Carbohydrates

Learning Outcomes

1. Identify a monosaccharide by structure.

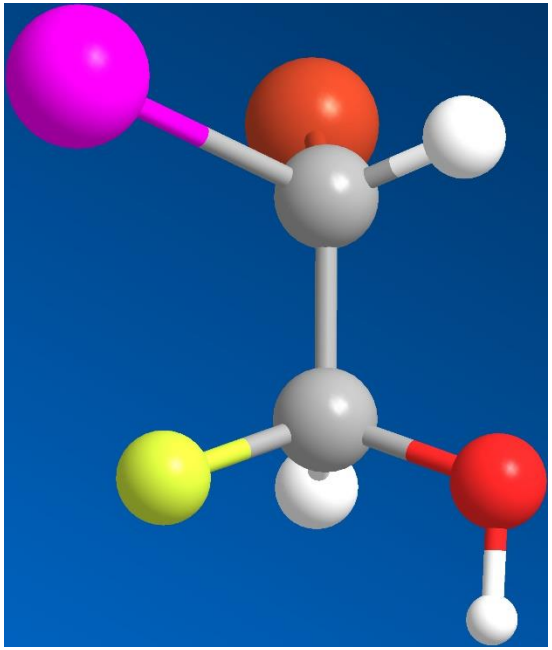
2. Understand that polysaccharides are formed by glycosidic bonds.

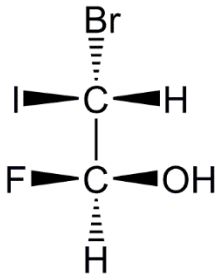
3. Understand the importance of α and β glycosidic bonds for human digestion of sugars.

4. **Chemical Connections: Testing for glucose**

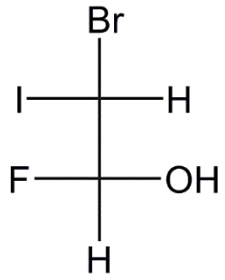
3-D Representations and Fischer Projections

Orange: Br
Purple: I
Yellow: F
White: H
Red: O





2-bromo-1-fluoro-2-iodoethan-1-ol



Fischer Projection of
2-bromo-1-fluoro-2-iodoethan-1-ol

Carbohydrates

Sugars, starch, and cellulose are all ***carbohydrates***. Carbohydrates have the general formula of $C_x(H_2O)_x$. Since the molecule has carbon and water, the name carbohydrate formed! The most classic example of a carbohydrate is D-glucose.

Carbohydrates in Food

Nutrition Facts

Serving Size 5 blocks (39 g)
Servings Per Container about 3

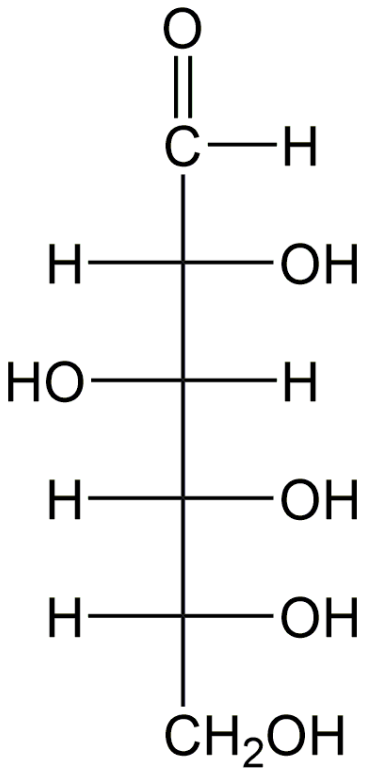
Amount Per Serving	% Daily Value*	Amount Per Serving	% Daily Value*
Calories 200			
Calories from Fat 100			
Total Fat 12 g	**18%**	**Total Carbohydrate** 23 g	**8%**
Saturated Fat 7 g	**35%**	Dietary Fiber < 1 g	**4%**
Trans Fat 0 g		Sugars 22 g	
Cholesterol 10 mg	**3%**	**Protein** 3 g	
Sodium 30 mg	**1%**		

Vitamin A 0% • Vitamin C 0% • Calcium 6% • Iron 6%

*Percent Daily Values (DV) are based on a 2,000 calorie diet.

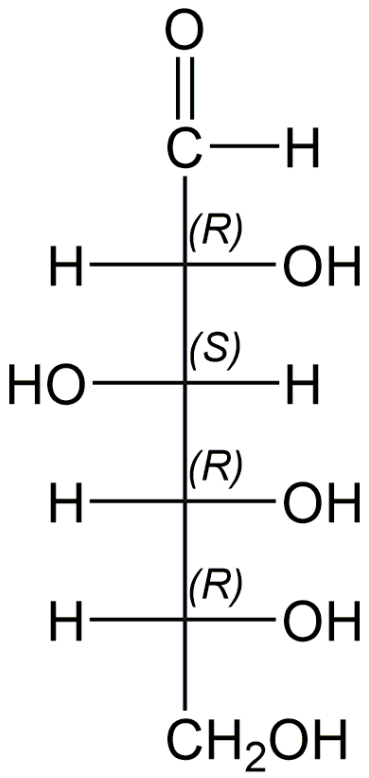
Sugars Are Often Represented By Fischer Projections

D-glucose is a monosaccharide.

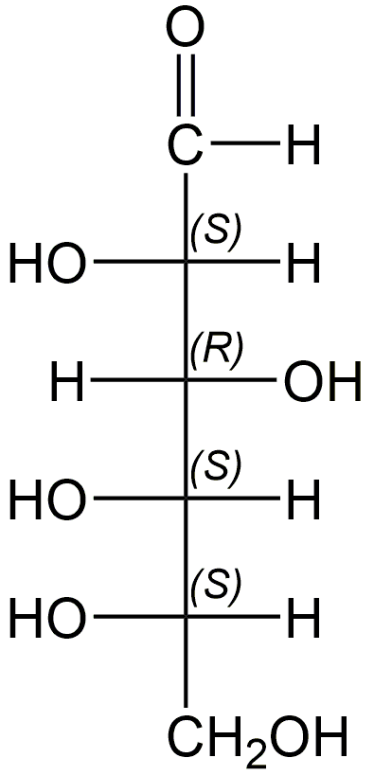


D-Glucose

D-Glucose and L-Glucose



D-Glucose

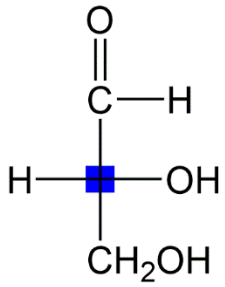


L-Glucose

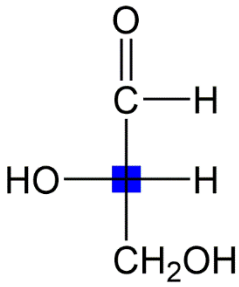
Assigning D or L Stereoisomers

How are D and L assigned?

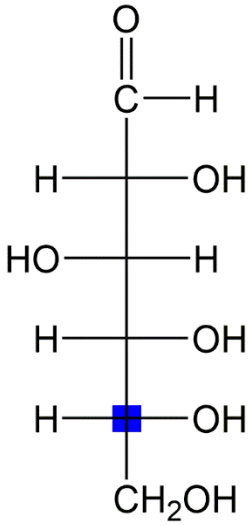
OH Direction	Configuration
Right	D
Left	L



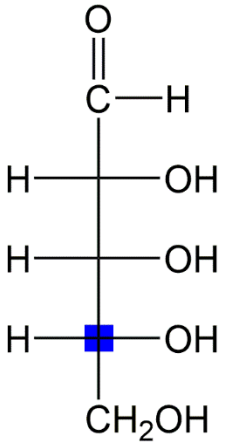
D-Glyceraldehyde



L-Glyceraldehyde



D-Glucose

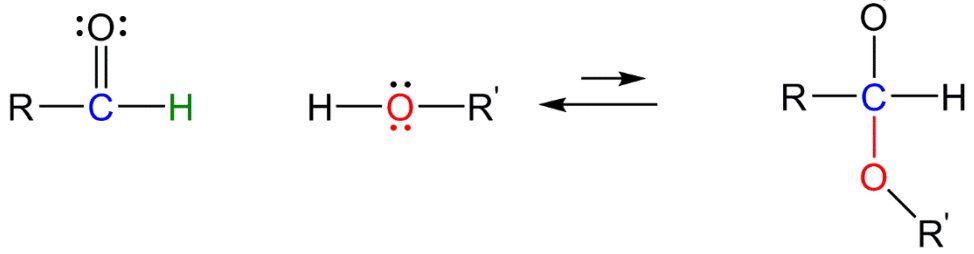


D-Ribose

Cyclic Monosaccharides

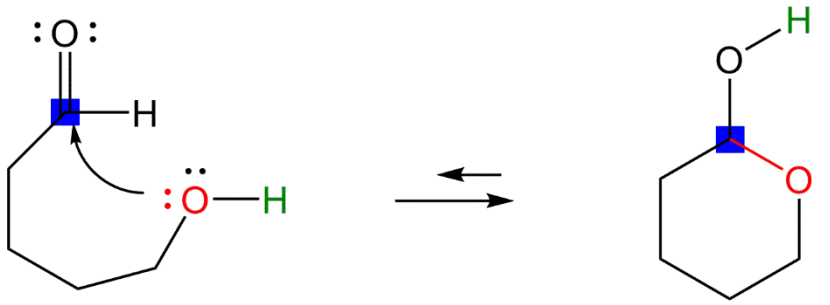
Bonus: Entropy favors the reactants
for the intermolecular reaction!

Intermolecular Reaction



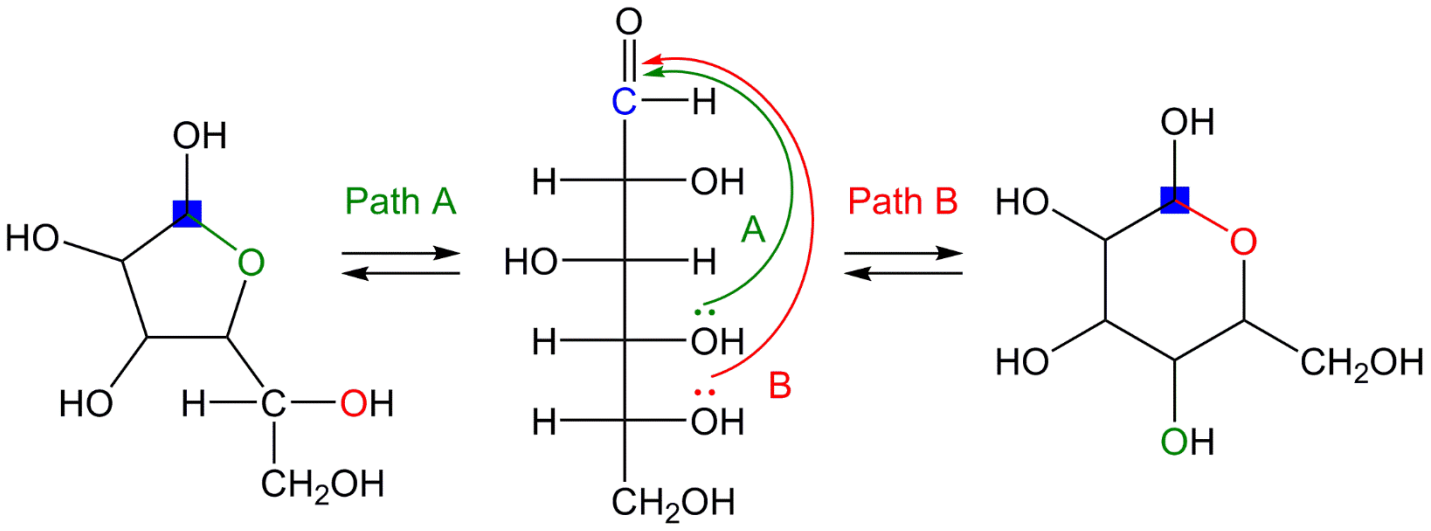
Hemiacetal

Intramolecular Reaction



Cyclic
Hemiacetal

Cyclic Hemiacetal Formation With D-Glucose

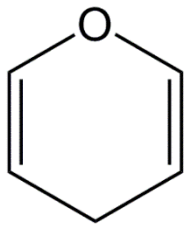


< 0.2%
Furanose

0.02 %
D-Glucose

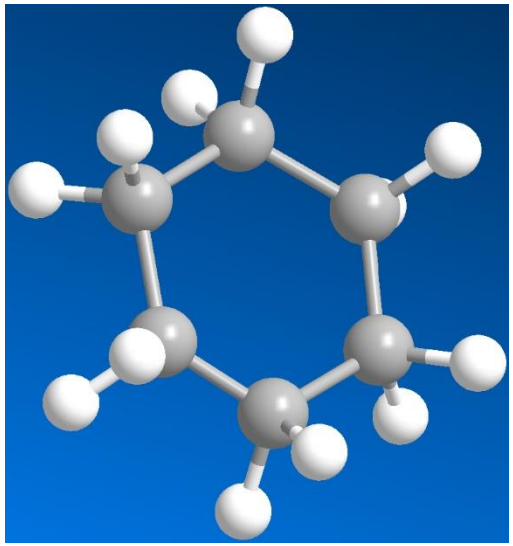
> 99.8 %
Pyranose

Furan

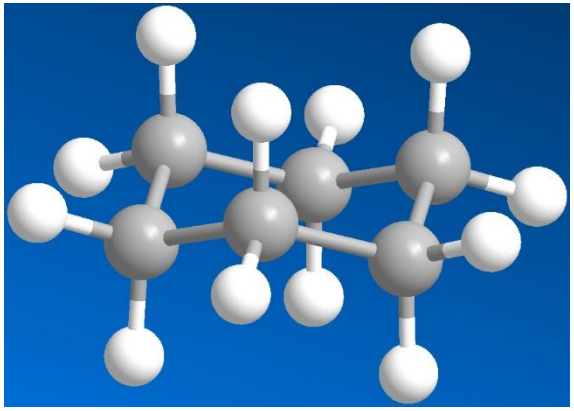


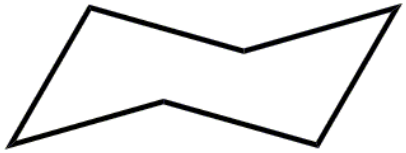
Pyran

Cyclohexane Geometry



Planar Cyclohexane
High-Energy Geometry



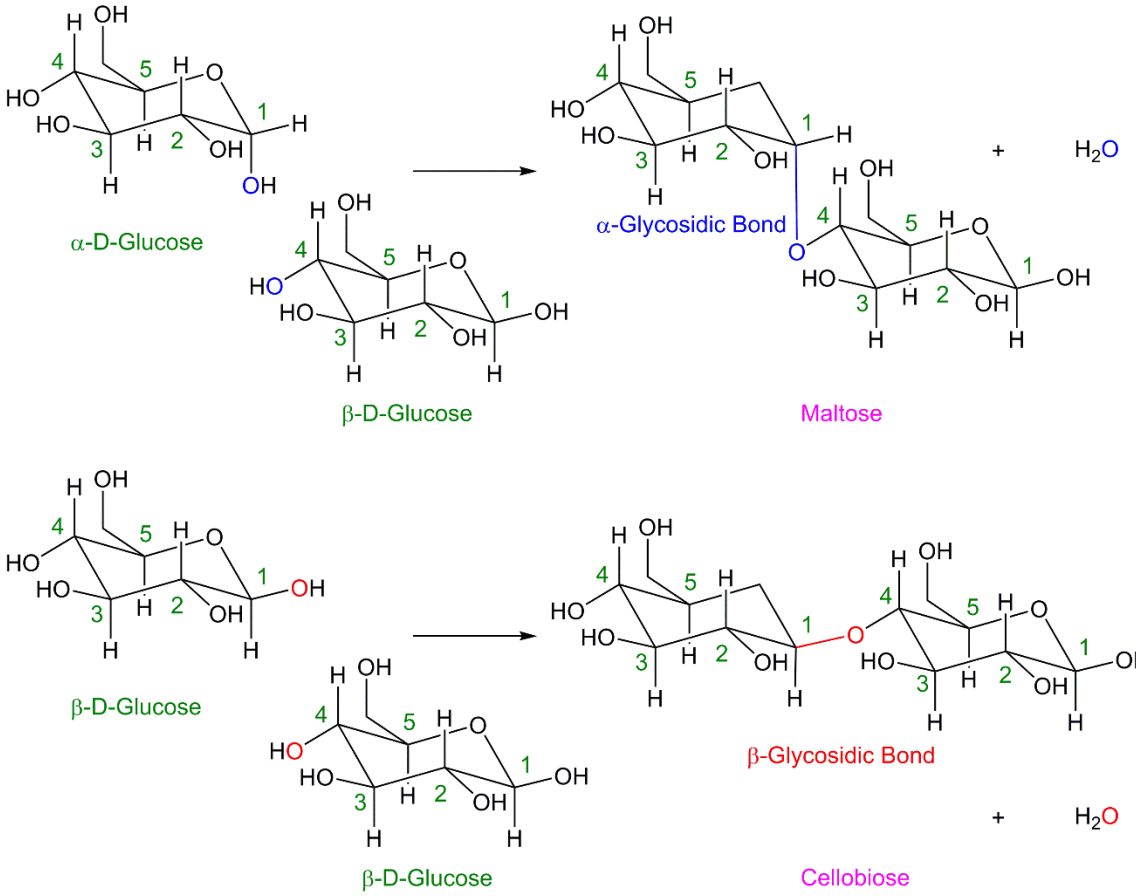


Non-Planar Cyclohexane
AKA: Chair Conformation
Experimental (Energy-Minimized) Geometry

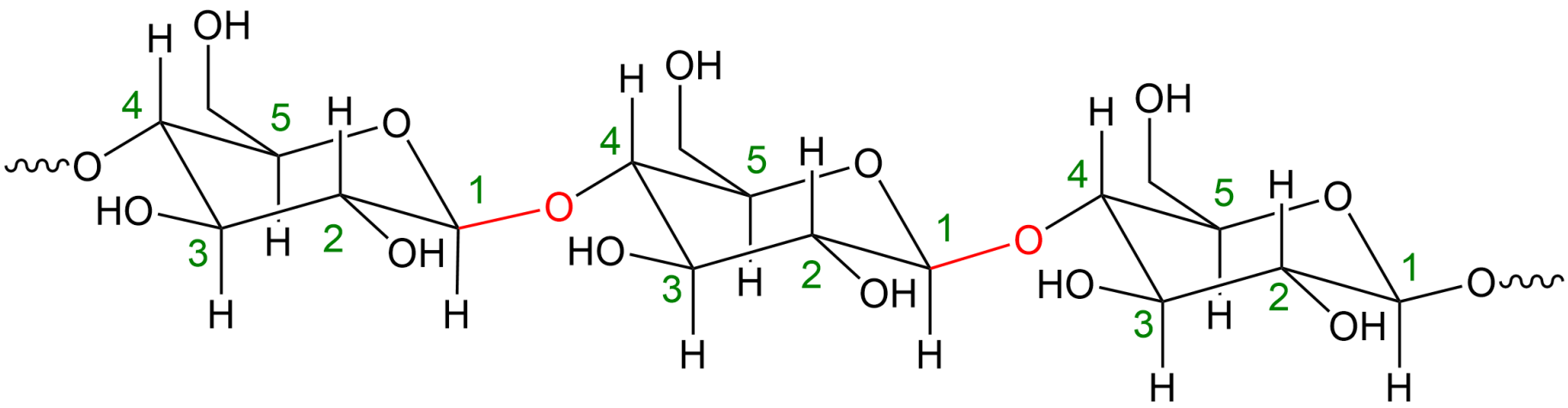
Disaccharides and the Glycosidic Bond: Monosaccharies Are Linked Via A Glycosidic Bond

Acid-catalyzed hydrolysis ("hydro" = water and "lysis" = to lose).

The mechanism details are ***not*** the focus here.



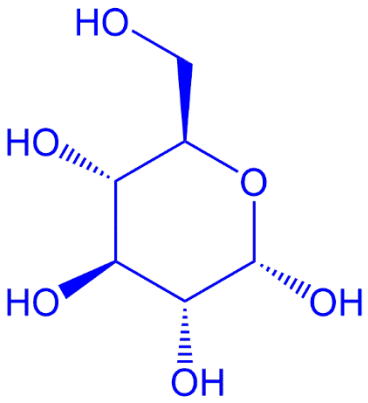
Polysaccharides Have Multiple Glycosidic Bonds And Are Biopolymers



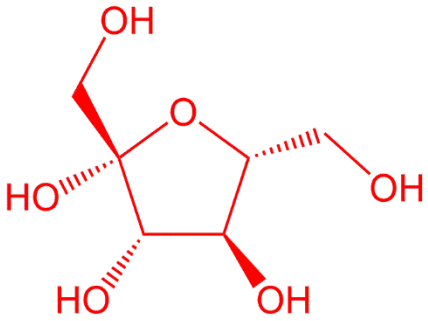
β-Glycosidic Bond β-Glycosidic Bond

Cellulose

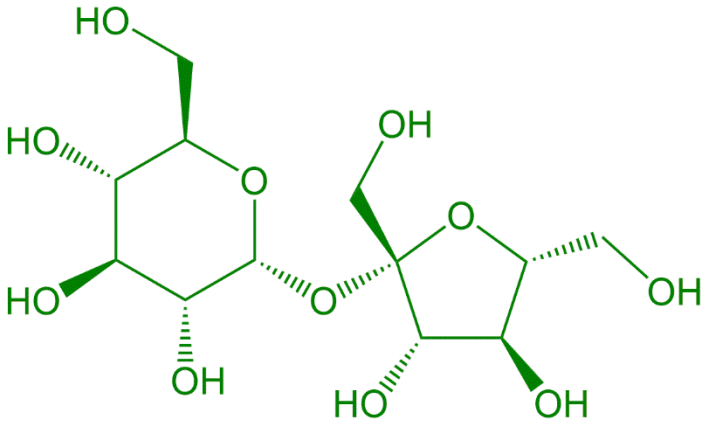
Table Sugar (Sucrose) is a Disaccharide!



Glucose



Fructose



Sucrose

Problem 1

In cooking, what we call sugar is the molecule sucrose. Invert sugar is another ingredient is also used in cooking: it is selected for its greater sweetness than sucrose and its ability to slow crystallization. As a result, invert sugars have a fairly long shelf-life. Watch the video “How to Make Invert Sugar at Home” and explain what invert sugar is in chemistry terms.

https://www.youtube.com/watch?v=T_i48zZDk44

Honey is Invert Sugar!

Problem 2

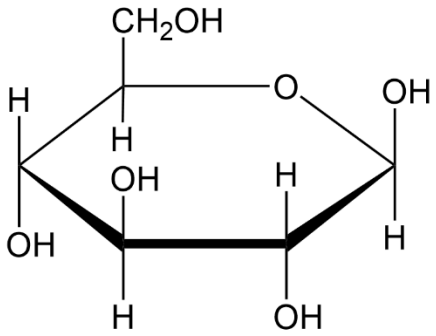
The table below lists disaccharides and polysaccharides with α-glycosidic bonds and β-glycosidic bonds.

Disaccharides			Polysaccharide	
α-Glycosidic Bond	β-Glycosidic Bond		α-Glycosidic Bonds	β-Glycosidic Bonds
Maltose	Cellobiose		Amylose Starch	Cellulose
Sucrose			Pectin	Chitin
Lactose				

What is the biological significance of saccharides having α- or β-glycosidic bonds for humans?

Testing for Glucose

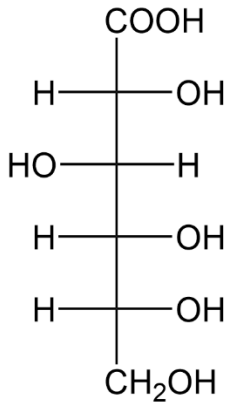
Step 1



D-Glucose

+ O_2 + H_2O

Glucose Oxidase



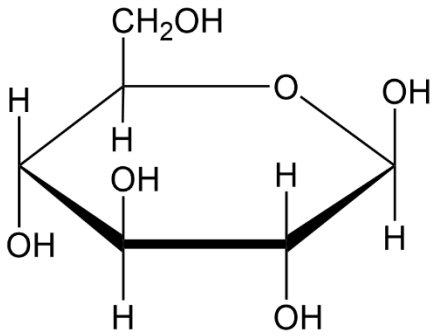
D-Gluconic Acid

+ **H_2O_2**

Hydrogen Peroxide

Testing for Glucose

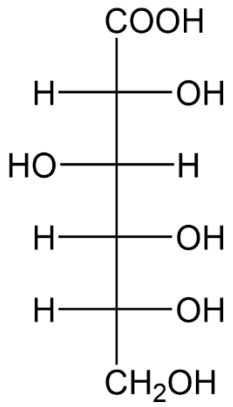
Step 1



D-Glucose

+ O_2 + H_2O

Glucose Oxidase

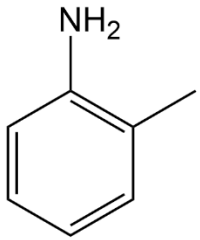


D-Gluconic Acid

+ **H_2O_2**

Hydrogen Peroxide

Step 2



2-Methylanaline

+ **H_2O_2**

Hydrogen Peroxide

Peroxidase

Colored Product