend through the cortex and partly into the medulla. A **nephron** (NEHF-rahn) is the individual filtering unit of the kidney. Each of your kidneys contains about 1 million nephrons.

A large volume of blood continually enters the kidneys through the renal artery and exits through the renal vein. The word *renal* means "relating to the kidneys." The function of the kidneys is largely controlled by how much water, salts, and other materials are concentrated in the blood. Hormones released in response to these concentrations help to regulate kidney function.

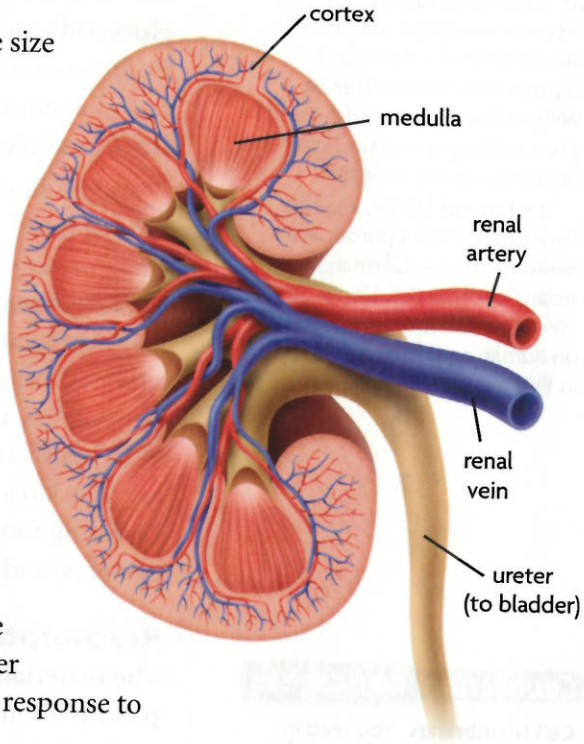


FIGURE 32.16 The bean-shaped kidneys are the main blood filtration and chemical balancing organs in the body. The cortex and medulla layers contain over 1 million nephrons, which are the kidneys' main filtering units.

Kidneys and Homeostasis

The kidneys have three basic functions in maintaining homeostasis.

- They remove waste products from the blood, such as those produced from digestion and cell respiration.
- They help to maintain electrolyte, pH, and fluid balances in the body.
- They release hormones that help to keep bones healthy, to produce red blood cells, and to regulate blood pressure.

What if the kidneys fail to work properly? Waste products quickly build up in the blood, causing serious disruptions in homeostasis in many organ systems. For example, imbalances in electrolytes such as sodium and potassium could disrupt the rhythm of the heart, causing the organ to fail. A buildup of toxic substances such as ammonium salts in the blood can impair the functioning of neurons in the brain. Someone with this condition would quickly become confused and disoriented.

Infer **What might be one reason why so many nephrons are needed in the kidneys?**

MAIN IDEA

Nephrons clean the blood and produce urine.

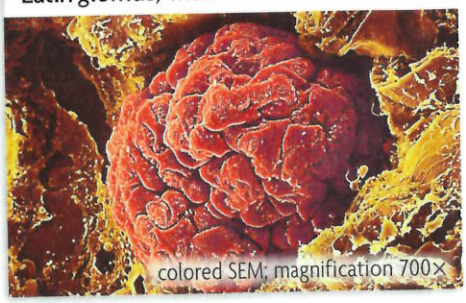
The nephrons clean the blood in a three-step process: filtration, reabsorption, and excretion. First, water and other materials move out of the capillaries and into the nephron. Next, some of these materials are reabsorbed and returned to the blood. Finally, the remaining waste products are excreted in the urine.

Filtration

As shown in **FIGURE 32.17**, each nephron is supplied with blood through an arteriole, a venule, and a tangled ball of capillaries that is known as the **glomerulus** (gloh-MEHR-yuh-luhs). Each glomerulus is tucked into a cup-shaped structure called Bowman's capsule.

VISUAL VOCAB

Glomerulus, a tangled ball of capillaries, is a word based on the Latin *glomus*, which means "ball."



colored SEM; magnification 700×

When the blood enters the kidneys, it flows into the arterioles and then moves into the glomerulus of each nephron. Because the blood is under pressure, small molecules such as water, amino acids, salts, glucose, electrolytes, and urea are pushed out of the capillaries and into Bowman's capsule. Urea is a waste product produced by the breakdown of proteins. Anything too large to move out of the capillaries—such as blood cells, plasma proteins, and platelets—stays in the blood.

VOCABULARY

At times, structures are named after the scientists who first identified them. **Bowman's capsule** was named after Sir William Bowman, a British surgeon and anatomist who identified this structure in 1831.

The **loop of Henle**, another structure in the nephron, was named after the German physician Friedrich G. J. Henle. He identified the loop in his book on human anatomy, published in 1873.

Reabsorption of Materials

The materials in Bowman's capsule are called the filtrate. The nephrons process about 180 liters (48 gal) of filtrate every day, yet only about 1 percent is excreted as urine. What happens to the other 99 percent?

Most of the filtrate is reabsorbed into the capillaries and returns to the blood. This process ensures that nutrients such as water, amino acids, glucose, and sodium (Na^+) are made available to the body. The reabsorption of water and Na^+ helps to maintain your fluid balance. For example, if you drink too much water, the nephrons will reabsorb less of the fluid and produce more urine. If you drink too little water, the nephrons will reabsorb more fluid and produce less urine.

Connecting CONCEPTS

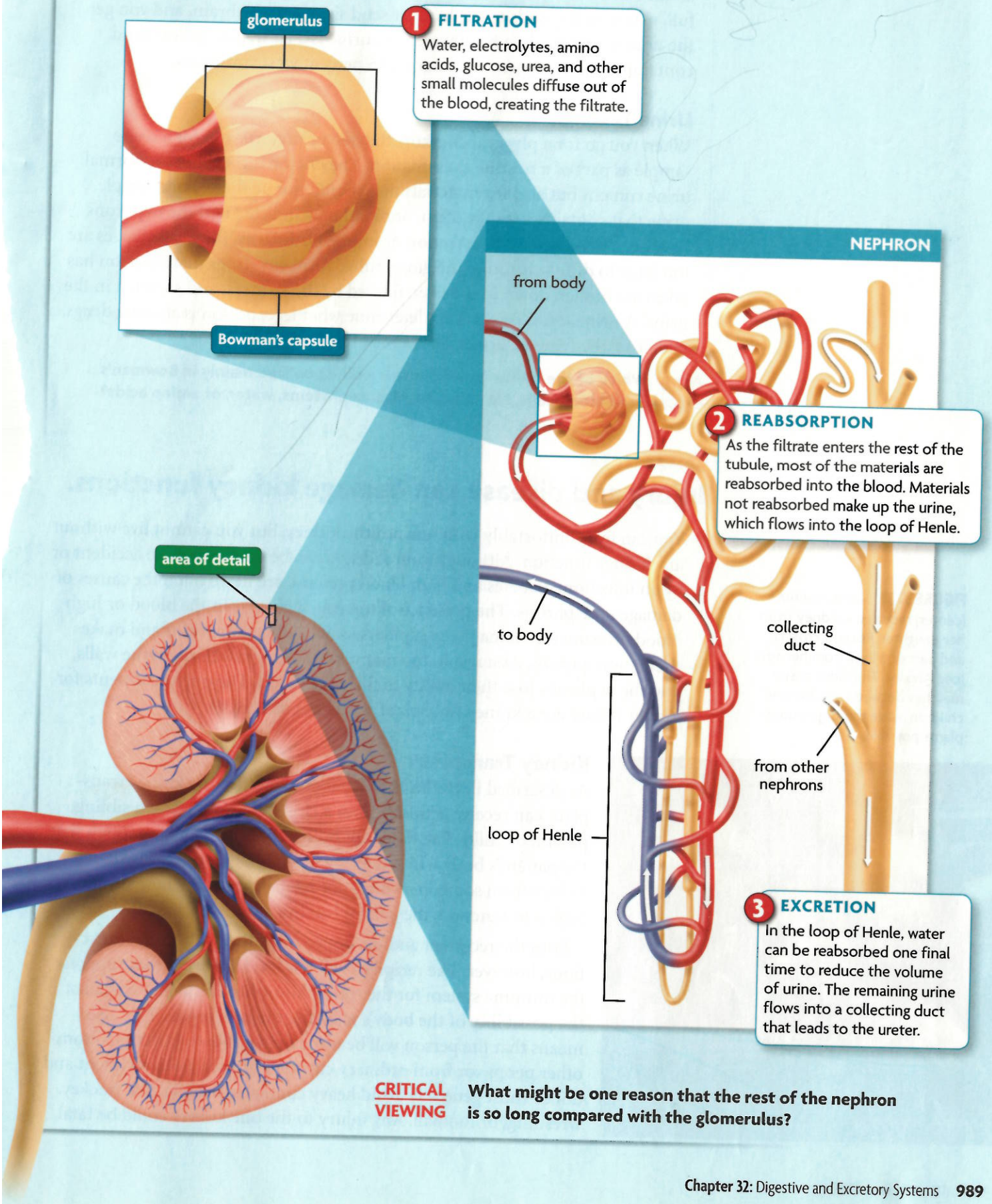
Cell Membranes You read in **Chapter 3** that materials diffuse into and out of cell membranes from areas of higher concentration to areas of lower concentration. In the glomerulus, molecules diffuse through capillary walls.

Excretion of Materials

Finally, the waste products that are not reabsorbed are excreted in the urine. Urine is made up of water, urea, excess salts, and other materials that remain in the filtrate. These materials include ions such as potassium and hydrogen. Removal of some of these ions helps to maintain homeostasis by keeping the pH of the blood within normal limits. Filtrate moves out of Bowman's capsule and is concentrated in the loop of Henle. The loop of Henle is where water is removed one final time to reduce the volume of urine.

FIGURE 32.17 Structures and Functions of the Nephron

The nephron filters the blood and produces urine through a three-step process.



CRITICAL VIEWING **What might be one reason that the rest of the nephron is so long compared with the glomerulus?**

The urine then moves into the collecting ducts. From there it flows through the ureter and into the urinary bladder. The adult bladder can hold about 1 liter (16 oz) of urine before it must be emptied. When the bladder is full, nerves in the walls of the bladder send signals to the brain, and you get the urge to urinate. In a healthy person, urine is a clear, pale-yellow fluid containing about 95 percent water and 5 percent waste products.

Urine Testing

When you go for a physical checkup, the doctor may ask you for a urine sample as part of a routine examination. The doctor is checking for normal urine content but also for materials that should not be there. For example, urine that contains sugar, protein, or blood may indicate that the nephrons have been damaged by an infection or injury. Ordinarily, these substances are too large to diffuse through the glomerulus. Also, any drugs that a person has taken are broken down in the liver, filtered by the kidneys, and excreted in the urine. A urine test is one way to determine whether a person is abusing drugs, and, if so, the types of drugs that may be involved.

Apply **Which of the following substances would you find mainly in Bowman's capsule: red blood cells, Na^+, glucose, plasma proteins, water, or amino acids?**

MAIN IDEA

Injury and disease can damage kidney functions.

You can live comfortably with one healthy kidney, but you cannot live without any kidney function. Although your kidneys can be damaged in an accident or by an infection, diabetes and high blood pressure are more often the causes of damage to nephrons. The presence of too much glucose in the blood or high blood pressure can damage the capillary walls in the glomerulus and make them more porous. As a result, too many substances pass through the walls, and the nephrons lose their ability to filter the blood. The only treatments for kidney failure are a kidney transplant or the use of dialysis.

FIGURE 32.18 Maria Alverez (center) received a kidney from her daughter, Rosario Proscia, and part of a liver from her son, José Alvarez. The close tissue matches between mother and children made the organ transplants possible.

Kidney Transplant

As described in **FIGURE 32.18**, a patient who needs a kidney transplant can receive a kidney from a close relative, such as a sibling, parent, or child. The tissues of both people are similar enough that the patient's body will accept the new kidney more easily than a kidney from someone who is not related. Once the new kidney begins to function, the patient can live a fairly normal life.

Both the recipient and the donor must live with some restrictions, however. The recipient will have to take drugs that suppress the immune system for the rest of his or her life to guard against the possibility of the body's rejecting the new organ. This also means that the person will be more vulnerable to infections from other people or from ordinary cuts and bruises. Both recipient and donor must generally avoid heavy contact sports, such as hockey, wrestling, or football. Any injury to the one kidney could be fatal.

Kidney Di

If a kidney ot available or the patient an urgery, dialysis can save the per **Dialysis** is a treatment in wh nt's blood is cleaned and chemic ed through a mechanical he blood is then returned to t's body.

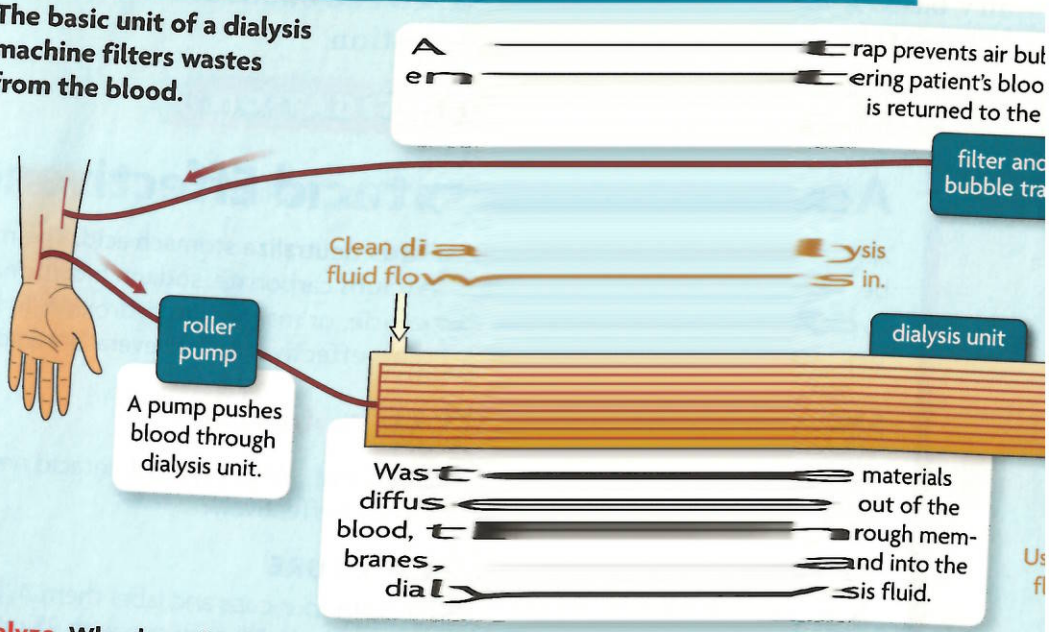
The mai dialysis machine, as shown in Fi ts like the glomerulus. Blood n a vein in the arm into the filte he tubing in the unit is poro apillary walls, which allow erials to diffuse into the dialysis uid is continually replaced to out of the unit. The chemical m fluid is as close to normal bloo e. The process takes 3 to 5 hours three times a week in the vith a smaller dialysis mac ient's home.

A few pa efer not to use a dialysis machine. Instead, they may be given per -ih-tuhn-EE-uhl) dialysis, in which the lining of the patient's ab a blood filter. Dialysis fluid is pumped through tubing into . Waste products and excess fluid move from the bloodstrea ysis solution. The waste-filled fluid is drained from the abdome d several times until the blood is cleaned and chemically balanc

Summarize E le without kidney function would need to have dialysis at least three t

FIGURE 32.19 Dialysis Proces

The basic unit of a dialysis machine filters wastes from the blood.



Analyze **Why does the dialysis fluid ne ed to be continually replaced?**

32.4 AS

REVIEWING EAS

1. How do the the excretor of wastes?
2. Give two ex dneys help to main
3. Describe the of the nephron an
4. Explain how lysis is similar to s Filter the blo

CRITICAL THINKING

5. **Apply** When kidney function is impaired, the pH level in the blood is disrupted. How would this loss of homeostasis affect the body's cells?
6. **Explain** Briefly explain the following sentence: "Filtration of the blood is relatively nonselective, but reabsorption of materials is selective."

Conne cting CONCEP

7. **Respi ation** Compare t alveol in the lungs to th nephr ns in the kidneys the w ys in which their tures a nd functions may similar

ONLI ClassZ

nquiry-based labs and online activities to deepen
rstanding of digestion.

INVESTIGATION

Antacid Effectiveness

Antacids neutralize stomach acid. The main ingredient may be calcium carbonate, sodium bicarbonate, aluminum hydroxide, or magnesium hydroxide. In this lab, you will test the effectiveness of several antacids.

SKILL Analyzing Data

PROBLEM Which type of antacid neutralizes stomach acid most effectively?

MATE

- 4 large
- marke
- 50-mL
- 100 m
- 8 pH
- antac
- antac
- antac
- antac
- knife
- mort
- scale
- stirre
- time

PROCEDURE

1. Obtain four cups and label them A, B, C, and D, respectively. Fill each cup with 25 mL of vinegar and measure and record the vinegar's pH in each cup.
2. Read the ingredients label and identify the active ingredient in each antacid. Determine how much of the active ingredient is in one dosage.
3. Your teacher will tell you the amount of each active ingredient you will be testing. Determine how much of each antacid you will need in order to test equal amounts of the different active ingredients. You might need to cut tablets into halves or quarters to make the amounts equal. Place tablet antacids in the pestle and grind them into powder. Design a data table like the one shown to the right.
4. Add antacid A to cup A. Stir the solution thoroughly. Wait one minute, then measure and record the pH in your data table. Record any observations of what occurs in the cup as the antacid dissolves. Clean the stirrer and the mortar and pestle (if needed).
5. Repeat step 4 with antacid B and cup B, antacid C and cup C, and antacid D and cup D, respectively.

TABLE 1. ANTA IONS

Antacid		D
Active ingredient (__mg)		
pH of vinegar before adding antacid		
pH of vinegar after adding antacid		
Observations		

ANALYZE AND CONCLUDE

1. **Analyze** Which antacid was most effective in neutralizing the ac d
   How do you know? What is the active ingredient in that antacid
2. **Experimental Design** Identify the independent and dependent v ri
   experiment. What is the operational definition of the depender t v
   variables were constants in the experiment?
3. **Infer** Why is it important for the environment of the stomach t t
   health effects might a person experience if too little hydrochlo ic
   in the stomach?

INVESTIGATION

Digesting Milk

In this lab, by testing two types of milk, you will try to determine why some people cannot digest milk.

SKILL Analyzing Data

PROBLEM Why are some people unable to digest milk?

MATERIALS

- 2 test tubes
- 5 cm tape
- marker
- 2 eye droppers
- 20 drops of milk A
- 20 drops of milk B
- 4 glucose test strips
- 2 drops of unknown solution
- 2 stirrers
- timer

PROCEDURE

1. Label one test tube A and one test tube B. Fill test tube A with 20 drops of milk A. Using a new dropper, fill test tube B with 20 drops of milk B.
2. Use a glucose test strip to test and record the concentration of glucose in test tube A. Use a new strip to test and record the concentration of glucose in test tube B.
3. Add one drop of the unknown solution into test tube A. Mix the milk and solution with a stirrer. After one minute, measure the concentration of glucose in the solution.
4. Using a new stirrer, repeat step 3 with test tube B.

ANALYZE AND CONCLUDE

1. **Contrast** What is the difference between milk A and milk B before the unknown solution was added? What happened to the milk in test tube A after the unknown solution was added?
2. **Infer** The unknown solution is not glucose. What could it be? (**Hint:** Identify the type of sugar naturally found in milk.)
3. **Analyze** What type of milk is milk B?
4. **Summarize** Explain why some people cannot digest regular milk.

Online BIOLOGY
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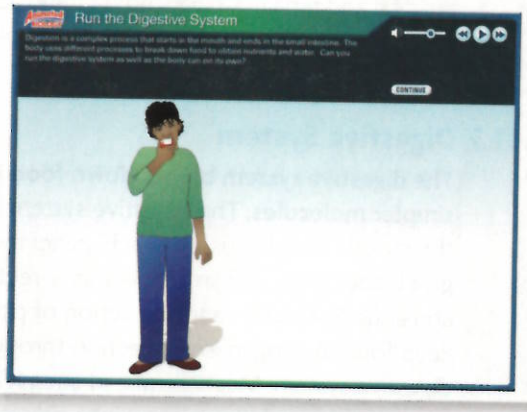
ANIMATED BIOLOGY

Run the Digestive System

The digestive system must get nutrients and water from food to the rest of the body. Move a snack from the mouth through the large intestine and get as much nourishment out of the food as possible.



WEBQUEST

Obesity is on the rise, but is the answer as simple as "eat less and exercise more"? In the WebQuest, you will examine the causes and health risks of obesity. How can people take control of their weight?

DATA ANALYSIS ONLINE

The hormone insulin helps to regulate glucose levels in the bloodstream. Graph the rate at which the pancreas releases insulin in response to changing glucose levels to see how quickly insulin acts to maintain homeostasis.

CHAPTER 32

Interactive Review @ CLASSZONE.COM

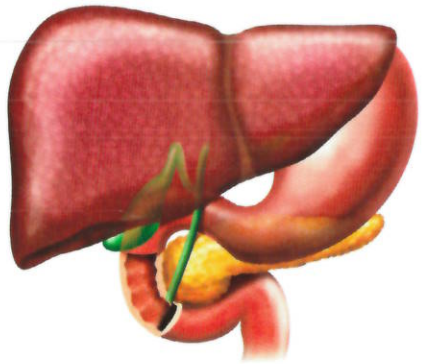
KEY CONCEPTS | Vocabulary Games | Concept Maps | Animated Biology | Online Quiz

32.1 Nutrients and Homeostasis

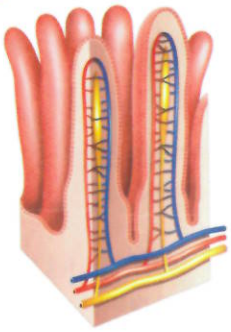
Cells require many different nutrients. Six types of nutrients are important to maintain homeostasis in the body: water, carbohydrates, proteins, fats, minerals, and vitamins. These nutrients help to maintain fluid balance, cell processes, functions such as digestion and elimination, and tissue building and repair. A balanced diet and adequate Calories are especially important during puberty, a time of rapid growth and development.

32.2 Digestive System

The digestive system breaks down food into simpler molecules. The digestive system includes the mouth, esophagus, stomach, pancreas, liver, gallbladder, large and small intestines, rectum, and anus. Sphincters and the action of peristalsis keep food moving in one direction through the digestive system. Mechanical and chemical digestion help to break down food into simpler molecules. The process of digestion begins in the mouth, continues in the stomach, and is completed in the duodenum of the small intestine.



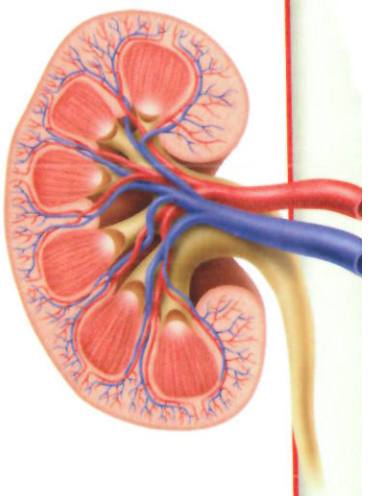
32.3 Absorption of Nutrients



Nutrients are absorbed and solid wastes eliminated after digestion. Most absorption of nutrients occurs in the small intestine. The small intestine has specialized structures—folds, villi, and microvilli—that increase the surface area so that more nutrients can be absorbed. Nutrients diffuse into the circulatory and lymphatic systems and are carried to all the cells. The large intestine absorbs water and eliminates the solid wastes that are the byproducts of digestion.

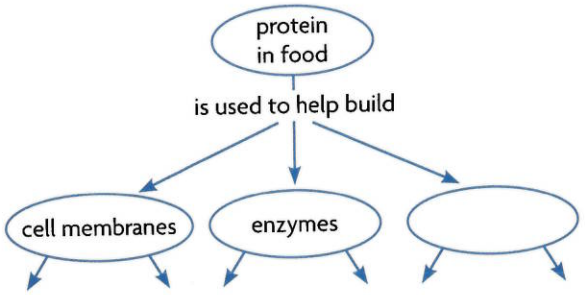
32.4 Excretory System

The excretory system removes wastes and helps maintain homeostasis. The excretory system includes the skin, lungs, kidneys, ureter, bladder, and urethra. The nephrons in the kidneys filter the blood, reabsorb needed materials, and excrete waste materials in the urine. A person whose kidneys stop functioning must have a kidney transplant or dialysis treatment to maintain the body's homeostasis.



Synthesize Your Notes

Concept Map Use this graphic organizer to help you recall the functions of each of the six types of nutrients.



Flow Chart A flow chart like the one below can help you remember the steps in digestion.

Chapter Assessment

Chapter Vocabulary

32.1 mineral, p. 973
vitamin, p. 974
Calorie, p. 975

32.2 digestion, p. 977
digestive system, p. 977
sphincter, p. 977
esophagus, p. 978
peristalsis, p. 978
stomach, p. 978
chyme, p. 979
small intestine, p. 980
bile, p. 980

32.3 absorption, p. 982
villi, p. 983
microvilli, p. 983

32.4 excretory system, p. 986
kidney, p. 986
ureter, p. 986
urinary bladder, p. 986
nephron, p. 987
glomerulus, p. 988
dialysis, p. 991

Reviewing Vocabulary

Vocabulary Connections

For each pair of words below, write a sentence to clearly show how the terms are connected. For example, for the terms *stomach* and *chyme*, you might write, "Digestive juices in your stomach turn food into a semiliquid substance called chyme."

1. esophagus, peristalsis
2. absorption, villi
3. ureter, urinary bladder
4. digestion, bile
5. small intestine, microvilli

Keep It Short

For each vocabulary term below, write a short phrase that describes its meaning. For example, a short phrase to describe *sphincter* might be "ring of muscle separating digestive sections."

6. vitamin
7. Calorie
8. nephron
9. glomerulus

Word Origins

10. The term *chyme* comes from the Greek word *khūmos*, meaning "juice." Using this meaning, explain how it relates to what chyme is.

11. The term *dialysis* is based on the Greek word *dialūein*, meaning "to break up or to dissolve." Explain how this meaning relates to the process of dialysis.

Reviewing MAIN IDEAS

12. List the six types of nutrients the body needs to maintain homeostasis. Which nutrients are the main sources of energy for the body?

13. Explain why meeting nutritional needs is particularly important during pre-teen and teen years.

14. Explain the main purpose of the digestive system. In which organs does the digestion of carbohydrates, proteins, and fats take place?

15. What is the difference between mechanical and chemical digestion? Give three examples of enzymes involved in chemical digestion.

16. Describe how the digestion of food is completed in the duodenum. What digestive organs are involved in this process?

17. How are the nutrients from digested foods transported from the small intestine to the body's cells?

18. What are the two main functions of the colon? How can diet affect the functions of this organ?

19. List the main organs of the excretory system. Give two examples of how this system helps the body maintain homeostasis.

20. The main functions of the kidneys are to maintain fluid and chemical balances in the body. Explain how the structure of the kidney helps it carry out these functions.

21. The nephrons filter the blood and produce urine. Describe the steps involved in this process.

22. How does diabetes or high blood pressure affect kidney function?

Critical Thinking

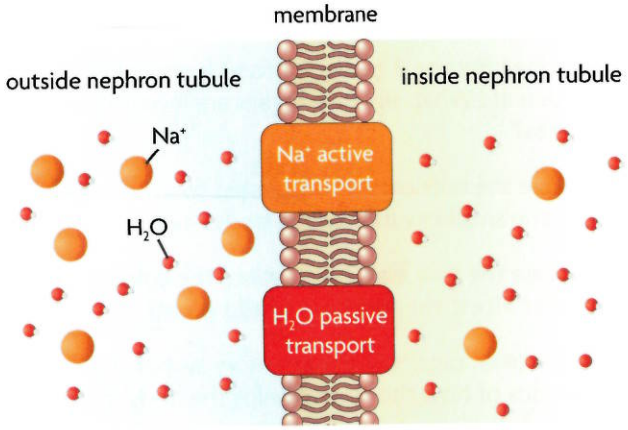
23. Analyze A deficiency in calcium can cause spasms in the calf muscles at night. A woman complains to her doctor about this problem, yet she gets plenty of calcium in her diet. The doctor wants to check her kidney functions. Why would he suspect a problem with her kidneys?

24. Infer A gastric ulcer is a type of sore that appears in the stomach lining. The ulcer can be caused by infection or by overuse of products like aspirin or ibuprofen. How might a gastric ulcer affect a person's ability to digest food in the stomach?

25. Infer A teenager wants to build muscle so he can compete better on the wrestling team. He decides to eat a diet of mostly meat and fruit juices. Within a week, he is constipated. What probably happened, and how can the problem be corrected?

Interpreting Visuals

Molecules move across a membrane by means of active or passive transport. In active transport, molecules can be pumped across a membrane into areas of higher or lower concentration. In passive transport, molecules can move only from an area of higher concentration to an area of lower concentration. Use the following diagram to answer the next three questions.



26. Analyze Look at the concentrations of Na^+ ions and H_2O in the diagram. Can more Na^+ ions move out of the tubule? Explain your answer.

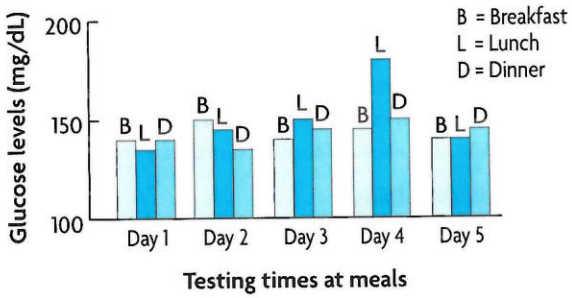
27. Infer The membrane can change to let more or less water through. If a person were dehydrated, how might the membrane change? Explain.

28. Evaluate If the body contains too much fluid, which way would H_2O molecules move across the membrane? Explain your answer.

Analyzing Data

To educate young people about diet and health, a local hospital offered glucose testing so teenagers could learn more about how their bodies were functioning. Testing was done one to two hours after each meal so that the food was digested and nutrients were absorbed into the body. In a healthy person, glucose levels should be 80–120 mg/dL of blood before a meal and less than 180 mg/dL after food is digested. The graph below shows the results for one teenager. Use the graph to answer the next two questions.

GLUCOSE LEVELS



29. Analyze What is the typical glucose range for this teenager after meals? Which point is the outlier in this data set?

30. Evaluate What are some possible explanations for the outlier data? How should the scientists proceed?

Connecting CONCEPTS

31. Blog a Snack-Food Challenge More companies are offering alternative, "healthier" snack foods, such as protein bars or fruit strips. Your challenge: Use your knowledge of food labels to compare the nutritional information on these products with other snack foods such as candy bars and potato chips. Write a blog entry on your findings, including each product's nutritional content, its cost, and where you can buy it.

32. Synthesize The photo on page 971 shows the specialized cells in the lining of the stomach. Use what you know about the digestive process and the digestive tract to explain why the processes that occur in the stomach could not occur anywhere else.