BIOCHEMISTRY

SUGARS: FISCHER & HAWORTH PROJECTIONS

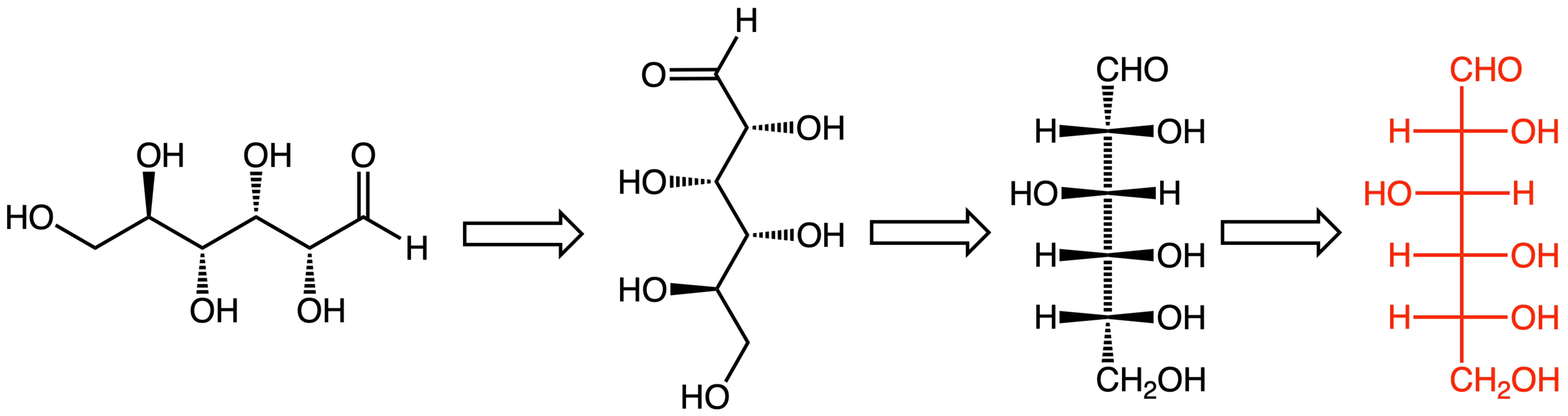
CHEMISTRY 165 // SPRING 2020

DR. MIOY T. HUYNH | 2020

What is a sugar?

Most sugars have the general formula: $C_X(H_2O)_Y$.

A single sugar unit (the simplest carbohydrate) is often referred to as a monosaccharide. When a polymer of monosaccharides is formed, we call it a polysaccharide (complex carbohydrate).



Because sugars have many chiral centers, they are often drawn using the Fischer Projection, which is shown on the far right-hand side.

Fischer projections: What do they tell us?

The Fischer projection of a sugar is a standardized shorthand for representing sugars.

Let's take the example of glucose, which is shown to the right in two forms/isomers.

Contained in the Fischer projection are several important pieces of information:

- The number of carbon atoms in the sugar (-ose).

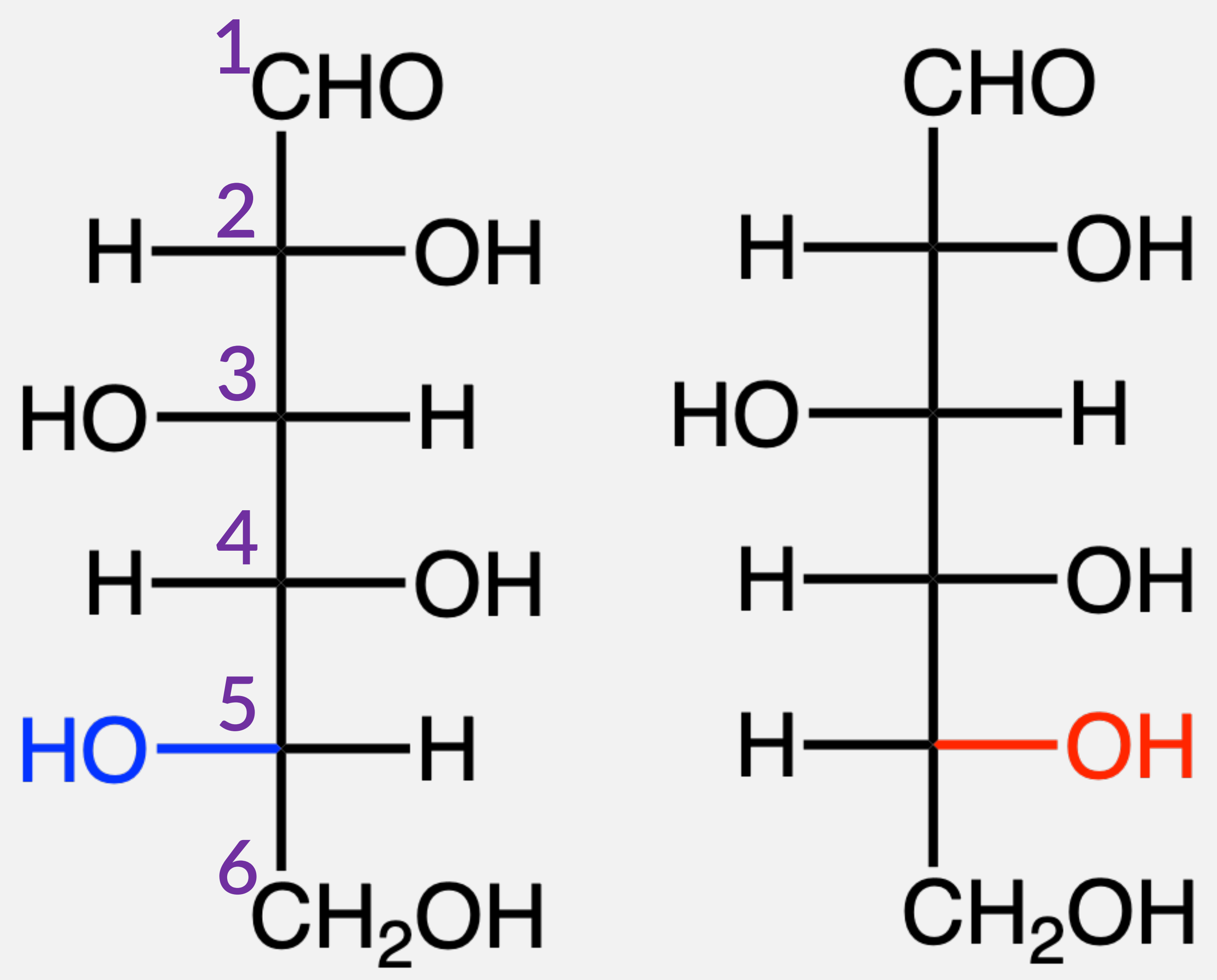
  Glucose is a 6-carbon sugar, so it is a hexose.

- The placement of the carbonyl (C=O) group, and whether it is a ketone (ketose) or aldehyde (aldose). The C=O is always placed at the beginning (top) of the sugar/saccharide.

  Glucose is an aldehyde, so it is an aldohexose.

- The configuration or stereochemistry of the last stereocenter (or chiral center).
  - If the –OH is on the left side, it is an L-sugar.
  - If the –OH is on the right side, it is a D-sugar.

GLUCOSE



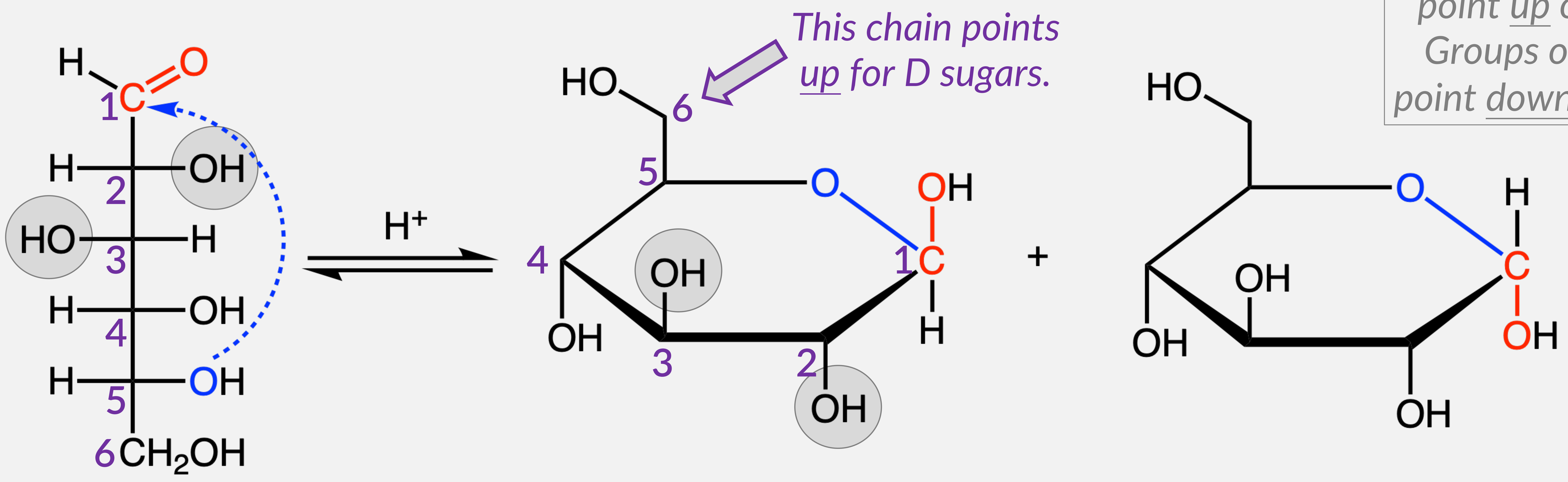
L-aldohexose D-aldohexose

Haworth projections: Cyclic sugars (Ex. 1)

Sugars often cyclize into 5- (furanose) or 6-membered (pyranose) rings in of acidic (H^+) medium.

Let's take the example of D-glucose (a D-aldohexose).

Groups on the left point up on the ring. Groups on the right point down on the ring.



D-glucose	β-D-glucopyranose	α-D-glucopyranose
(aldohexose)	(β → -OH on ^{1}C points up)	(α → -OH on ^{1}C points down)

The anomeric carbon is the ^{1}C which is the only carbon attached to two O atoms.

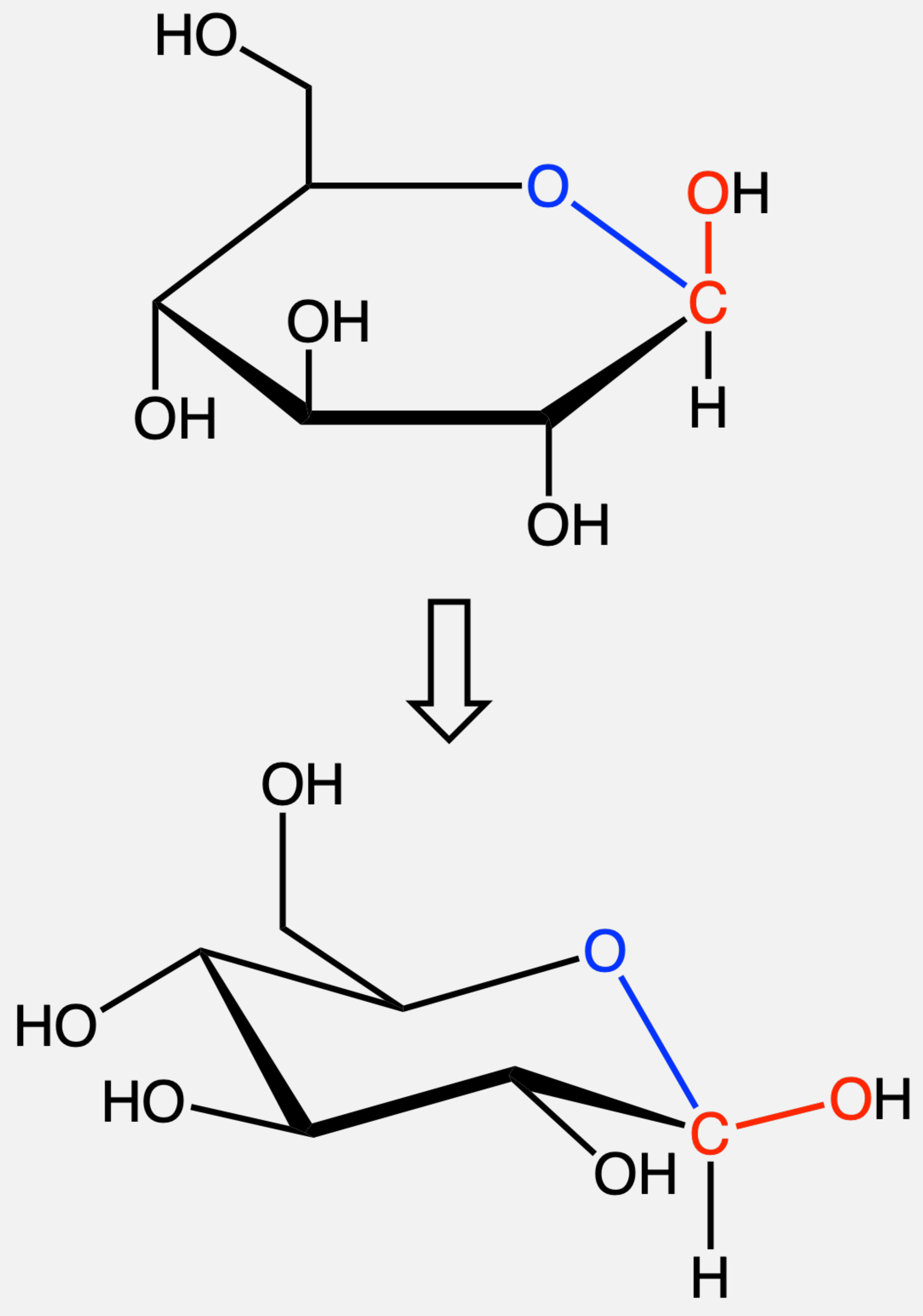
The α- and β-pyranoses are isomers that are called anomers.

Chair conformations

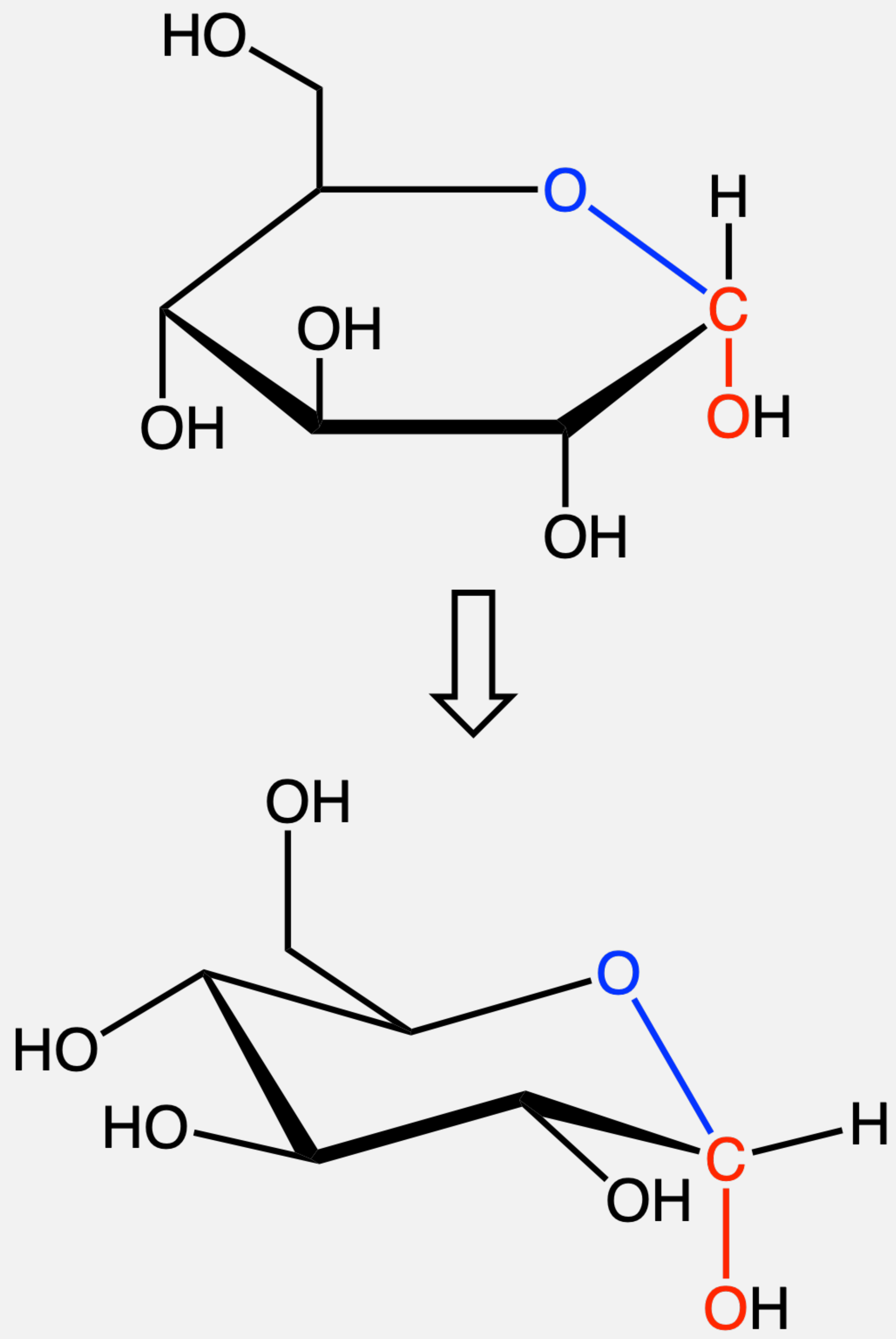
6-membered (pyranose) rings exist in a chair conformation because of the angles on the *sp*^{3}-hybridized carbons.

Let's take the example of D-glucose (a D-aldohexose).

β-D-glucopyranose



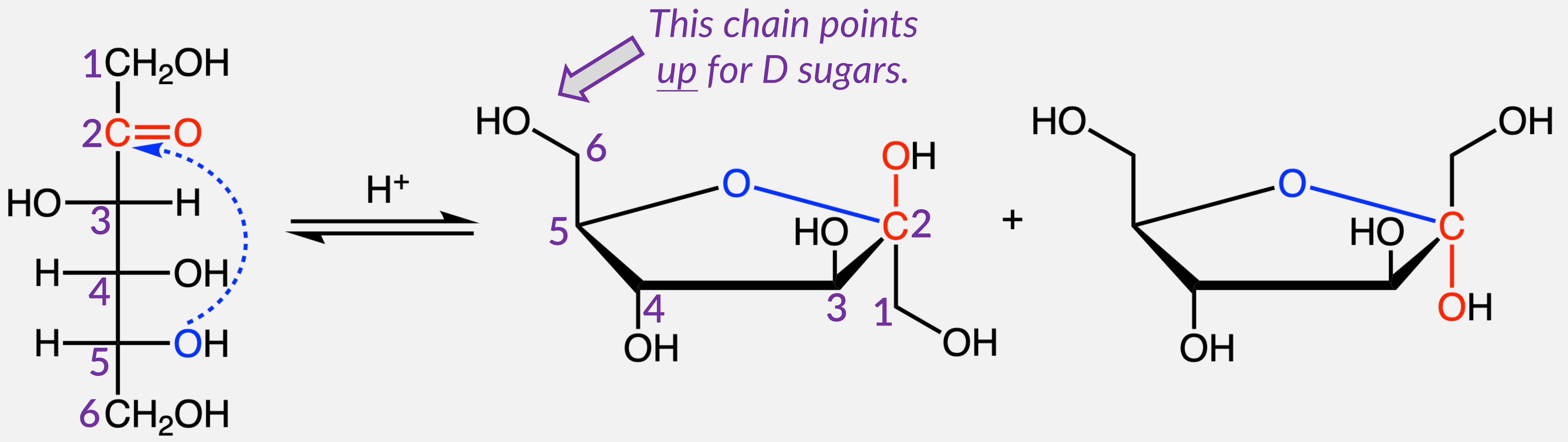
α-D-glucopyranose



Haworth projections: Cyclic sugars (Ex. 2)

Sugars often cyclize into 5- (furanose) or 6-membered (pyranose) rings in of acidic (H^+) medium.

Let's take the example of D-fructose (an D-ketohexose).



D-fructose

(ketohexose)

β-D-fructofuranose

(β → -OH on ^{2}C points up)

α-D-fructofuranose

(α → -OH on ^{2}C points down)

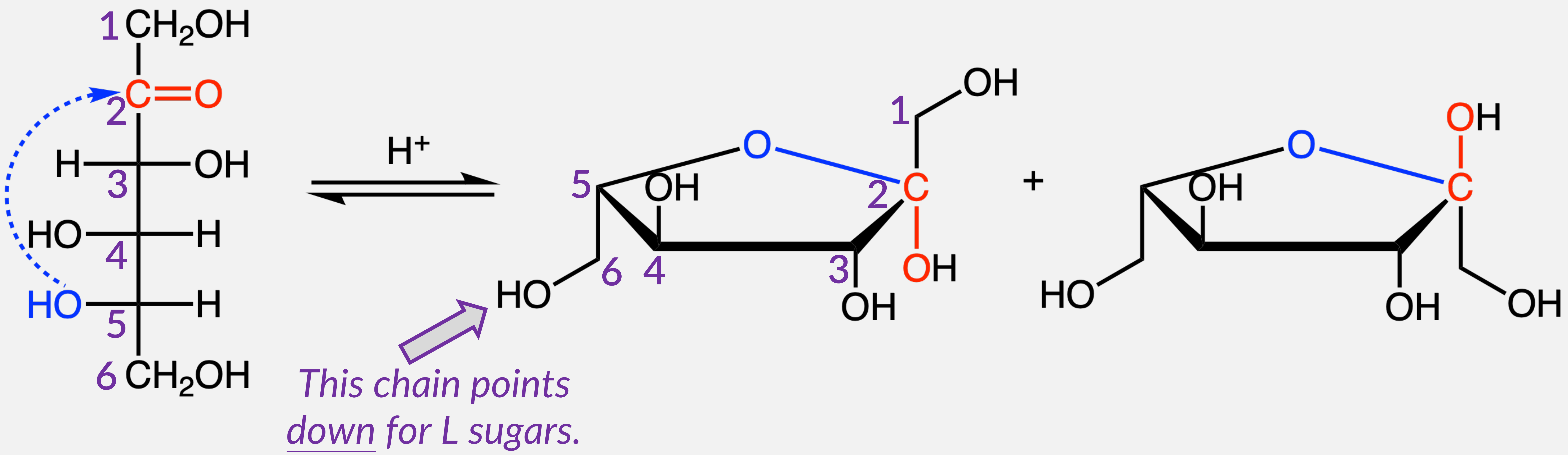
The anomeric carbon is the ^{2}C which is the only carbon attached to two O atoms.

The α- and β-furanoses are isomers that are called anomers.

Haworth projections: Cyclic sugars (Ex. 3)

Most sugars are D-sugars. But what about L-sugars?

Let's take the example of L-fructose (an L-ketohexose).



L-fructose

(ketohexose)

β-L-fructofuranose

(β → -OH on ^{2}C points down)

α-L-fructofuranose

(α → -OH on ^{2}C points up)

The anomeric carbon is the ^{2}C which is the only carbon attached to two O atoms.

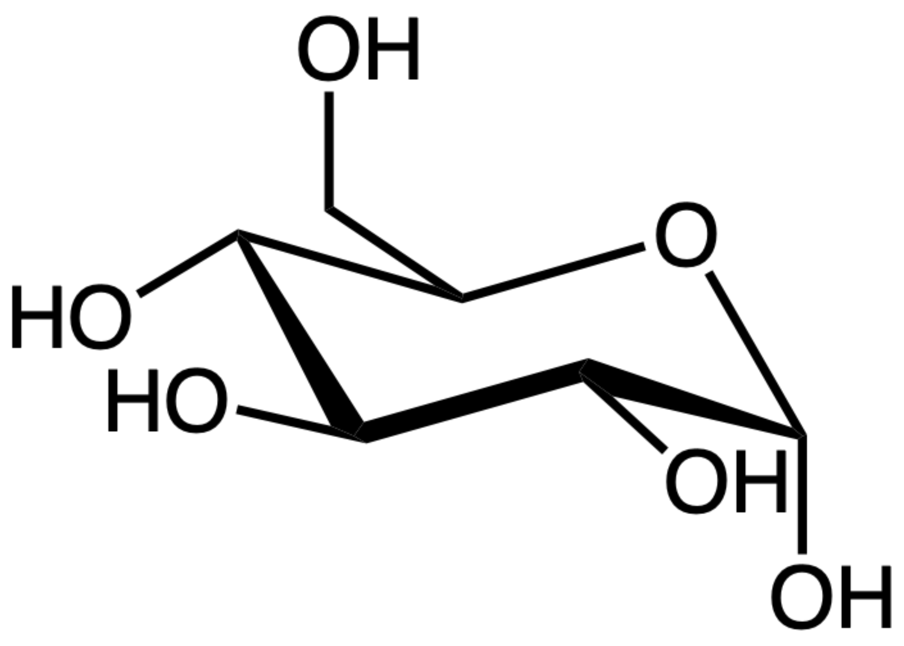
The α- and β-furanoses are isomers that are called anomers.

PRACTICE PROBLEM 1

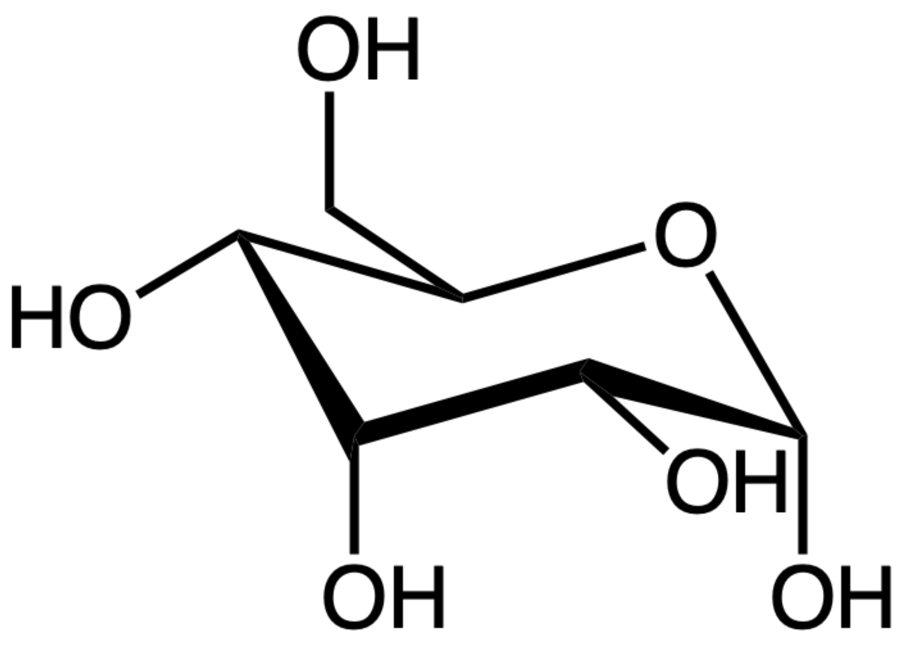
Which of the following monosaccharides are β-anomers?

— answer —

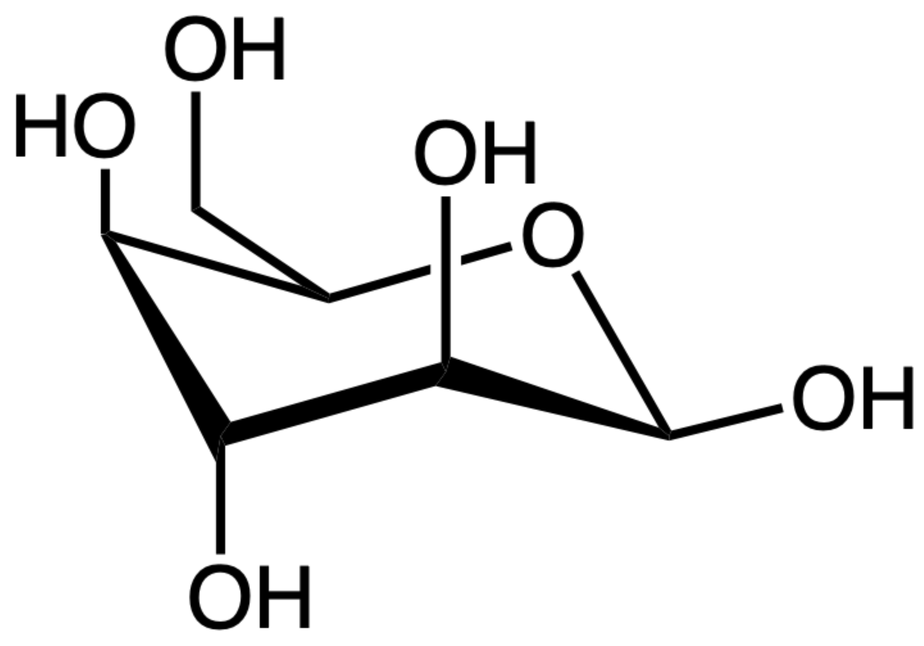
A



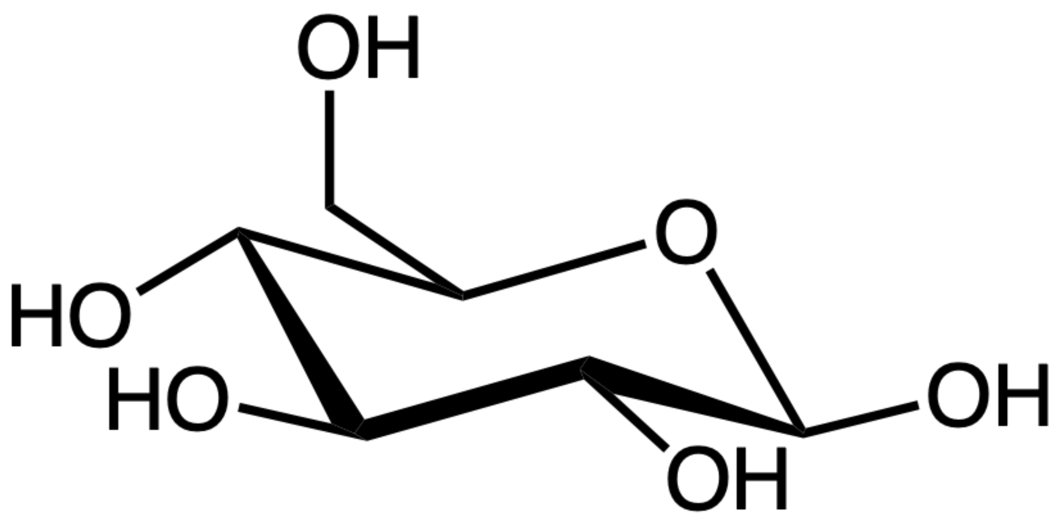
B



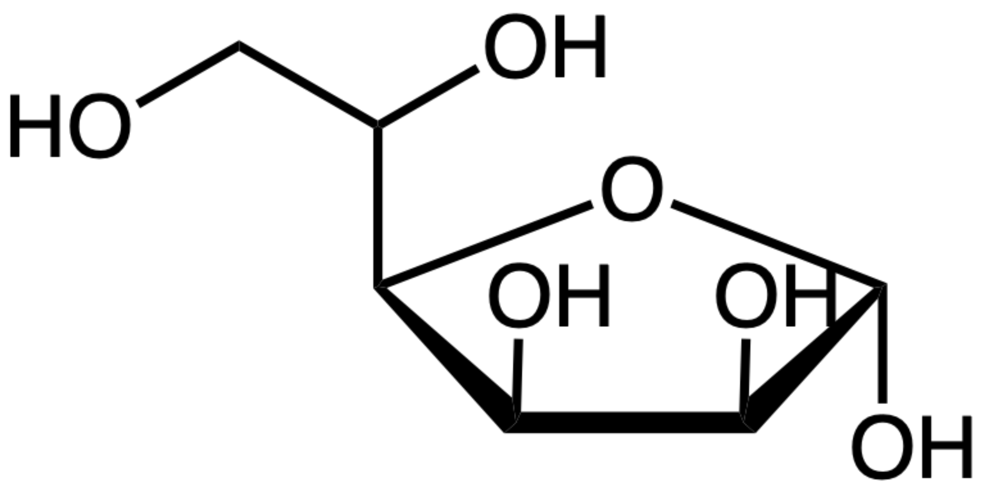
C



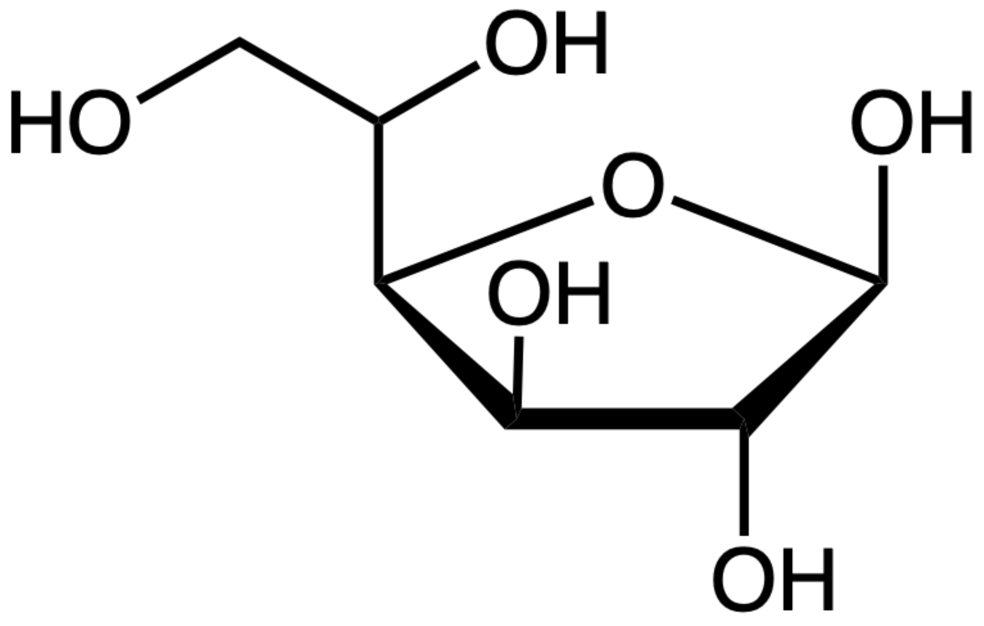
D



E



F



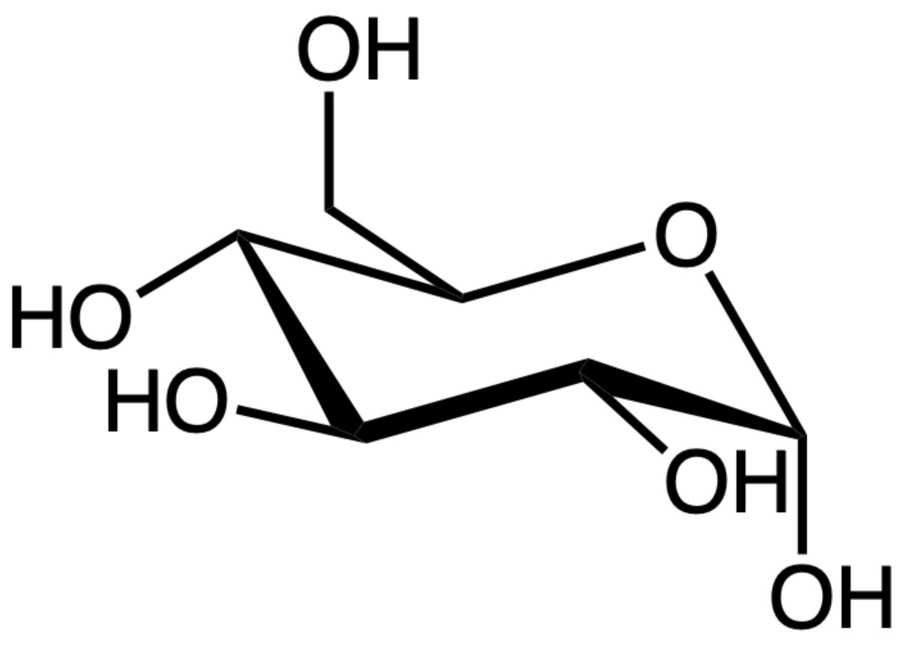
PRACTICE PROBLEM 1

Which of the following monosaccharides are β-anomers?

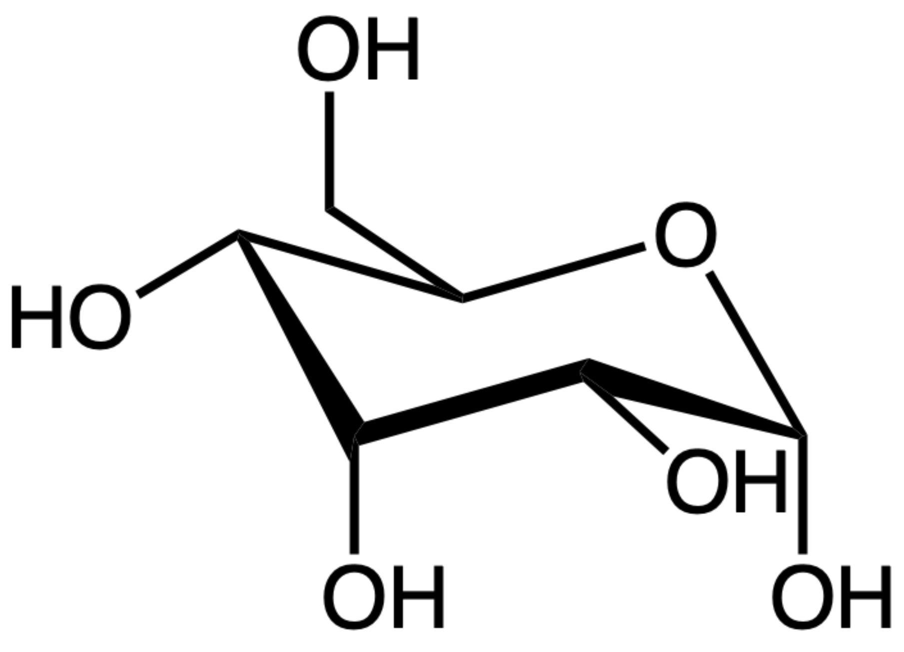
— answer —

The β-anomer has the –OH on the anomeric carbon pointing up for these D-sugars.

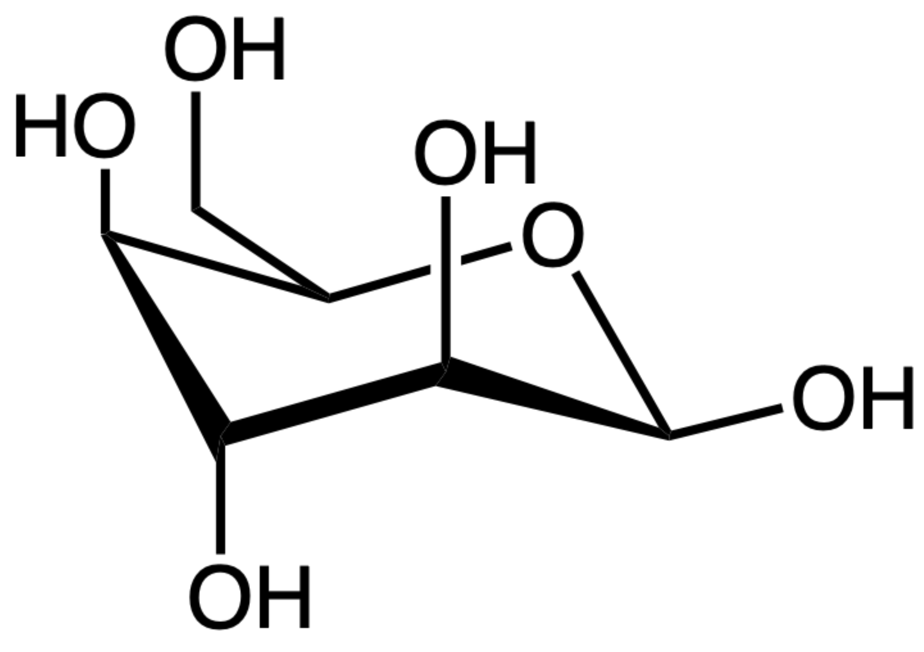
A



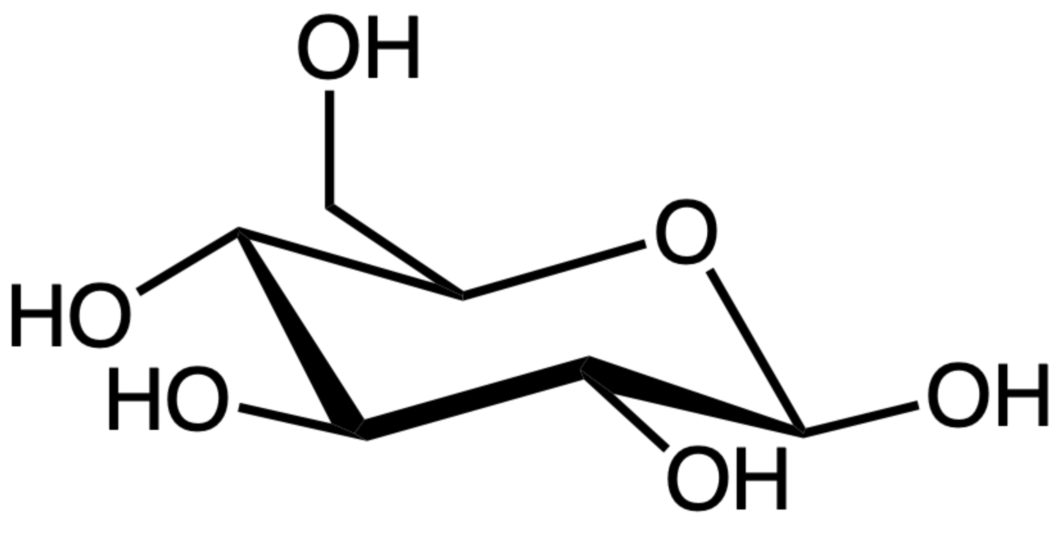
B



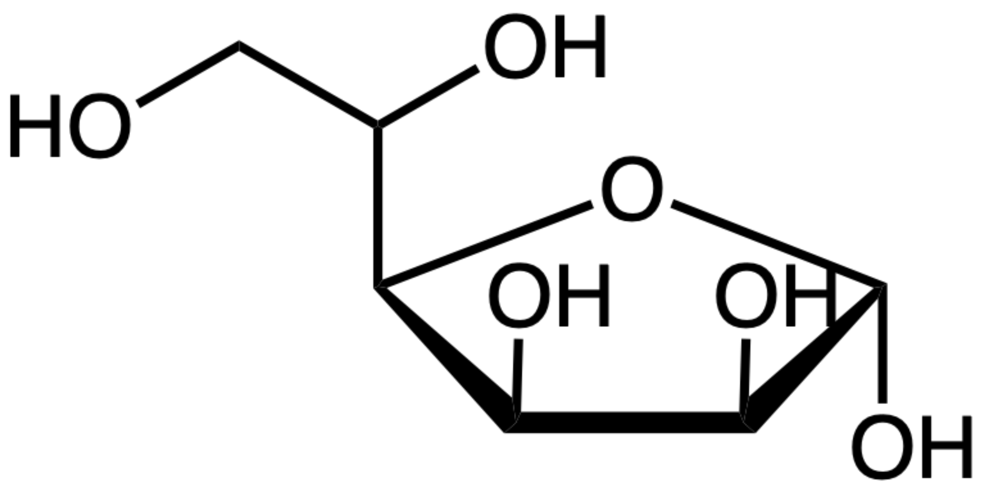
C



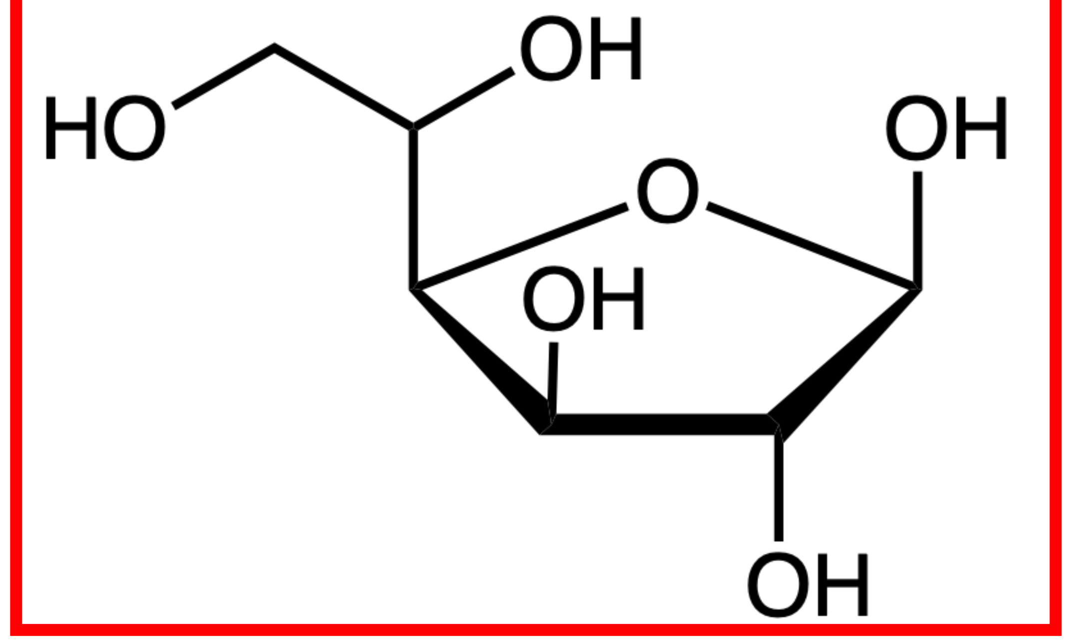
D



E



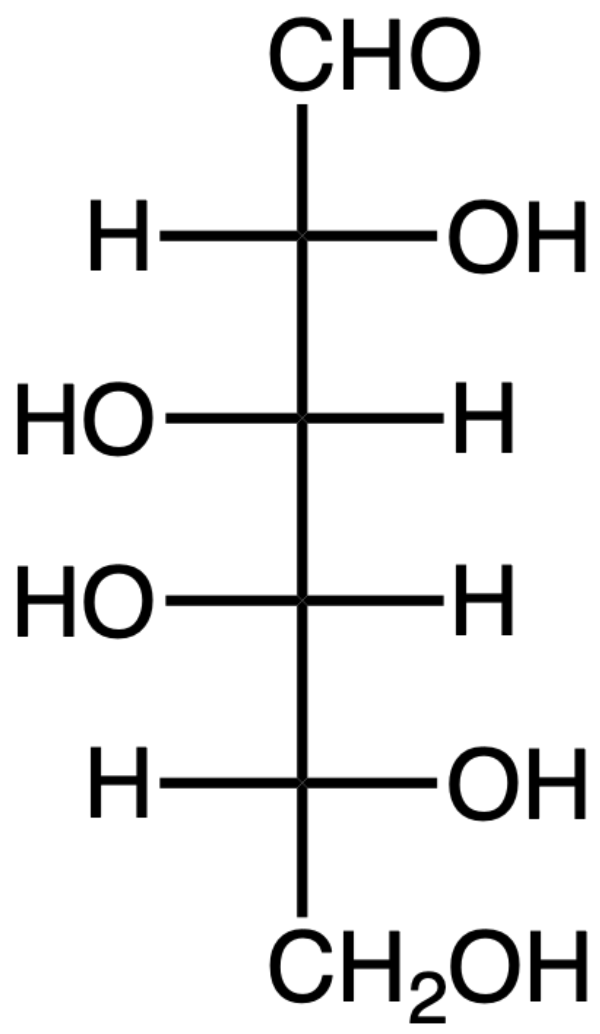
F



PRACTICE PROBLEM 2

Draw the Haworth projection for the β-puranose form of D-galactose based on its Fischer projection.

— answer —



PRACTICE PROBLEM 2

Draw the Haworth projection for the β-puranose form of D-galactose based on its Fischer projection.

— answer —

The β-anomer has the –OH on the anomeric carbon pointing up for D-sugars.