POLYMERS

Properties of plastics:-

1. They do not conduct electricity or heat
2. They are unreactive. Most are not affected by air, water, acid or other chemicals. This means they are usually safe for storing things in, including food.
3. They are usually light to carry, much lighter than wood, stone or glass or most metals.
4. They do not break when you drop them. You have to hammer most rigid plastics quite hard, to get them to break.
5. They are strong. This is because their long molecues are attracted to each other. Most plastics are hard to tear or pull apart.
6. They do not catch fire easily, but when we heat them, some soften and melt and some char.

Examples of different polymers and their uses:-

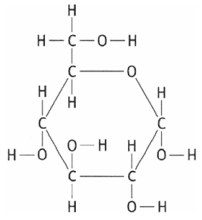
Polymer	Examples of uses
Polythene	Plastic bags and gloves, Clingfilm, mugs, bowls, chairs, etc.
Polyvinyl Chloride (PVC)	Water pipes, wellingtons, hoses, covering for electric cables.
Polypropene	Crates, ropes
Polystyrene	Used as expanded polystyrene in fast-food cartons, packaging, and insulation for roofs and walls
Teflon	Coating on frying pans to make them onn-stick, fabric protector, windscreen wipers, flooring
Nylon	Ropes, fishing nets and lines, tents, curtains
Terylene	Clothing, thread

1. Natural Polymers:-

Examples of naturally occurring polymers are silk, wool, DNA, cellulose, carbohydrates, proteins, etc.

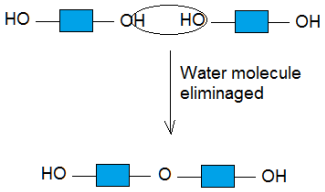
Carbohydrates:-

Carbohydrates contain just carbon, hydrogen and oxygen. Glucose ($C_6H_{12}O_6$) is called simple carbohydrate. It is also called a monosaccharide, which means a single sugar unit. The structure of glucose is as under:

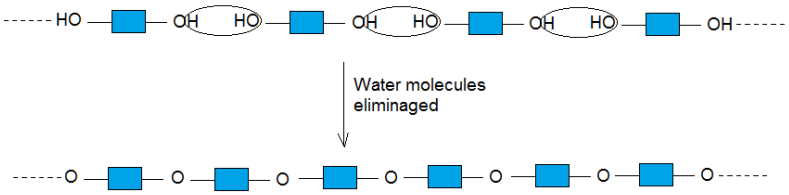


1. We can draw a glucose molecule like this, showing the two groups that react.

2. Two glucose molecules can join like this, giving maltose, a disaccharide:



3. Hundreds or thousands can join in the same way, giving starch, a complex carbohydrate. It is also called polysaccharide.



In reaction-2, two molecules join, eliminating a small molecule (water). So it is a condensation reaction. Reaction-3 is a condensation polymerization. So starch is a polymer.

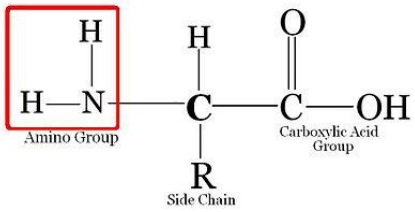
<u>Cellulose:-</u>

Cellulose is also a polysaccharide. Its molecules are built from at least 1000 glucose units. But they are joined differently than those in starch, so cellulose has quite different properties.

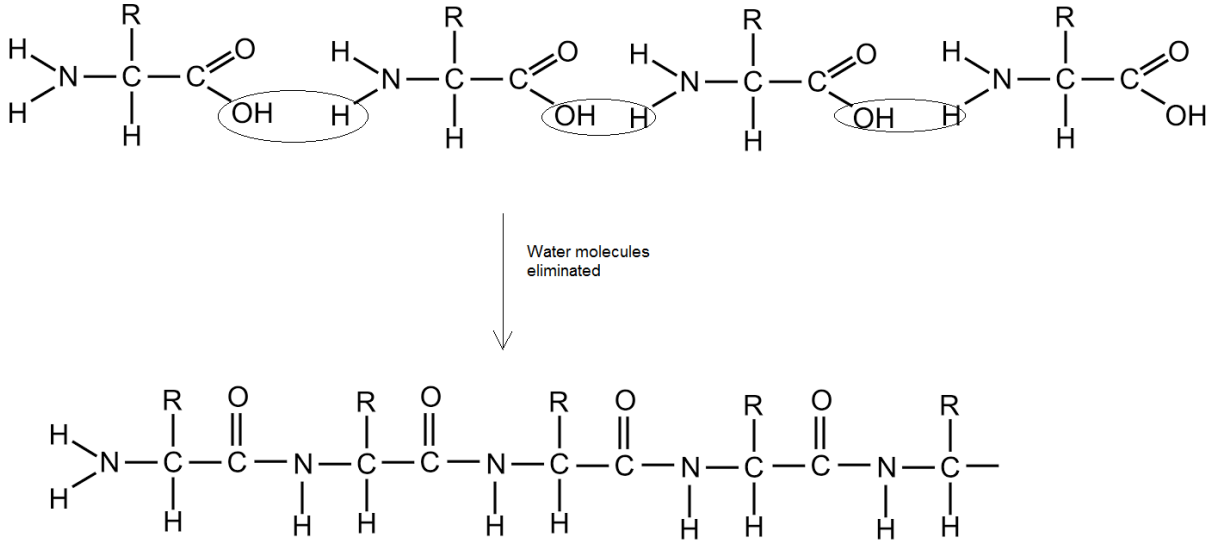
The cell walls in plants are made of cellulose. So we eat cellulose every time we eat cereals, vegetables, and fruits. We can't digest it, but it helps to clean out our digestive system. We call it fibre.

<u>Protein:-</u>

Proteins are polymers built up from molecules of amino acids. Amino acids contain carbon, hydrogen, oxygen and nitrogen, and some contain Sulphur. The general structure of an amino acid molecule is as under:



Amino acids join up to make proteins. The reaction is hereunder:



From 60 to 6000 amino acid units can join to make a macromolecule of protein. They can be different amino acids, joined in different orders – so there are a huge number of proteins. The reaction is a condensation polymerization with loss of water molecules. It has amide linkage same as in case of nylon.

The importance of proteins in your food

When your body digests food, it breaks the proteins back down to amino acids. These then join up again to make proteins your body needs.

For example all these substances in your body are proteins:

- the enzymes that act as catalysts for reactions in your body cells
- the collagen in your skin, bones, and teeth
- the keratin that forms your hair
- haemoglobin, the red substance in blood, that carries oxygen
- hormones, the chemicals that dictate how you grow and develop.

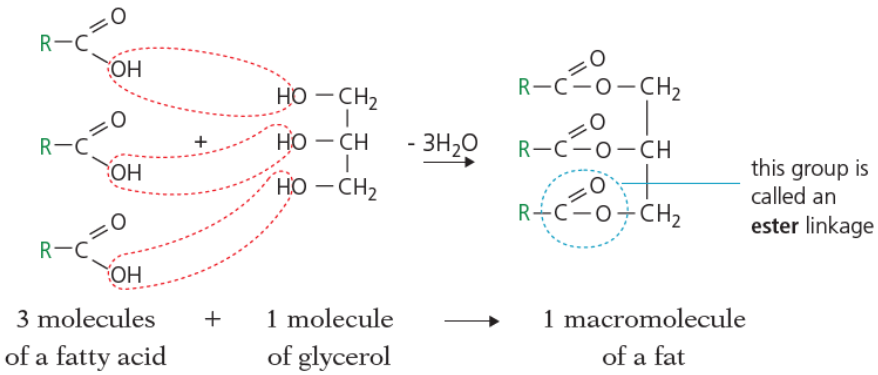
Fats:-

Foods also contain natural fats and oils (liquid fats). Complex carbohydrates, and proteins, are polymers. But fats are not made by polymerisation, so they are not polymers. They are esters: compounds formed from an alcohol and an acid.

- The alcohol is always glycerol, a natural alcohol with three OH groups. (Its chemical name is propan-1,2,3-triol.)
- The acids are natural carboxylic acids, usually with long carbon chains. They are called fatty acids. For example palmitic acid, $C_{15}H_{31}COOH$.

How fats are formed:-

This shows the reaction between glycerol and a fatty acid. R stands for the long chain of carbon atoms with hydrogen atoms attached, in the acid:



This is a **condensation** reaction.

Breaking down the macromolecules:-

Hydrolysis is a reaction in which molecules are broken down by reaction with water.

Hydrolysis in the digestive system:-

Starch and any disaccharides get broken down to glucose. Our body cells use this glucose to provide energy, in a process called respiration. It is the reverse of photosynthesis:

$C_6H_{12}O_6$ (aq) + $6O_2$ (g) -------> $6CO_2$ (g) + $6H_2O$ (l) + energy

Proteins get broken down to amino acids which our body then uses to build up the proteins it needs. Fats and Oils which are esters get broken down in to glycerol and fatty acids. These are used for energy or to make new fats for cell membranes, or to be stored.

Hydrolysis of complex carbohydrates by acids or enzymes to give simple sugars:-

(ester in a veg. oil) + (water) ---(in presence of an enzyme as catalyst)---> (fatty acid) + (glycerol)

Hydrolysis in the lab:-

Macromolecule	Conditions for the hydrolysis	Complete hydrolysis gives ...
starch	heat with dilute hydrochloric acid	glucose
proteins	boil with 6M hydrochloric acid for 24 hours	amino acids
fats	boil with dilute sodium hydroxide	glycerol plus the sodium salts of the fatty acids ($R-COO^-\ Na^+$)

Making soap from fats and oils:-

The sodium salts of fatty acids are used as soap. So soap is made in factories by boiling fats and oils with sodium hydroxide, as above. For example,