Chapter 15 Carbohydrates

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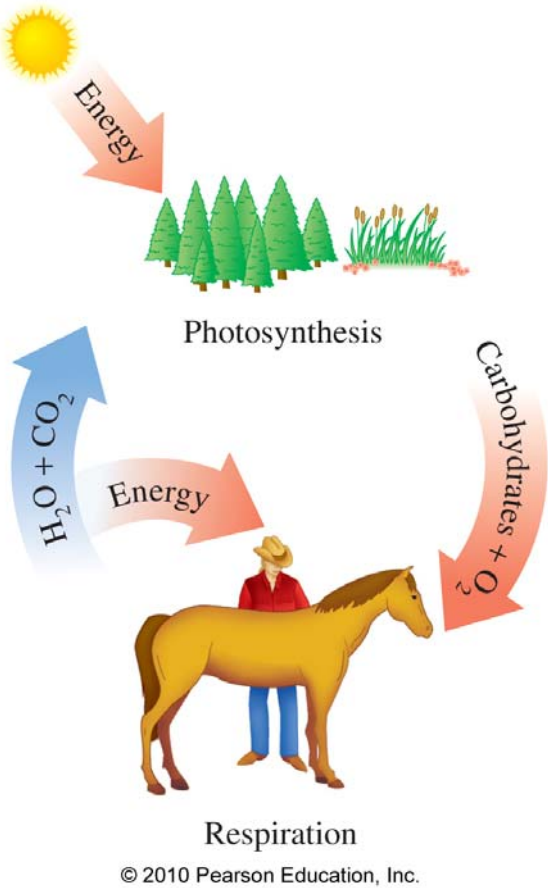
Carbohydrates are produced by photosynthesis in plants; glucose is synthesized in plants from CO_2, H_2O, and sunlight; it is oxidized in living cells to produce CO_2, H_2O, and energy



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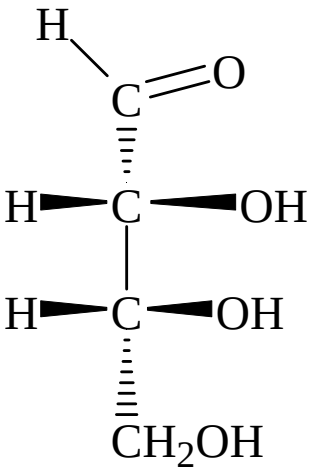
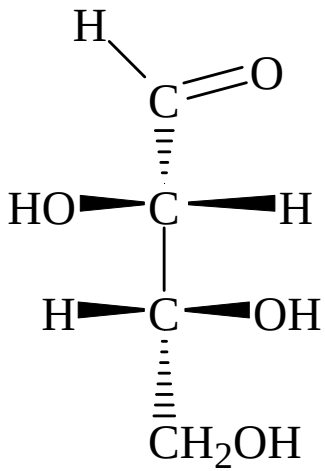


D-erythrose



D-Threose

stereoisomers: Isomers which differ only in how the groups are orientated in space

chiral carbon: a carbon with 4 different substituents

What do you think is the relationship between these two structures?

Are they the same?

Are they different?

If they are different, are they mirror image isomers or just different?

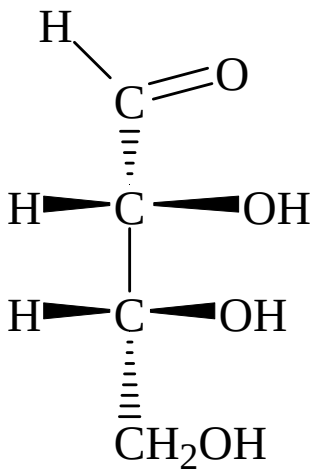
Are they both D isomers?

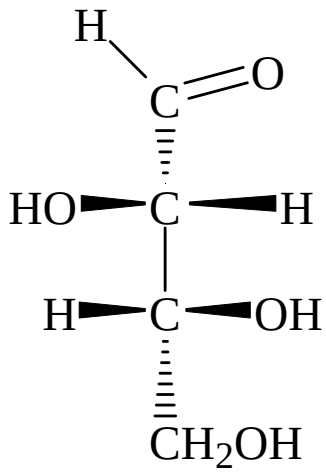
How many chiral carbon atoms are there? 2

What is the maximum number of stereoisomers $2^n = 4$

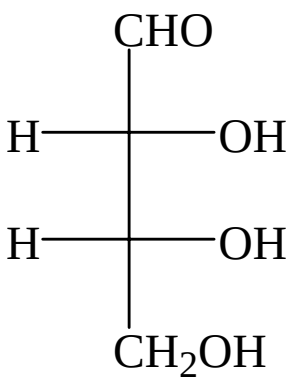
Fischer Projections

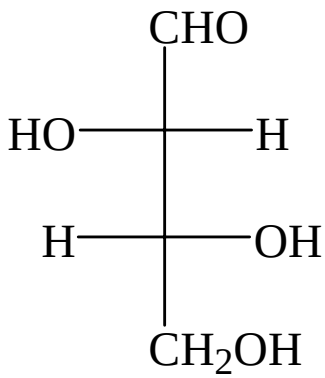
Take the carbon backbone and line vertically so that the top and bottom point into the plane of the screen; the remaining two substituents, usually an –H and an –OH in sugars will be pointing out of the screen. In the case below, the solid C-C bond lies on the screen and the CHO and CH_2OH point into the screen

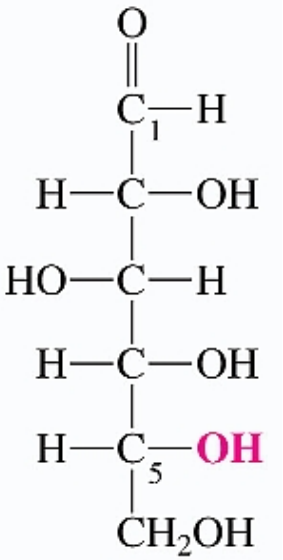




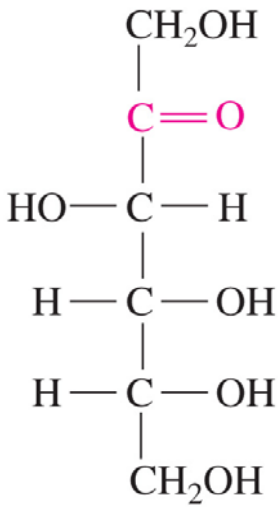
The Fischer projection would be written as:





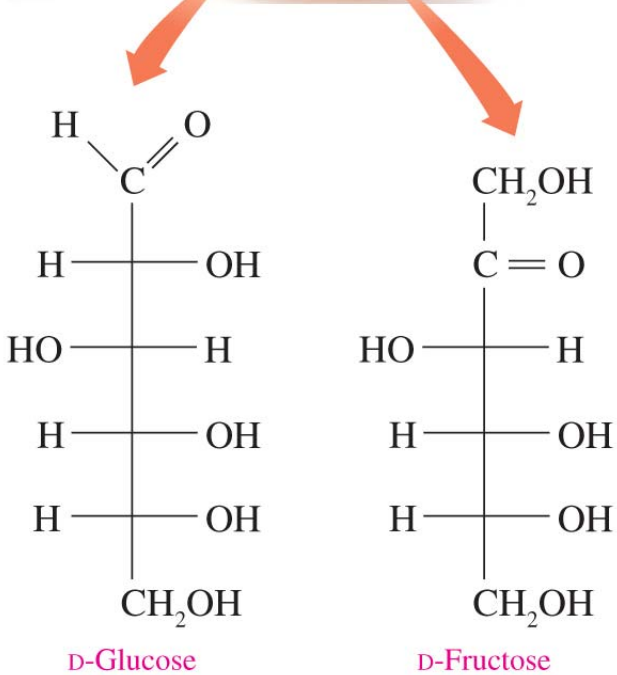


D- Glucose



D- Fructose (ketohexose)

Table sugar is made up of one molecule of glucose and one of fructose



D-Glucose D-Fructose

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Sugars are not found in nature as linear molecules as we have been drawing them.

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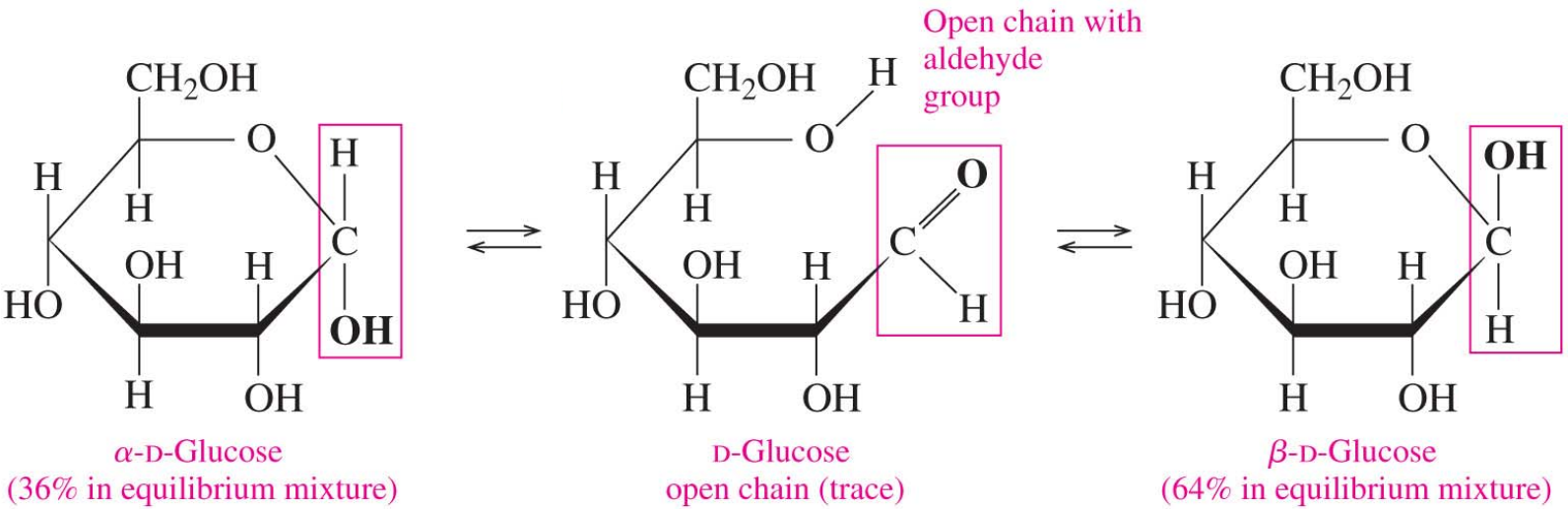
When placed in an aqueous solution, the cyclic structure open and closes

α-D-glucose converts to β-D-glucose and back;

there is only a small amount of open chain



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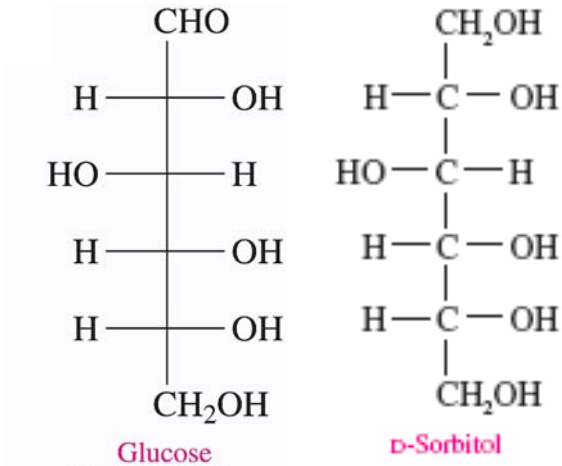
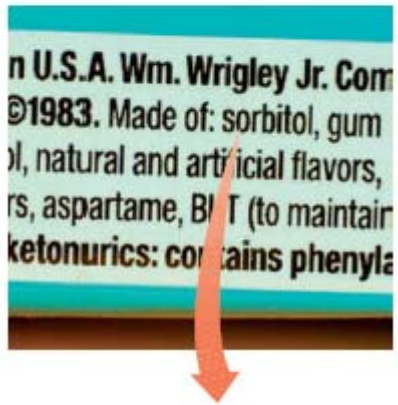
Fructose behaves similarly but also differently

Reduction of glucose

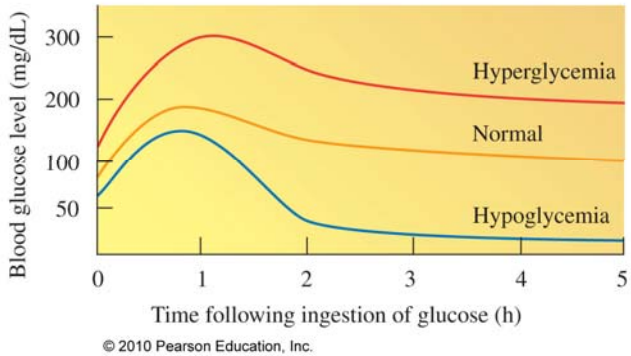




In the human body,

glucose has a normal blood level of 70–90 mg/dL

a glucose tolerance test measures blood glucose for several hours after ingesting glucose



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Blood glucose that exceeds 160 mg/dL is excreted in urine

TABLE 15.1 Glucose Test Results

Color (of Benedict's test)	Glucose Present in Urine	
	% (m/v)	mg/dL
Blue	0	0
Blue-green	0.25	250
Green	0.50	500
Yellow	1.00	1000
Brick-red	2.00	2000

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A more specific test is to use the enzyme glucose oxidase which oxidizes glucose and produces H_2O_2. The hydrogen peroxide produced oxidizes a dye that produces different colors depending on the amount of H_2O_2 present in the urine

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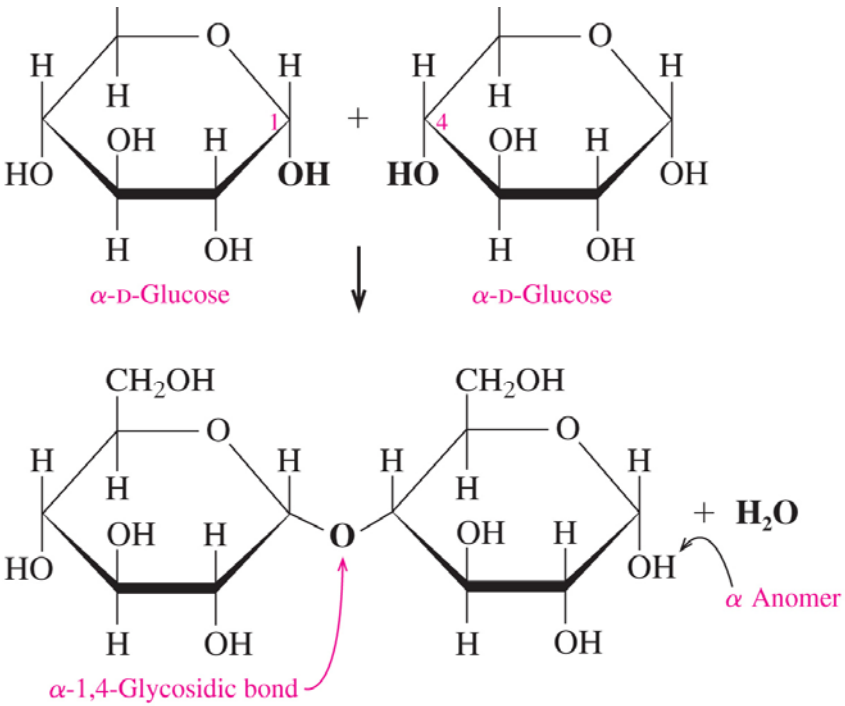
Disaccharides

A **disaccharide** consists of two monosaccharides

Monosaccharides	**Disaccharide**
Glucose + glucose	maltose + H_2O



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Maltose is
a disaccharide also known as *malt sugar*
composed of two D-glucose molecules
obtained from the hydrolysis of starch

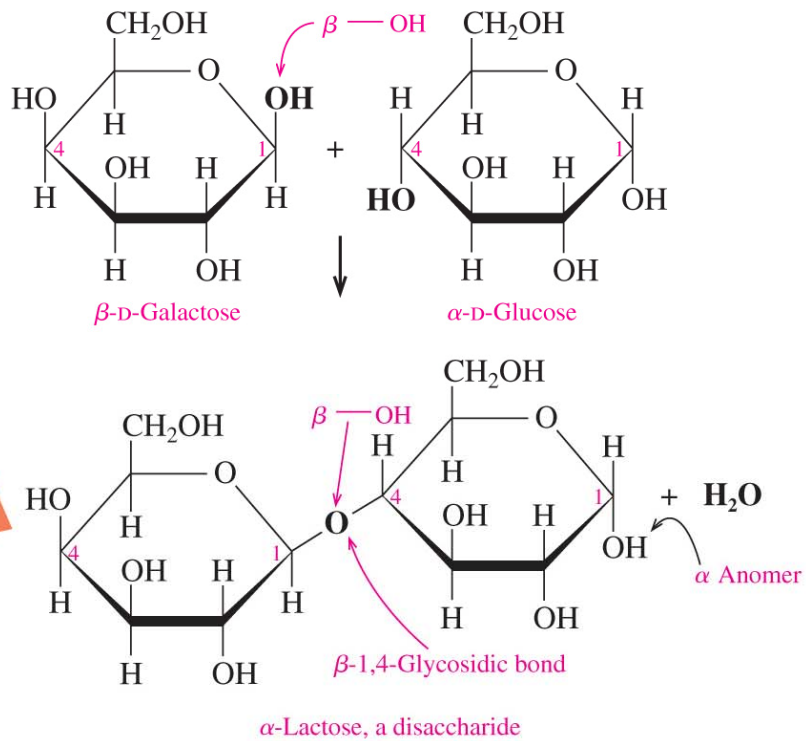
Lactose

is a disaccharide of β-D-galactose and α- *or* β-D-glucose

contains a β-1,4-glycosidic bond

is found in milk and milk products

is found in both the α- and β- forms



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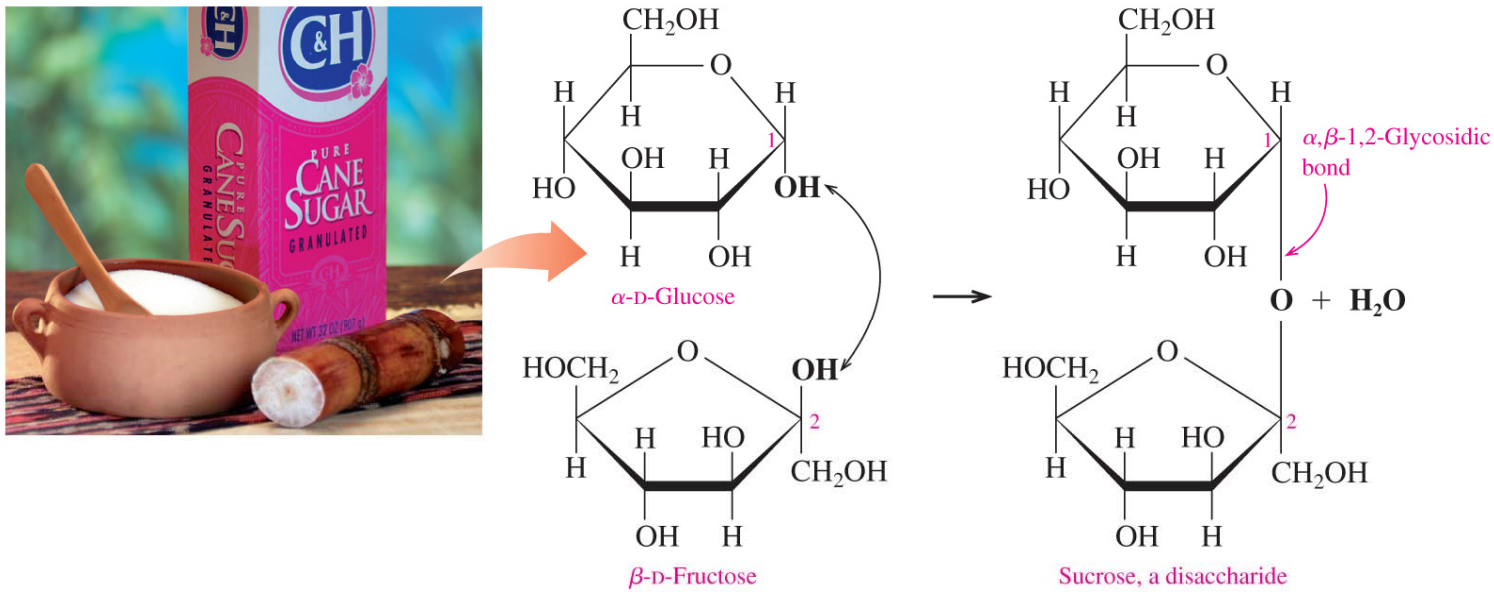
Sucrose, or *table sugar*,
is obtained from sugar cane and sugar beets
consists of α-D-glucose and β-D-fructose
has an α,β-1,2-glycosidic bond



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Artificial Sweetners

Artificial sweetners have a similar caloric value per mole as sucrose; why do diet drinks claim to have zero calories?

Sugars and artificial sweeteners differ in sweetness are compared to sucrose (table sugar), which is assigned a value of 100

TABLE 15.2 Relative Sweetness of Sugars and Artificial Sweeteners

	Sweetness Relative to Sucrose (= 100)
Monosaccharides	
Galactose	30
Glucose	75
Fructose	175
Disaccharides	
Lactose	16
Maltose	33
Sucrose	100 = reference standard
Sugar Alcohols (Polyols)	
Sorbitol	60
Maltitol	80
Xylitol	100
Artificial Sweeteners (Noncarbohydrate)	
Aspartame	18 000
Saccharin	45 000
Sucralose	60 000
Neotame	1 000 000

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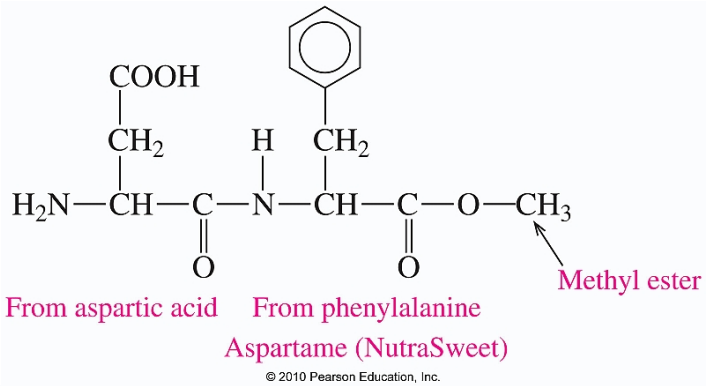

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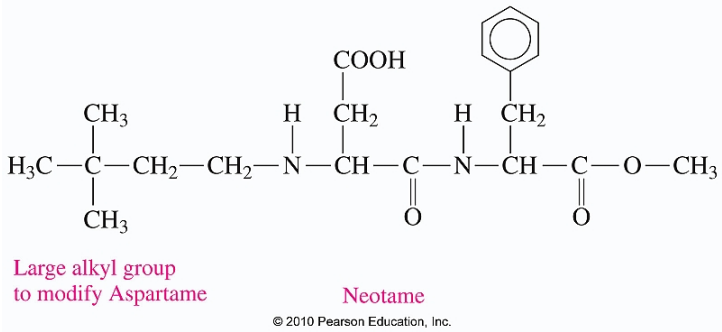

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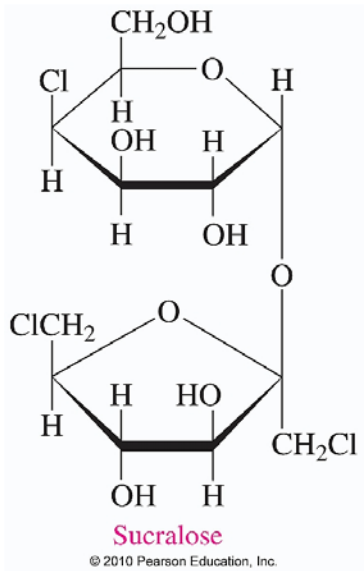

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TABLE 15.2 Relative Sweetness of Sugars and Artificial Sweeteners

	Sweetness Relative to Sucrose (= 100)
Monosaccharides	
Galactose	30
Glucose	75
Fructose	175
Disaccharides	
Lactose	16
Maltose	33
Sucrose	100 = reference standard
Sugar Alcohols (Polyols)	
Sorbitol	60
Maltitol	80
Xylitol	100
Artificial Sweeteners (Noncarbohydrate)	
Aspartame	18 000
Saccharin	45 000
Sucralose	60 000
Neotame	1 000 000

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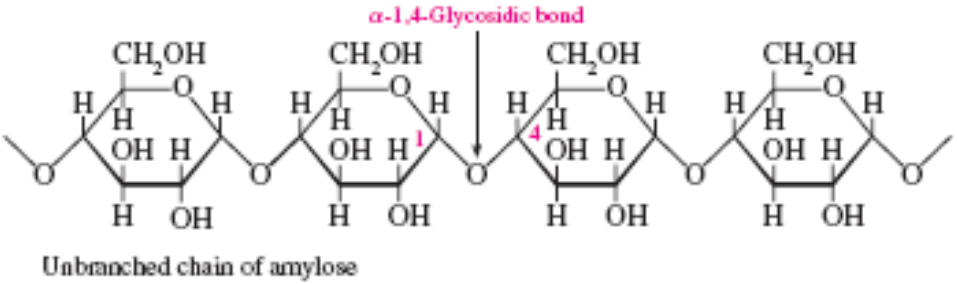
Polysaccharides are polymers of D-glucose

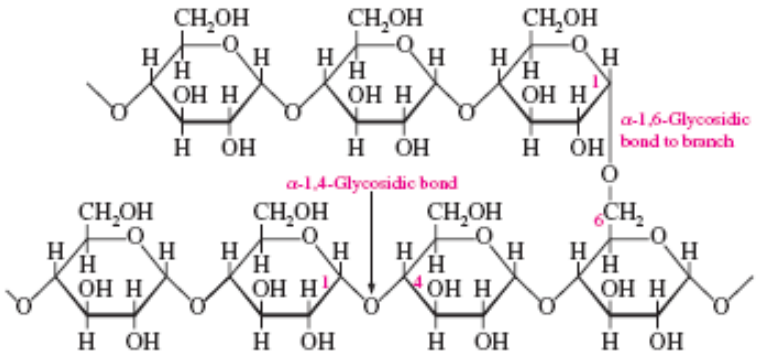
they include amylose and amylopectin, starches made of α-D-glucose;

they include glycogen (animal starch in muscle), made of α-D-glucose

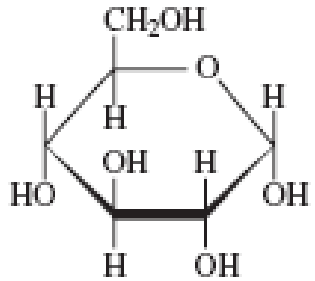
they include cellulose (plants and wood), made of β-D-glucose



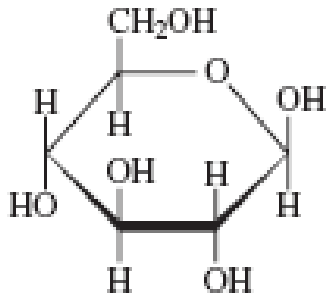
Unbranched chain of amylose



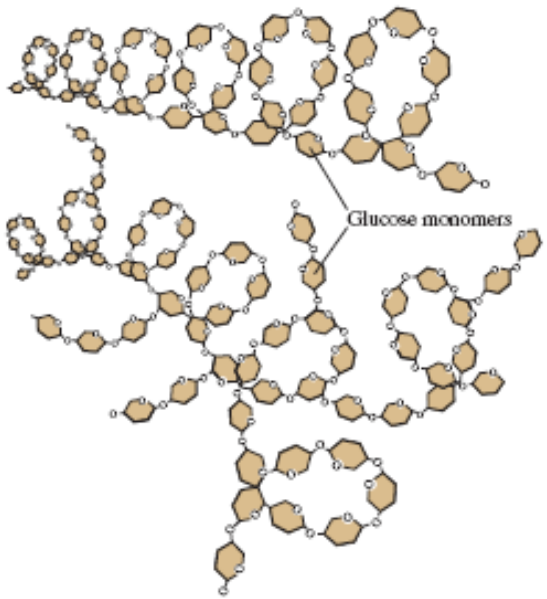
Branched-chain of amylopectin



α-D-Glucose



β-D-Glucose

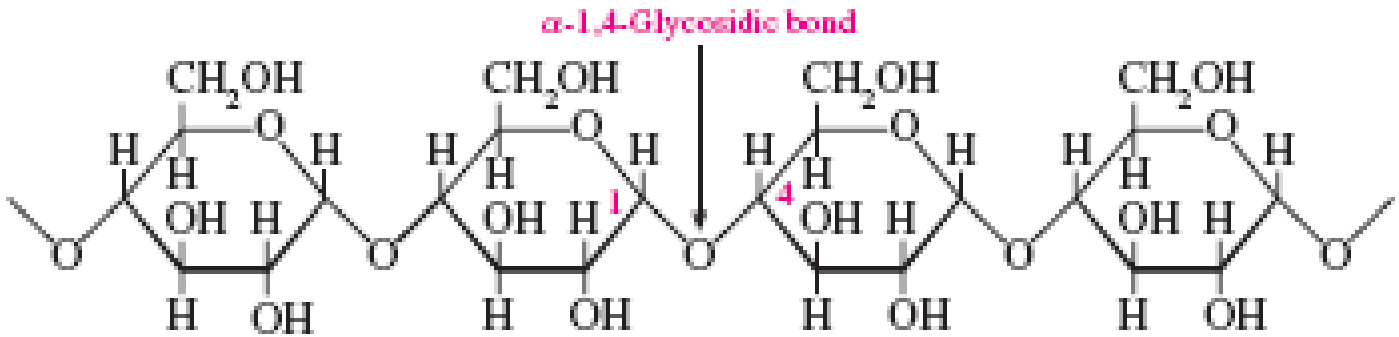


Amylose (20%)

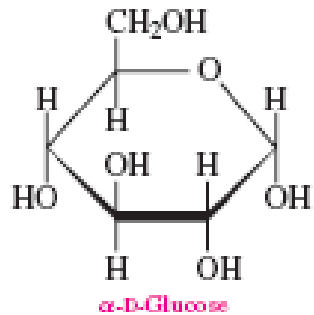
Amylopectin (80%)

Polysaccharides are polymers of D-glucose
they include amylose and amylopectin, starches made of α-D-glucose;

Amylose is a polymer of α-D-glucose molecules linked by α-1,4 glycosidic bonds to form a continuous (unbranched) chain

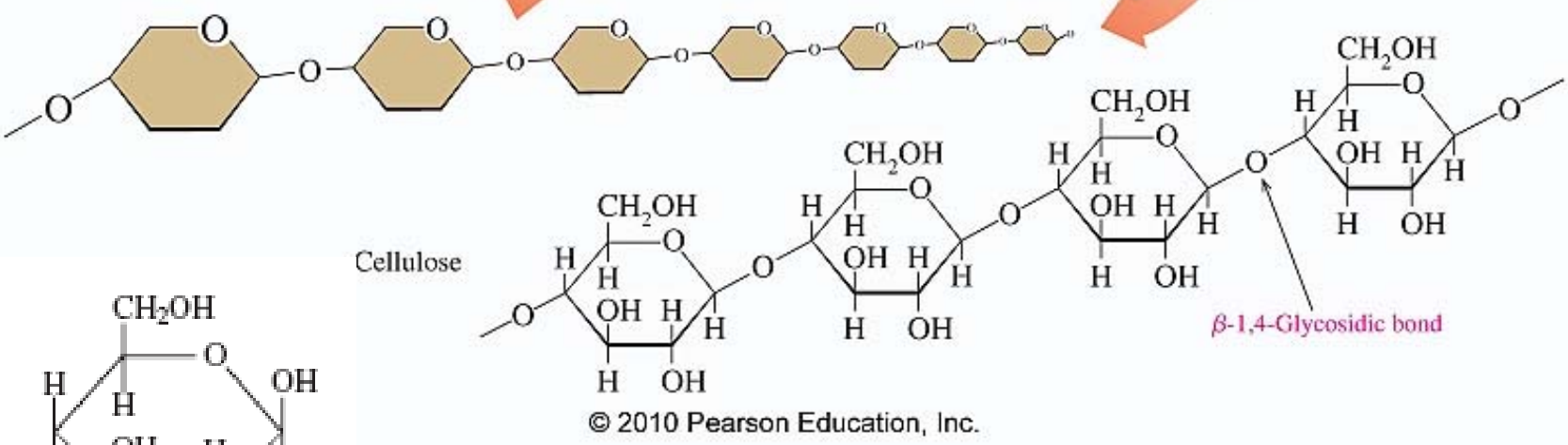


Unbranched chain of amylose

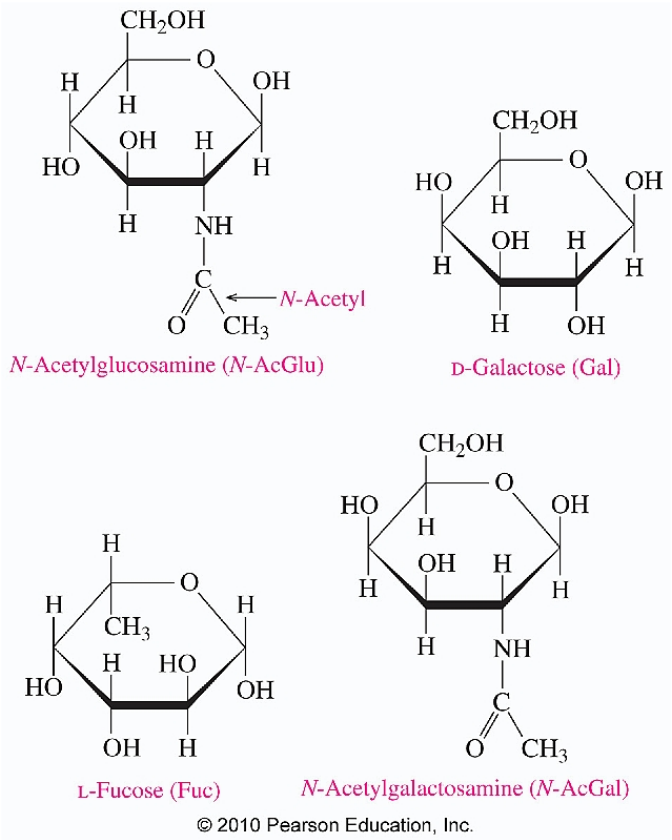


α-D-Glucose

Cellulose (plants and wood), is also made of D-glucose but the linkage is now β



The blood types A, B, and O are determined by saccharides attached to the surface of red blood cells. In type O, the end saccharides are *N*-acetylglucosamine, galactose, and fucose. These same three end saccharides also occur in type A and type B blood. In type A, the galactose is bonded to *N*-acetylgalactosamine. In type B, the galactose is bonded to another galactose. Thus, blood types A and B are determined by an end *N*-acetylgalactosamine (type A) or an end galactose (type B). In type AB, both sequences are at the ends of the saccharide chains



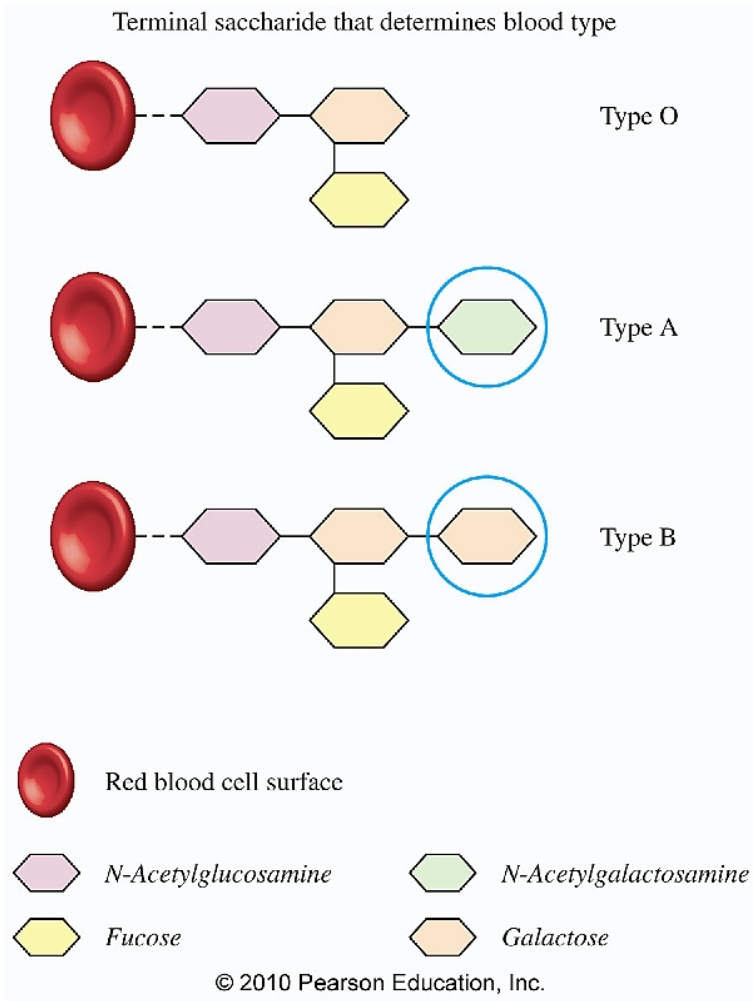


TABLE 15.3 Compatibility of Blood Groups

Blood Type	Antibodies Against	Can Receive
A	B	A, O
B	A	B, O
AB[a]	None	A, B, AB, O
O[b]	A, B	O

[a]AB universal recipient
[b]O universal donor

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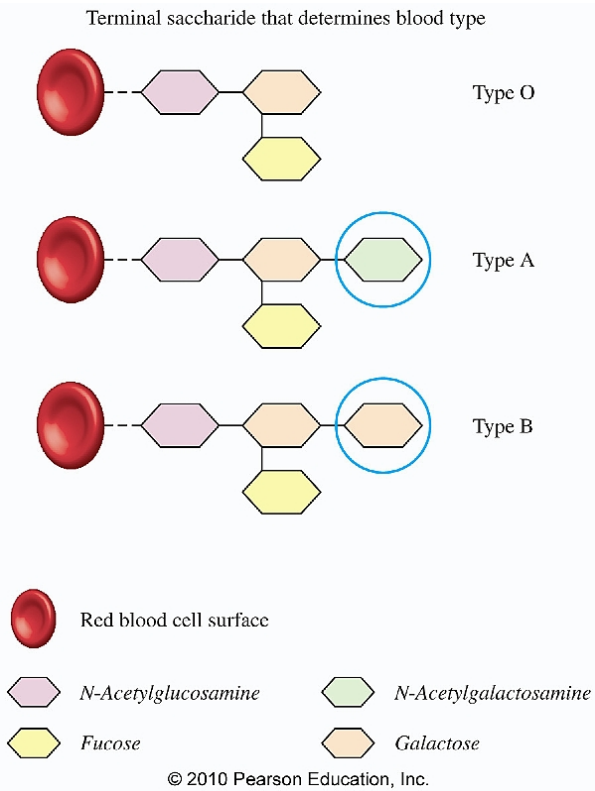

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