Biology. Carbohydrates: Chemistry & Identification Lab Name:

Introduction: Today, scientists use a combination of biology and chemistry for 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.

Objectives: Upon completing this lab, you will

1. Learn how to write a molecular formula for several carbohydrates
2. Learn how to read a structural formula for several carbohydrates
3. Use models to construct the main types of carbohydrates
4. Identify the three main types of carbohydrates by using chemical tests
5. Test different food samples to determine what type of carbohydrate they are.

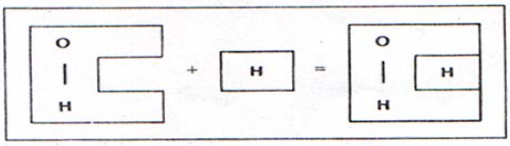
REMEMBER: Models do not represent the actual three-dimensional shapes of the molecules. Models serve to help you learn how smaller molecules can be grouped into larger, more complex molecules.

Materials:

Paper models – scissors – test tubes – test tube holder – marker – Benedict's solution – iodine solution – droppers – hot plate – water – beaker – monosaccharide solution – disaccharide solution – polysaccharide solution – various non-colored carbohydrate solutions.

Pre-lab Questions: Write your responses to these questions on your lab sheet

1. What elements make up water?
2. What does the number 2 following H tell you?
3. Why does the oxygen symbol (O) not have a subscript?
4. What is a molecular formula? What is the molecular formula for water?
5. How many molecules of water are represented by the formula H_2O?
6. What is a structural formula? What is the structural formula of water?
7. What do the lines between O and H in the structural formula of water represent?
8. How can water be represented using a paper model? Use the following diagram.



I. Procedure: Paper Lab

A. Monosaccharides (single molecule sugars)

A single molecule sugar is called a monosaccharide. The prefix "mono" means one. However, one molecule can have different molecular structures due to a different arrangement of atoms. Three common monosaccharides are glucose, fructose, and galactose.

Examine the structural formulas of these three sugars (Figure 6-1) and answers the following questions

1. What three elements are present in the three monosaccharides?
2. Add subscripts to the following to indicate the proper molecular formula (see question sheet)
3. How many times as many hydrogen atoms as oxygen atoms in a molecule of glucose? fructose? galactose?
4. Are there two times as many hydrogen atoms as oxygen atoms in a molecule of water?
5. Compare the structural formula of glucose to fructose
   a. Are they exactly the same shape?
   b. Are they both monosaccharides?

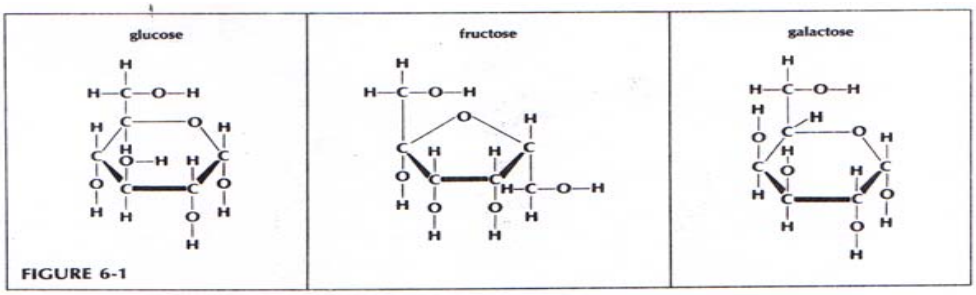


FIGURE 6-1

B. Disaccharides (double molecule sugars)

Two monosaccharides sugar molecules can join chemically to form a larger carbohydrate molecule called a double sugar, or disaccharide. The prefix "di-" means two. By chemically joining a glucose molecule with a fructose molecule, a double sugar called sucrose is produced. This type of bond between monosaccharide units is called a glycosidic linkage.

Use the paper models supplied in this lab to complete the following questions.

- Cut out models of one glucose and one fructose molecule. Cut along solid lines only.

6. Do the glucose and fructose models fit together easily 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 the dotted lines.

7. Does removing the –H and –OH ends now allow the molecules to fit easily together?

8. The –H and –OH ends that we removed can also fit together with each other to form a molecule. This new molecule has what molecular formula? and is called?

9. Write the molecular formula for sucrose by adding together the molecular formulas for glucose and fructose and then subtracting the formula for water, H_2O. (Use molecular formulas for finding this).

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 an attempt to join the two new glucose model molecules like puzzle pieces.

10. What must be removed from the glucose molecules so that they easily fit together?
11. Write the molecular formula for maltose? (Use molecular formulas for finding this)
12. How does the molecular formula for sucrose compare to maltose?

C. Polysaccharides

Just as double sugars were formed from two single sugar molecules, polysaccharides are formed when many single sugars are joined 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.

13. In order to bond a monosaccharide to an existing chain, what molecule must be added?
14. If a chain of 5 monosaccharides are to be linked together, how many water molecules must be removed?
15. How does the number of glycosidic linkages compare to the number of water molecules produced?

II. Procedure: Identification of Carbohydrates

A. Chemical Tests on Known Carbohydrates

Benedict's Test

1. Fill a 500 mL beaker half full of water. Bring the water to a boil on a hot plate. CAUTION: HOT WATER!!!
2. Number three clean test tubes; 1, 2, & 3 and add a carbohydrate solution to each:
    - Tube 1 – 20 drops of monosaccharide solution
    - Tube 2 – 20 drops of disaccharide solution
    - Tube 3 – 20 drops of polysaccharide solution
3. Add 10 drops of Benedict's solution to each tube. CAUTION: *If you spill Benedict's solutions, clean it up with a wet paper towel and tell your teacher.*
4. Place the three test tubes in the hot water bath for 5 minutes.
5. Use a test tube clamp to remove the tubes from the hot water bath
6. Observe any color changes in the solutions. NOTE: *A color change may or may not occur when Benedict's solution is added to a carbohydrate. A change from blue to green, yellow, orange or red occurs if a <u>monosaccharide is present</u> (a positive Benedict's test). The original blue color will remain after heating if a disaccharide or polysaccharide is present (a negative Benedict's test).*
7. Record in **Data table 1** the color of the solutions in the tubes in the column marked "Benedict's color".
8. Record in **Data table 1** if the Benedicts test was positive or negative for each carbohydrate.
9. Clean your test tubes out with soapy water and a test tube brush.

Iodine Test

1. Number three clean test tubes: 1, 2, & 3 and add a carbohydrate solution to each:
    - Tube 1 – 20 drops of monosaccharide solution
    - Tube 2 – 20 drops of disaccharide solution
    - Tube 3 – 20 drops of polysaccharide solution
2. Add 4 drops of iodine solution to each tube. CAUTION: *If iodine spills, use a wet paper towel to wipe it up and inform your teacher.*
3. Mix the contents of each tube by gently swirling.
4. Record **in Data table 1** the color of the solutions in the three tubes in the column marked "Iodine color". NOTE: A color change may or may not occur when iodine solution is added to a carbohydrate. A change from its original rust color to a deep blue-black occurs if a polysaccharide is present. The original color of the iodine remains is a disaccharide or monosaccharide sugar is present.
5. Record in **Data table 1** if the Iodine test was positive or negative for each carbohydrate.
6. Clean your test tubes out with soapy water and a test tube brush.

B. Chemical Tests on Unknown Carbohydrates

Having tested known carbohydrates, you are now ready to test some unknown substances. By comparing results of the Benedict's and iodine test in **Data table 1**, you should be able to classify known substances as either monosaccharides, disaccharides, or polysaccharides.

1. Number five clean test tubes; 1, 2, 3, 4, & 5 and add 10 drops of each of the following solutions
    - Tube 1 – 10 drops of honey solution
    - Tube 2 – 10 drops of liquid oats solution
    - Tube 3 – 10 drops of table sugar solution
    - Tube 4 – 10 drops of apple juice solutions
    - Tube 5 – 10 drops of powdered sugar solution
2. Add 10 drops of Benedict's solution to each test tube
3. Place all five test tubes into a hot water bath for 5 minutes. (You will be able to tell positive and negative results in just a couple of minutes)
4. Remove the test tubes from the hot bath with test tube clamp and record your results in **Data table 2**.
5. Clean your test tubes out with soapy water and a test tube brush.
6. Number five clean test tubes; 1, 2, 3, 4, & 5 and add 10 drops of each of the following solutions
    - Tube 1 – 10 drops of honey solution
    - Tube 2 – 10 drops of liquid oats solution
    - Tube 3 – 10 drops of table sugar solution
    - Tube 4 – 10 drops of apple juice solutions
    - Tube 5 – 10 drops of powdered sugar solution
7. Add 4 drops of iodine solution to each test tube and mix by swirling.
8. Record your results in **Data table 2**.
9. Clean your test tubes out with soapy water and a test tube brush.
10. On the basis of your Benedict's test and Iodine test, identify the type of carbohydrate each unknown is and record this in **Data table 2**.

Biology: Carbohydrate Test Question & Data Sheet Names:

Pre-lab Questions: Write your responses to these questions on your lab sheet

1. What elements make up water? _____

2. What does the number 2 following H tell you? _____

3. Why does the oxygen symbol (O) not have a subscript? _____

4. What is a molecular formula? What is the molecular formula for water? _____

5. How many molecules of water are represented by the formula H_2O?_____

6. What is a structural formula? What is the structural formula of water?_____

7. What do the lines between O and H in the structural formula of water represent? _____

8. How can water be represented using a paper model? Use the following diagram.
_____

Monosaccharides:

1. What three elements are present in the three monosaccharides? _____

2. Add subscripts to the following to indicate the proper molecular formula
glucose: C__H__O__ fructose: C__H__O__ galactose: C__H__O__

3. How many times as many hydrogen atoms as oxygen atoms in a molecule of glucose? fructose? galactose?
Glucose: _____ fructose: _____ galactose: _____

4. Are there two times as many hydrogen atoms as oxygen atoms in a molecule of water? _____

5. Compare the structural formula of glucose to fructose
a. Are they exactly the same shape? _____
b. Are they both monosaccharides?_____

Disaccharides:

6. Do the glucose and fructose models fit together easily to form a sucrose molecule? _____

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

8. The –H and –OH ends that we removed can also fit together with each other to form a molecule. This new molecule has what molecular formula? What is it called? _____

9. Write the molecular formula for sucrose by adding together the molecular formulas for glucose and fructose and then subtracting the formula for water, H_2O. (Use molecular formulas for finding this). _____

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

11. Write the molecular formula for maltose? (Use molecular formulas for finding this) _____

12. How does the molecular formula for sucrose compare to maltose? _____

Polysaccharides

13. In order to bond a monosaccharide to an existing chain, what molecule must be added? _____

14. If a chain of 5 monosaccharides are to be linked together, how many water molecules must be removed?_____

15.How does the number of glycosidic linkages compare to the number of water molecules produced? _____

Data Tables:

Data Table 1: Results of Tests with Known Carbohydrates					
Tube	**Carbohydrate**	**Benedict's color after heating**	**Benedict's test (+ or -)**	**Iodine color after addition**	**Iodine test (+ or -)**
1	Monosaccharide				
2	Disaccharide				
3	Polysaccharide				

Data Table 2: Results of Tests with Unknown Carbohydrates				
Tube	**Unknown Carbohydrate**	**Benedict's test (+ or -)**	**Iodine test (+ or -)**	**Type of Carbohydrate**
1	Honey			
2	Oats			
3	Table Sugar			
4	Apple			
5	Powdered Sugar			

Post Lab Questions

1. What elements make up all carbohydrates? _____

2. What is the general formula for any monosaccharide? _____

3. What is the general formula for any polysaccharide? _____

4. Using Benedict's and Iodine tests, how can you tell if a carbohydrate is the following?
   a. monosaccharide: _____

   b. disaccharide _____

   c. polysaccharide _____

Models of Monosaccharides