

## Discussion Exercise 6: Carbohydrate Structure

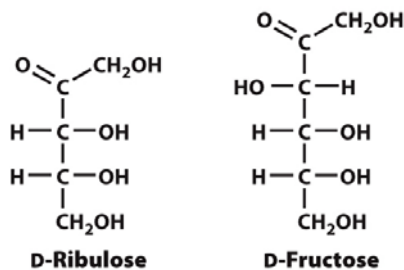
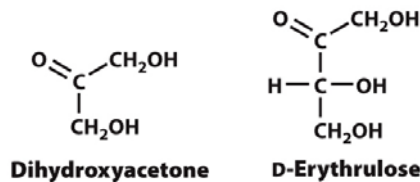
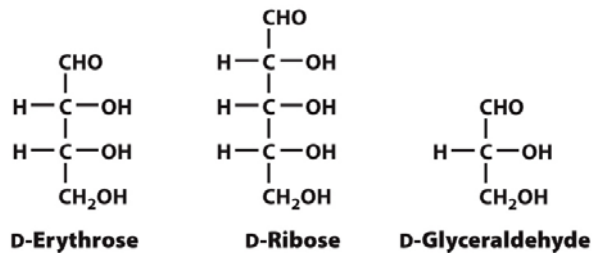
### Skill 1: Understand structure of straight-chain carbohydrates in terms of stereochemistry, aldose/ketose, and number of carbons

- D-sugars are naturally occurring. The lowest chiral carbon in a Fischer projection has its hydroxyl group to the right.
- Aldoses contain aldehyde and ketoses contain ketones. They can be isomerized into one another.
- Epimers are related to each other by having the opposite stereochemistry at one carbon
- **You should know the structures of dihydroxyacetone, D-glyceraldehyde, D-ribose, D-glucose, D-mannose, D-galactose, D-fructose**

Problem 1: Indicate whether these pairs are epimers, aldose/ketose pairs, or neither. (See Stryer problem 10.4.)

- A. D-glyceraldehyde and dihydroxyacetone
- B. D-glucose and D-mannose
- C. D-glucose and D-fructose
- D. D-galactose and D-glucose
- E. D-galactose and D-mannose

Problem 2: To which class of sugars do these monosaccharides belong? (see Stryer problem 10.5)

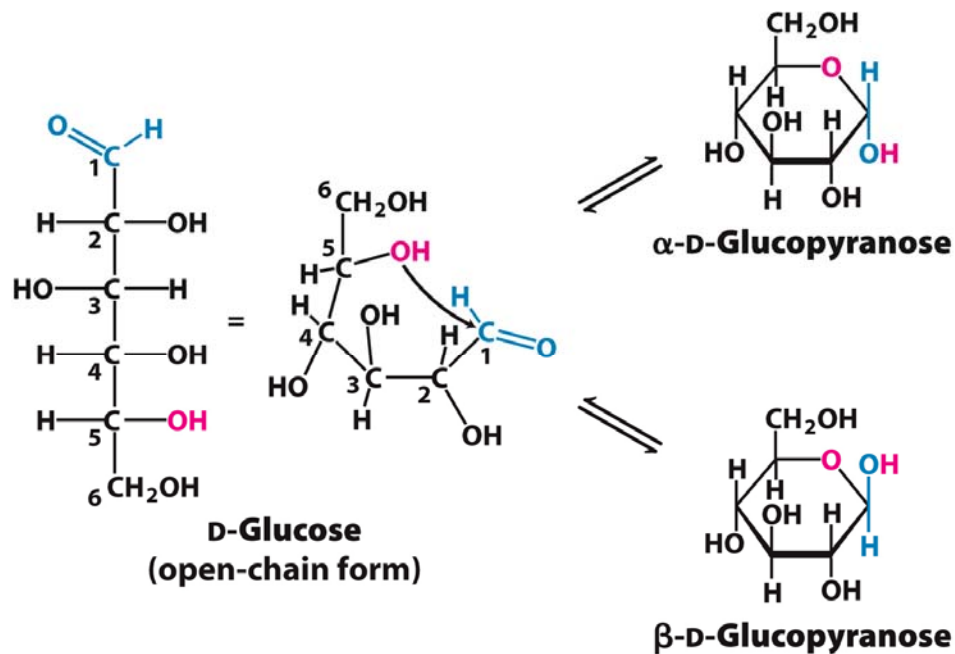


**Problem 3:** Although an aldose with four asymmetric carbon atoms is capable of forming 16 diastereomers, only 8 of the isomers are commonly observed. The seven below are all related to the structure of D-glucose. Based on the information given, draw their structures. (See Stryer Problem 10.6)

- A. D-Allose: C-3 epimer
- B. D-Altrose: Isomeric at C2 and C3
- C. D-Mannose: C2 epimer
- D. D-gulose: Isomeric at C3 and C4
- E. D-idose: isomeric at C2, C3, and C4
- F. D-galactose: C4 epimer
- G. D-talose: isomeric at C2 and C4

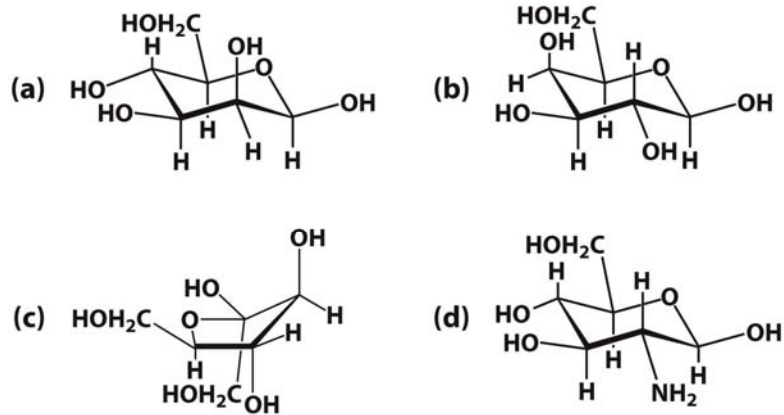
**Skill 2: Draw structures of the interconversion of cyclized and straight chain carbs**

- Monosaccharides cyclize by forming intramolecular hemiacetals
- Two anomers can form. If the hemiacetal hydroxyl group is “down” then it is the  $\alpha$ -anomer. If it is drawn “up, then it is the  $\beta$ -anomer.
- If the straight chain form is known, the cyclic form is drawn by making a six member ring, positioning carbon-6 “up” for D-sugars, and filling in hydroxyl groups “up” if they are on the left side of the Fisher projection, and “down” if they are on the right side of the Fisher Projection. The straight chain product can be drawn from the cyclic carbohydrate in a similar process.



**Figure 10.3**  
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Problem 4: Identify these four sugars. (See Stryer problem 10.)



Problem 10.10  
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Problem 5: Draw the straight chain form of D-mannose. Then draw  $\alpha$ -D-mannopyranose.

Problem 6: Draw the  $\beta$ -anomer of the pyranose of the C-4 epimer of D-galactose. Name this compound.

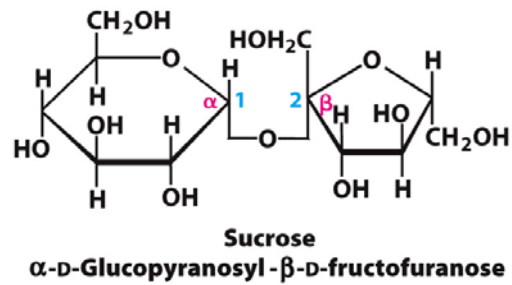
**Skill 3: Draw and understand the structures of disaccharides and compounds containing glycosidic bonds.**

- The hemiacetal of a cyclic carbohydrate is reactive. It will condense with alcohols to form a glycosidic bond (an acetal.)
- When two monosaccharides condense, the linkage can be named according to which anomer formed, and which numbered carbons form the linkage. For example, an  $\alpha(1 \rightarrow 4)$  linkage means that the acetal carbon is #1, and is linked “down” through the alcohol found on carbon #6 of the next sugar.
- Reducing sugars have hemiacetals that are in equilibrium with the open chain form. Nonreducing sugars have no hemiacetal functional group, and therefore are not reactive to making new glycosidic bonds with alcohols.

Problem 7: Draw the structure of maltose, which is a disaccharide made up to two glucose units linked by a  $\alpha(1 \rightarrow 4)$  linkage.

Problem 8: Glucose reacts slowly with hemoglobin and other proteins to form covalent bonds. Why is glucose reactive? What is the nature of the product formed? (See Stryer problem 10.7)

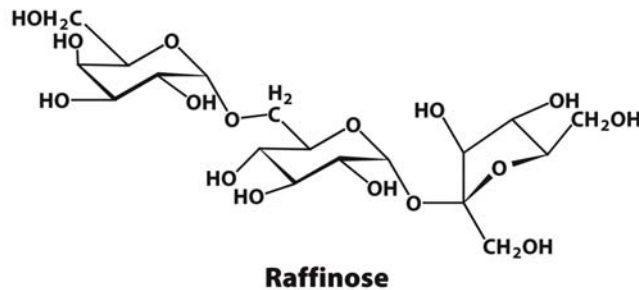
**Problem 9:** Explain why sucrose is a non-reducing sugar, but glucose and fructose (which make up sucrose) are reducing sugars. (See Stryer problem 10.8)



**Skill 4:** Apply the fact that glycoside bond formation is a condensation reaction and glycoside bond breaking is a hydrolysis reaction.

- Glycosidic bond formation is a condensation—bringing two smaller molecules together with loss of water. They are catalyzed by glycotransferases.
- Glycoside bond breaking is a first step in digestion of poly and oligosaccharides. It is a hydrolysis reaction. Maltase hydrolyzes maltose, lactase hydrolyzes lactose, etc.

**Problem 10:** Raffinose is a minor constituent in sugar beets. Is it a reducing sugar? What are the monosaccharides that compose raffinose? What products form when it is treated by  $\beta$ -galactosidase, and enzyme that hydrolyses lactose residues from oligosaccharides? (See Stryer problem 10.12.)



Problem 10.12  
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