

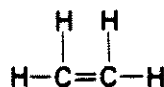
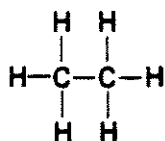
## ACTIVITY 2-2. ORGANIC CHEMISTRY

### carbon bonds

All organic compounds contain carbon. The outer shell of the carbon atom contains four electrons. In organic compounds, each carbon atom fills its outer shell by sharing four pairs of electrons with other atoms. That is, each carbon atom forms four covalent bonds. Some of these bonds may form between one carbon atom and another. A framework of carbon-to-carbon bonds forms the basic structure in most organic compounds. A carbon atom may be joined to another atom by a single bond, a double bond, or a triple bond.

### Question

The following structural formulas show three different compounds of carbon and hydrogen. Below each structural formula, write the empirical formula for that compound. Label the double and triple bonds in these structures.

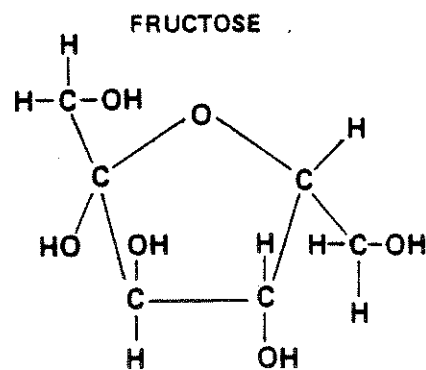
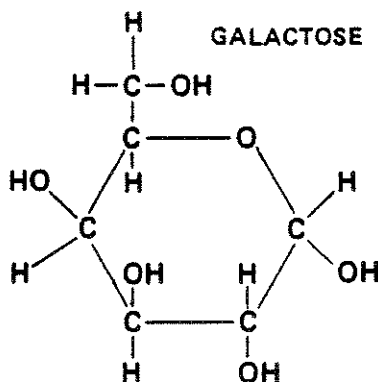
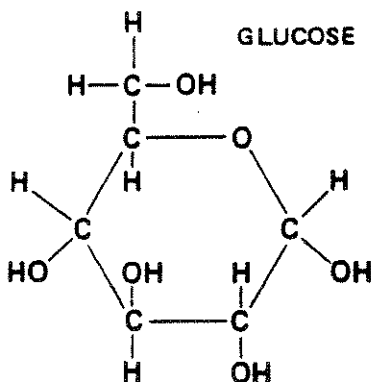


### carbohydrates

Carbohydrates are organic compounds composed of carbon, hydrogen, and oxygen. The proportion of hydrogen atoms to oxygen atoms in carbohydrates is the same as in water—two hydrogens to one oxygen. There are three basic types of carbohydrates—monosaccharides, disaccharides, and polysaccharides.

### mono-saccharides

Monosaccharides, or simple sugars, are the least complicated carbohydrates. In biology the three most common simple sugars are glucose, galactose, and fructose. These three sugars all have the same empirical formula ( $\text{C}_6\text{H}_{12}\text{O}_6$ ), but their atoms are arranged differently (see below).



### Questions

- In what way do glucose and galactose differ from each other? Circle the parts of both compounds that show this difference.
- Another name for glucose is \_\_\_\_\_.
- The simplest possible formula that illustrates the proportion of elements in monosaccharides is \_\_\_\_\_.



**disaccharides** When two monosaccharides combine, they form a *disaccharide*. A disaccharide can consist either of two molecules of the same simple sugar combined or of two different simple sugars combined. Some common disaccharides are maltose, sucrose, and lactose.

## Questions

1. Name the monosaccharides that make up the following disaccharides:  
maltose:  
sucrose:  
lactose:
2. What is the empirical formula for maltose, sucrose, and lactose?
3. Why is the empirical formula not double that of the monosaccharides?
4. What are the common names for sucrose and lactose?

**polysaccharides and polymers** The most complex carbohydrates are the polysaccharides, which are made up of long chains of glucoselike units. Starch, cellulose, and glycogen are polysaccharides. Large molecules made up of chains of repeating units are called *polymers*. Polysaccharides, such as the ones mentioned above, are polymers.

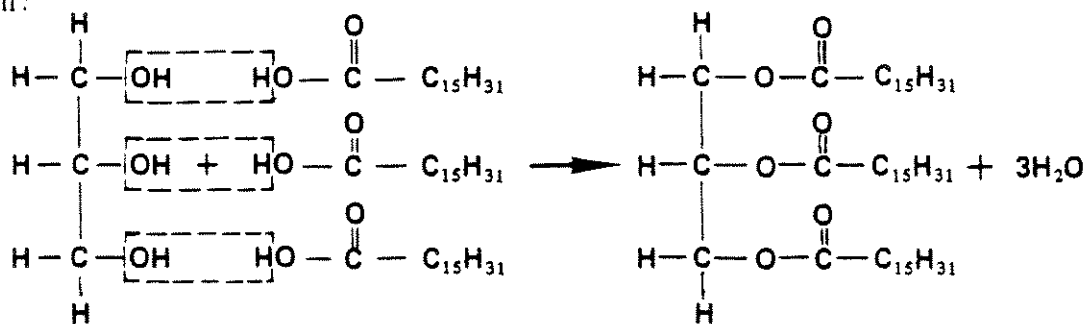
## Questions

1. What substance is the repeating unit that makes up starch, cellulose, and glycogen?
2. Starch, cellulose, and glycogen are all made up of the same repeating unit. In what way do these three substances differ from one another?
3. Name another type of compound (beside polysaccharides) that fits the definition of a polymer.

**lipids** Lipids are a group of organic compounds that include fats, oils, waxes, and related substances. Lipids are composed of carbon, hydrogen, and oxygen, but there is no definite ratio of hydrogen to oxygen atoms in lipids as there is in carbohydrates. Simple lipids, which are the most common type, are made up of three fatty acid molecules and one glycerol molecule.

## Questions

1. Label each of the components in the equation below. What type of reaction is shown in the equation?



2. What type of compound is glycerol?
3. Write the empirical formula for fatty acids.
4. What is the difference between a saturated and an unsaturated fatty acid?

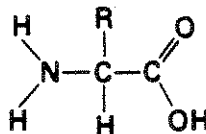
## proteins

Proteins are the most abundant type of organic compound in cells. They are made up of many amino acid molecules bonded together. Proteins, which may be very large and complex, play a wide variety of roles in the cell. Some are structural, others are hormones, neurohumors, enzymes, or pigments.

Amino acids are made up of carbon, hydrogen, oxygen, and nitrogen; some also contain sulfur. Amino acids are bonded together to form proteins by dehydration synthesis. The type of bond formed between amino acids is called a *peptide bond*. It involves a carboxyl group from one molecule and an amino group from the other.

## Questions

1. Name three foods that are high in protein.
2. Below is the general formula for an amino acid. Circle the amino group and the carboxyl group.



3. Using the general formula for amino acids, in the space below show the formation of a peptide bond.

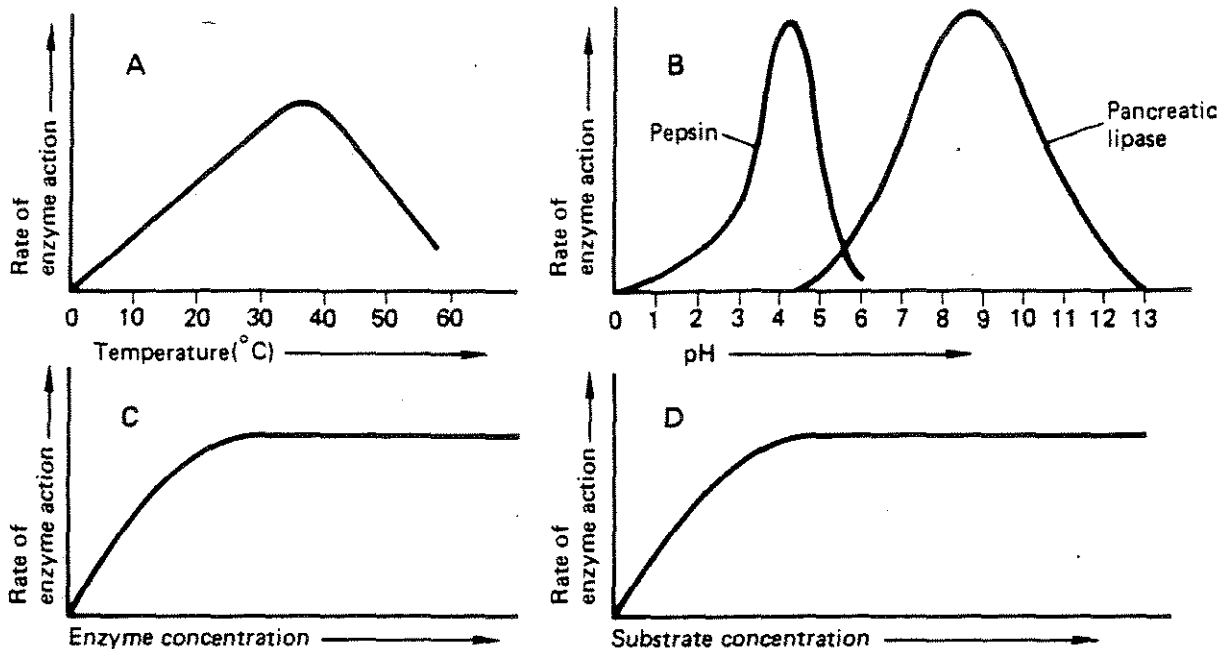
4. What does the R represent in the general formula for amino acids?
5. If the R is a hydrogen atom, what amino acid is formed?
6. If the R is a methyl group ( $\text{CH}_3$ ), what amino acid is formed?

### enzymes

Enzymes are proteins that act as *catalysts* in living cells. A catalyst increases the rate of a chemical reaction, allowing it to proceed rapidly when it would otherwise occur only very slowly. Enzymes are highly specific in their catalytic activity. The specificity of enzyme action is the result of a "lock-and-key" arrangement in which the enzyme and the substance it reacts with (the *substrate*) join together to form an enzyme-substrate complex. When the reaction is completed, the enzyme and the newly formed reaction products separate, leaving the enzyme unchanged. Enzymes are highly efficient catalysts, and only small quantities are needed to catalyze the reaction of relatively large amounts of materials. Each enzyme has an optimum range of temperature and pH at which it operates most efficiently.

### Questions

1. Is an enzyme "used up" by the reaction it catalyzes? Explain.
2. In what way does an enzyme affect the reaction it catalyzes? How does the enzyme produce this effect?
3. What is meant by *enzyme specificity*?
4. What is the *active site* of an enzyme?
5. The substance with which an enzyme reacts is its \_\_\_\_\_.
6. Could life as we know it exist without enzymes? Explain.



Questions 7-10 are based on the graphs above.

7. According to graph A, at what temperature is enzyme activity the greatest?
8. According to graph B, what is the optimum pH for pepsin? As pH increases above that point, what happens to enzyme activity?
9. According to graph C, how does increasing enzyme concentration affect the rate of enzyme action when the substrate concentration remains constant?
10. According to graph D, how does increasing substrate concentration affect the rate of enzyme action when enzyme concentration remains constant?

**nucleic acids** There are two types of nucleic acids found in living organisms—DNA (deoxyribonucleic acid) and RNA (ribonucleic acid). Both are giant molecules of high molecular weight, consisting of a series of *nucleotide* units bonded together. Each nucleotide consists of a five-carbon sugar bonded to a nitrogen base and a phosphate group. DNA contains the hereditary information, while RNA functions in protein synthesis.

## Questions

1. What are the three basic components of the nucleotides that make up nucleic acids?
2. Where is DNA found in the cell?
3. Describe the basic functions of DNA.
4. Describe the basic functions of RNA.

**REVIEW EXERCISES: UNIT 2**

A. Using the vocabulary terms in the following list, fill in the blanks in the statements below.

atom	hydrolysis	pH
atomic number	ionic bonding	polymer
carbohydrate	isotope	polysaccharide
colloid	lipid	protein
compound	mass number	proton
covalent bonding	mixture	radioactive decay
dehydration synthesis	monosaccharide	radioactivity
disaccharide	neutron	solution
electron	nucleic acid	suspension
element	nucleus	

1. A material with definite properties and definite chemical composition is a \_\_\_\_\_.
2. A substance that cannot be broken down into other substances by ordinary chemical means is a(n) \_\_\_\_\_.
3. A substance formed by the chemical combination of two or more elements is a(n) \_\_\_\_\_.
4. The basic unit of structure of all elements is the \_\_\_\_\_.
5. Atoms are made up of three types of particles: \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_.
6. The dense central portion of the atom is the \_\_\_\_\_.
7. The number of protons in the nucleus of its atoms is the \_\_\_\_\_ of an element.
8. The number of protons plus the number of neutrons in the nucleus of an atom is its \_\_\_\_\_.
9. Different varieties of the same element having different numbers of neutrons in their nuclei are called \_\_\_\_\_.
10. The breakdown of an unstable isotope to an isotope of another element with the release of radiation is called \_\_\_\_\_, or \_\_\_\_\_.
11. Chemical bonding in which there is a transfer of electrons from one atom to another is \_\_\_\_\_.
12. Chemical bonding in which there is a sharing of electrons between atoms is \_\_\_\_\_.

13. Measurement of the hydrogen ion concentration of a solution may be given in terms of \_\_\_\_\_.
14. A purely physical association of substances is a \_\_\_\_\_.
15. Three types of mixtures are \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_.
16. The four most important types of organic compounds found in living cells are \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_.
17. Glucose is a \_\_\_\_\_; maltose is a \_\_\_\_\_; and starch is a \_\_\_\_\_.
18. The type of reaction by which proteins are synthesized is \_\_\_\_\_.
19. The type of reaction by which carbohydrates are broken down is \_\_\_\_\_.
20. Large molecules made up of chains of repeating units are \_\_\_\_\_.

**B.** Place the letter of the definition in the space to the left of the term it defines.

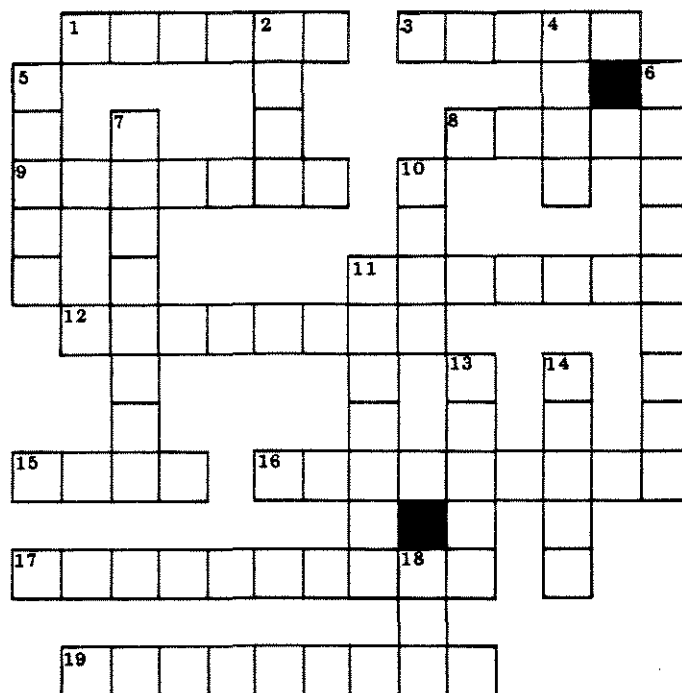
- |                                |   |
|--------------------------------|---|
| _____ 1. amino acids           | A. Type of reaction by which complex molecules are synthesized from simple molecules. |
| _____ 2. enzymes               | B. A substance composed of similar repeating units.                                   |
| _____ 3. nucleic acids         | C. Proteins that act as organic catalysts.  |
| _____ 4. unsaturated fat       | D. Digestion is accomplished by this type of reaction.                                |
| _____ 5. amino group           | E. COOH   |
| _____ 6. hydrolysis            | F. RNA and DNA  |
| _____ 7. carboxyl group        | G. Alcohol found in lipids.   |
| _____ 8. dehydration synthesis | H. Units of which proteins are composed.  |
| _____ 9. glycerol              | I. A lipid containing carbon atoms with double bonds between them.                    |
| _____ 10. polymer              | J. NH <sub>2</sub>  |

**C.** In the answer space for each question, write the letter of the choice that best completes the statement.

- \_\_\_\_\_ 1. The unit of structure of all elements is the (a) neutron (b) atom (c) proton (d) electron
- \_\_\_\_\_ 2. The mass number of an atom is (a) the number of protons in the nucleus (b) the number of neutrons in the nucleus (c) the number of protons plus the number of neutrons in the nucleus (d) the number of electrons in the nucleus
- \_\_\_\_\_ 3. Isotopes of the same element differ from one another in the (a) number of protons in the nucleus (b) number of neutrons in the nucleus (c) number of electrons (d) location of electrons

- \_\_\_\_\_ 4. Chemical bonds in which electrons are shared between atoms are called (a) ionic (b) covalent (c) divalent (d) electronic
- \_\_\_\_\_ 5. Chemical bonds in which there is a transfer of electrons from one atom to another are called (a) ionic (b) covalent (c) divalent (d) electronic
- \_\_\_\_\_ 6. A pH of 7 indicates a (a) strong acid (b) strong base (c) neutral solution (d) weak base
- \_\_\_\_\_ 7. Organic compounds always contain (a) oxygen (b) proteins (c) nitrogen (d) carbon
- \_\_\_\_\_ 8. Carbohydrates are composed of (a) carbon, nitrogen, and oxygen (b) nitrogen, oxygen, and hydrogen (c) carbon, hydrogen, and oxygen (d) sulfur, nitrogen, and carbon
- \_\_\_\_\_ 9. Glucose and fructose are both (a) monosaccharides (b) disaccharides (c) polysaccharides (d) starches
- \_\_\_\_\_ 10. Maltose and sucrose are both (a) monosaccharides (b) disaccharides (c) polysaccharides (d) starches
- \_\_\_\_\_ 11. Monosaccharides join to form disaccharides by (a) hydrolysis (b) hydration (c) dehydration synthesis (d) dehydrolysis
- \_\_\_\_\_ 12. Disaccharides are broken down into their component monosaccharides by (a) hydrolysis (b) hydration (c) dehydration synthesis (d) dehydrolysis
- \_\_\_\_\_ 13. Cellulose and glycogen are (a) proteins (b) fatty acids (c) polysaccharides (d) disaccharides
- \_\_\_\_\_ 14. Simple lipids consist of (a) three fatty acid molecules and one glycerol (b) fatty acids only (c) glycerol only (d) amino acids
- \_\_\_\_\_ 15. The bonds between amino acids in proteins are (a) peptide bonds (b) unsaturated (c) hydrolytic (d) carboxylic
- \_\_\_\_\_ 16. Enzymes are (a) carbohydrates (b) lipids (c) proteins (d) hormones
- \_\_\_\_\_ 17. Enzymes (a) decrease reaction rates (b) increase reaction rates (c) are involved only in synthetic reactions (d) are involved only in hydrolytic reactions
- \_\_\_\_\_ 18. Nucleic acids are composed of (a) a nitrogen base, five-carbon sugar, and phosphate (b) a nitrogen base, six-carbon sugar, and phosphate group (c) a nitrogen base, five-carbon sugar, and carboxyl group (d) a nitrogen base, phosphate group, and glucose
- \_\_\_\_\_ 19. DNA (a) is the site of protein synthesis (b) contains the hereditary information (c) is found only in the cytoplasm (d) is found only in animal cells
- \_\_\_\_\_ 20. RNA is involved in (a) lipid synthesis (b) carbohydrate synthesis (c) protein synthesis (d) DNA synthesis

## PUZZLE: UNIT 2



### Across

1. Number of protons in nucleus is \_\_\_\_\_ number.
3. Glucose is a simple \_\_\_\_\_.
8. Proteins are made up of \_\_\_\_\_ acids.
9. Positively charged particles found in nucleus.
11. Substance that cannot be broken down by ordinary chemical reactions.
12. Type of chemical bond in which electrons are shared.
15. Number of protons plus neutrons in nucleus is \_\_\_\_\_ number.
16. Substances formed by chemical combination of two or more elements.
17. Type of reaction by which proteins and carbohydrates are broken down.
19. Negatively charged particles found outside nucleus.

### Down

2. Element that rusts.
4. Substance with pH of 2 is strong \_\_\_\_\_.
5. Substance made up of three fatty acid molecules and one glycerol molecule.
6. Homogeneous mixtures of two or more substances that do not settle on standing.
7. Substances in which particles larger than those of solutions are dispersed within a medium.
10. NaCl is common table \_\_\_\_\_.
11. Proteins that act as catalysts within cells.
13. Basic units of structure of elements.
14. Type of bond in which there is a transfer of electrons.
18. Atom or group of atoms with electrical charge.