ANSWER KEY

# 3

# THE CHEMISTRY OF ORGANIC MOLECULES

## CHAPTER REVIEW

Carbon's unique properties permit the formation of many kinds of **organic molecules.** At the molecular level, this variety accounts for the diversity of living things. Many organic molecules have a carbon backbone plus functional groups. Some common functional groups are the hydroxyl, carbonyl, carboxyl, amino, sulphydryl, and phosphate groups.

Several types of small, organic molecules—monosaccharides, fatty acids, amino acids, and nucleotides—serve as the **monomers** (building blocks) of **polymers** (larger organic molecules). These polymers (e.g., carbohydrates, lipids, proteins, nucleic acids) have important biological functions. When a **dehydration reaction** occurs, two monomers bond chemically as a water molecule is lost. Repetition of this process produces even larger molecules—the polymers—in a cell. The reverse reaction, **hydrolysis,** breaks down polymers into their chemical subunits.

Several classes of organic molecules have biological importance. One of these, the **carbohydrates,** consists of several subclasses: the monosaccharides (e.g., glucose), the disaccharides (e.g., sucrose), and the polysaccharides (e.g., starch). The monosaccharides and disaccharides—the sugars—provide an immediate energy source for organisms. Some polysaccharides store energy (i.e., starch), whereas others contribute structurally (i.e., cellulose).

**Fatty acids** and **glycerol** are the building blocks of fats and oils. Fatty acids may be either saturated or unsaturated. Fats and oils store energy efficiently. **Waxes** and **phospholipids** differ in some of their components compared to fats. These structural differences endow these molecules with different biological abilities. Phospholipids, for example, are a major component of plasma membrane structure and help determine a membrane's properties. **Steroids** are derived from cholesterol; their structure consists of four fused carbon rings.

**Proteins** have a variety of biological functions, including support, enzymatic, transport, and hormonal regulation. The monomers of these polymers are **amino acids. Peptide bonds** join amino acids within the **polypeptides** of protein molecules. Proteins exhibit several levels of structure. The primary structure of a protein is the order of the amino acids bonded together. Several other structural levels (secondary, tertiary, quaternary) account for the molecule's three-dimensional shape and for the protein's biological properties.

**DNA** and **RNA** are **nucleic acids. Nucleotides,** the monomers of nucleic acids, contain a phosphate, a nitrogen-containing base, and a pentose sugar. DNA makes up the genes in cells. The DNA molecule is a double helix—it has the appearance of a twisted ladder. Sugar and phosphate molecules make up the sides of the ladder, and hydrogen-bonded bases named adenine, guanine, cytosine, and thymine make up the rungs of the ladder. The sequence of bases in DNA stores information regarding the order in which amino acids are to be joined within a protein. RNA conveys this information from the nucleus to the cytoplasm, and therefore is an intermediary in the synthesis of proteins.

The nucleotide ATP is composed of adenosine and three phosphate groups. ATP is a high-energy molecule. Whenever cells need energy, ATP is broken down to ADP + P, and energy is released.

## STUDY EXERCISES

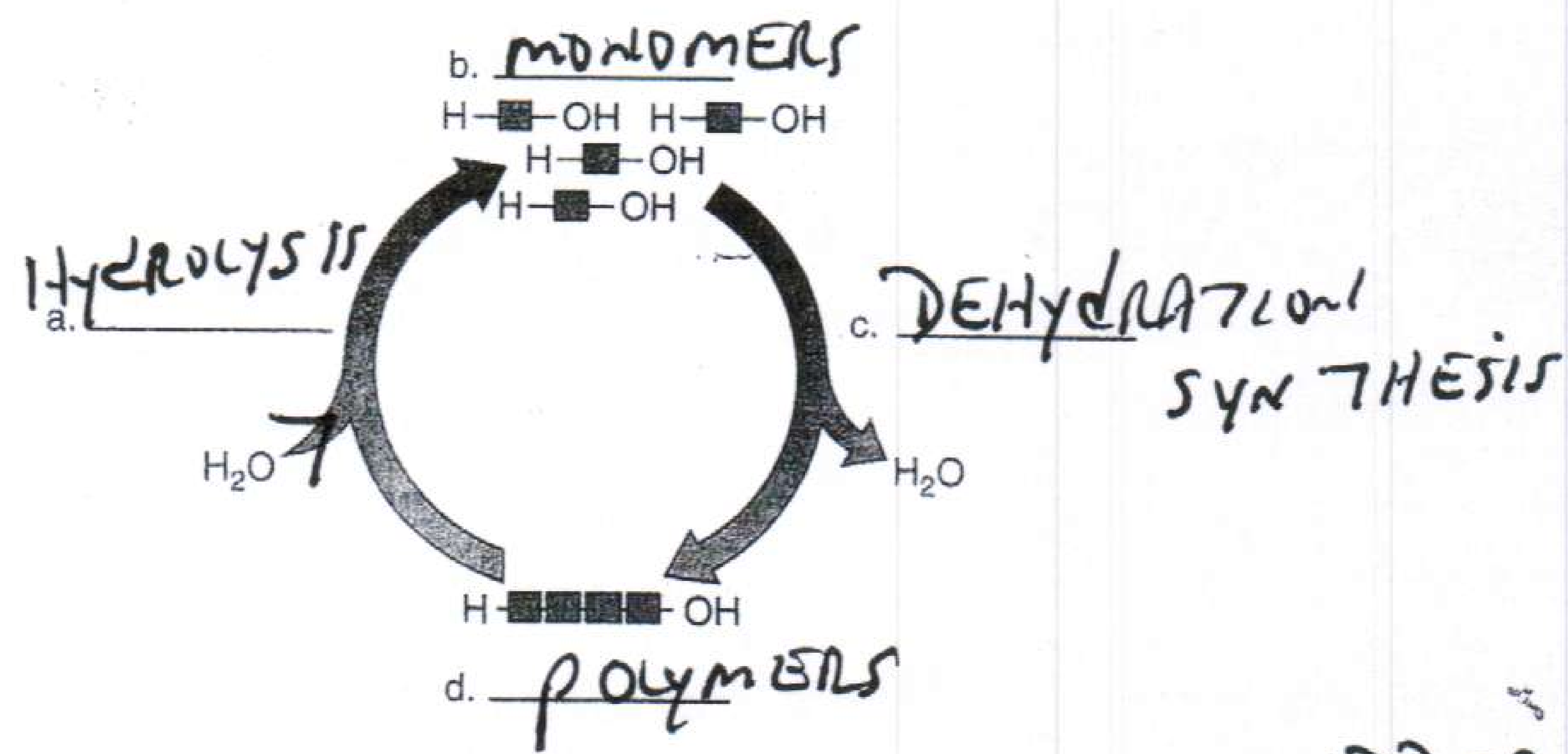
Study the text section by section as you answer the questions that follow.

### 3.1 ORGANIC MOLECULES (PP. 36–38)

- The four classes of organic molecules in cells are carbohydrates, lipids, proteins, and nucleic acids.
- The characteristics of organic compounds depend on the chemistry of carbon.
- Variations in carbon skeletons and the attached functional groups account for the great diversity of organic molecules.
- Large organic molecules called polymers form when their specific monomers join together.

1. Indicate whether these statements about a carbon atom are true (T) or false (F):
   a. F There are two electrons in its outer shell.
   b. T It can bond to other carbon atoms.
   c. T It can share two pairs of electrons with another atom.
   d. F Chains of 50 atoms are unusual in living systems.
2. Label the following diagram using the functional group names.
   amino
   carboxyl
   hydroxyl
   carbonyl (ketone)

   a. KETONE — R—C(=O)—R
   b. CARBOXYL — R—C(=O)—OH
   c. HYDROXYL — R—OH
   d. AMINO — R—N(H)—H
3. Place a check next to the functional group(s) that can ionize (take on or give up a hydrogen ion).
   a. ____ amino
   b. ✓ carboxyl
   c. ____ hydroxyl
   d. ____ carbonyl (ketone)
4. The term that refers to two structurally dissimilar molecules with the same molecular formula is ISOMERS
5. Give the subunit molecule(s) for each of the larger molecules listed.
   polysaccharide a. MONOSACCHARIDE
   fat b. GLYCEROL and c. FATTY ACIDS
   polypeptide d. AMINO ACIDS
   DNA, RNA e. NUCLEOTIDE
6. Label the following diagram using the alphabetized list of terms.
   dehydration reaction
   hydrolysis reaction
   monomers
   polymer

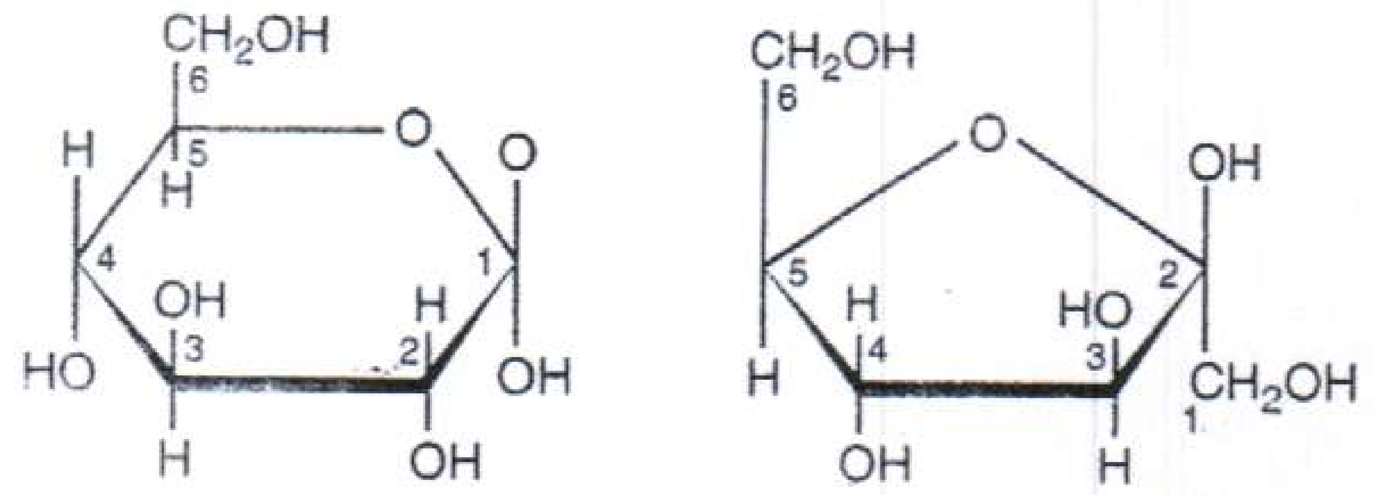



   e. During a hydrolysis reaction, is water added to or taken away from the reactants? ADDED
   f. During a dehydration reaction, is water added to or taken away from the reactants? TAKEN AWAY

## 3.2 Carbohydrates (pp. 38–41)

- Glucose is an immediate energy source for many organisms.
- Some carbohydrates (starch and glycogen) function as short-term stored energy sources.
- Other carbohydrates (cellulose and chitin) function as structural components of cells.

7. Write the molecular formula beneath each of these structural formulas by indicating the number of carbons, hydrogens, and oxygens in each.




ISOMERS

a. $C_6H_{12}O_6$ b. $C_6H_{12}O_6$

8. Complete the following table:

| Carbohydrate | Monosaccharide Composition | Biological Function |
|---|---|---|
| sucrose | GLUCOSE + FRUCTOSE | TRANSPORT SUGAR |
| lactose | GLUCOSE + GALACTOSE | MILK SUGAR |
| maltose | Glucose + Glucose | DIGESTION |
| starch | 3+ Glucose molecule | ENERGY STORAGE |
| glycogen | MONOSACCHARIDES - Glucose | ENERGY STORAGE |
| cellulose | Glucose | CELL WALLS |
| chitin | Glucose | EXOSKELETON |

9. a. Which molecules in the first column of the table in question 8 are disaccharides? 1, 2, 3

b. Which are polysaccharides? 4, 5, 6, 7

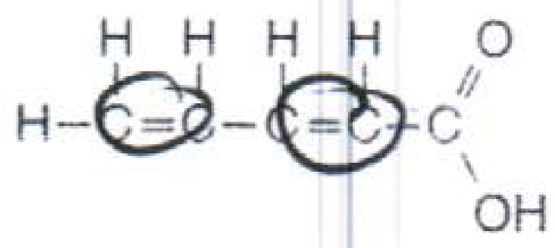
## 3.3 Lipids (pp. 42–45)

- Lipids vary in structure and function.
- Fats function as long-term stored energy sources.
- Cellular membranes, including the plasma membrane, are a bilayer of phospholipid molecules.
- Certain hormones are derived from cholesterol, a complex ring compound.

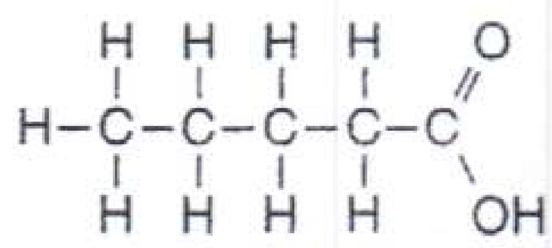
10. Complete the following table:

| Lipid | Monomers | Biological Function |
|---|---|---|
| fats and oils (triglycerides) | GLYCEROL + FATTY ACIDS | ENERGY STORAGE |
| phospholipids | GLYCEROL + F.A. + PHOSPHATE | CELL MEMBRANE |
| waxes | GLYCEROL + F.A. | PROTECTION + STRUCTURE |

11. Write the word *saturated* or *unsaturated* beneath the appropriate structure.

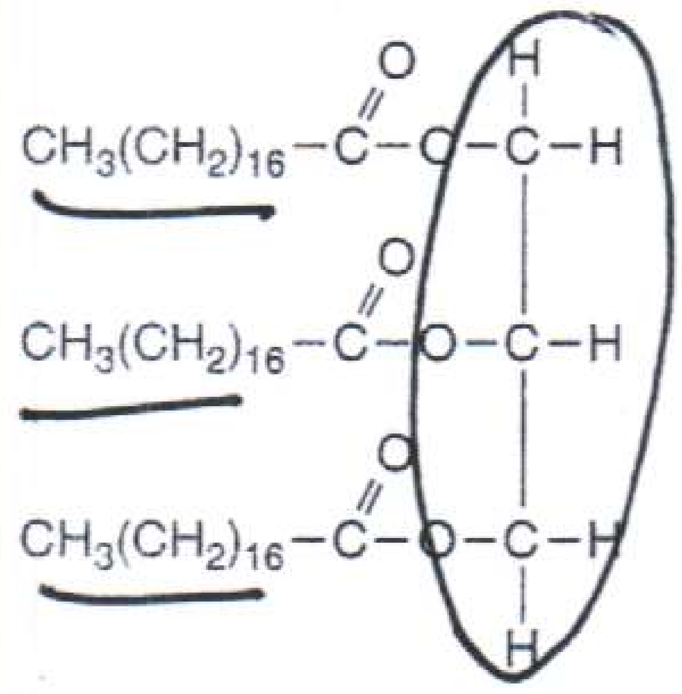


a. UNSAT



b. SAT

12. In the following representation of a fat, draw a circle around the portion derived from glycerol. Draw lines under the portions derived from fatty acids.



13. When phospholipids are placed in water, the a. PHOSPHATE face outward and the b. FATTY ACIDS face each other. This property makes phospholipids suitable molecules to form the c. MEMBRANE of cells.

14. Examples of steroids are a. TESTOSTERONE, b. ESTROGEN, and c. CORTISOL.

15. Each steroid differs from other steroids by the SIDE CHAINS OR RINGS attached to the carbon skeleton.

## 3.4 Proteins (pp. 46–49)

- Proteins serve many and varied functions, such as support, enzymes, transport, defense, hormones, and motion.
- Each protein has levels of structure resulting in a particular shape. Hydrogen, ionic, and covalent bonding, plus hydrophobic interactions, all help maintain a protein's normal shape.

16. Complete the following table:

| Protein | Biological Function |
|---|---|
| enzymes | ORGANIC CATALYSTS |
| actin, myosin | CONTRACTILE FIBERS |
| insulin | SUGAR METABOLISM |
| hemoglobin | $O_2$ CARRIER IN BLOOD cells |

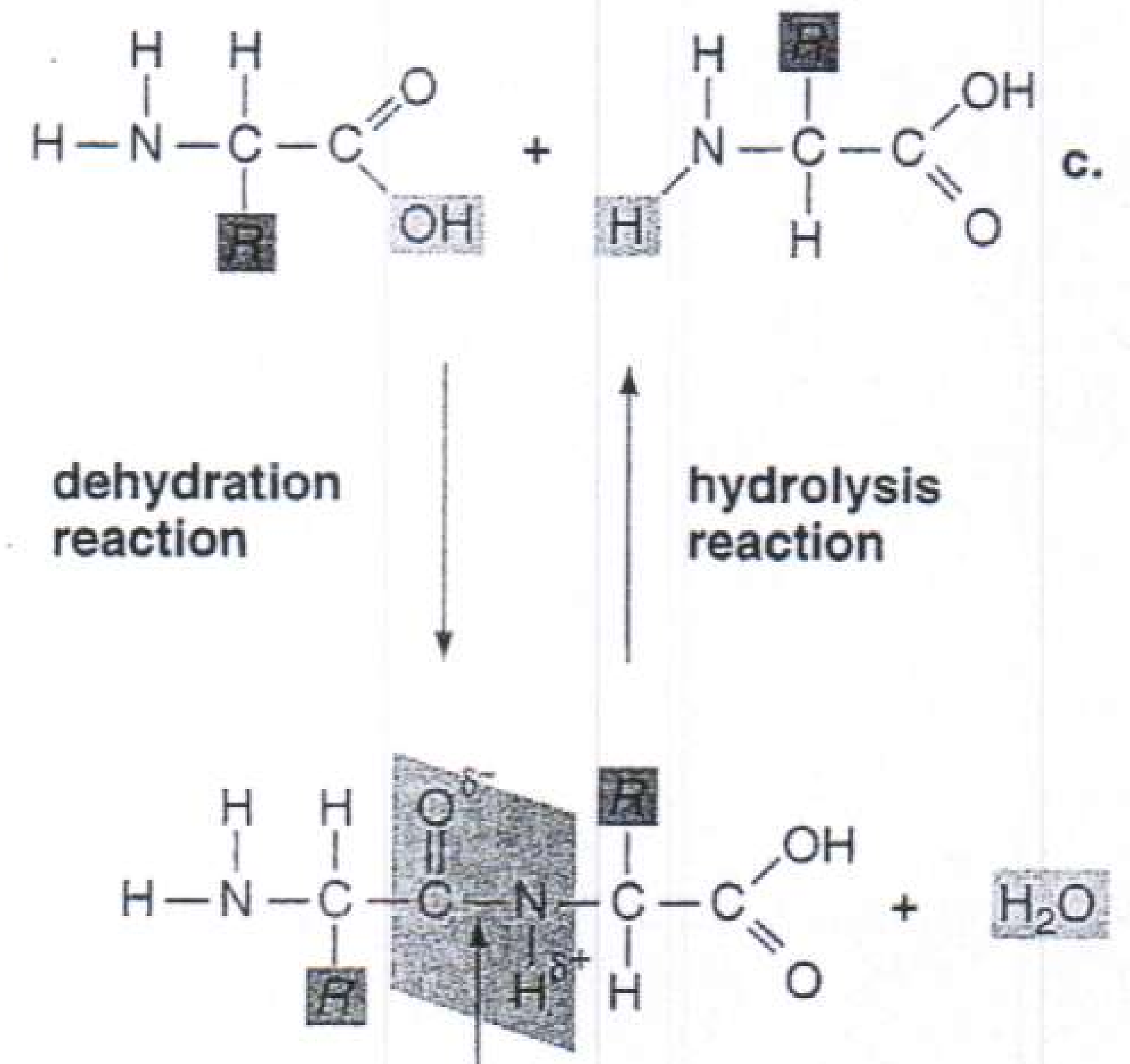
## Peptides (p. 46)

17. Label the following diagram using the alphabetized list of terms. (One term is used twice.)

acidic group
amino acid
amino group
peptide bond

a. A.A.
b. A.A

e. AMINO GROUP



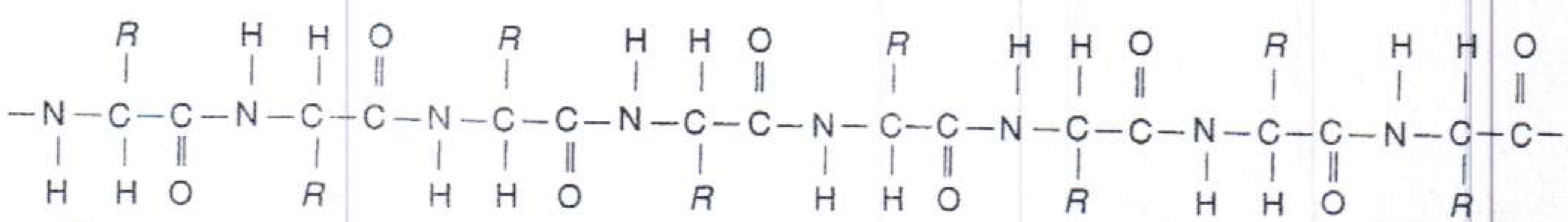

c. ACID GROUP

R = rest of the molecule

d. PEPTIDE BOND

## Shape of Proteins (p. 48)

18. Study this representation of a polypeptide.



a. This is the PRIMARY structure of a protein.

b. What are R groups? SIDE CHAIN of THE AMINO ACID

c. What two shapes characterize the secondary structure of a protein? α HELIX + B SHEET

d. What type of bond between amino acids is necessary to maintain secondary shape? Hydrogen

e. How does the tertiary shape of a globular protein come about?
PROTEIN FOLDING AND H BONDS

f. What would cause a protein to have a quaternary shape? JOINING TOGETHER SECONDARY STRUCTURES

19. a. CHAPERONE proteins help new proteins fold into their normal shape. In Creutzfeldt-Jakob disease, an infectious protein called a(an) b. PRION is misfolded resulting in disease.

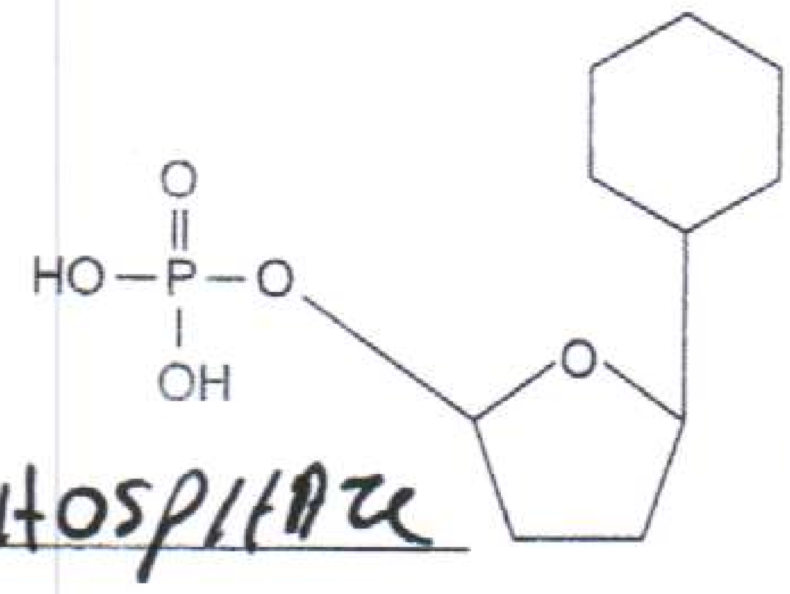
MAD COW DISEASE

## 3.5 Nucleic Acids (pp. 50–52)

- Genes are composed of DNA (deoxyribonucleic acid). DNA specifies the correct ordering of amino acids in proteins, with RNA as an intermediary.
- The nucleotide ATP serves as a carrier of chemical energy in cells.

20. Both DNA and RNA are polymers of NUCLEOTIDES

21. On the following diagram, label the components of a nucleotide.
    nitrogen-containing base
    phosphate
    pentose sugar

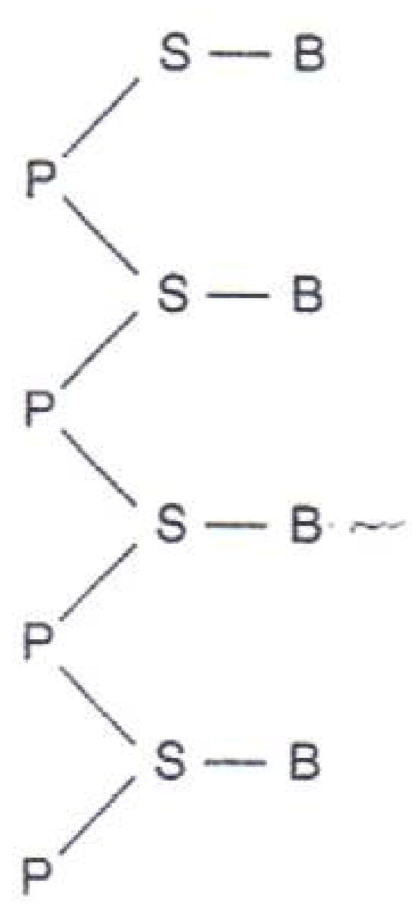



a. BASE

b. SUGAR

c. PHOSPHATE

22. Refer to the following diagram of a strand of nucleotides to answer questions *a–d*.
    a. What molecule is represented by S? SUGAR
    b. What molecule is represented by B? BASE
    c. How many different types of B are in DNA? 4
    d. What type of bond is represented by the lines? PHOSPHATE / DISULFIDE



23. a. Complete the following table to distinguish DNA from RNA:

| | DNA | RNA |
|---|---|---|
| Sugar | DEOXYRIBOSE | RIBOSE |
| Bases | A T G C | A U G C |
| Strands (how many?) | 2 | 1 |
| Helix (yes or no) | Y | N |

b. What are the functions of DNA and RNA? DNA - STORAGE RNA TRANSFER

## ATP (Adenosine Triphosphate) (P. 52)

24. ATP is a(n) a. RNA ; its structure consists of three b. PHOSPHATE groups attached to c. ADENOSINE the pentose sugar.

25. Complete this reaction: ATP → ADP +Ⓟ+ a. ENERGY . When cells need b. ENERGY , they break down the molecule c. ADP + P .