Chapter 2: Biological molecules

▼ 2.1. The building blocks of life

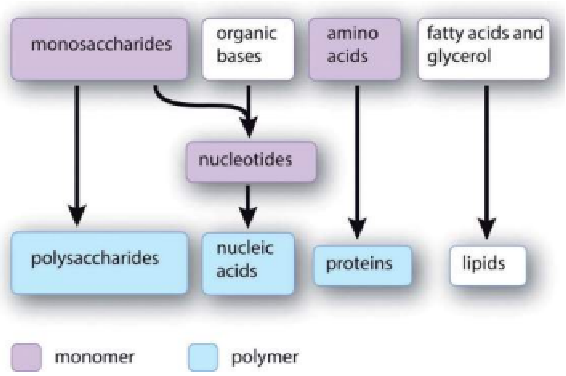


Figure 2.2 The building blocks of life.

▼ 2.2. Monomers, polymers and macromolecules

▼ Define monomer.

A monomer is a relatively simple molecule which is used as a basic building block for the synthesis of a polymer; many monomers are joined together to make the polymer, usually by condensation reactions; common examples of molecules used as monomers are monosaccharides, amino acids and nucleotides.

▼ Define polymer.

A polymer is a giant molecule made from many similar repeating subunits joined together in a chain; the subunits are much smaller and simpler molecules known as monomers; examples of biological polymers are polysaccharides, proteins and nucleic acids.

▼ Define macromolecule.

A macromolecule is a large biological molecule such as a protein, polysaccharide or nucleic acid.

▼ 2.3. Carbohydrates

▼ Define carbohydrates.

Carbohydrates are molecules which consist of only carbon, hydrogen and oxygen and they are made up of long chains of sugar units called **saccharides**.

There are three types of saccharides; monosaccharide, disaccharide and polysaccharides.

The bond between the chain is called glycosidic bond and is **formed by condensation reaction, and broken by hydrolysis.**

Monosaccharides

Monosaccharide is a molecule consisting of a single sugar unit with the general formula $(CH_2O)_n$.

They are small organic molecules used as building blocks of complex carbohydrates.

Name three monosaccharides.

Glyceride - triose used in metabolic reactions.

Ribose - pentose sugar which is a component of nucleic acid.

Glycose - monosaccharide consisting of 6 carbon atoms in each molecule, it is the main substrate for respiration therefore it is of great importance, It has two isomers - alpha and beta glucose. (picture down on the page)

Disaccharides

Disaccharide is a sugar molecule consisting of two monosaccharides joined together by a glycosidic bond (`o')

It is formed in a condensation reaction between two monosaccharides.

Name three disaccharides.

Maltose - disaccharide formed by condensation of two glucose molecules.

Sucrose - Glucose + Fructose

Lactose - Glucose + Galactose

Polysaccharides

Polysaccharide is a polymer whose subunits are many monosaccharides joined together by glycosidic bonds.

Name three polysaccharides.

Glycogen and **starch** which are both formed by the condensation of alpha glucose.

Cellulose formed by the condensation of beta glucose.

Glycogen

Glycogen is the main energy storage molecule in animals and it is formed from many molecules of alpha-glucose joined together by 1,4 and 1,6 glycosidic bonds. It has a large number of side branches meaning that the nergy can be released quickly. Moreover, it is a relatively large but compact molecule thus maximizing the amount of energy it can store.

Starch

Starch stores energy in plants and it is a mixture of two polysaccharides called amylose and amylopectin

Amylose

An unbranched chain of glucose molecules joined by 1,4 glycosidic bonds, as a result of that amylose is coiled and thus it is vary compact molecule meaning it can store a lot of energy in a small space.

▼ Amylopectin

Amylopectin is branched and it is made up of glucose molecules joined together by 1,4 and 1,6 glycosidic bonds, due to the presence of many side branches it is a rapidly digested by enzymes therefore energy is released quickly.

▼ Cellulose

Cellulose is component of cell walls in plants and it’s composed of long, unbranched chains of beta glucose which are joined by glycosidic bonds. Microfibrils are strong threads which are made of long cellulose chains joined together by hydrogen bonds and they provide structural support in plant cells.

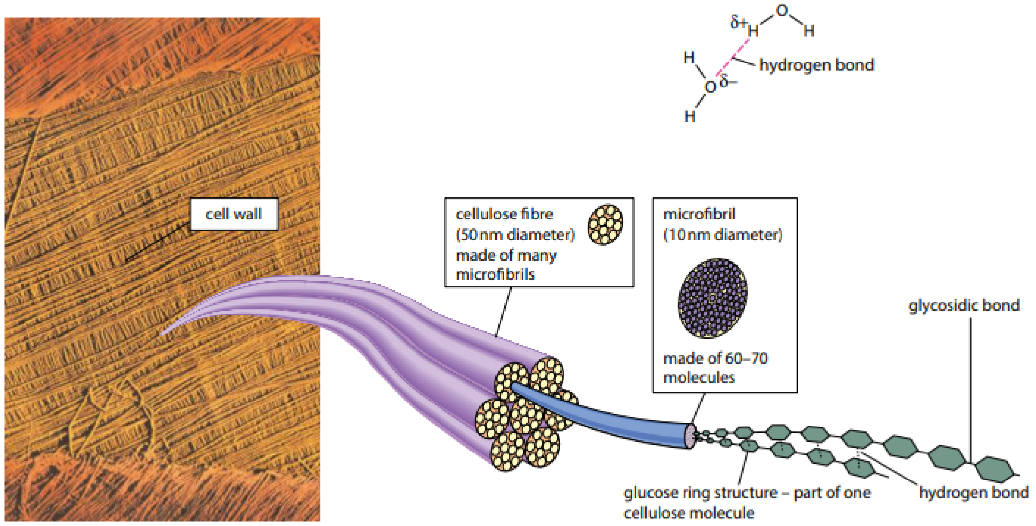


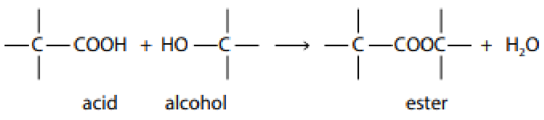
Figure 2.10 Structure of cellulose.

▼ 2.4. Lipids

▼ Lipids.

Lipids are biological molecules which are only soluble in organic solvents such as alcohols. There are two types of lipids.

They are formed by ester bond.



▼ What are the two types of lipids?

Saturated lipids such as those found in animal fats - saturated lipids don’t contain any carbon-carbon double bonds. Too much saturated fat can increase the cholesterol levels in blood thus increasing the risk of coronary heart disease.

Unsaturated lipids which can be found in plants - unsaturated lipids contain carbon-carbon double bonds and melt at low temperatures that saturated fats. Unsaturated fats are healthy as they provide essential fatty acids.

▼ Why does unsaturated fats melt at low temperatures.

The greater the number of unsaturated bonds, the weaker the intermolecular bonds resulting in lower melting point, and as a result of that saturated fats which don't contain any double bonds are solid at room temperature and unsaturated lipids are liquid at room temperature.

▼ Fatty acids

Fatty acids are a series of acids, some of which are found in fats (lipids). They contain the acidic group –COOH, known as a carboxyl group.

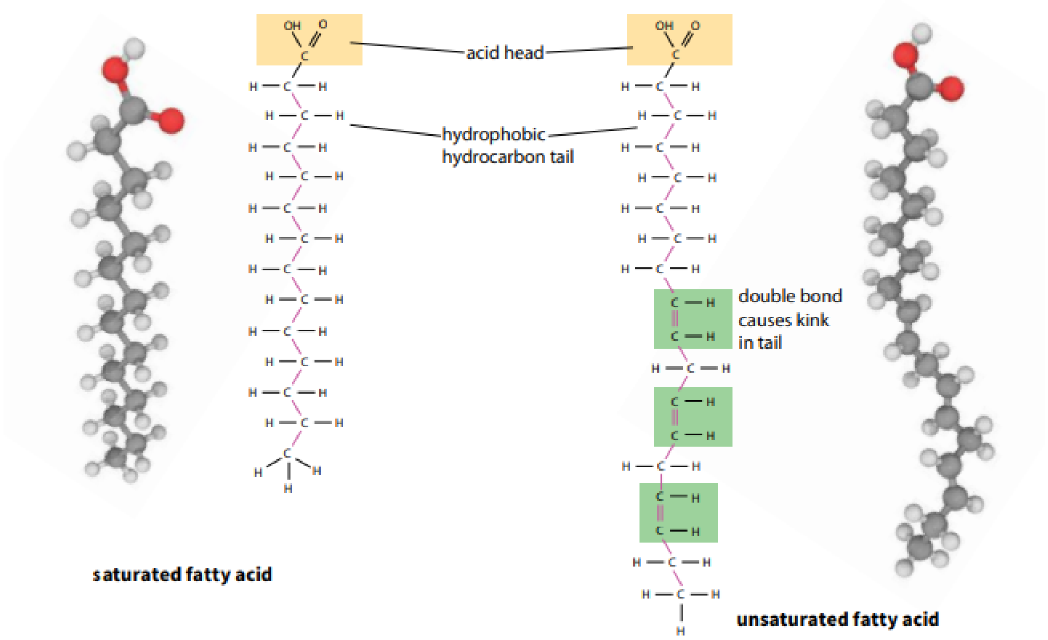


Figure 2.11 Structure of a saturated and an unsaturated fatty acid. Photographs of models are shown to the sides of the structures. In the models, hydrogen is white, carbon is grey and oxygen is red.

▼ Triglycerides

Triglycerides are non-polar and hydrophobic molecules. They are lipids composed of one molecule of glycerol and 3 fatty acids joined together by ester bonds formed in condensation reactions. There are many different types of fatty acids and they vary in chain length, presence and number of double bonds. Also, some triglycerides contain a mix of different fatty acids.

▼ For what are triglycerides used for?

Triglycerides are used as **energy reserves** in plant and animal cells.

Acts as an **insulator** against loss of heat.

An unusual role for lipids is as a metabolic **source of water**.

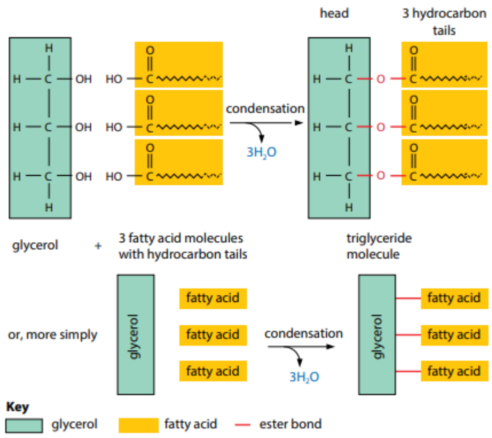


Figure 2.12 Formation of a triglyceride from glycerol and three fatty acid molecules.

▼ Phospholipids

In phospholipids, one of the fatty acids of a triglyceride is substituted by a phosphate containing group. Phosphate heads are **hydrophilic** and the tails are **hydrophobic** and as a result phospholipids form **micelles** when they are in contact with water, as heads are on the outside as they are attracted to water and tails are on the inside as they move away from water. The hydrophobic/hydrophilic nature of phospholipids is what makes cell membranes selectively permeable.

▼ 2.5. Proteins

▼ Protein

Protein is a polymer of amino acids. Amino acids contain -NH2, carboxylic group and a variable R group which is a carbon-containing chain. There are 20 different amino acids with different R groups. Amino acids are joined by **peptide bonds** formed in condensation reactions, and can be broken by hydrolysis.

A dipeptide contains two amino acids and polypeptides contain three or more amino acids.

The structure of proteins is determined by the order and number of amino acids, bonding present and the shape of the protein.

▼ Primary structure

Primary structure of a protein is the order and number of amino acids in a protein.

▼ Secondary structure

Secondary structure is the structure of a protein molecule resulting from the regular coiling or folding of the chain of amino acids, e.g. an α-helix or β-pleated sheet.

The type of bonding is determined by the type of bonding present such as:

▼ Hydrogen bonding

The weak bonds between a slightly positive charged hydrogen atom and another slightly negative charged atom (usually oxygen, nitrogen or fluorine.)

▼ Ionic bonding

Attraction between oppositely charged R groups.

▼ Disulpide bridges

When 2 cysteine amino acids come into close contact and the sulfur in each cysteine forms a bond.

▼ Tertiary structure

Tertiary structure of a protein is the 3D shape of the protein, it can be globular or fibrous.

▼ Globular

Globular proteins such as enzymes are compact. They are also soluble.

Hemoglobin is water soluble globular protein

▼ Fibrous

Fibrous proteins such as keratin are long thus can be used to form fibre. These are insoluble.

For instance, collagen is a fibrous protein of a great strength due to the presence of both hydrogen and covalent bonds in the structure. Collagen molecules wrap around each other and form fibrils which form strong collagen fibres. Collagen forms the structure of bones, cartilage and connective tissue and is a main component of tendons which connect muscles to bones.

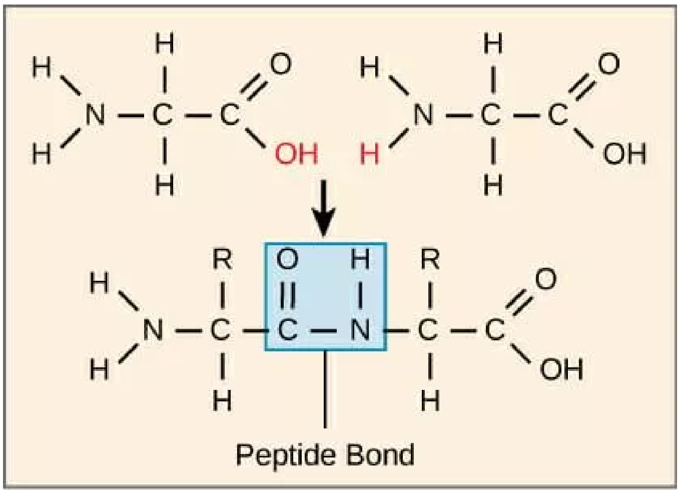
▼ Quaternary structure

Quaternary structure of a proteins consists of 2 or more subunits (polypeptide chains) closely packed together.

Hemoglobin is a protein with quaternary structure that carries oxygen in the blood. It has a quaternary structure consisting of 2 alpha subunits and 2 beta subunits. Each polypeptide chain contains a prosthetic(non-protein) group -haem (Fe2+).

The oxygen can bind to the mean haem group and be released when required.

▼ Peptide bond



▼ 2.6. Water

Water is a very important molecule which is a major component of cells.

▼ What are the qualities of water

1. Water is a polar molecule due to the uneven distribution of charges within the molecule.
2. It is a **metabolite** in a metabolic reactions such as condensation and hydrolysis which are used in forming and breaking chemical bonds.
3. It is a solvent in which many metabolic reactions occur.
4. It has a high specific heat capacity meaning that a lot of energy is required to warm water up therefore minimizing temperature fluctuations in living things therefore it acts as a buffer.
5. It has a relatively large latent heat of vaporization meaning evaporation of water provides a cooling effect with little water loss.
6. There is a strong cohesion between molecules enabling effective transport of water in tube-like transport cells as the strong cohesion support columns of water(capillary action), as a result of strong cohesion the surface tension at the water-air boundary is high.

	Globular protein, e.g. haemoglobin	Fibrous protein, e.g. collagen	Monosaccharide	Disaccharide	Glycogen	Starch	Cellulose	Lipid
monomer	✗	✗	✓	✗	✗	✗	✗	✗
polymer	✓	✓	✗	✗	✓	✓	✓	✗
macromolecule	✓	✓	✗	✗	✓	✓	✓	✗
polysaccharide	✗	✗	✗	✗	✓	✓	✓	✗
contains subunits that form branched chains	✗	✗	✗	✗	✓	✓	✗	✗
contains amino acids	✓	✓	✗	✗	✗	✗	✗	✗
made from organic acids and glycerol	✗	✗	✗	✗	✗	✗	✗	✓
contains glycosidic bonds	✗	✗	✗	✓	✓	✓	✓	✗
contains peptide bonds	✓	✓	✗	✗	✗	✗	✗	✗
one of its main functions is to act as an energy store	✗	✓	✗	✓	✓	✓	✗	✓
usually insoluble in water	✗	✓	✗	✗	✓	✓	✓	✓
usually has a structural function	✗	✓	✗	✗	✗	✗	✓	✗
can form helical or partly helical structures	✓	✓	✗	✗	✗	✓		✗
contains the elements carbon, hydrogen and oxygen only	✗	✗	✓	✓	✓	✓	✓	✓

Category	Example
structural	1. collagen 2. keratin
enzyme	galactase , amylase
hormone	insulin
respitory pigment	haemoglobin and myoglobin
defensive	antibodies
Contractile	actin and myosin
storage	casein

Collagen	Haemoglobin
Fibrous	Globular
Helical	Partly helical
Triple helix	Alpha helix
Phrosthetic group absent	Phrosthetic group present
Insoluble in water	Soluble in water

▼ Three characters of monosaccharide

1. Dissolves easily in water
2. Sweet
3. General formula is (C(H2O))n

▼ 2 functions of lactose

1. Used as a source of energy
2. Could be digested into monosaccharides and be used as building blocks.

▼ What is the formula for calculating the number of different tripeptides that can be formed from two different amino acids?

2^3 = (number of amino acids)^(number of chain)

▼ State three features that α-helices and beta sheets (β-sheets) have in common.

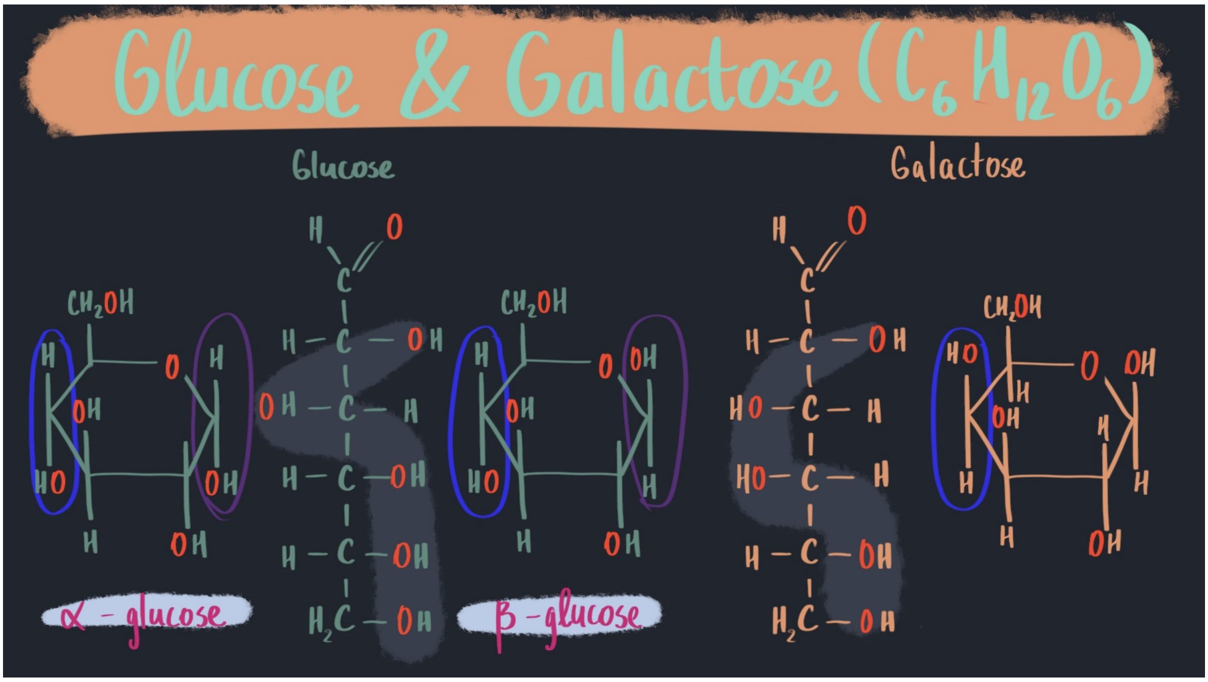
1. Hydrogen bonds
2. Secondary structures
3. All the -NH and -C=O groups of peptide bonds are involved

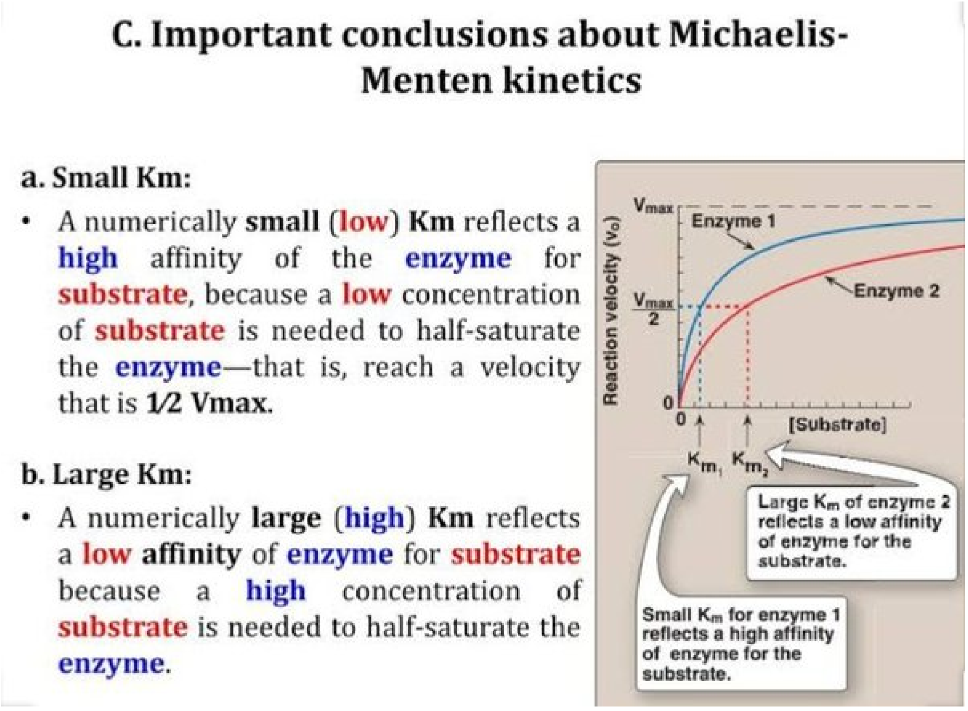
▼ State one way in which the structure of haemoglobin is related to its function.

Iron combines with oxygen

GALACTOSE WILL BE DRAWN 'UPSIDE DOWN' AS IN THE DISACCHARIDE.

DON'T FORGET TO NUMBER THE CARBON ATOMS WHEN DRAWING HELICAL STRUCTURES.





Fibrous proteins

	Fibrous	Globular
Molecules	Long , thin Lie side by side to form fibres.	Fold into spherical 3-D shape.
Examples	- Keratin (in hair) - Collagen (in skin and bone).	- Haemoglobin - Insulin - Enzymes
Solubility in water	Insoluble	Soluble
Roles	Structural: - Collagen in bone and cartilage - Keratin in fingernails and hair.	Metabolic - Enzymes in all organisms, - Plasma proteins, antibodies in mammals.

If you have any questions reach out to**: 23C Chinguun.M, IG: @chinguun__0511, FB: Chinguun Tsetsgee.**
Or post questions on the discord server for help!