Review the Concepts

Work through the following exercises to review the concepts in this chapter. For additional review, check out the activities at www.mybiology.com. The website offers a pre-test that will help you plan your studies.

Exercise 1 (Module 3.1)

The great variety of organic compounds results from the ability of carbon atoms to form four bonds, creating branching chains of different lengths. Several hydrocarbon molecules, consisting only of carbon and hydrogen, are shown in Module 3.1. Practice seeing the versatility of carbon by sketching some hydrocarbon molecules of your own, as suggested below.

1. Sketch a hydrocarbon molecule that is a straight chain, containing 5 carbon atoms and 12 hydrogen atoms, molecular formula C_5H_{12}:

   Question: Why does each carbon bond to 4 other atoms?

2. Now sketch a shorter hydrocarbon chain, with only four carbon atoms:

   Question: What is the molecular formula ($C_?H_?$) of the above molecule?

3. Sketch another five-carbon hydrocarbon, but this time include one double bond:

   Question: What is the molecular formula of this molecule?

4. Sketch a five-carbon hydrocarbon molecule that is branched (and contains no double bonds):

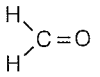
   Question: What is the molecular formula of this molecule? What is the term for its relationship to molecule 1 (in this exercise)?

5. Sketch two five-carbon hydrocarbon molecules in the form of rings, one without double bonds and one with one double bond.

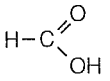
   Question: How many hydrogen atoms are in each of these molecules?

Exercise 2 (Module 3.2)

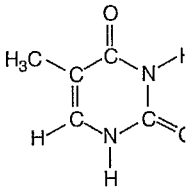
Functional groups participate in chemical changes and give each molecule unique properties. Circle the functional groups that are discussed in this module in the molecules below. Label an example of each of the following: **hydroxyl group, carbonyl group, carboxyl group, amino group,** and **phosphate group, methyl group.** There are a total of ____ hydroxyl group(s), ____ carbonyl group(s), ____ carboxyl group(s), ____ amino group(s), ____ phosphate group(s), and ____ methyl group(s). (The properties of the molecules are described at the right.)



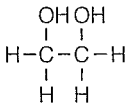
Formaldehyde is the starting point for making many chemicals.



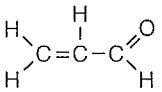
Formic acid gives ant venom its sting.



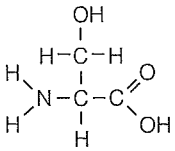
Thymine is one of the "bases" that make up the DNA genetic code.



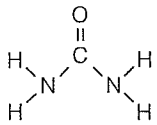
Ethylene glycol is in automobile antifreeze.



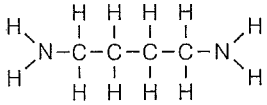
Acrolein is produced when meat is heated; it is the barbecue smell.



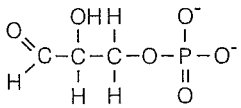
Serine is part of many protein molecules.



Urea is a waste product in urine.



Putrescene's name is descriptive; it is produced in rotting flesh.



G3P is an intermediate step in plants' production of sugar.

Exercise 3 (Module 3.3)

There are four main classes of macromolecules. Most are polymers, assembled from smaller monomers in a process called a dehydration reaction. Hydrolysis breaks polymers back down to monomers. State whether each of the following relates to dehydration (D) or hydrolysis (H).

_____ 1. Connects monomers to form a polymer.
_____ 2. Produces water as a by-product.
_____ 3. Breaks up polymers, forming monomers.
_____ 4. Water is used to break bonds between monomers.
_____ 5. Joins amino acids to form a protein.
_____ 6. Glycerol and fatty acids combine this way to form a fat.
_____ 7. Occurs when polysaccharides are digested to form monosaccharides.
_____ 8. —H and —OH groups form water.
_____ 9. Nucleic acid breaks up to form nucleotides.
_____ 10. Water breaks up, forming —H and —OH groups on separate monomers.

Exercise 4 (Modules 3.3–3.7)

Review carbohydrates by filling in the blanks in the following story.

Carbohydrates are a class of molecules ranging from the simplest sugars, called [1]_____, to giant molecules called [2]_____, built of many sugars. Carbohydrates are the main fuel molecules for cellular work.

Plants make their own carbohydrates, but humans, like all animals, must obtain them from plants or other animals. Imagine eating a piece of whole-wheat bread spread with strawberry jam. It contains a mixture of carbohydrates, along with other macromolecules such as [3]_____ and [4]_____. Much of the carbohydrate in the bread itself is in the form of a polysaccharide called [5]_____, which is simply a chain of [6]_____ monomers. The monomers were linked together in the wheat plant in a process called a [7]_____ reaction. As the glucose units joined, [8]_____ was produced as a by-product. When you swallow a bite of bread, digestive juices in the intestine separate the monomers in the opposite reaction, called [9]_____. In the intestine, this is actually a two-step process. Secretions from the pancreas first break the starch down to maltose, a type of carbohydrate called a [10]_____, which consists of two glucose monomers. Secretions from the walls of the intestine complete the process, breaking each maltose molecule down to two individual glucose molecules. Each glucose is a [11]_____-shaped molecule, containing [12]_____ carbon atoms.

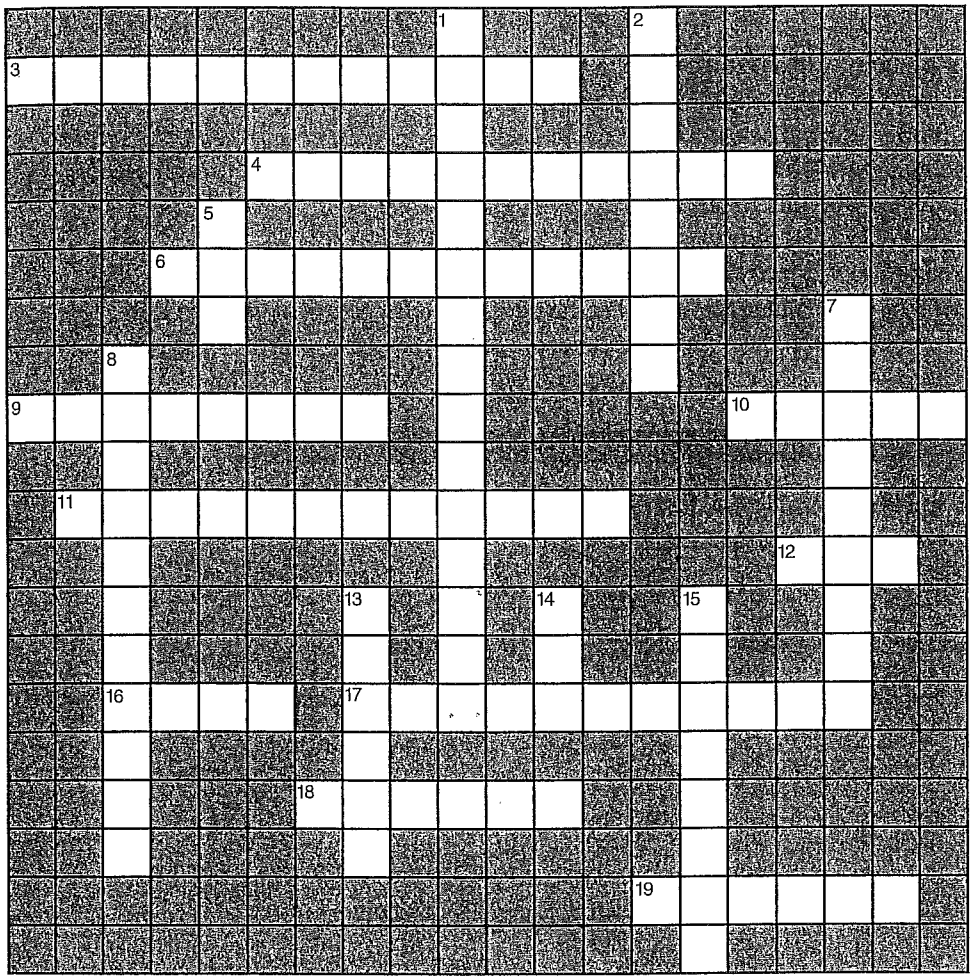
There are other carbohydrates in the bread and jam. Whole-wheat flour contains the tough coats of the wheat seeds. These contain a lot of [13]_____, the fibrous polysaccharide that makes up plant cell walls. Like starch, it is made of glucose monomers, but these monomers are [14]_____ in a different orientation. The human digestive tract is not capable of [15]_____ cellulose, so it passes through the digestive tract unchanged, in the form of [16]_____. Sucrose, a [17]_____ refined from sugar cane or sugar beets, may be used to sweeten

the strawberry jam. Each sucrose molecule is hydrolyzed in the small intestine to form one molecule of [18]_____ and one molecule of [19]_____. This homemade jam naturally also contains a small amount of fructose, a [20]_____ that is naturally produced by strawberries and is considerably sweeter than sucrose. (High-fructose corn syrup, or HFCS, used to sweeten many processed foods, is produced by hydyrolyzing [21]_____ and using enzymes to convert the resulting [22]_____ to fructose. The increase in use of HFCS may be linked to the recent increase in [23]_____, [24]_____, and other chronic diseases.)

Once all the carbohydrates have been hydrolyzed to small monosaccharides, they can be absorbed by the body. Glucose and fructose pass through the wall of the intestine and into the bloodstream, which carries them to the liver. Like all carbohydrate molecules, these sugars are [25]_____, so they easily dissolve in the water of blood plasma. In the liver, the fructose is converted to glucose. This process is relatively easy because glucose and fructose are [26]_____, having the same molecular formula, written [27]_____, but slightly different structures. Glucose circulates around the body as "blood sugar" and is taken up by the cells for fuel as needed. Extra glucose molecules are taken up by liver and muscle cells and linked together by [28]_____ synthesis to form a polysaccharide called [29]_____. This molecule is similar to plant [30]_____, except it is more branched. Later the glycogen can be hydrolyzed to release [31]_____ into the blood.

Exercise 5 (Modules 3.8–3.10)

Review the structures and functions of lipids by completing the following crossword puzzle.



Across

3. ____ means that hydrogen has been added to unsaturated fats.
4. ____ is a steroid common in cell membranes.
6. A ____ is similar to a fat; found in cell membranes.
9. A fat molecule is composed of ____ and three fatty acids.
10. Glycerol and three____ acids make a triglyceride.
11. ____ is another name for "fat."
12. A ____ forms a waterproof coat that keeps a fruit or insect from drying out.
16. Olive and corn ____ are examples of unsaturated fats.
17. Fats with double bonds are said to be ____.
18. ____ is a lipid-containing deposit in a blood vessel.
19. ____ are grouped together because they do not mix well with water.

Down

1. ____ is a condition where lipid-containing deposits build up in blood vessels.
2. Female and male sex hormones are examples of ____.
5. ____ is an illegal steroid recently banned by the Olympic Committee, FDA, and professional sports.
7. Animal fats are said to be ____.
8. Lipids are water-avoiding, or ____ substances.
13. Unsaturated fats contain more ____ bonds than saturated fats.
14. A ____ is a large molecule whose main function is energy storage.
15. ____ steroids are dangerous synthetic variants of testosterone.

Exercise 6 (Module 3.11)

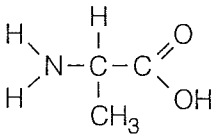
Everything a cell does involves proteins. Eight functions of proteins are discussed in Module 3.11 (enzymes, transport proteins, etc). Match each of the functional types with one of the descriptions below.

_____ 1. Hemoglobin carries oxygen in the blood.
_____ 2. A protein in muscle cells enables them to move.
_____ 3. Antibodies fight disease-causing bacteria.
_____ 4. Collagen gives bone strength and flexibility.
_____ 5. Insulin signals cells to take in and use sugar.
_____ 6. A protein in a cell receives the insulin signal.
_____ 7. Proteins in seeds provide food for plant embryos.
_____ 8. A protein called sucrase promotes the chemical conversion of sucrose into monosaccharides.

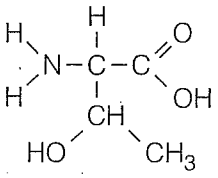
Exercise 7 (Modules 3.12–3.13)

Three amino acids not shown in the modules are diagrammed below.

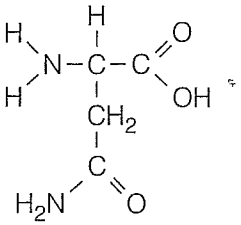
1. Draw a box around the unique R group of each, and label it **R group**.
2. Draw a red circle around the amino group of each, and label it **amino group**.
3. Draw a blue triangle around the acid group of each, and label it **acid group**.



Alanine



Threonine

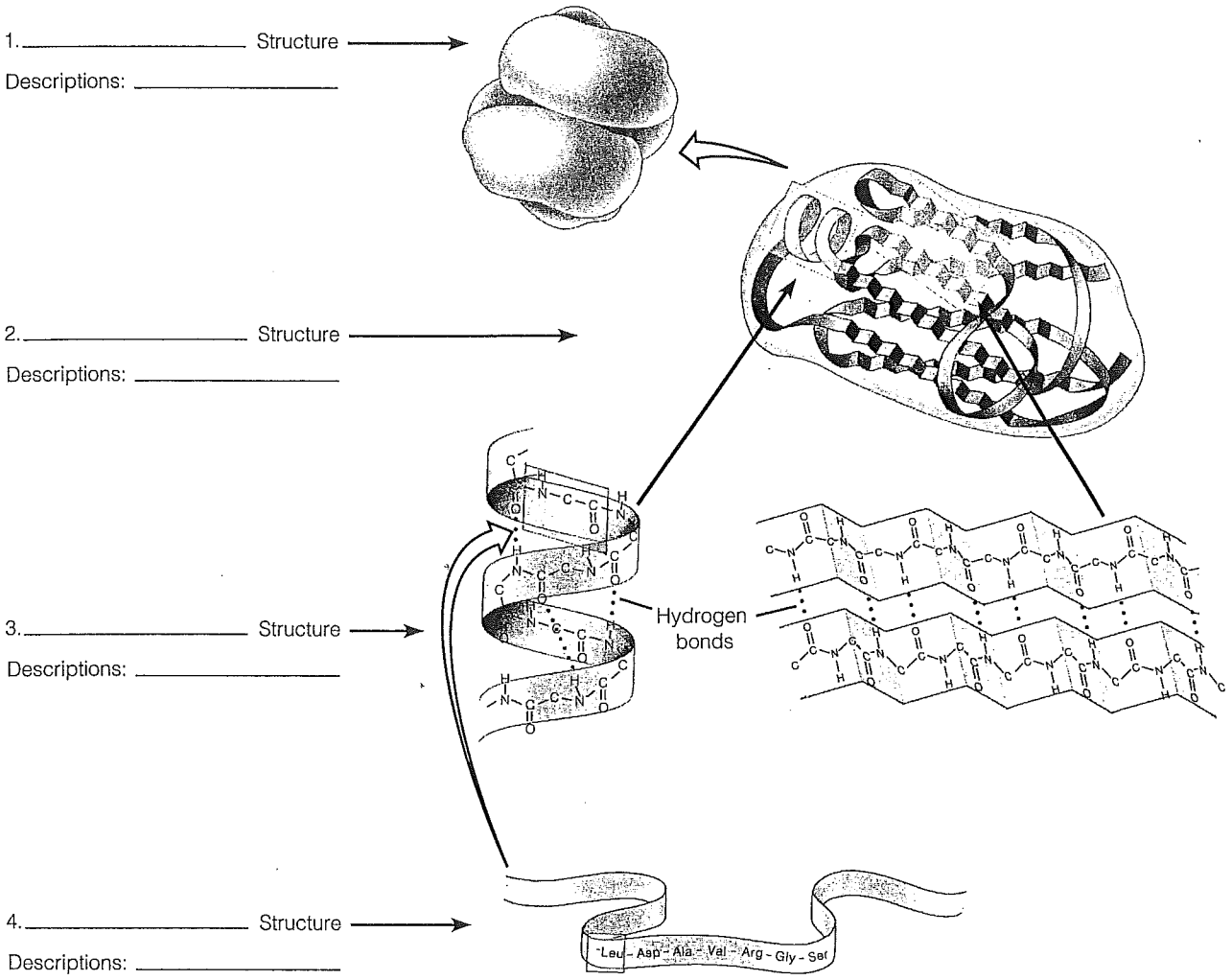


Asparagine

4. In the space below, sketch the three amino acids to show how they would join to form a tripeptide. What is this chemical reaction called? How many molecules of water would be formed? Show where the water would come from.

Exercise 8 (Modules 3.12–3.14)

Identify each of the levels of protein structure in the diagrams. Then choose the descriptions from the list below that go with each of the levels.



Choose from these descriptions:

A. Overall three-dimensional shape
B. Amino acid sequence
C. Even a slight change in this can alter tertiary structure.
D. This level occurs in proteins with more than one polypeptide subunit.
E. Coiling and folding produced by hydrogen bonds between —NH and C=O groups
F. Not present in all proteins
G. Level of structure that is held together by peptide bonds
H. Alpha helix and pleated sheet
I. Stabilized by clustering of hydrophobic R groups, hydrogen bonds, ionic bonds, and sometimes even covalent bonds
J. "Globular" or "fibrous" might describe this level of structure.
K. Folding that results from interactions among R groups of amino acids in the polypeptide chain.

Test Your Knowledge

Multiple Choice

1. Cellulose is a _____ made of many _____.
   a. polypeptide . . . monomers
   b. carbohydrate . . . fatty acids
   c. polymer . . . glucose molecules
   d. protein . . . amino acids
   e. lipid . . . triglycerides

2. In a hydrolysis reaction _____, and in this process water is _____.
   a. a polymer breaks up to form monomers . . . consumed
   b. a monomer breaks up to form polymers . . . produced
   c. monomers are assembled to produce a polymer . . . consumed
   d. monomers are assembled to produce a polymer . . . produced
   e. a polymer breaks up to form monomers . . . produced

3. The four main categories of macromolecules in a cell are
   a. proteins, DNA, RNA, and steroids.
   b. monosaccharides, lipids, polysaccharides, and proteins.
   c. proteins, nucleic acids, carbohydrates, and lipids.
   d. nucleic acids, carbohydrates, monosaccharides, and proteins.
   e. RNA, DNA, proteins, and carbohydrates.

4. A major characteristic that all lipids have in common is
   a. they are all made of fatty acids and glycerol.
   b. they all contain nitrogen.
   c. none of them is very high in energy content.
   d. they are all acidic when mixed with water.
   e. they don't dissolve well in water.

5. A flower's color is determined by the genetic instructions in its
   a. proteins.
   b. lipids.
   c. carbohydrates.
   d. nucleic acids.
   e. all of the above.

6. The most concentrated source of stored energy is a molecule of
   a. DNA.
   b. cellulose.
   c. fat.
   d. protein.
   e. glucose.

7. In some places the backbone of a protein molecule may twist or fold back on itself. This is called _____, and the coils or folds are held in place by _____.
   a. tertiary structure . . . hydrogen bonds
   b. primary structure . . . covalent bonds
   c. secondary structure . . . peptide bonds
   d. tertiary structure . . . covalent bonds
   e. secondary structure . . . hydrogen bonds

8. A hydrophobic amino acid R group would be found where in a protein?
   a. forming a peptide bond with the next amino acid in the chain
   b. on the outside of the folded chain, in the water
   c. on the inside of the folded chain, away from water
   d. forming hydrogen bonds with other R groups
   e. only at one end of a protein chain

9. The overall three-dimensional shape of a polypeptide is called the
   a. double helix.
   b. primary structure.
   c. secondary structure.
   d. tertiary structure.
   e. quaternary structure.

10. How many different *kinds* of protein molecules are there in a typical cell?
    a. four
    b. twenty
    c. about a hundred
    d. thousands
    e. billions

11. Estrogen, cholesterol, and other steroids are examples of
    a. polysaccharides.
    b. lipids.
    c. polypeptides.
    d. triglycerides.
    e. fats.

12. Functional groups called _____ groups are often used to transfer energy between organic molecules.
    a. hydroxyl
    b. amino
    c. carboxyl
    d. carbonyl
    e. phosphate

13. The "building blocks" of nucleic acid molecules are called
    a. polysaccharides.
    b. amino acids.
    c. fatty acids.
    d. nucleotides.
    e. DNA and RNA.

Essay

1. Briefly describe the various functions of proteins in the cell and body.
2. Animal fats tend to be solid at room temperature, plant oils more liquid. Explain how a difference in the chemical structure of their molecules causes this physical difference.
3. What forces and bonds maintain the three-dimensional folded shape of a protein molecule? How does this relate to the sensitivity of proteins to changes in their environment?
4. Using circles to represent monosaccharides, show the difference between glucose, maltose, and starch. Maltose is an example of what kind of carbohydrate? Starch is an example of what kind of carbohydrate?
5. Sketch a protein molecule, using squares connected by lines to represent amino acids connected by peptide bonds. Does your protein display primary, secondary, and tertiary structure? Where?

Apply the Concepts

Multiple Choice

1. Citric acid makes lemons taste sour. Which of the following is a functional group that would cause a molecule such as citric acid to be acidic?
    a. hydroxyl
    b. hydrocarbon
    c. amino
    d. carbonyl
    e. carboxyl

2. Which of the following do nucleic acids and proteins have in common?
    a. They are both made of amino acids.
    b. Their structures contain sugars.
    c. They are hydrophobic.
    d. They are large polymers.
    e. They each consist of four basic kinds of subunits.

3. A biochemist is analyzing a potato plant for the disaccharide sucrose. Where would he be most likely to find it?
    a. in cell membranes
    b. in grains in the cells of underground tubers (potatoes)
    c. in the nuclei of potato cells
    d. in the sap of the potato plant
    e. in the walls of the potato plant cells

4. Which of the following ranks the molecules in the correct order by size?
    a. water . . . sucrose . . . glucose . . . protein
    b. protein . . . water . . . glucose . . . sucrose
    c. water . . . protein . . . sucrose . . . glucose
    d. protein . . . sucrose . . . glucose . . . water
    e. glucose . . . water . . . sucrose . . . protein

5. How does glucose differ from sucrose, cellulose, and starch?
    a. It is a carbohydrate.
    b. It is larger.
    c. The others are polysaccharides.
    d. It is a monosaccharide.
    e. It contains carbon, hydrogen, and oxygen.

6. Seth noticed that his friend Jon had gained a little weight during the holidays. He commented, "Storing up some _____ for the winter, I see."
    a. polysaccharides
    b. triglycerides
    c. nucleotides
    d. polypeptides
    e. steroids

7. How does DNA differ from RNA?
    a. DNA is larger.
    b. One of their nitrogenous bases is different.
    c. They contain different sugars.
    d. DNA consists of two strands in a double helix.
    e. All of the above are differences.