Name _____ Date _____

CHEMISTRY OF CARBOHYDRATES

6

Biologists today depend on chemists for much of their understanding of life and life processes. Thus, an understanding of some chemistry of living things is necessary. Carbohydrates make up a large group of chemical compounds found in cells. Carbohydrates are an energy source or are used in making cell structures.

In this investigation, you will

(a) learn to interpret the molecular formulas of some carbohydrates.

(b) use models to learn to interpret the structural formulas of some carbohydrates.

REMEMBER: Models do not represent the actual three-dimensional shapes of the molecules. Models serve to help you learn how smaller molecules can be grouped into larger, more complex molecules.

Materials

scissors

Procedure

Part A. Water

- Examine the chemical formula of water, H_2O.

Question: What elements make up water?

Answer: H represents the element hydrogen. O represents the element oxygen. Water is made up of hydrogen and oxygen.

Question: What does the number 2 following H tell you?

Answer: The number 2 represents the number of atoms of hydrogen. A number, called a subscript, following a chemical symbol indicates the number of atoms of that particular element.

Question: Why does oxygen not have a subscript?

Answer: No subscript indicates there is only one atom.

Question: How many molecules of water are represented by the formula H_2O?

Answer: One molecule is represented. The number of molecules is indicated by a number to the left of the formula. No number indicates one molecule.

Question: What is a molecular formula? What is the molecular formula of water?

Answer: A molecular formula shows the total number of atoms for *each element* in a molecule. The molecular formula of water is H_2O.

Question: What is a structural formula? What is the structural formula of water?

Answer: A structural formula attempts to show the three-dimensional organization of the molecule. The structural formula of water is  .

Question: What do the lines between O and H in the structural formula of water represent?

Answer: These lines represent chemical bonds or points of attachment between the atoms.

Part B. Carbohydrates

Carbohydrates contain three different elements—carbon (C), hydrogen (H), and oxygen (O).

There are many different types of carbohydrates. They have been placed into three groups—monosaccharides, disaccharides, and polysaccharides.

Group 1. Monosaccharides (single molecule sugars)

Three examples of monosaccharides are glucose, fructose, and galactose.

• Examine the structural formulas for these three sugars.

1. What three elements are present in glucose, fructose, and galactose? _____

2. How many atoms of carbon are present in a molecule of

   glucose? _____

   fructose? _____

   galactose? _____

3. Add subscripts to the following that indicate the proper molecular formula. Do this by counting the total number of carbon, hydrogen, and oxygen atoms in each molecule.

   glucose $C_{\_}H_{\_}O_{\_}$

   fructose $C_{\_}H_{\_}O_{\_}$

   galactose $C_{\_}H_{\_}O_{\_}$

4. How many times larger is the number of hydrogen atoms than oxygen atoms in a molecule of

   glucose? _____

   fructose? _____

   galactose? _____

5. (a) How many times larger is the number of hydrogen atoms than oxygen atoms in a molecule of water, H_2O? _____

   (b) Is the number the same for monosaccharides and for water? _____

The prefix "mono-" means one. Monosaccharides are sugars that are made up of only one molecule. Thus, they are called single sugars. The one molecule, however, can have different shapes due to a different arrangement of atoms.

• Compare the structural formula of glucose to fructose.

6. (a) Are they exactly the same in shape? _____

   (b) Are they both monosaccharides? _____

Group 2. Disaccharides (double molecule sugars)

Two monosaccharide sugar molecules can join together chemically to form a larger carbohydrate molecule called a double sugar, or disaccharide. The prefix "di-" means two. By chemically join-

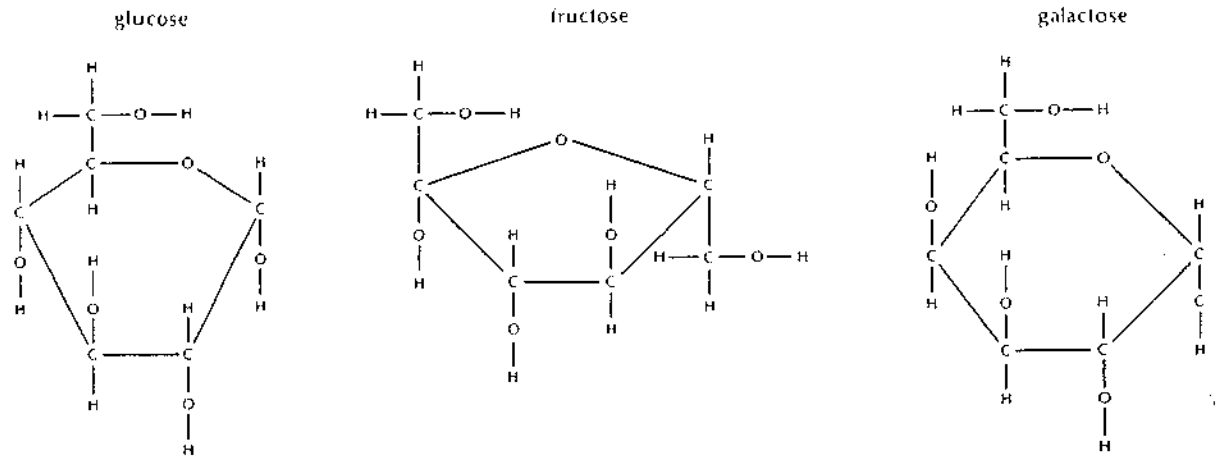

FIGURE 6-1

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ing a glucose molecule with a fructose molecule, a double sugar called sucrose is produced. Use the paper models on page 29 to illustrate this process.

• Cut out a glucose and a fructose paper model molecule from page 29. You may want to paste the page on lightweight cardboard before cutting out the models. *Cut along solid lines only.* Attempt to join the two molecules together like puzzle pieces.

7. Do the glucose and fructose fit easily together to form a sucrose molecule?

_____

• In order to join the molecules, remove an —OH end from one molecule and an —H end from another. Cut along dotted lines.

8. Does removing the —H and —OH ends now allow the molecules to fit easily together? _____

9. The —H and —OH ends that were removed can also fit together with each other to form a molecule. This new molecule has a molecular formula of _____ and is called _____.

10. Write the molecular formula for sucrose by adding together the molecular formulas for glucose and fructose and then subtracting water, H_2O. (Use structural formulas for this, not the models.) _____

Different disaccharide molecules can be made by joining other monosaccharides in different combinations. By chemically joining a glucose molecule with another glucose molecule, a double sugar called maltose is formed.

• Cut out and attempt to join the two new glucose model molecules together like puzzle pieces.

11. Do the molecules fit easily together to form maltose? _____

12. What must be removed from the glucose model molecules so that they easily fit together? _____

13. Write the molecular formula for maltose. (See question 10.) _____

14. (a) How does the molecular formula for sucrose compare to maltose? _____

_____

(b) How many times larger is the number of hydrogen atoms than oxygen atoms in a disaccharide? _____

(c) How many monosaccharide molecules are needed to form one sucrose molecule? _____

(d) How many monosaccharide molecules are needed to form one maltose molecule? _____

(e) How do the molecules of sucrose and maltose differ? (Use models in order to answer.) _____

_____

Group 3. Polysaccharides (many molecule sugars)

Just as double sugars were formed from two single sugar molecules, polysaccharides are formed when many single sugars are joined together chemically. The prefix "poly-" means many. Starch, glycogen, and cellulose are the three most common polysaccharides in biology. They consist of long chains of glucose molecules joined together.

• Construct a starch molecule by joining three glucose molecules. This will represent only a small part of a starch molecule because starch consists of hundreds of glucose molecules.

15. What must be removed from the glucose model molecules in order to have them easily fit together? _____

The molecular formula for a polysaccharide is written as $(C_6H_{10}O_5)n$. The *n* equals the number of times the $C_6H_{10}O_5$ group is repeated. You can see this group as the middle glucose of your model. REMEMBER: The —H and —OH ends of the middle molecule are missing.

16. (a) What is the smallest number of glucose molecules that can form a polysaccharide? _____

(b) How many times larger is the number of hydrogen atoms than oxygen atoms in a polysaccharide molecule? _____

Analysis

1. Name the three categories of carbohydrates studied in this investigation. _____

_____

2. What three elements are present in all carbohydrates? _____

_____

3. Give the names of two monosaccharide molecules studied. _____

_____

4. Give the names of two disaccharide molecules studied. _____

_____

5. Give the name of one polysaccharide molecule studied. _____

6. (a) How many times larger is the number of hydrogen atoms than oxygen atoms in all carbohydrates? _____

(b) In water? _____

7. (a) What molecules combine to form disaccharides? _____

(b) What molecules combine to form polysaccharides? _____

8. (a) What ends of sugars are removed when sugar molecules join to form either disaccharides or polysaccharides? _____

(b) What molecule do these ends form when they fit together? _____

9. "Mono-" means one, "di-" means two, and "poly-" means many. Why are these terms used in describing the three types of sugars? _____

_____

_____

10. The word carbohydrate is derived from carbon and water (hydrate). Explain why this combination correctly describes this chemical group. _____

_____

_____

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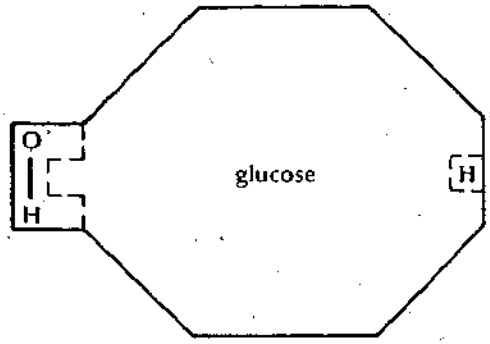
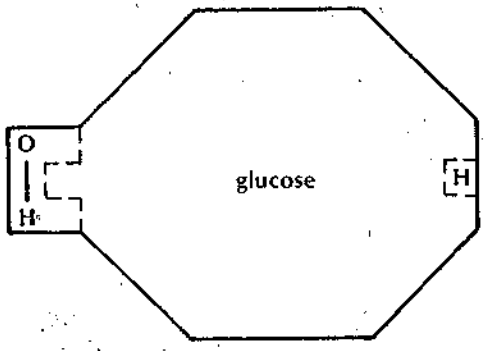
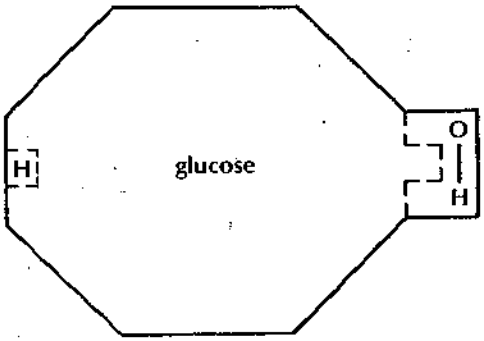
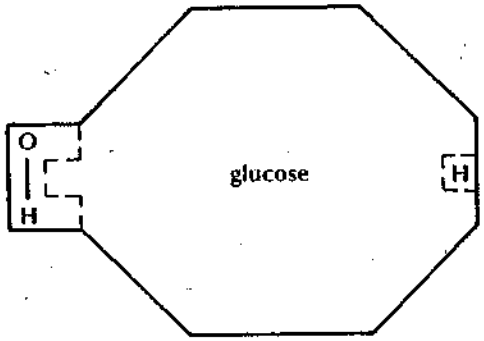
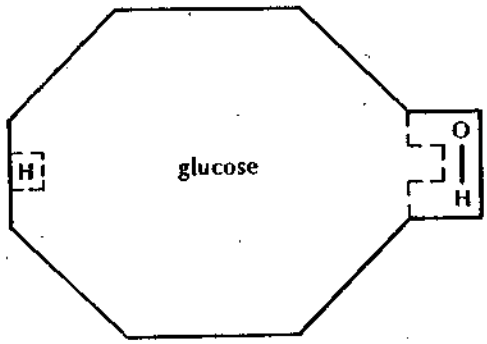
models of glucose

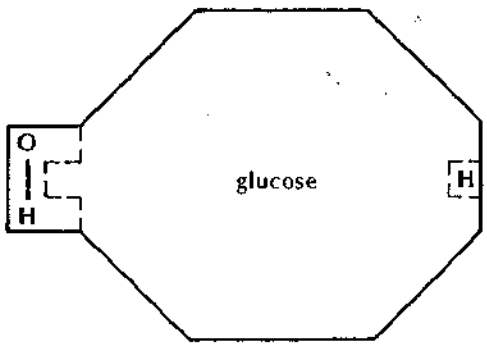




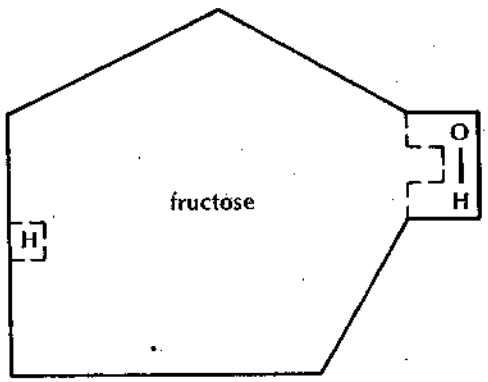








model of fructose



(only end atoms of hydrogen and oxygen are shown in models)