

What was the last thing you ate? Or might you be snacking right now? What makes you feel hungry? Why do you need to eat? What is in food that your body needs? Why are some kinds of food better for you than others? What happens to food after you eat it? How is the way you eat and process food different from the eating and digestion processes of other animals? What are calories? Vitamins and minerals? Fiber? And what are the latest recommendations regarding sodium, saturated fat, cholesterol, and dieting? These and many other questions about nutrition and digestion are considered in this chapter.

Organizing Your Knowledge

Exercise 1 (Module 21.1)

Test your knowledge of animal diets and feeding methods by filling in this chart. Most examples are from the module; others are animals with which you are probably familiar. For diet, you may choose from omnivore, herbivore, and carnivore. There are several feeding methods: Animals can be absorptive feeders, suspension feeders, substrate feeders, fluid feeders, or bulk feeders.

<i>Animal</i>	<i>Diet</i>	<i>Feeding Method</i>
1. Cow		
2. Earthworm		
3. Aphid		
4. Humpback whale		
5. Human being		
6. Tapeworm		
7. Shark		
8. Female mosquito		
9. Clam		
10. Grasshopper		

Exercise 2 (Modules 21.2 – 21.3)

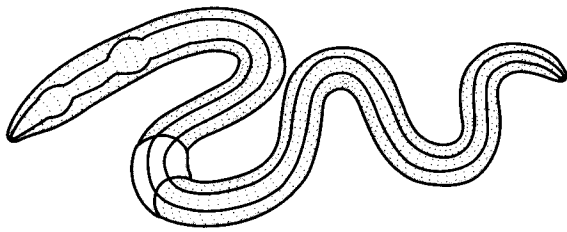
Read about the four stages of food processing and kinds of digestive systems. Then connect the two by (1) labeling the drawings, and (2) coloring the drawings to show which digestive stages occur in each portion of these alimentary canals. On the drawings label **mouth**, **pharynx**, **esophagus**, **crop**, **gizzard**, **stomach**, **intestine**, and **anus**. Then color the alimentary canals to show where each stage in food processing occurs. Use yellow for **ingestion** (including swallowing and storage), red for **digestion**, green for **absorption**, and blue for **elimination**. (If two processes occur in the same area, mix the colors.)

Ingestion ○

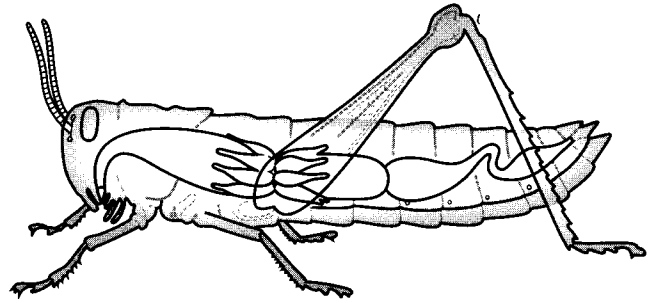
Digestion ○

Absorption ○

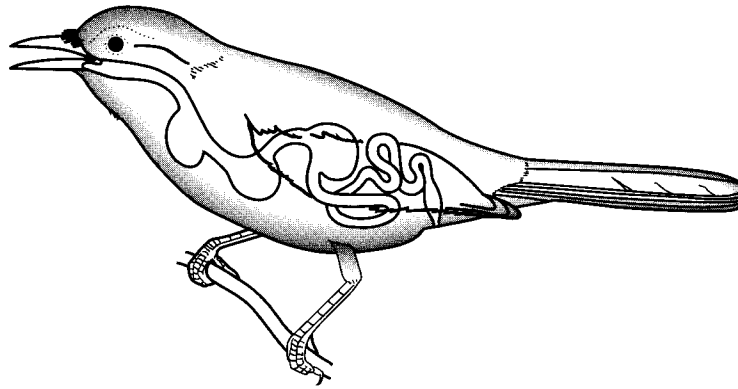
Elimination ○



Earthworm



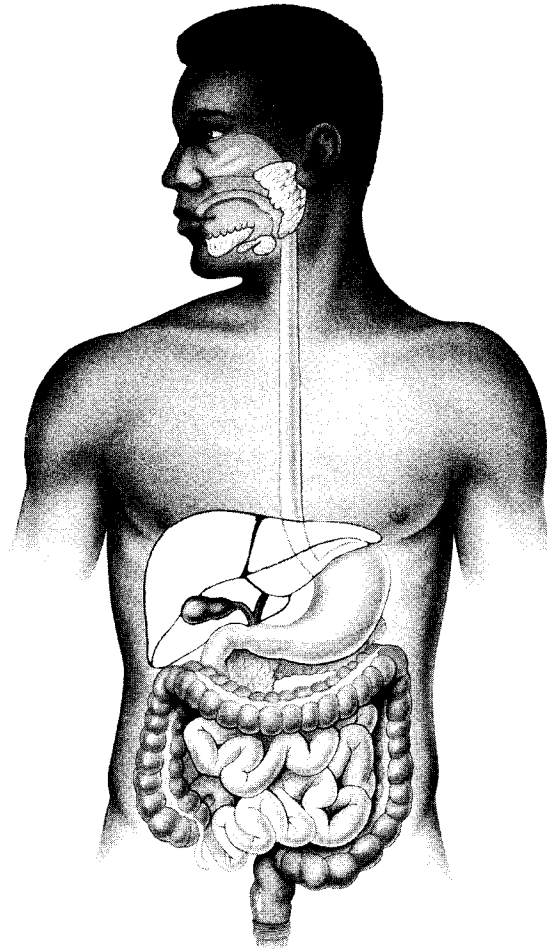
Grasshopper



Bird

Exercise 3 (Module 21.4)

Picture the parts of the human digestive system and their relationships to one another. Label and color these parts of the digestive system on the diagram below: **stomach, oral cavity, small intestine, esophagus, rectum, pancreas, gallbladder, mouth, large intestine, tongue, salivary glands, anus, liver, pyloric sphincter, and pharynx.**



Exercise 4 (Modules 21.4 – 21.7)

Identify the part of the digestive tract described in each of the following statements. Some answers occur more than once.

- | | |
|-------|---|
| _____ | 1. Kind of front tooth used for biting |
| _____ | 2. Largest digestive gland |
| _____ | 3. Muscles of esophagus that contract above a bolus |
| _____ | 4. The opening through which wastes are eliminated |
| _____ | 5. Where liver secretions are stored |
| _____ | 6. A ring of muscle that controls food leaving the stomach |
| _____ | 7. The throat |
| _____ | 8. The digestive gland above and to the right of the stomach |
| _____ | 9. Back teeth that grind and crush food |
| _____ | 10. Muscles of the esophagus that contract below swallowed food |
| _____ | 11. Where food goes after it leaves the stomach |

- _____ 12. Digestive gland below the stomach
- _____ 13. Where taste buds are located
- _____ 14. The portion of the tract that wraps around the small intestine
- _____ 15. Pointed teeth that are overdeveloped in Count Dracula
- _____ 16. Where the tongue and teeth are located
- _____ 17. The portion of the canal between the esophagus and the small intestine
- _____ 18. The technical name for a swallowed ball of food
- _____ 19. Digestive glands that secrete into the oral cavity
- _____ 20. Where final steps of digestion and absorption of nutrients occur
- _____ 21. Where water is absorbed and feces are formed
- _____ 22. A flap of cartilage and connective tissue that keeps food out of the trachea
- _____ 23. The pyloric sphincter regulates its exit
- _____ 24. The muscular tube from the pharynx to the stomach
- _____ 25. The portion of the canal just before the anus
- _____ 26. The mouth opens into this portion of the canal

Exercise 5 (Modules 21.7 – 21.11)

Web/CD Activity 21A *Digestive System Function*

The following story will help you to visualize the movement of food through the stomach and intestine and the processes that occur there. Write the proper word in each blank.

The experimental subject has been complaining of intestinal pain, but his doctors have been unable to pinpoint its cause. Your assignment is to inspect the linings of his stomach and small intestine. You step into the Microtron and are quickly reduced to microscopic size. You enter the subject via a drink of water, and the swallowing reflex sweeps you into the ¹ _____, the tube to the stomach. A wave of muscle contraction, called ² _____, propels you forward. Ahead, the opening broadens, and you tumble into the stomach.

The subject has been on a liquid diet, so the stomach is filled with clear fluid instead of ³ _____—the normal mixture of food particles and gastric juice. Huge folds in the stomach lining look like underwater ridges and valleys. Periodic waves of peristalsis sweep across this landscape like earthquakes. As you approach the stomach wall, you note that the lining is dotted with numerous pits—the openings of tubular ⁴ _____, which produce ⁵ _____, the stomach's digestive fluid.

You enter one of the pits and swim into the gastric gland. Your instruments indicate an increase in secretion of gastric juice. The presence of food—and you—in the stomach causes cells in the stomach wall to secrete a hormone called ⁶ _____, which (along with nerve signals) stimulates secretion of gastric juice.

Several kinds of cells line the walls of the gastric gland. Many of the cells are undergoing ⁷ _____, rapidly replacing cells that are damaged in this harsh environment. Deep in the gland, large parietal cells secrete ⁸ _____. Nearby chief cells secrete inactive pepsinogen, which quickly changes into the enzyme ⁹ _____ when it comes into contact with the acid. The function of pepsin is to begin the digestion of

¹⁰ _____, preparing them for further digestion in the ¹¹ _____.
 Secreting the enzyme in inactive form ¹² _____ the cells where it is produced. ¹³ _____ cells secrete thick ¹⁴ _____, which helps protect the stomach lining.

You exit the gland and continue your inspection of the stomach lining. The opening from the esophagus, where you entered the stomach, is sealed tightly. There is little evidence of backflow of acid chyme into the esophagus, which might cause ¹⁵ _____. Nowhere do you see any evidence of a ¹⁶ _____—an open sore that develops in the stomach lining. It used to be thought that this happened when there was too much pepsin or acid, or not enough ¹⁷ _____. Evidence now points to ¹⁸ _____ by a prokaryote—*Helicobacter pylori*—which damages the stomach lining.

The stomach's exit is guarded by a tightly closed doughnut of muscle, the ¹⁹ _____. As you approach, it opens to allow a squirt of liquid to leave the stomach. Soon you enter the next portion of the digestive tract, the ²⁰ _____.

This organ is much narrower than the cavernous stomach. It looks like a curving, twisting tunnel. The first few inches is called the duodenum. Here you see a jagged sore, tucked into a fold in the wall of the duodenum—a duodenal ²¹ _____. This must be the cause of the problem. The medical team will have to deal with this.

Continuing your survey of the small intestine, you note an opening where fluid is squirting into the duodenum. This is the duct through which ²² _____ from the gallbladder and an alkaline, enzyme-rich solution from the ²³ _____ enter the small intestine. The alkaline solution ²⁴ _____ acid from the stomach. Bile, produced by the ²⁵ _____ and stored in the gallbladder, contains bile salts that break up ²⁶ _____ into small droplets, a process called ²⁷ _____. This makes it easier for pancreatic enzymes to digest them. An enzyme called ²⁸ _____ breaks fat molecules down into fatty acids and glycerol. Other pancreatic enzymes, trypsin and chymotrypsin, continue the digestion of ²⁹ _____ that began in the stomach. They break polypeptides down to smaller polypeptides, and then peptidases break these smaller polypeptides down to ³⁰ _____. Pancreatic amylase hydrolyzes ³¹ _____ to form maltose, a disaccharide. Other enzymes digest it and other disaccharides to form ³² _____. Nucleases digest DNA and RNA.

Contractions in the walls of the small intestine gently propel you along. The next two portions of the small intestine are specialized for ³³ _____ of nutrients. The surface is highly folded, with numerous small projections called ³⁴ _____. You swim downward, and the villi surround you like the huge rubbery trunks of some inflatable forest. Their surfaces look and feel velvety, because the epithelial cells covering them bear their own tiny projections called ³⁵ _____. All these folds give the small intestine a huge surface area—over 600 square meters! You press your light against the surface of one of the villi. Inside, you can see the ghostly outlines of ³⁶ _____ vessels and a network of ³⁷ _____. Nutrients are pumped or ³⁸ _____ through the intestinal epithelium and enter these vessels. The capillaries join to form a large blood vessel that carries blood directly to the liver, where nutrients are converted to forms the body needs. For example, the liver stores excess glucose in the form of a polysaccharide called ³⁹ _____.

As you finish your inspection of the small intestine, you see the sphincter ahead that controls the movement of unabsorbed food material into the ⁴⁰ _____, or colon. The colon is where ⁴¹ _____ is absorbed and undigested material is turned into ⁴² _____, which are stored in the rectum and expelled through the anus. That part of the digestive system is not on your itinerary! You work your way through the wall and into a blood vessel, and are soon back in the lab, munching on a sandwich.

Exercise 6 (Module 21.12)

Match each of the following animals with a description of its digestive tract.

- | | |
|---------------|---|
| ___ 1. Horse | A. Digestive system gets simpler when it becomes an adult and changes to a carnivorous diet |
| ___ 2. Coyote | B. Microbes in cecum digest cellulose, and some nutrients are absorbed in colon |
| ___ 3. Frog | C. Ruminant herbivore |
| ___ 4. Cow | D. Reingests fecal pellets to obtain nutrients |
| ___ 5. Rabbit | E. Carnivore with relatively simple digestive system |
| ___ 6. Deer | F. Rechews "cud," which is further digested by microbes and enzymes in four-chambered stomach |

Exercise 7 (Module 21.13)

This module is short, but it is an important introduction to the subject of nutrition. See if you can summarize the module in a sentence of *exactly* 25 words.

Exercise 8 (Module 21.14)

Cellular metabolism breaks down the molecules in food and uses the energy released to build ATP, which in turn fuels body activities. The energy in food is measured in Calories (which are actually kilocalories). To get a handle on the energy contents of foods and the energy consumed by body activities, calculate how much you would need to exercise to use the calories in the food listed on the next page (similar to Table 21.14).

First, you need to calculate your own weight in kilograms. One kilogram equals 2.2 pounds, so:

$$\text{your weight (in kg)} = \frac{\text{your weight (in lb)}}{2.2} = \underline{\hspace{2cm}}$$

Next you need to calculate how many kcal/min you use performing various activities:

$$\text{kcal/min you use} = \text{kcal/kg/min (from table)} \times \text{your weight (in kg)}$$

Use the above formula to figure out how many kcal/min you would use jogging, swimming, and walking. Then write the figures in the spaces on the next page.

Finally, use the following formula to figure out how long you would have to exercise to use up the energy in a food item, and write the figures in the table:

$$\text{exercise time} = \frac{\text{energy in food}}{\text{kcal/min you use}}$$

Food-exercise energy equivalents:

	<i>Jogging</i>	<i>Swimming</i>	<i>Walking</i>
Speed	9 min/mile	30 min/mile	20 min/mile
kcal/kg/min	0.173	0.132	0.039
kcal/min for you:	_____	_____	_____

Number of minutes you would have to do the above exercises to consume the calories in:

Big Mac 560 kcal	_____	_____	_____
Cheese pizza—slice 450 kcal	_____	_____	_____
Coca-Cola—10 oz 144 kcal	_____	_____	_____
Whole-wheat bread—slice 86 kcal	_____	_____	_____

(You may want to look at the labels to get the energy contents of some of your favorite foods. You can record their exercise equivalents in the spaces below.)

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Exercise 9 (Modules 21.15 – 21.19)

Vitamins, minerals, and certain fats and amino acids are all essential nutrients. They are substances an animal cannot make that must be obtained in food. These and other nutrients are listed on food labels. There is a lot of detail in these modules, so try to focus on overall concepts. These concepts, the names of some nutrients, and principles of food labeling are useful in completing this crossword puzzle.

Across

4. The minerals sodium and ____ are important in acid-base and water balance.

7. Excess ____-soluble vitamins are not stored, but excreted from the body.

8. A diet low in one or more essential amino acids can lead to ____ deficiency.

9. The vitamin debate is mainly about ____.

12. ____ acid (vitamin C) is important in collagen synthesis.

13. Most vitamins function as ____.

14. There are ____ essential amino acids that must be obtained from the diet.

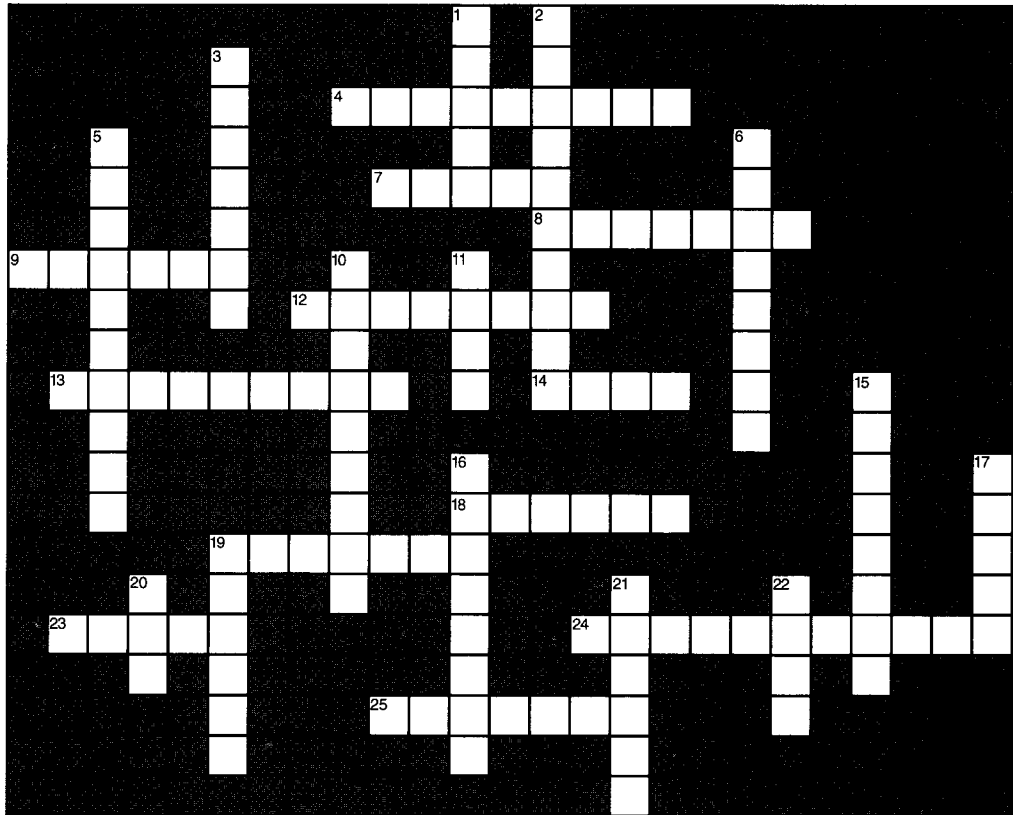
18. We need the mineral ____ to make the hormone thyroxine.

19. A ____ is an essential organic nutrient needed in very small quantities.

23. All essential amino acids can be obtained from a combination of corn and ____.

24. Packages list ____ and nutritional information.

25. ____ is a mineral important in bones, teeth, muscle, nerves, and blood clotting.

**Down**

1. Ingredients are listed on packages from greatest amount to ____ amount.

2. Vitamin D aids in the ____ and use of calcium and phosphorus.

3. The B ____ vitamins are important coenzymes in cellular metabolism.

5. Calcium and ____ are important in building the skeleton.

6. Most victims of malnutrition are ____.

10. The amino acids that body cells cannot make are called ____ amino acids.

11. ____ is a component of hemoglobin and enzymes of energy metabolism.

15. The energy content of foods is expressed in ____.

16. ____ are elements other than C, H, O, and N.

17. The body can make fats by combining fatty ____ with molecules such as glycerol.

19. Vitamin A is important for normal ____.

20. ____-soluble vitamins (vitamins A, D, etc.) can be stored in the body.

21. Essential amino acids are most easily obtained from ____ sources.

22. ____ are minimal standards of nutrients established by nutritionists for preventing deficiencies.

Exercise 10 (Modules 21.19 – 21.20)

It is important to read food labels because certain ingredients and nutrients are more healthful than others. For a healthy lifestyle, one should try to maximize (↑) which of the following and minimize (↓) which others?

- | | |
|-----------------------------------|--|
| _____ 1. Blood cholesterol levels | _____ 10. HDLs |
| _____ 2. Vegetable oils | _____ 11. Unsaturated fats |
| _____ 3. Sodium | _____ 12. Foods rich in vitamins A and C |
| _____ 4. Total fat intake | _____ 13. Alcohol intake |
| _____ 5. High-fiber foods | _____ 14. Vegetables from the mustard family, such as broccoli and cabbage |
| _____ 6. Exercise | _____ 15. Smoked and cured foods |
| _____ 7. Smoking | _____ 16. Animal fats |
| _____ 8. LDLs | _____ 17. Trans fats |
| _____ 9. Saturated fats | |

Testing Your Knowledge**Multiple Choice**

- The box elder bug is an insect that sucks plant juices. It is a
 - suspension-feeding omnivore.
 - substrate-feeding herbivore.
 - suspension-feeding herbivore.
 - fluid-feeding herbivore.
 - fluid-feeding carnivore.
- Which of the following lists the four stages of food processing in order?
 - ingestion, digestion, absorption, elimination
 - digestion, ingestion, absorption, elimination
 - ingestion, absorption, elimination, digestion
 - ingestion, digestion, elimination, absorption
 - absorption, digestion, ingestion, elimination
- Which of the answers below would *not* work in the following sentence? "In order for the body to absorb and use _____, they must be broken down by hydrolysis into _____."
 - polysaccharides . . . monosaccharides
 - amino acids . . . proteins
 - fats . . . glycerol and fatty acids
 - disaccharides . . . monosaccharides
 - starch . . . monosaccharides
- How does a gastrovascular cavity differ from an alimentary canal? The gastrovascular cavity
 - stores food but does not digest it.
 - is usually much larger.
 - has only one opening.
 - functions in digestion but not absorption.
 - can use only small food particles.
- In humans, most nutrient molecules are absorbed by the
 - stomach.
 - liver.
 - small intestine.
 - large intestine.
 - pancreas.
- The largest variety of digestive enzymes function in the
 - large intestine.
 - oral cavity.
 - stomach.
 - gallbladder.
 - small intestine.
- After nutrients are absorbed, the blood carries them first to the
 - brain.
 - pancreas.
 - kidneys.
 - liver.
 - large intestine.
- Digestion of proteins begins in the _____, and digestion of polysaccharides begins in the _____.
 - mouth . . . stomach
 - stomach . . . small intestine
 - stomach . . . mouth
 - stomach . . . stomach
 - small intestine . . . stomach

9. In humans, a major function of the large intestine is
 - a. absorption of water.
 - b. digestion of food molecules.
 - c. breakdown of toxic substances.
 - d. absorption of nutrients.
 - e. storage of food before it is digested and absorbed.
10. The energy needed to fuel essential body processes is called
 - a. essential nutrient level.
 - b. metabolism.
 - c. recommended daily allowance.
 - d. optimum energy intake.
 - e. basal metabolic rate.
11. Which of the following statements about fat is *incorrect*?
 - a. People of many cultures think fat is beautiful.
 - b. It is best to strive to have as little body fat as possible.
 - c. Too much fat in the diet can lead to cardiovascular disease.
 - d. A moderate amount of fat contributes to a healthy immune system.
 - e. Most excess calories in food are stored by the body in fat.
12. Which of the following is *not* an essential nutrient?
 - a. iron
 - b. glucose, a monosaccharide
 - c. methionine, an amino acid
 - d. sodium
 - e. pantothenic acid, a vitamin
13. Which of the following is an organic molecule needed by the body in small amounts?
 - a. protein
 - b. zinc
 - c. vitamin C
 - d. monosaccharide
 - e. calcium
14. ____ are needed in the diet as components of teeth and bone, regulators of acid-base and water balance, and parts of certain enzymes.
 - a. Amino acids
 - b. Fats
 - c. Minerals
 - d. Nucleic acids
 - e. Vitamins
15. To maintain health, it is best to try to
 - a. decrease intake of unsaturated fats.
 - b. decrease HDL levels in the blood.
 - c. decrease intake of saturated fats.
 - d. maintain a diet in which at least 35% of calories come from fat.
 - e. increase LDL levels in the blood.

Essay

1. Why do the nutrient molecules contained in the food that you eat have to be digested before your body can use them?
2. In a few sentences, compare the digestive system of a grasshopper with that of a human.
3. Describe the substances in saliva and their roles in the function of the digestive tract.
4. Plants are difficult to digest. Describe how the digestive tracts and habits of three different herbivorous mammals are suited to a plant diet.
5. Briefly describe the potential problems with fad diets. What is the best approach to healthy, effective weight control?
6. Describe the kinds of information you can get from reading the labels on food. How might this information be useful?

Applying Your Knowledge

Multiple Choice

1. Which of the following do a wolf, a hummingbird, a termite, and an elephant have in common?
 - a. All are omnivores.
 - b. All are substrate feeders.
 - c. All are ingestive feeders.
 - d. All are carnivores.
 - e. All are herbivores.
2. How would you expect the digestive system of a hawk, a carnivore, to compare with that of a finch, a seed-eater?
 - a. The hawk would have a larger gastrovascular cavity.
 - b. The finch digestive system would be longer (relative to body size).
 - c. The hawk would have a gizzard, but the finch would not.
 - d. The hawk digestive system would be longer.
 - e. The hawk would lack both crop and gizzard.

3. Which of the following might make the most effective antiulcer medication? A chemical that
 - a. stimulates parietal cells of the gastric glands.
 - b. kills bacteria in the stomach.
 - c. inhibits mucous cells of the gastric glands.
 - d. stimulates secretion of bile.
 - e. stimulates gastritis.
4. The lungs are folded into many small air sacs and blood vessels, which divide to form many small capillaries that increase the transfer of substances through their walls. The structures in the digestive system similar in function to these air sacs and capillaries are the
 - a. villi.
 - b. colon and rectum.
 - c. gastric glands.
 - d. high-density lipoproteins.
 - e. sphincters.
5. Imagine that you have eaten a meal containing the following nutrients. Which would *not* have to be digested before being absorbed?
 - a. protein
 - b. polysaccharide
 - c. disaccharide
 - d. nucleic acid
 - e. amino acid
6. Aunt Rose had her gallbladder removed and afterward
 - a. could not eat foods containing large amounts of fat.
 - b. had trouble digesting proteins.
 - c. could eat monosaccharides and disaccharides but not polysaccharides.
 - d. had to wash her food down with large quantities of water.
 - e. needed to take an amino acid supplement.
7. Laxatives work in the large intestine to relieve constipation. Which of the following would probably *not* be an effective laxative? A substance that
 - a. contains lots of fiber.
 - b. promotes water absorption in the large intestine.
 - c. speeds up movement of material through the large intestine.
 - d. decreases water absorption in the large intestine.
 - e. stimulates peristalsis.
8. It is important to get some vitamin B-1 every day, but it is all right if intake of vitamin A varies a bit. Why?
 - a. Vitamin B-1 is an essential nutrient, and vitamin A is not.
 - b. Vitamin A can be stored by the body, but vitamin B-1 cannot.
 - c. The body needs much larger amounts of vitamin B-1 than of vitamin A.
 - d. The body requires vitamin B-1, but vitamin A is just an "extra."
 - e. Vitamin A is water-soluble, and vitamin B-1 is fat-soluble.
9. Why does your body need grams of carbohydrates each day but only milligrams of vitamins, thousands of times less?
 - a. Carbohydrates are used up, but vitamins are reusable.
 - b. The body needs carbohydrates to function, but not vitamins.
 - c. Vitamins contain much more energy per gram.
 - d. The body makes vitamins itself but needs to get carbohydrates from food.
 - e. Carbohydrates are essential nutrients, but vitamins are not.
10. Joe is trying to decide whether to buy a candy bar or some gumdrops to reward himself for losing 10 pounds. Both are 300 calories. Most of the calories in the candy bar come from fat, and most calories in the gumdrops come from carbohydrate. If Joe wants to keep his weight under control, it would be best to buy the
 - a. gumdrops, because the body tends to hoard carbohydrates.
 - b. gumdrops, because the body tends to hoard fat.
 - c. candy bar, because the body tends to hoard carbohydrates.
 - d. candy bar, because the body tends to hoard fat.
 - e. It doesn't matter; calories are calories, whatever the source.

Essay

1. James and Michael are both working out to build up their muscles. Muscle is mostly protein, so they both are on high-protein diets. James is eating twice as much meat as normal. Michael is a vegetarian, so he is consuming plant foods high in protein, such as beans and peanuts. What are the pros and cons of each diet?

2. It is sometimes necessary to remove a diseased portion of the digestive system, but usually a patient can get along on a modified diet. It would be most difficult to live without which of the following, and why? Stomach, large intestine, gallbladder, small intestine, salivary gland.
3. The pancreas does not actually secrete the protein-digesting enzymes trypsin and chymotrypsin. It secretes substances called trypsinogen and chymotrypsinogen, which are converted to trypsin and chymotrypsin by a substance secreted by the walls of the small intestine. What do you think is the reason for this two-step process?
4. NASA calculates that an astronaut uses an average of 2500 kcal of food energy per day. How many liters of oxygen will the astronaut consume in a day? (See Module 21.14 in the text.)
5. Professor T. Herman Thimblebottom suspects that the element scandium is an essential mineral in the human diet. How might he go about demonstrating this? Why might it be difficult?
6. Look at some food labels. How many calories are contained in one serving of one of the foods? How far would you have to jog, swim, or walk to use the calories?

Extending Your Knowledge

1. Do you ever read the labels on food products? It can be very informative and entertaining. Look at some food labels. Which ingredients are present in the largest amounts? How much sugar does the product contain? (Remember, there are many words for sugar.) Which ingredients have value as nutrients, and which merely “improve” the taste, texture, appearance, or storage of the food? Is this food high in fat? Saturated or unsaturated fat? Calories? Sodium? How do more “natural” foods compare with more “processed” foods? How do “light” foods compare with regular ones?
2. Are you eating a healthy diet and getting enough exercise? How would you evaluate your diet, given the information in this chapter? Outline changes in your diet and lifestyle that could decrease your chances of developing cancer or cardiovascular disease.