CHARBOHYDRATE

Carbohydrates are molecules that contain **carbon, hydrogen,** and **oxygen**.

There are twice as many hydrogen atoms as carbon or oxygen atoms.

The **general formula** for a carbohydrate can be written as $C_x(H_2O)_y$.

They act as the source of energy (e.g. glucose), as a store of energy (e.g. starch and glycogen) and as structural units (e.g. cellulose in plants and chitins in insects).

Most carbohydrates are **polymers**.

Polymers are large, complex molecules composed of long chains of monomers.

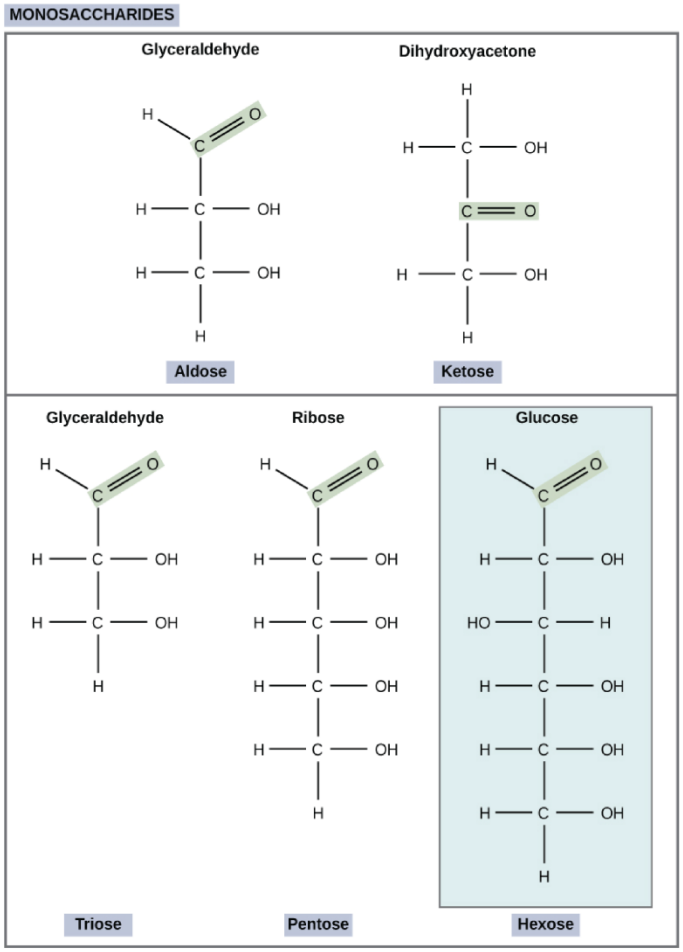
Monomers are small, basic molecular units.

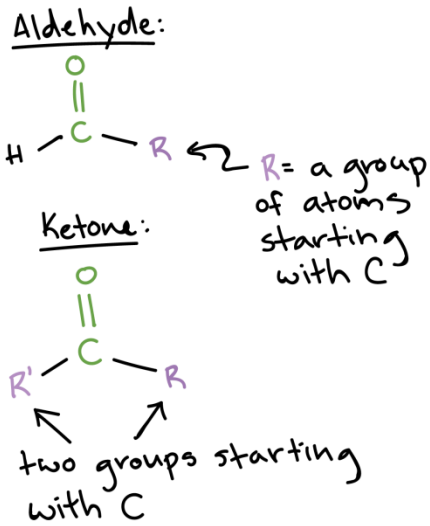
Carbohydrates can be divided into **three groups**: **monosaccharides, disaccharides**, and **polysaccharides.**

MONOSACCHRIDES

- **Monosaccharides** are simple sugars in which there are one oxygen atom and two hydrogen atoms for each carbon atom present in the molecule.
- They have **general formula** as $(CH_2O)_n$.
- Monosaccharides are **reducing sugars**.
- The test for reducing sugar is called **Benedict's test**.
- They are **sugars**, which taste sweet, are soluble in water and are insoluble in non-polar solvents.
- They exist in **straight chains** or **in the ring** or **cyclic forms**.
- They are classified according to the number of carbon atoms in each molecule as **trioses (3C), tetroses (4C), pentoses (5C), hexoses (6C), heptoses (7)** and so on.
- The names of all sugars end with **-ose**.
- **Examples:** Glyceraldehyde (triose), Erythrose (tetrose), Ribose (pentose), Glucose (hexose), Fructose (hexose), Galactose (hexose), Sedoheptulose (heptose), etc.
- They are important building blocks for large molecules.

STRUCTURE





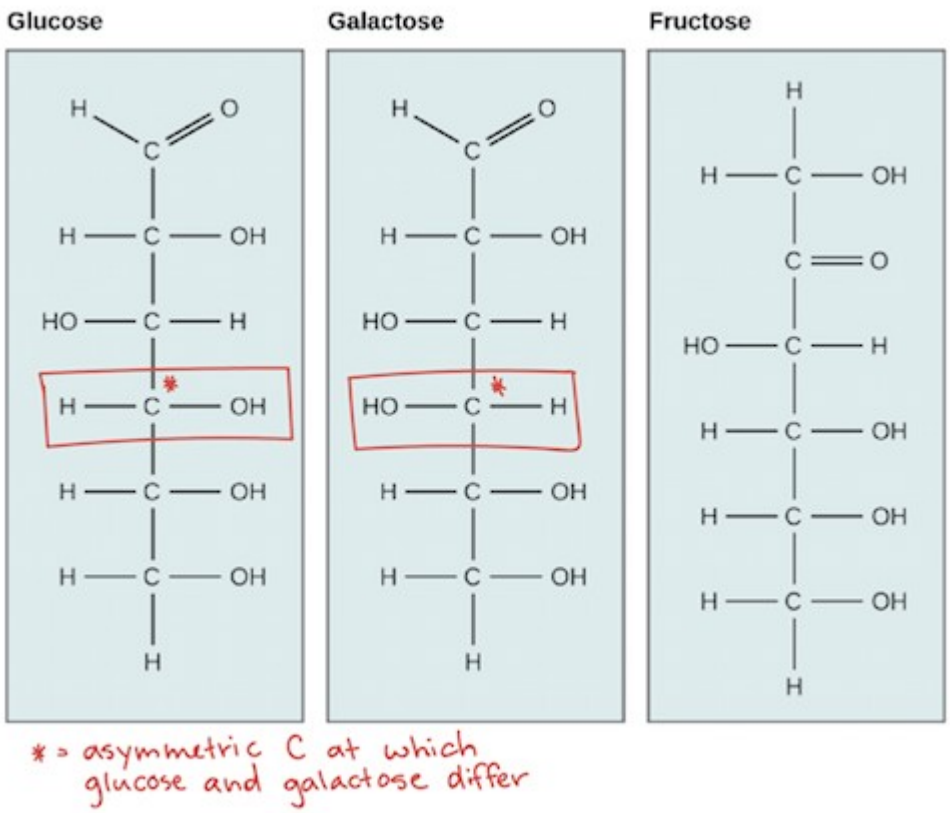
Most of the oxygen atoms in monosaccharides are found in hydroxyl (OH) groups, but one of them is part of a carbonyl (C=O) group. The position of the carb(C=O) group can be used to categorize the sugars:

- If the sugar has an **aldehyde group**, meaning that the carbonyl C is the last one in the chain, it is known as an **aldose.**
- If the carbonyl C is internal to the chain, so that there are other carbons on both sides of it, it forms a **ketone group** and the sugar is called a **ketose**.

Sugars are also named according to their number of carbons: some of the most common types are trioses (three carbons), pentoses (five carbons), and hexoses (six carbons).

Glucose and its isomers-

Glucose, galactose, and fructose have the same chemical formula ($C_6H_{12}O_6$), but they differ in the organization of their atoms, making them **isomers** of one another. Fructose is a **structural isomer** of glucose and galactose, meaning that its atoms are actually bonded together in a different order.



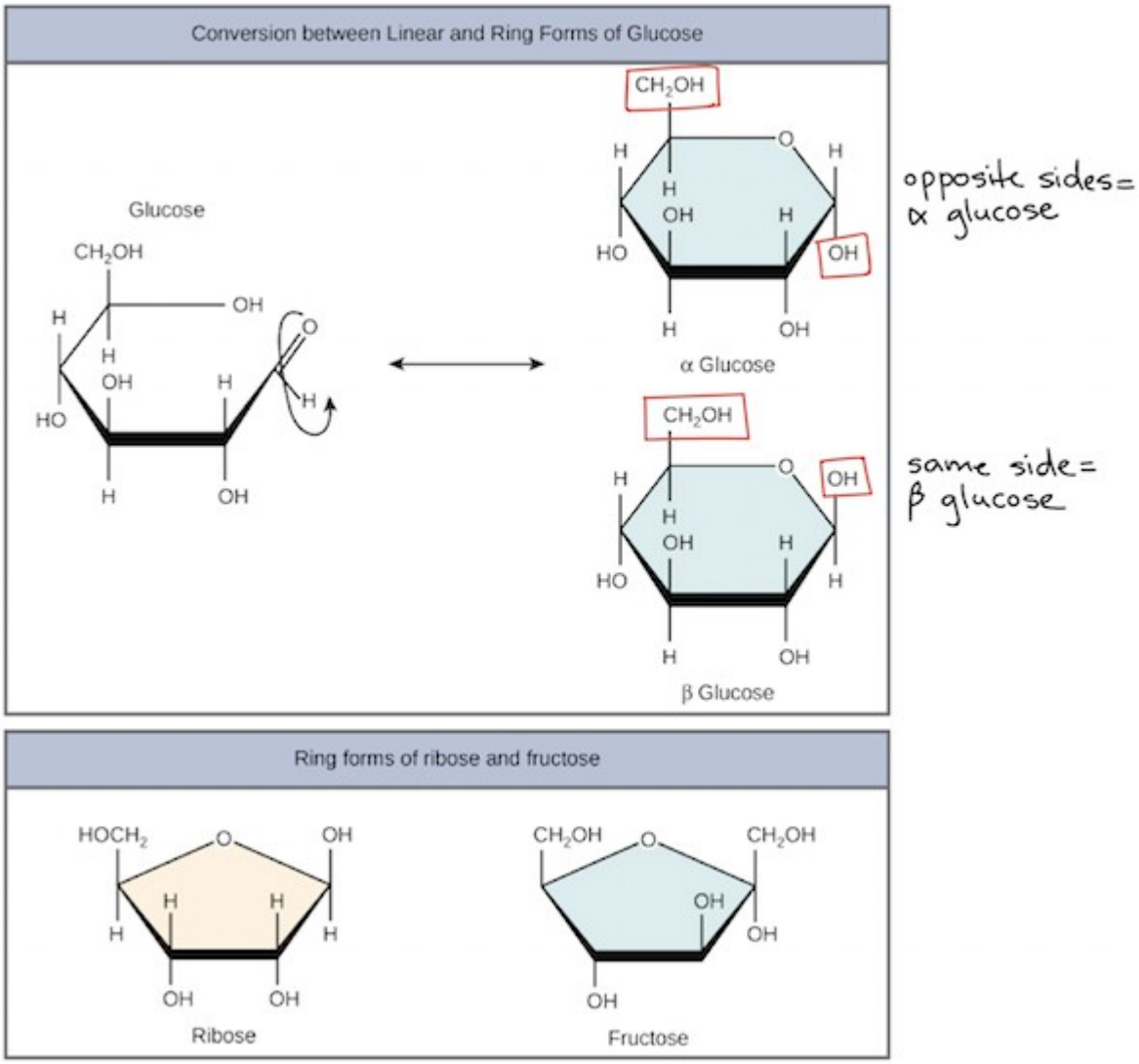
Glucose and galactose are **stereoisomers** of each other: their atoms are bonded together in the same order, but they have a different 3D organization of atoms around one of their asymmetric carbons. You

can see this in the diagram as a switch in the orientation of the hydroxyl(OH) group, marked in red.

Ring forms of sugars

sugars we've looked at so far are linear molecules (straight chains). That may seem odd because sugars are often drawn as rings. As it turns out both are correct: many five- and six-carbon sugars can exist either as a linear chain or in one or more ring-shaped forms. equilibrium strongly favors the ring forms (particularly in aqueous, or water-based, solution). For instance, in solution, glucose's main configuration is a six-membered ring.

S

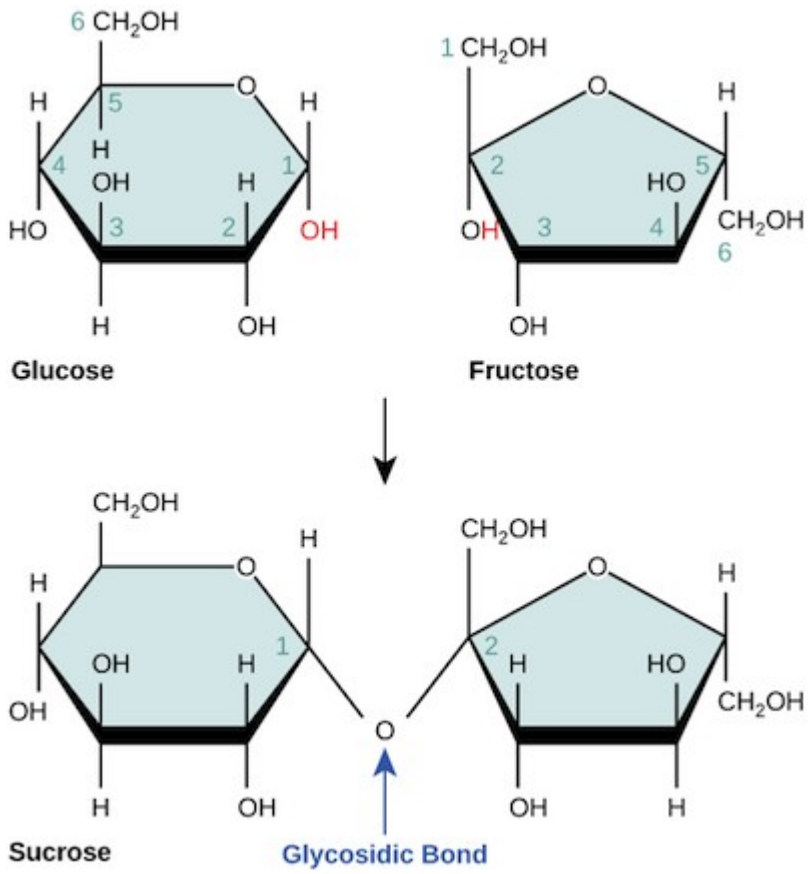


Disaccharides

Disaccharides (*di-* = “two”) form when two monosaccharides join together via a dehydration reaction

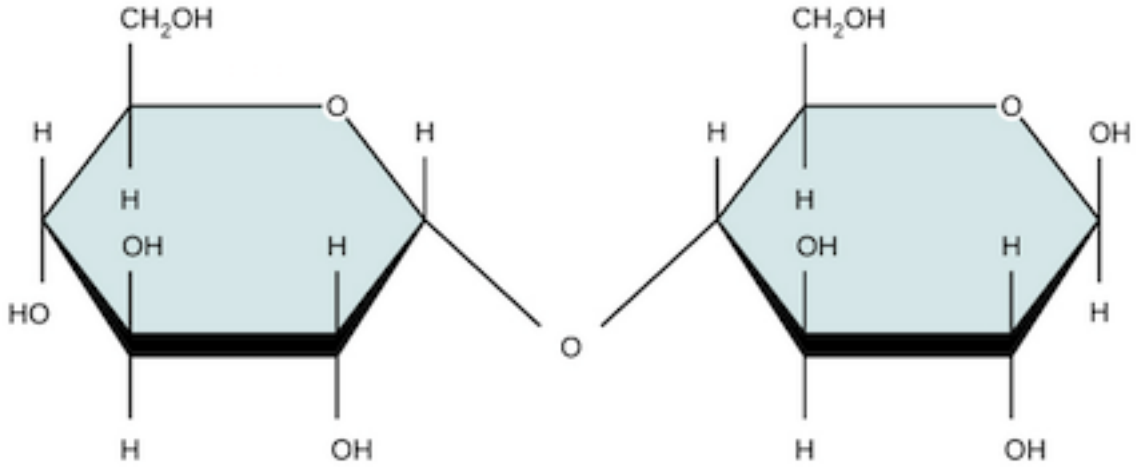
In this process, the hydroxyl group of one monosaccharide combines with the hydrogen of another, releasing a molecule of water and forming a covalent bond known as a glycosidic linkage.

the diagram below shows glucose and fructose monomers combining via a dehydration reaction to form sucrose, a disaccharide we know as table sugar.

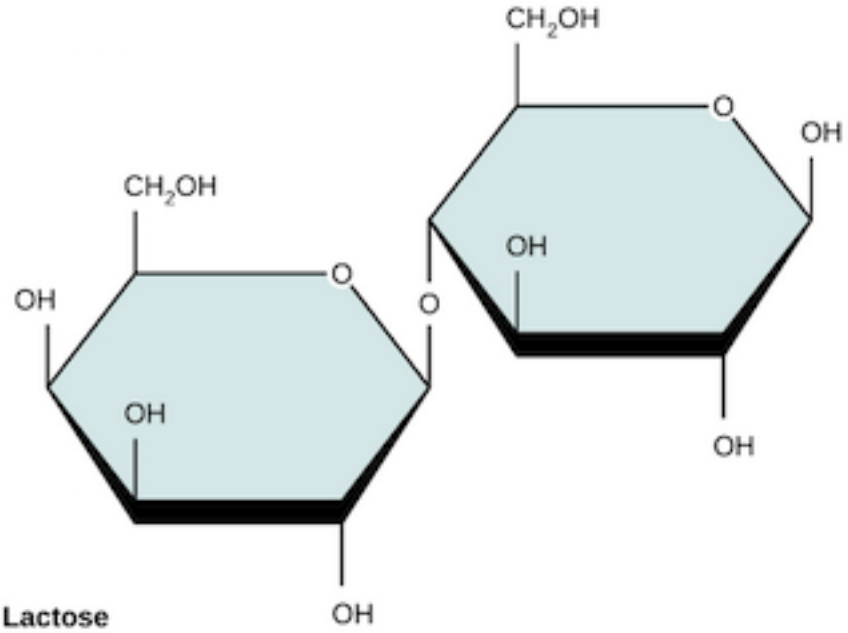


Examples: Maltose is formed from two α-glucose molecules joined together by a glycosidic bond. **Sucrose** is formed from a condensation reaction between a glucose molecule and a fructose molecule. **Lactose** is formed from glucose and a galactose molecule.

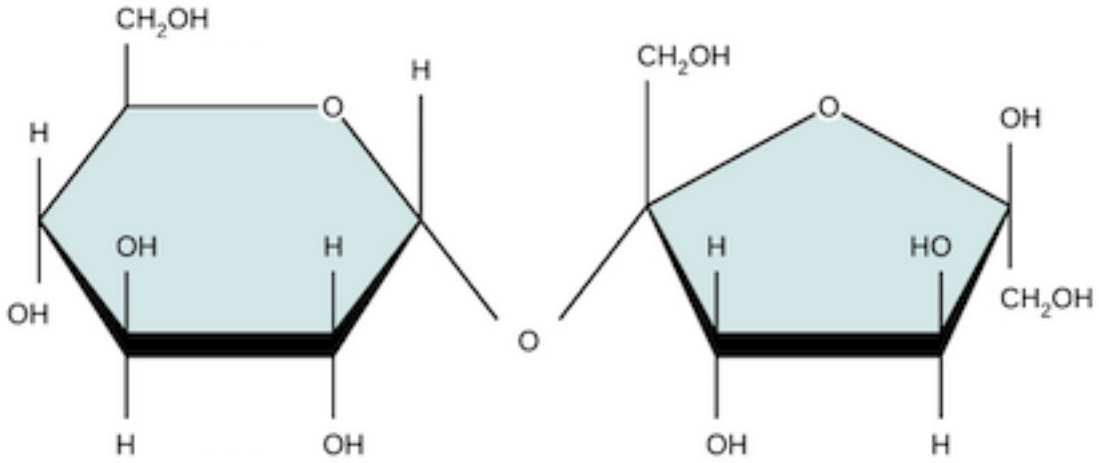
Sucrose is a **non-reducing sugar**.



Maltose



Lactose



Sucrose

Disaccharides can be split apart into two monosaccharides by breaking the glycosidic bond by adding water molecules, which is known as **hydrolysis reaction** Sucrose is the transport sugar

Polysaccharides

- molecules linked by glycosidic bonds between carbon 1 and carbon 4.
- **Starch** is the main energy storage materials in plants. **Glycogen** is the main energy storage materials in animals. **Cellulose** is the major component of cell walls in plants.The test for starch is called an iodine test.A long chain of monosaccharides linked by glycosidic bonds is (*poly*- = "many"). known as a **polysaccharide**

Polysaccharides are polymers formed by combining many monosaccharide molecules (more than two) by condensation reactions.

Molecules with 3-10 sugar units are known as **oligosaccharides** while molecules containing 11 or more monosaccharides are **true polysaccharides**.

Polysaccharides **do not taste sweet**.

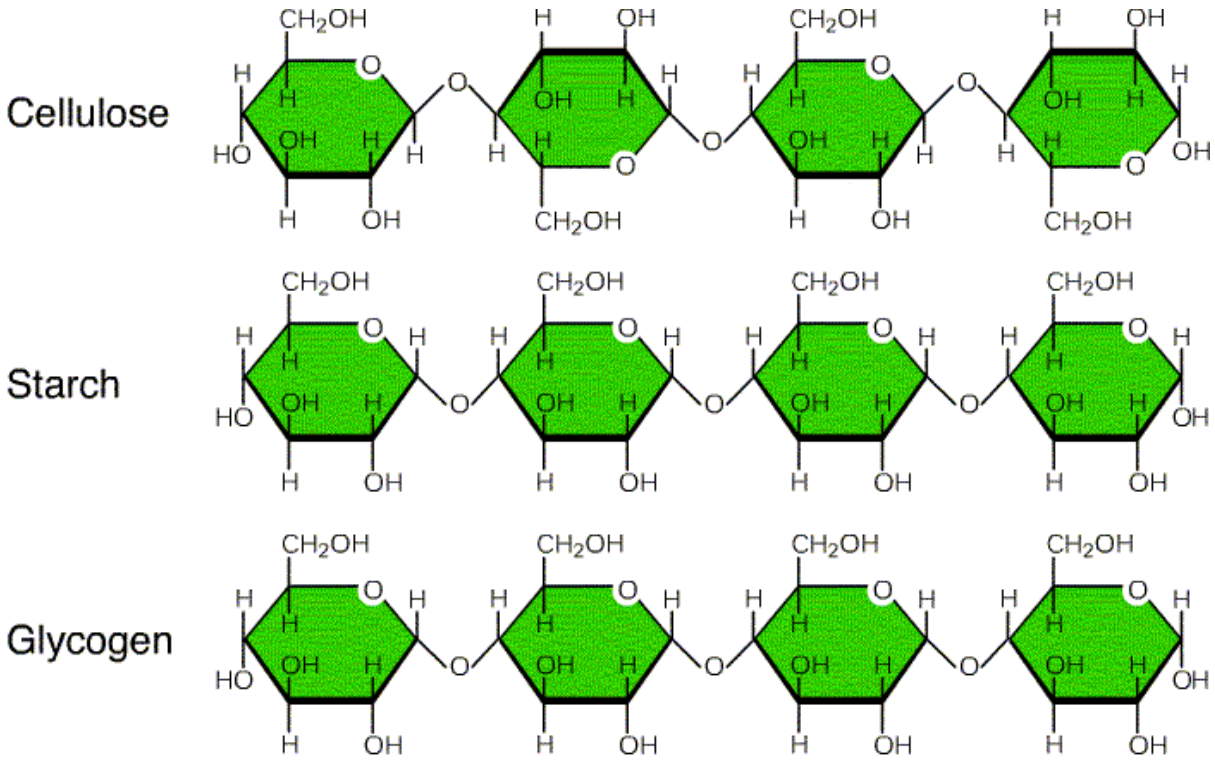
Because their molecules are so enormous, the majority of polysaccharides **do not dissolve in water**.

Polysaccharides made solely from one kind of monosaccharides are called **homopolysaccharides** (Starch) while those made of more than one monomer are called **heteropolysaccharides** (Hyaluronic acid).

Starch, glycogen, cellulose, and chitin are some major examples of polysaccharides important in living organisms.

- **Starch** is made up of long chains of α-glucose (Amylose and Amylopectin). **Glycogen** is made of α-glucose linked together

by glycosidic bonds. Cellulose is also made of many β-glucose called an **Iodine test**.

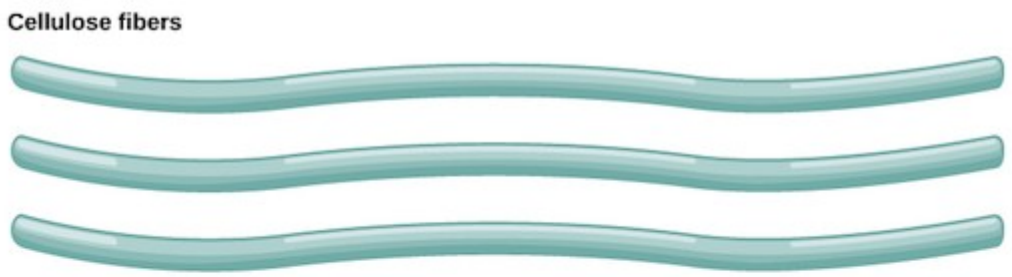


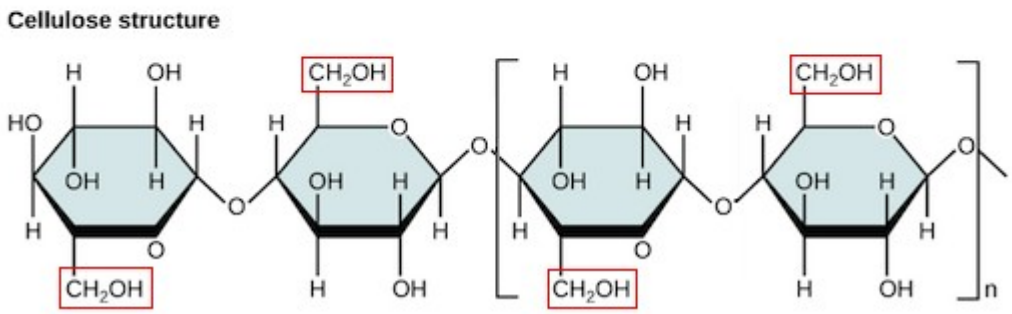
Starch is the stored form of sugars in plants and is made up of a mixture of two polysaccharides, amylose and amylopectin (both polymers of glucose).

- **Amylose** consists entirely of unbranched chains of glucose monomers connected by 1-4 linkages.
- **Amylopectin** is a branched polysaccharide. Although most of its monomers are connected by 1-4 linkages, additional 1-6 linkages occur periodically and result in branch points.

Glycogen is the storage form of glucose in humans and other vertebrates. it is even more highly branched than amylopect

Cellulose, for example, is a major component of plant cell walls, which are rigid structures that enclose the cells (and help make lettuce and other veggies crunchy). Wood and paper are mostly made of cellulose, and cellulose itself is made up of unbranched chains of glucose monomers linked by 1-4 glycosidic bonds.





The β glycosidic linkages in cellulose can't be broken by human digestive enzymes, so humans are not able to digest cellulose.