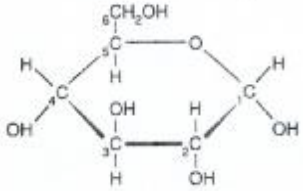
Unit 2

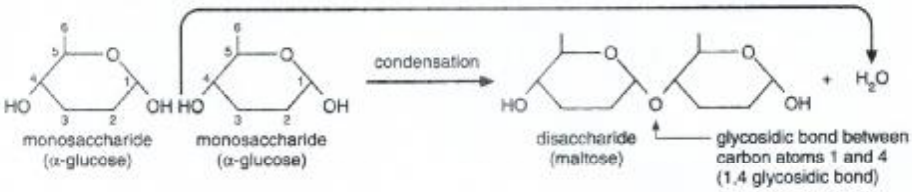
CARBOHYDRATES

- **Carbohydrates** are organic molecules containing the elements carbon, hydrogen, and oxygen. They are found in all living organisms.
- The simplest sort of carbohydrate is a **monosaccharide** or single sugar molecule. There are many different types of monosaccharide, but they all have the general formula $C_nH_{2n}O_n$. This tells us that they always contain twice as many hydrogen atoms as they do carbon or oxygen atoms. Different types of monosaccharide are divided up according to the exact number of carbon atoms that they contain.
- **Triose** monosaccharides have three carbon atoms.
- **Pentose** monosaccharides have five carbon atoms. Examples include **ribose** and **deoxyribose**, which are used in the construction of larger molecules like RNA (ribonucleic acid) and DNA (deoxyribonucleic acid) (see unit 10).
- **Hexose** monosaccharides have six carbon atoms. Examples include **glucose**, **galactose**, and **fructose**, which all have the formula $C_6H_{12}O_6$. Because they are built out of the same atoms, arranged differently, we describe these hexose sugars as **isomers**. The structural formula of **α-glucose** is shown below.



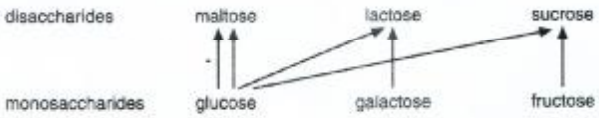
As you can see in the diagram, the carbon atoms are numbered, clockwise, from one to six. An alternative form of glucose is **β-glucose**, in which the OH group, attached to carbon atom number one, sticks up above the ring, with the H below.

- Two monosaccharides can be joined together by a **condensation reaction**, in which water is removed, to produce a **disaccharide**. The bond formed between the two monosaccharides is known as a **glycosidic bond**. A diagram showing the formation of the disaccharide **maltose**, from two molecules of α-glucose, is shown below.



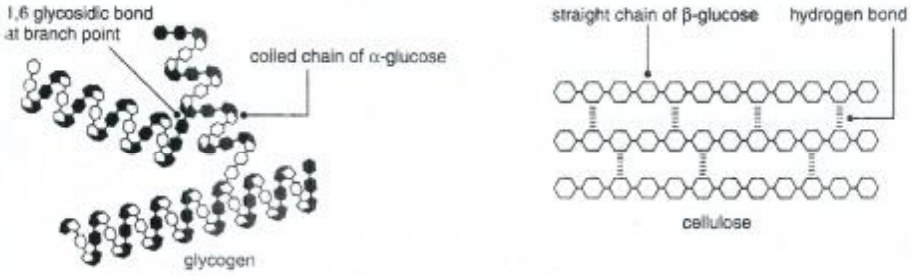
The bond formed in this case is called a **1,4 glycosidic bond**, because it links the first carbon of one monosaccharide with the fourth carbon of the other.

- Other disaccharides include **lactose** and **sucrose**. Here is a summary of disaccharide formation.



- All the monosaccharides and disaccharides are sugars. They come in the form of sweet, white crystals that can dissolve in water. The sugar that we put in our tea and coffee is sucrose. This is obtained from plants, such as sugar cane, where it is naturally used as a transport carbohydrate (see unit 21).
- If many monosaccharides are joined in a chain the result is a **polysaccharide**. Examples include **glycogen**, **starch**, and **cellulose**.
- Glycogen and starch are **storage carbohydrates**. They are manufactured when an organism has spare glucose to hand, and broken down again when glucose is running low. Glycogen is used by animals and starch by plants.

- Both molecules are built from coiled chains of α-glucose. Glycogen consists of branching chains, with **1,6 glycosidic bonds** at the branch points. Starch is a mixture of two types of molecule: **amylopectin**, which is branched, and **amylose**, which isn't.
- Because of their large size, both glycogen and starch are **insoluble**. This means that they can't diffuse out of the cells they're stored in, or cause osmotic problems. Because they contain branching chains, they are **compact**, which means that they can store a lot of energy in a small space.
- Cellulose is a **structural carbohydrate** that is used to build **cell walls** in a plant (see unit 5). It consists of straight chains of β-glucose which are linked together by hydrogen bonds to form a rigid structure, similar to scaffolding.



Glycogen and cellulose