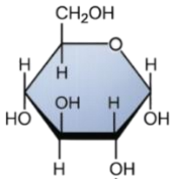
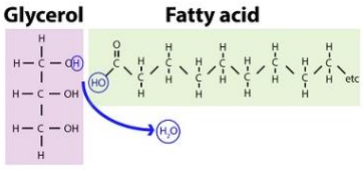
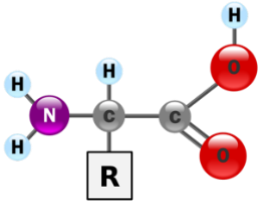
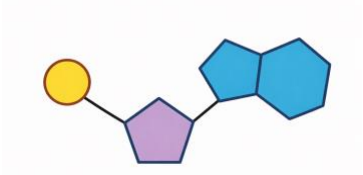
Chapter 3: The Molecule of Cells

Campbell Biology: Concepts & Connections 9E (Taylor et al.)

Connecting the Concepts

1. Complete the following table to help you review the structures and functions of the four classes of organic molecules.

Classes of Molecules and Their Components	Functions	Examples
Carbohydrates  Monosaccharide	Energy for cell, raw material b. _____ Plant cell support	a. _____ Starch, glycogen c. _____
Lipids (don't form polymers)  Components of a fat molecule	Energy storage e. _____ Hormones	d. _____ Phospholipids f. _____
Proteins g. _____ h. _____  i. _____ Amino Acid	j. _____ k. _____ l. _____ Transport Communication n. _____ Storage Receive signals	Lactase Hair, tendons Muscle Proteins m. _____ signal proteins Antibodies Proteins in seeds Receptor proteins
Nucleic Acids o. _____. P. _____  q._____ Nucleotide	Heredity s. _____	r. _____ DNA and RNA

Testing Your Knowledge

Level 1: Knowledge / Comprehension

1. Organic molecules virtually always contain the elements
    a. carbon and nitrogen
    b. nitrogen and sulfur
    c. hydrogen and carbon
    d. carbon and oxygen

2. What makes a fatty acid an acid?
    a. It does not dissolve in water.
    b. It is capable of bonding with other molecules to form a fat.
    c. It has a carboxyl group that can donate and H^+ to a solution.
    d. It contains only two oxygen atoms.

3. Cows can derive nutrients from cellulose because
    a. they produce enzymes that recognize the shape of the glucose-glucose bonds and hydrolyze them.
    b. they re-chew their cud to break down cellulose fibers.
    c. their digestive tract contains microorganisms that can hydrolyze the bonds of cellulose.
    d. they convert cellulose to starch and can digest starch.

4. Of the following functional groups, which is/are polar, tending to make organic compounds hydrophilic?
    a. Carbonyl
    b. Amino
    c. Hydroxyl
    d. All of the above

5. Which statement is true?
    a. Steroids are saturated fats that are mainly found in animal cell membranes.
    b. Phospholipids have a hydrophilic head and two hydrophobic fatty acid tails.
    c. Saturated fats are insoluble in water, but fatty acids will dissolve in vinegar.
    d. Saturated fats are converted into unsaturated fats by removing double bonds in the fatty acid tails.

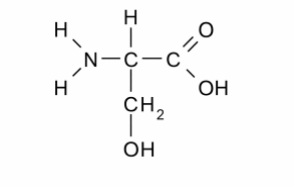
Level 2: Application / Analysis

6. A shortage of phosphorus in the soil would make it especially difficult for a plant to manufacture
    a. DNA.
    b. proteins.
    c. cellulose.
    d. sucrose.

7. Which of the following substances is a major component of the cell membrane of a fungus?
    a. cellulose
    b. chitin
    c. cholesterol
    d. phospholipids

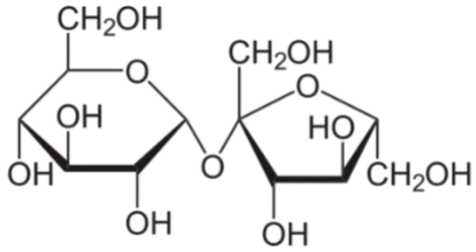
8. Which structural level of a protein would be least affected by a disruption in hydrogen bonding?
    a. primary structure
    b. secondary structure
    c. tertiary structure
    d. quaternary structure

9. Circle and name the functional groups in this organic molecule. What type of compound is this? For which class of macromolecules is it a monomer?



10. Most proteins are soluble in the aqueous environment of a cell. Knowing that, where in the overall three-dimensional shape of a protein would you expect to find amino acids with hydrophobic R groups?

11. Sucrose is broken down in your intestine to the monosaccharides glucose and fructose, which are then absorbed into your blood. What is the name of this type of reaction? Using this diagram of sucrose, show how this would occur.



12. Explain the role of complementary base pairing in the functions of nucleic acids.

13. Explain why replacing one amino acid in a protein with another one may cause the protein to malfunction.

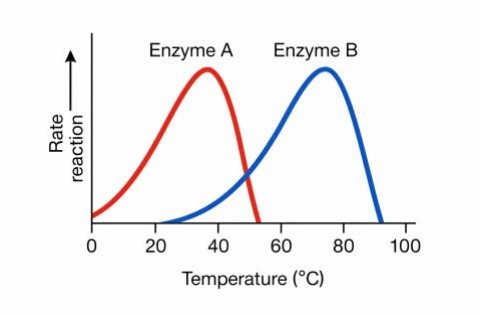
Level 3: Synthesis / Evaluation

14. The diversity of life is staggering. Yet the molecular logic of life is simple and elegant: Small molecules common to all organisms are ordered into unique macromolecules. Explain why carbon is central to this diversity of organic molecules. How do carbon skeletons, chemical groups, monomers, and polymers relate to this molecular logic of life?

15. How can a cell make many different kinds of proteins out of only 20 amino acids? Of the myriad possibilities, how does the cell "know" which proteins to make?

16. Human cells cannot make some kinds of unsaturated fatty acids that are essential for cell membranes to function properly. What is nature's solution to this problem?

17. Enzymes usually function best at an optimal pH and temperature. The following graph shows the effectiveness of two enzymes at various temperatures.



a. At which temperature does enzyme A perform best? Enzyme B?

b. One of these enzymes is found in humans and the other in thermophilic (heat-loving) bacteria. Which enzyme would you predict comes from which organism?

c. From what you know about enzyme structure, explain why the rate of the reaction catalyzed by enzyme A slows down at temperatures above 40°C (140°F).

18. Another aspect of the Nurses' Health Study introduced in Module 3.9 looked at the percentage of change in the risk of coronary heart disease associated with substituting one dietary component for another. These results estimated that replacement of 5% of energy from saturated fat in the diet with unsaturated fats would reduce the risk of heart disease by 42%, and that the replacement of 2% of energy from trans fat with unsaturated fats would reduce the risk by 53%. Explain what these numbers mean.

<Answer Key>

1. a. glucose; b. energy storage; c. cellulose; d. fats; e. cell membrane component; f. steroids; g. amino group; h. carboxyl group; i. R group; j. enzyme; K. structural proteins; l. movement; m. membrane transport protein; n. defense; o. phosphate group; p. nitrogenous base; q. ribose or deoxyribose; r. DNA; s. code for proteins

2. c 3. c 4. c 5. d 6. b 7. a 8. d 9. a

10. Circle NH_2, an amino group; COOH, a carboxyl group; and OH, a hydroxyl group on the R group. This is an amino acid, a monomer of proteins. The OH group makes it a polar amino acid.

11. Amino acids with hydrophobic R groups are most likely to be found clustered together in the interior of a protein, sheltered from the surrounding water.

12. This is a hydrolysis reaction, which consumes water. It is essentially the reverse of the diagram in Figure 3.5, except that fructose has a different shape than glucose.

13. The complementary base pairing of the two strands of DNA makes possible the precise copying of DNA every time a cell divides, ensuring that genetic information is faithfully transmitted. Complementary base pairing is involved in transferring information from DNA to RNA to specify the order of amino acids in a polypeptide. In some types of RNA, complementary base pairing enables RNA molecules to assume specific three-dimensional shapes that facilitate diverse functions.

14. Each amino acid has a different R group that determines its shape, size, and charge. Protein function depends on its unique 3D shape, so changing even one amino acid may affect its functionality.

15. Carbon forms four covalent bonds, either with other carbon atoms, producing chains or rings of various lengths and shapes, or with other atoms, such as characteristic chemical groups that confer specific properties on a molecule. This bonding capability is the basis for the incredible diversity of organic compounds. Organisms can link a small number of monomers into different arrangements to produce a huge variety of polymers.

16. The 20 amino acids that are found in proteins can be arranged in many different sequences into chains of many different lengths. The sequences of DNA nucleotides in the genes of a cell dictate the amino acid sequences of its polypeptide chains.

17. We derive these unsaturated fatty acids by eating the plants that make them or by consuming the animals that eat these plants. During digestion, the fatty acids stay intact and can be used directly by cell machinery for production of new cell membranes.

18. a. A: at about 37°C; B: at about 78°C

b. A: from humans (human body temperature is about 37°C); B: from thermophilic bacteria

c. Above 40°C, the human enzyme denatures and loses its shape and thus its function. The increased thermal energy disrupts the weak bonds that maintain secondary and tertiary structure in an enzyme.

19. These results indicate that replacing either saturated or trans fats in the diet with unsaturated fats reduces the risk of coronary heart disease. The benefit is greater (risk reduced the most) when trans fats are replaced, even though the quantity of energy in the diet replaced was only 2% rather than the 5% of saturated fats replaced.