

# Monomers and Polymers I

There is an extensive variety of life, both today and in the past, however the biochemical properties that make up life have always been similar. Despite the large range of life on Earth, the cells of every living organism all contain the same types of compounds: carbohydrates, lipids, proteins and nucleic acids – this provides indirect evidence for evolution. Carbohydrates, lipids and proteins are also important components of our diet.

**Carbohydrates** are respiratory substrates of cells and are comprised of carbon, hydrogen and oxygen atoms. Note: In every carbohydrate there are always twice the number of hydrogen atoms as there are oxygen atoms. For example glucose:  $C_6H_{12}O_6$ .

**Lipids** (or 'fats') are important components of plasma membranes.

**Proteins** are very important in forming cellular structures, such as receptors. They can also function as enzymes and can be used as chemical messengers.

**Nucleic acids** (Adenine, Thymine/ Uracil, Cytosine and Guanine) are the single units of the genetic code used in the production of proteins. The genetic code is the same in all living organisms, this also provides evidence for evolution.

As different cells are specialised to perform different functions, the proteins and carbohydrates of cells from different tissues can be different. Due to this, the most common component of cells is water.

## I. Monomers

**Monomers** are small, single units that make up larger molecules, known as **polymers**. In order to create a polymer, many monomers are linked together by reactions known as condensation reactions, this involves the release of a water molecule.

Examples of monomers include: monosaccharides (the units of carbohydrates), nucleotides (the units of DNA) and amino acids (the units of proteins).

## II. Monosaccharides

A **monosaccharide** is a type of carbohydrate molecule in which the atoms are arranged in a single 'ring' structure. **Hexoses** are monosaccharides that contain 6 carbon atoms in each molecule, they all have the chemical formula  $C_6H_{12}O_6$  but are arranged differently, resulting in different molecules.

Four important hexoses are shown in the following diagram, they are:  $\alpha$ - glucose,  $\beta$ - glucose, fructose and galactose.

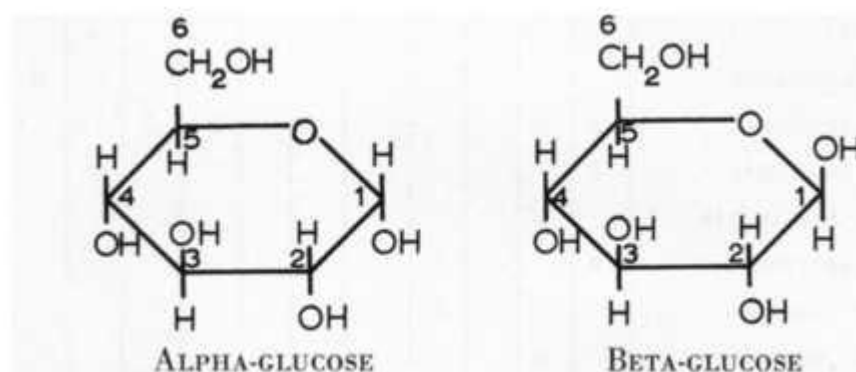


Image source: <http://www.thescienceforum.com/biology/15811-molecular-difference-between-alpha-beta-glucose.html>

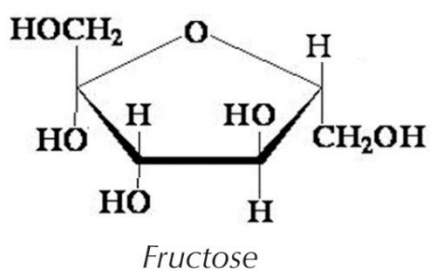


Image source: <http://imagefiesta.com/beta-l-fructose>

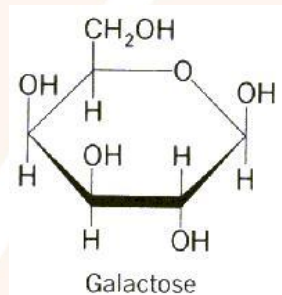


Image source:  
<http://www.warenkennis.nl/suiker/produktie.htm>

The numerical system shown in  $\alpha$  and  $\beta$  glucose is the number of the carbon being referred to and is used to describe where the link is made between two monomeric units, this will be explained more later.

### III. Disaccharides

A **disaccharide** is formed when two monosaccharides molecules are linked together. Examples of disaccharides are maltose, sucrose and lactose.

- One **maltose** molecule is formed when two  $\alpha$  glucose molecules are linked together.
- One **sucrose** molecule is formed when one  $\alpha$  glucose molecule is linked to one fructose molecule.
- One **lactose** molecule is formed when one  $\beta$  glucose molecule is linked to one molecule of galactose.

The chemical structures of maltose, sucrose and lactose are shown in the following diagram:

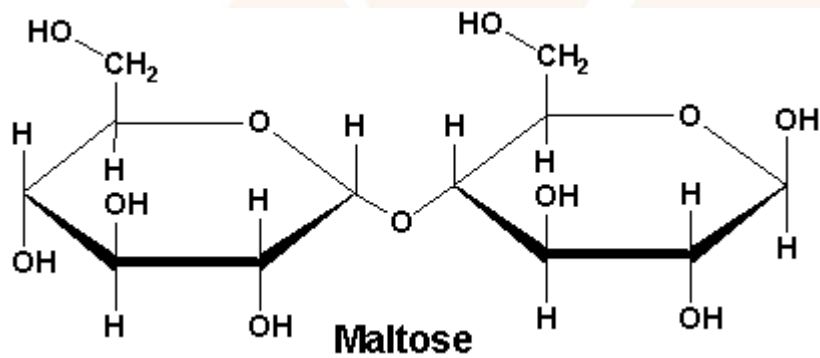
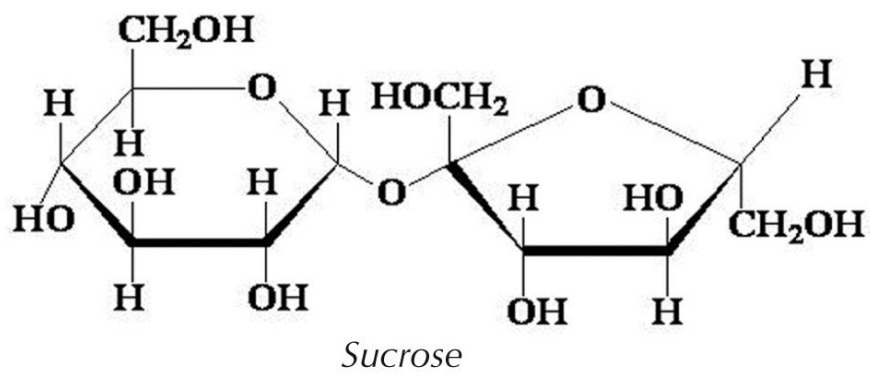


Image Source: <http://oregonstate.edu/dept/biochem/hhmi/hhmiclasses/bb450/winter2002/ch09/maltose.htm>



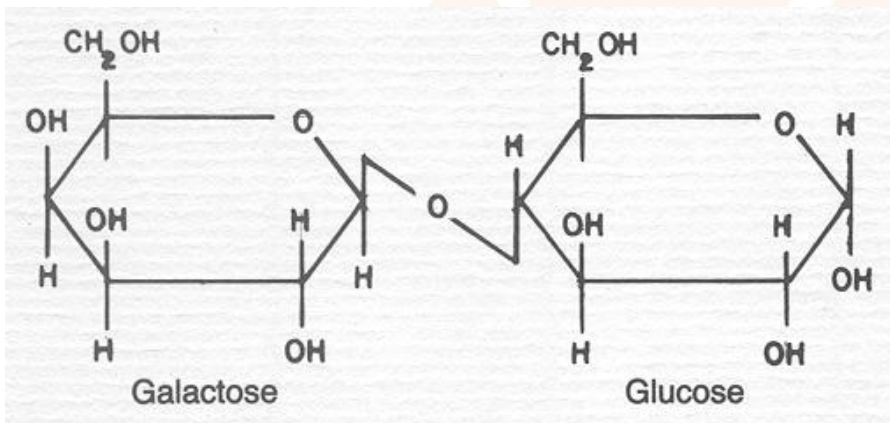


Image Source: <http://naturalnutmeg.com/good-carbs-bad-carbsits-anything-but-simple/>

Note: The molecular formula of each disaccharide is NOT  $C_{12}H_{24}O_{12}$  as you would expect, but instead is  $C_{12}H_{22}O_{11}$  –this is because every time a bond forms between two monosaccharides to form a disaccharide, one molecule of water, or  $H_2O$ , is released.

#### IV. The Condensation Reaction

A condensation reaction occurs when two monosaccharide molecules join to form a disaccharide molecule. During this reaction, a hydroxyl ( $-OH$ ) group is taken from one monosaccharide and a hydrogen atom ( $H$ ) is taken from the other monosaccharide to release the molecule of water, this allows a bond to be formed that holds the two monosaccharides together. An example of this reaction could be when two  $\alpha$ - glucose molecules are joined by a condensation reaction to form a single maltose molecule, this is shown in the following diagram:

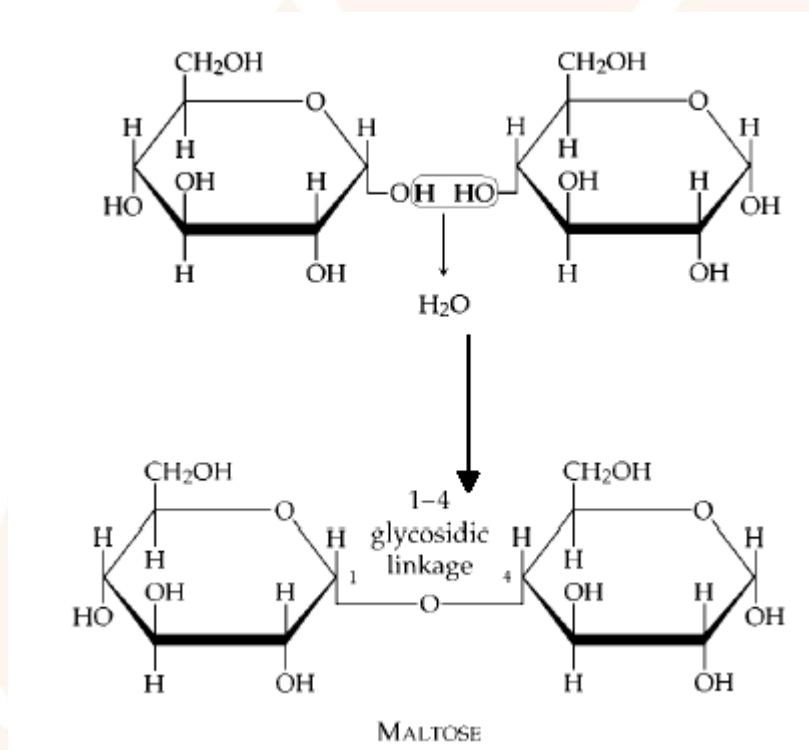


Image source: <http://soltechenergies.net/wp-admin/js/condensation-reaction-for-carbohydrates-805.gif>

## V. The Hydrolysis Reaction

When water is added to a disaccharide, a reaction known as a **hydrolysis reaction** occurs. A hydrolysis reaction is the opposite reaction to a condensation reaction, whereby a molecule of water is 'added back', thus splitting the disaccharide into its monosaccharide components. An example of a hydrolysis reaction is shown in the following diagram, whereby one molecule of water is hydrolysed into two molecules of  $\alpha$ - glucose.

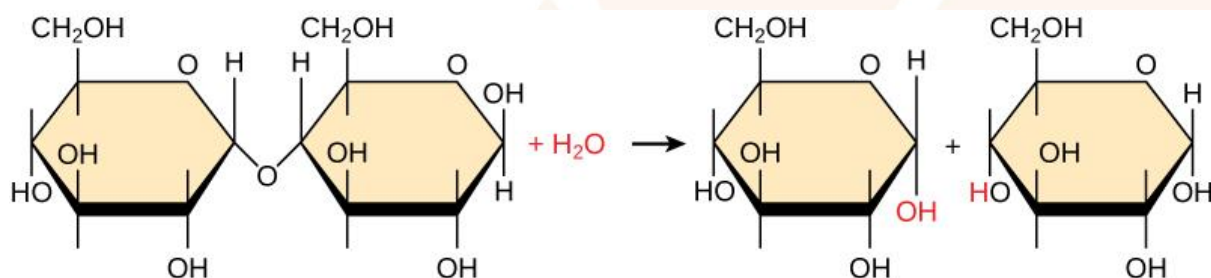


Image Source: [http://cnx.org/resources/bac340d3e94099ab5cf86f612177b6bc4c941ebd/Figure\\_03\\_01\\_02.jpg](http://cnx.org/resources/bac340d3e94099ab5cf86f612177b6bc4c941ebd/Figure_03_01_02.jpg)

## VI. Bonding Nomenclature

The bond that holds the two  $\alpha$  - glucose molecules together is called an  $\alpha$  - 1, 4- glycosidic bond because:

- It joins two  $\alpha$  - glucose molecules
- The bond formed is between carbon atom **1** of the glucose molecule and carbon atom **4** of the other.
- The bond is between two glucose molecules (**glycosidic**)

# Multiple Choice Questions

1. **A monomer is:**
  - A) The opposite of a polymer
  - B) A single molecule
  - C) A single unit of a polymer
  - D) Formed by the addition of two polymers
2. **What are monosaccharides an example of?**
  - A) Nucleic acid monomers
  - B) Carbohydrate monomers
  - C) Lipid monomers
  - D) Proteins
3. **Name three monosaccharides:**
  - A) Sucrose, Maltose, Galactose
  - B) Maltose,  $\alpha$ - glucose,  $\beta$ - glucose
  - C) Fructose, Galactose,  $\beta$ - glucose
  - D) Maltose, Sucrose, Fructose
4. **What is true of the condensation reaction?**
  - A) A molecule of water is released
  - B) It is the reaction used to split a disaccharide into its two monosaccharide components
  - C) It is the reaction used to join two different monosaccharides only
  - D) The addition of water is required for the condensation reaction to take place.
5. **What is the molecular formula of a disaccharide?**
  - A)  $C_6H_{12}O_6$
  - B)  $C_{12}H_{24}O_{12}$
  - C)  $C_{12}H_{22}O_{11}$



D)  $C_{10}H_{12}O_4$

6. What is the name of the bond formed between two monosaccharides after a condensation reaction has taken place?

- A) A hydrogen bond
- B) An ester bond
- C) A glycosidic bond
- D) An ionic bond

7. How many carbon atoms are in hexose carbohydrates?

- A) 5
- B) 6
- C) 7
- D) 8

8. What is the difference between different monosaccharides?

- A) They have different numbers of hydrogen atoms per molecule
- B) They have a different arrangement of atoms
- C) They have a different number of oxygen atoms
- D) They have a different number of carbon atoms

9. Which of these disaccharides is not comprised of  $\alpha$ - glucose?

- A) Maltose
- B) Sucrose
- C) Lactose
- D) None of the above

10. What is hydrolysis?

- A) The digestion of sugars
- B) The breaking down of one disaccharide molecule into its component monosaccharides
- C) The joining of two monosaccharides to make a disaccharide

D) The splitting of a water molecule

**Answers:**

1. C
2. B
3. C
4. A
5. C
6. C
7. B
8. B
9. C
10. B