

## Carbohydrates Lecture Guide

### Purpose

The purpose of this lecture guide is to guide you through the lecture and highlight important topics. This assignment will help to increase your knowledge and familiarity with carbohydrates and the different types of stereoisomers.

**Student Learning Outcomes:** After completing this lecture guide, you will be able to:

- Classify the types of carbohydrates.
- Classify monosaccharides based on their chemical composition.
- Compare stereoisomers of monosaccharides.
- Distinguish between types of stereoisomers.
- Identify chemical structures of the common monosaccharides.
- Differentiate between the condensation and hydrolysis of carbohydrates.
- Recognize the bonding properties of reducing sugars.
- Describe structural components of complex carbohydrates.
- Describe the role of carbohydrates as cell markers.
- Describe structural components of complex carbohydrates.
- Distinguish between storage and structural polysaccharides.

### Criteria

This worksheet is optional and will not count as a grade.

1. Carbohydrates are \_\_\_\_\_ molecules that contain carbon, hydrogen, and oxygen. The suffix for these compounds is typically \_\_\_\_\_.
2. The simplest type of carbohydrate is a \_\_\_\_\_, which contains only one sugar unit. When two sugar units combine to form a larger carbohydrate, the compound is classified as a \_\_\_\_\_. When the carbohydrate contains between three and nine sugar units, it represents a \_\_\_\_\_. When ten or more sugar units are present, the carbohydrate is classified as a \_\_\_\_\_.
3. Monosaccharides contain a minimum of three carbon and have the general molecular formula of \_\_\_\_\_. All monosaccharides contain the \_\_\_\_\_ functional group and either a \_\_\_\_\_ or \_\_\_\_\_ carbonyl-containing group.

4. The type of carbonyl group present in a monosaccharide can be used to classify the molecule. If an aldehyde is present, the monosaccharide is classified as an \_\_\_\_\_. If the compound contains the ketone functional group, it is classified as a \_\_\_\_\_. The classification can also indicate the number of carbon atoms present in the molecule. If the monosaccharide contains three carbon atoms, it is classified as a \_\_\_\_\_. A monosaccharide with four carbon atoms is classified as a \_\_\_\_\_, those with five carbons represent a \_\_\_\_\_, and molecules with six carbons are \_\_\_\_\_. The classifications can be combined to indicate the carbonyl group and number of carbons. For example, glucose represents an \_\_\_\_\_.
5. Multiple different types of aldohexose (and other types of) molecules can exist. These compounds represent \_\_\_\_\_ since they have the same molecular formula but different three-dimensional structures. These isomers can be classified based on the symmetry of their mirror images. If the objects or molecules have symmetry and an identical mirror image, they are \_\_\_\_\_. If the objects or molecules have no symmetry and the mirror images are nonsuperimposable, they are called \_\_\_\_\_. These nonsuperimposable mirror images are called \_\_\_\_\_ and the molecules will have one or more \_\_\_\_\_ (tetrahedral carbon with four different groups attached to it).
6. Enantiomers differ in their \_\_\_\_\_. One enantiomer is dextrorotatory, meaning that it rotates light \_\_\_\_\_ and the other is

levorotatory because it rotates light \_\_\_\_\_. When an equal amount of both enantiomers is present, the mixture is known as a \_\_\_\_\_ mixture.

7. Stereoisomers can be distinguished from one another based on the arrangement of groups around the \_\_\_\_\_ present in the molecule. The total number of possible stereoisomers can be determined using the \_\_\_\_\_ equation, where n represents the number of carbon atoms.
8. When comparing stereoisomers, if the groups attached to each chiral center in the molecule have the opposite arrangement, the molecules are \_\_\_\_\_. If the arrangement around more than one, but less than all chiral centers is different, the stereoisomers are classified as \_\_\_\_\_.
9. Monosaccharides are commonly drawn using \_\_\_\_\_, which show groups on horizontal and vertical lines. Groups located on the \_\_\_\_\_ line represent groups directed away from the viewer. Groups on the \_\_\_\_\_ line are those that are directed towards the view. A \_\_\_\_\_ is represented by the intersection of the horizontal and vertical lines.
10. When comparing Fischer Projections of stereoisomers, the arrangement of groups around the \_\_\_\_\_ line is what differs. If all the horizontal arrangements are different, the molecules represent \_\_\_\_\_. If more than one, but less than all the horizontal arrangements are different, they represent \_\_\_\_\_.

11. Carbohydrates are given the \_\_\_\_\_ or \_\_\_\_\_ designation. Naturally occurring sugars have the \_\_\_\_\_ designation. When using the Fischer Projection to determine whether a monosaccharide represents a D- or L-sugar, you must look at the arrangement of the \_\_\_\_\_ on chiral carbon \_\_\_\_\_ to/from the carbonyl carbon. If the -OH group points to the right, it represents a(n) \_\_\_\_\_ sugar. If the -OH group points to the left, it is a(n) \_\_\_\_\_ sugar.
12. The most abundant monosaccharide is \_\_\_\_\_, which is also referred to as blood sugar or dextrose. Another common monosaccharide is \_\_\_\_\_, which combines with glucose to form lactose. This sugar is a(n) \_\_\_\_\_ of glucose because it is a stereoisomer that differs only around one chiral carbon. Another epimer of glucose is \_\_\_\_\_, which is found in some fruits such as cranberries. These three monosaccharides are each classified as a(n) \_\_\_\_\_, because they contain an aldehyde functional group and a total of six carbon atoms. Another common monosaccharide is \_\_\_\_\_, which is also referred to as fruit sugar. The sugar is a \_\_\_\_\_ of glucose instead of an epimer.
13. When drawing the Fischer Projections of the four common monosaccharides, the structures of fructose, galactose, and mannose can be derived from glucose. Since galactose and fructose are epimers of glucose, the structures are identical except for the arrangement around one chiral carbon. In galactose, only carbon \_\_\_\_\_ differs from glucose. In mannose, only carbon \_\_\_\_\_ has a different arrangement. Fructose, which is classified as a \_\_\_\_\_ since it has the carbonyl on carbon 2 and a total of six carbon atoms, can also be drawn based on

the structure of glucose. The difference in these molecules occurs at carbons \_\_\_\_\_ and \_\_\_\_\_, while all other chiral carbon arrangements remain the same.

14. When two monosaccharides become chemically combined, the carbohydrate is referred to as a \_\_\_\_\_. The formation of this carbohydrate results in the sugar units forming an ether, which is referred to as a \_\_\_\_\_.
15. When naming glycosidic bonds, the name must indicate alpha or beta for all \_\_\_\_\_ carbons involved in the linkage. The notation should also indicate the \_\_\_\_\_ of each monosaccharide present in the linkage.
16. The carbon that was originally the carbonyl carbon is referred to as the \_\_\_\_\_ carbon. If that carbon is involved in a glycosidic bond (not free), the carbohydrate is referred to as a \_\_\_\_\_ sugar. If that carbon is not involved in a glycosidic bond (free), the molecule is referred to as a \_\_\_\_\_ sugar.
17. Three common disaccharides include D-glucose being linked to a second D-sugar. Malt sugar is another name for \_\_\_\_\_. This disaccharide contains \_\_\_\_\_-D-glucose and a second D-glucose that combine via a(n) \_\_\_\_\_ glycosidic linkage. Since this compound has a free anomeric carbon, it is classified as a \_\_\_\_\_ sugar. Milk sugar is another name for \_\_\_\_\_. This disaccharide contains \_\_\_\_\_-D-\_\_\_\_\_ and D-glucose that combine via a(n) \_\_\_\_\_ glycosidic linkage. Since this compound has a free anomeric carbon, it is classified as a \_\_\_\_\_ sugar. Table sugar is another name for \_\_\_\_\_. This disaccharide contains \_\_\_\_\_-D-glucose and \_\_\_\_\_ that combine via a(n) \_\_\_\_\_ glycosidic linkage.

This disaccharide is classified as a \_\_\_\_\_ sugar since both anomeric carbons are involved in the glycosidic bond.

18. Oligosaccharides contain \_\_\_\_\_ sugar units that are chemically combined. This class of carbohydrates play important roles with \_\_\_\_\_ and help to distinguish the blood types. The four types of blood in the ABO blood system are \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_. Of the types, Type \_\_\_\_\_ is considered the universal donor and Type \_\_\_\_\_ is the universal receiver.
19. \_\_\_\_\_ is a carbohydrate that helps prevent blood clotting.
20. Blood sugar is another name for \_\_\_\_\_. When the level is consistently lower than normal, the condition is known as \_\_\_\_\_. When the blood sugar level is consistently higher than normal, the condition is known as \_\_\_\_\_.
21. When ten or more monosaccharides become chemically combined, the carbohydrate is classified as a \_\_\_\_\_. There are two types of this complex carbohydrate, \_\_\_\_\_ and \_\_\_\_\_, and they differ by the type of glucose and glycosidic bonds present. Storage polysaccharides contain only \_\_\_\_\_ glucose molecules and structural polysaccharides contain \_\_\_\_\_ glucose.
22. The storage polysaccharide found in plants is \_\_\_\_\_. This carbohydrate contains a mixture of a straight-chain and branched-chain polysaccharide. The straight-chain polysaccharide, \_\_\_\_\_, makes up a smaller portion of starch. This molecule contains \_\_\_\_\_ glycosidic bonds. The major component of starch is the

branched-chain polysaccharide \_\_\_\_\_. This molecule contains \_\_\_\_\_ glycosidic bonds and branches at approximately every \_\_\_\_\_ glucose units. The \_\_\_\_\_ glycosidic bond is where the branching occurs.

23. The storage polysaccharide found in animals is \_\_\_\_\_. This branched-chain polysaccharide contains \_\_\_\_\_ glycosidic bonds and is structurally similar to \_\_\_\_\_. The key structural difference is that glycogen branches at approximately every \_\_\_\_\_ glucose units.

24. The structural polysaccharide composed of only  $\beta$ -D-glucose is \_\_\_\_\_. This molecule is a \_\_\_\_\_-chain polysaccharide that contains \_\_\_\_\_ glycosidic bonds. This polysaccharide \_\_\_\_\_ be digested by humans.