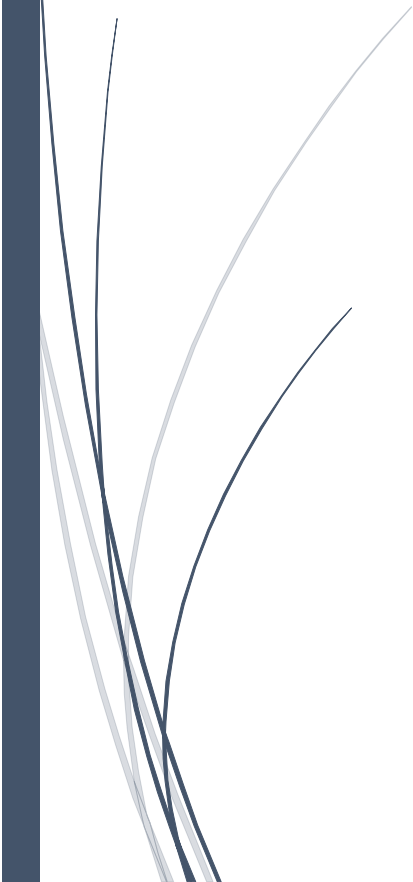
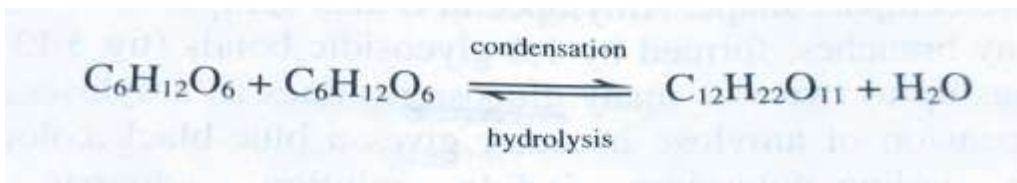


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# *Disaccharides*



A disaccharide (also called a double sugar or bivose) is the sugar formed when two monosaccharides (simple sugars) are joined by glycosidic linkage. Like monosaccharides, disaccharides are soluble in water. They are formed when two monosaccharides, usually hexoses, combine by means of a chemical reaction known as **condensation**. This means the removal of water as shown in the figure below. Three common examples are **sucrose, lactose, and maltose**.



Disaccharides are one of the four chemical groupings of carbohydrates (monosaccharides, disaccharides, oligosaccharides, and polysaccharides). The most common types of disaccharides—sucrose, lactose, and maltose—have 12 carbon atoms, with the general formula  $C_{12}H_{22}O_{11}$ . The differences in these disaccharides are due to atomic arrangements within the molecule.

The joining of simple sugars into a double sugar happens by a condensation reaction, which involves the elimination of a water molecule from the functional groups only.

Breaking apart a double sugar into its two simple sugars is accomplished by hydrolysis with the help of a type of enzyme called a disaccharidase. As building the larger sugar ejects a water molecule, breaking it down consumes a water molecule. These reactions are vital in metabolism. Each disaccharide is broken down with the help of a corresponding disaccharidase (sucrase, lactase, and maltase).

## CLASSIFICATION

There are two functionally different classes of disaccharides:

- **Reducing disaccharides**, in which one monosaccharide, the reducing sugar of the pair, still has a free hemiacetal unit that can perform as a reducing aldehyde group; lactose, maltose and cellobiose are examples of reducing disaccharides, each with one hemiacetal unit, the other occupied by the glycosidic bond, which prevents it from acting as a reducing agent. They can easily be detected by the Woehlk test or Fearon's test on methylamine.

- **Non-reducing disaccharides**, in which the component monosaccharides bond through an acetal linkage between their anomeric centers. This results in neither monosaccharide being left with a hemiacetal unit that is free to act as a reducing agent. Sucrose and trehalose are examples of non-reducing disaccharides because their glycosidic bond is between their respective hemiacetal carbon atoms. The reduced chemical reactivity of the non-reducing sugars in comparison to reducing sugars, may be an advantage where stability in storage is important.

## FORMATION

The formation of a disaccharide molecule from two monosaccharide molecules proceeds by displacing a hydroxyl radical from one molecule and a hydrogen nucleus (a proton) from the other, so that the now vacant bonds on the monosaccharides join the two monomers together. The vacant bonds on the hydroxyl radical and the proton unite in their turn, forming a molecule of water, that then goes free. Because of the removal of the water molecule from the product, the term of convenience for such a process is "dehydration reaction" (also "condensation reaction" or "dehydration synthesis"). For example, milk

sugar (lactose) is a disaccharide made by condensation of one molecule of each of the monosaccharides glucose and galactose, whereas the disaccharide sucrose in sugar cane and sugar beet, is a condensation product of glucose and fructose. Maltose, another common disaccharide, is condensed from two glucose molecules.

The dehydration reaction that bonds monosaccharides into disaccharides (and also bonds monosaccharides into more complex polysaccharides) forms what are called glycosidic bonds.

## **PROPERTIES**

The glycosidic bond can be formed between any hydroxyl group on the component monosaccharide. So, even if both component sugars are the same (e.g., glucose), different bond combinations (regiochemistry) and stereochemistry (alpha- or beta-) result in disaccharides that are diastereoisomers with different chemical and physical properties.

Depending on the monosaccharide constituents, disaccharides are sometimes crystalline, sometimes water-soluble, and sometimes sweet-tasting and sticky-feeling. Maltose, cellobiose, and chitobiose are hydrolysis products of the polysaccharides starch, cellulose, and chitin, respectively.

### Common Disaccharides

Disaccharide	Unit 1	Unit 2	Bond
Sucrose (table sugar, cane sugar, beet sugar, or saccharose)	Glucose	Fructose	$\alpha(1\rightarrow2)\beta$
Lactose (milk sugar)	Galactose	Glucose	$\beta(1\rightarrow4)$
Maltose (malt sugar)	Glucose	Glucose	$\alpha(1\rightarrow4)$
Trehalose	Glucose	Glucose	$\alpha(1\rightarrow1)\alpha$
Cellobiose	Glucose	Glucose	$\beta(1\rightarrow4)$
Chitobiose	Glucosamine	Glucosamine	$\beta(1\rightarrow4)$

Less common Disaccharides includes:

Disaccharide	Units	Bond
Kojibiose	two glucose monomers	$\alpha(1\rightarrow2)$ <sup>[10]</sup>
Nigerose	two glucose monomers	$\alpha(1\rightarrow3)$
Isomaltose	two glucose monomers	$\alpha(1\rightarrow6)$
$\beta,\beta$ -Trehalose	two glucose monomers	$\beta(1\rightarrow1)\beta$
$\alpha,\beta$ -Trehalose	two glucose monomers	$\alpha(1\rightarrow1)\beta$ <sup>[11]</sup>
Sophorose	two glucose monomers	$\beta(1\rightarrow2)$
Laminaribiose	two glucose monomers	$\beta(1\rightarrow3)$
Gentiobiose	two glucose monomers	$\beta(1\rightarrow6)$
Trehalulose	a glucose monomer and a fructose monomer	$\alpha(1\rightarrow1)$
Turanose	a glucose monomer and a fructose monomer	$\alpha(1\rightarrow3)$
Maltulose	a glucose monomer and a fructose monomer	$\alpha(1\rightarrow4)$
Isomaltulose	a glucose monomer and a fructose monomer	$\alpha(1\rightarrow6)$
Gentiobiulose	a glucose monomer and a fructose monomer	$\beta(1\rightarrow6)$
Mannobiose	two mannose monomers	either $\alpha(1\rightarrow2)$ , $\alpha(1\rightarrow3)$ , $\alpha(1\rightarrow4)$ , or $\alpha(1\rightarrow6)$
Melibiose	a galactose monomer and a glucose monomer	$\alpha(1\rightarrow6)$
Melibiulose	a galactose monomer and a fructose monomer	$\alpha(1\rightarrow6)$

Rutinose	a rhamnose monomer and a glucose monomer	$\alpha(1\rightarrow6)$
Rutinulose	a rhamnose monomer and a fructose monomer	$\beta(1\rightarrow6)$