

Biomolecules

4 major types of macromolecules are found in the living organisms. Most of these macromolecules are polymers and made up of small building units called monomers.

Monomers

Smallest unit which cannot be further broken down.

Polymers

Polymers are made up of many monomers joined together.

Carbohydrates

Carbohydrates are hydrated carbons as they contain the general formula $(CH_2O)_n$. Most carbohydrates have a sweet taste and are soluble in water. They can be classified into different types based on the number of monomers present.

Monosaccharides

These are the simplest carbohydrates. Thus, they cannot be further broken down.

They have a sweet taste. There are different types of monosaccharides based on the number of carbons present.

Example: glucose, galactose, ribose, etc

Ring Structure Of Monosaccharides

Monosaccharides exist in 2 structural forms. They are either in a linear form or folds to make a ring structure. These ring structures

are formed when the aldehyde group on C 1 reacts with a hydroxyl group on C4.

There are two types of ring structures of glucose.

It can be alpha glucose or beta glucose. Both of them are isomers. That is they are the mirror image of each other.

If the hydroxyl group is present below the ring the molecule is alpha glucose.

If the hydroxyl group is present above the ring the molecule is beta glucose.

Role Of Monosaccharide In Living Organisms

They serve as the major source of energy due to the abundant carbon and hydrogen bonds.

Besides, they also take part in the formation of other macromolecules such as sucrose, starch, etc.

Disaccharides

Disaccharides are formed when two monosaccharides join together.

The bond between them is called glycosidic.

Glucose + Glucose	Maltose
Glucose + Fructose	Sucrose
Glucose + Galactose	Lactose

Formation Of Dissacharide By Condensation Reaction

When two monosaccharides are joined together and a molecule of water is removed. This reaction is called a condensation reaction.

Example

When fructose and glucose are joined together a molecule of sucrose will be formed with the removal of a water molecule.

Splitting Of Dissacharides

Disaccharides can be split into monosaccharides by adding water molecules. This type of reaction is called hydrolysis.

Example

Sucrose can be broken down into fructose and glucose with hydrolysis.

Benedict Test:

Sucrose is a non-reducing sugar that is why it gives a negative Benedict test. But when it is hydrolyzed it forms glucose and fructose. These are reducing sugar thus after hydrolysis sucrose gives a positive Benedict test.

In the same way, other disaccharides can be broken down into monosaccharide by hydrolysis.

Polysaccharides

Polysaccharides contain numerous monosaccharide linked together by condensation.

They do not dissolve in water thus form a good compound for storing energy or are used for making strong structural compounds.

They can be broken down into disaccharides by hydrolysis which can be further broken down into monosaccharide.

There are different types of polysaccharides.

Glycogen

Glycogen is polymers of alpha glucose. Most of the bonds between them are alpha 1-4. That means carbon 1 of the first molecule is linked to carbon 4 of the other molecule.

There are few alpha 1-6 bonds as well. These bonds form the branches in the compound. These branches increase the rate of hydrolysis as they provide numerous sites for the enzyme to act on.

Glycogen is found in animals and fungi.
Their function is to store energy.

Starch

Starch is found in plants only. They consist of amylose and amylopectin. Both of them are polymers of alpha glucose. Natural starch has 10-20% of amylose and the rest of it contains amylopectin.

Amylose

Amylose consist of alpha 1-4 bonds only. Thus it forms a long chain of glucose. The chain spirals on itself and is held together by hydrogen bonds.

Amylopectin

It consists of alpha 1-6 bonds as well. Thus, they have a highly branched structure. Short branches of around 30 glucose molecules are held by 1-6 linkage. These branches are present after every 20-30 glucose molecules.

Cellulose

Cellulose consists of long chains of Beta glucose which are held together by beta 1-4 bonds.

The difference in cellulose and other polysaccharide is that it is a

polymer of Beta glucose.

It has a straight structure and there is no spiraling. It forms a very strong structure which is difficult to digest as very few animals have enzymes that break Beta 1-4 links.

Thus, cellulose is usually found in the plant cell wall to give them support.

Role Of Polysaccharides In Living Organisms

Starch and glycogen are used by cells for storing energy. This is because they are complex and do not dissolve in water.

Cellulose due to its strong structure is a major component of the plant cell wall.

Lipids

Lipids consist of a class of different molecules that are insoluble in water.

The most common of them is triglycerides.

Triglycerides

It consists of three fatty acid chains joined with glycerol molecule hence called triacylglycerol or triglycerides. They are linked together by ester bonds.

They are nonpolar molecules thus insoluble in water but dissolves in organic solvents.

Types Of Triglycerides

Saturated Fatty Acids/ Fats

Saturated fatty acids are also called as fats.

They contain fatty acids having only single covalent bonds. That is why they are usually solid at room temperature.

Saturated fatty acids do not have a kink in their structure. Thus they organize in a regular fashion which makes them solid.

Unsaturated Fatty Acids/ Oils

Unsaturated fatty acids are also called oils.

They contain fatty acids having one or more double or triple covalent bonds. That is why they are liquid at room temperature.

Why Unsaturated Fatty Acids Are Liquid

Unsaturated bonds create a kink in the structure of fatty acid chains. This kink prevents the molecules from organizing regularly. Thus, making them liquid at room temperature.

Role Of Tryglycerides

They are a long term reservoir of energy. Lipids store more amount of energy than carbohydrates as it contains more carbon and hydrogen bonds.

Fats are stored in various parts of the human body. Below the skin, it functions as an insulator to keep the body warm.

Phospholipids

In phospholipid one of the three fatty acids is replaced by a phosphate group.

Thus, one end of the molecule is hydrophilic(water-loving) and the

other end is hydrophobic(does not dissolve in water).
Due to this dual nature, it is called amphipathic.

Role Of Phospholipid

Phospholipid plays a very important role in the cell membrane of living organisms.

Proteins

Protein is the polymer of amino acids.

Amino Acids

The amino acid is the monomers that join together to form proteins.

Structure

Amino acid comprises of a primary carbon which is linked to carboxylic acid on one side and an amino group on the other side. The other side has a radical group that varies in different amino acids.

There are 20 different types of amino acids based on the R group they contain. This R group makes the protein acidic, basic or neutral.

Linking Of Amino Acids

Two amino acids are linked together by condensation. The bond between them is called a peptide bond.

Breaking Of Peptide Bonds

Peptide bonds can be broken down by hydrolysis.

Primary, Secondary And Tertiary Structure Of Proteins:

Amino acids are linked together to form polypeptides. These molecules can be arranged in different structural forms.

Primary Structure:

A linear chain of amino acids is called the primary structure.

The amino acids are held together by peptide bonds only.

Secondary Structure

The primary structure is folded to form a secondary structure.

The chain can be folded into ways it can either an alpha helix (3d structure) or Beta pleated sheet (twisted).

The helix has numerous hydrogen bonds between amino acids. This gives the structure stability.

Tertiary Structure

The coiling and twisting of secondary structure result in a final 3d structure called tertiary.

There are different bonds which give the structure stability.

- Hydrogen bonds: Between amino acids.
- Sulfide bonds: Formed between sulfur atoms present in cysteine.

- Ionic bonds: Formed between R group having opposite charges.

Amino acids may be hydrophobic or hydrophilic. Based on the medium in which they are present the arrangement of amino acids is different. In a polar solvent, the hydrophilic molecules are present on the outer side while hydrophobic amino acids are present inside the protein.

Quaternary Structure

Two tertiary chains present together to make a quaternary structure.

They contain the same bond which is present in the tertiary structure.

Globular And Fibrous Proteins

There are two types of 3d structure of protein ie globular or fibrous.

Their different structure helps them in different roles they perform in the body.

	Fibrous Proteins	Globular Proteins
Molecule	The molecules are arranged in long strands.	The molecules are coiled upon each other.
Solubility	Insoluble	Soluble
Function	Provide strength and stability	Perform different functions: Transport catalysis
Example	Keratin	Enzymes Hemoglobin Myoglobin

Collagen Fiber As Fibrous Protein

Collagen is an alpha fibrous protein. It consists of 3 polypeptide chains.

Collagen molecules coils around to form collagen fibrils.

Collagen fibrils wrap around itself to form collagen fibers.

The polypeptide chains lie side by side one another and are held together by hydrogen bonds.

Function Of Collagen

Provide support and strength.

Relationship Between Structure And Function Of Collagen

Structure	Function	Explanation
Large Size Of Molecules	Insoluble	<p>The size of molecules is large. This makes the protein fibres insoluble in water.</p> <p>This property gives it stability.</p>
3 Chains	High Tensile Strength	<p>The three chains of protein wound around each other gives the molecules high tensile strength.</p> <p>Thus, they are difficult to break.</p>
Glycine	Short Structure	<p>Glycine has H as R group this makes the structure short.</p> <p>The compactness of protein chains makes it stable.</p>
Lycine	Fibres	<p>The lycine molecule in the chain makes</p>

		covalent bond with R group of other lysine molecules.
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This is essential for formation of bonds between different chains.

Hemoglobin

Hemoglobin has a quaternary structure.

It consists of two alpha globins and two beta globins. Besides this, it also consists of an inorganic heme group.

Heme group consists of an Iron molecule. Iron holds oxygen atoms that are transported to different tissues.

Relationship Between Structure And Function Of Hemoglobin

Structure	Function	Explanation
Heme Group	Oxygen Transport	Each heme group consist of a iron atom. The iron binds with oxygen.
Tertiary Structure	Soluble	<p>The polypeptide chains consist of both hydrophobic and hydrophilic components.</p> <p>Hydrophobic end are buried inside hydrophilic molecules.</p> <p>This makes the structure soluble in water.</p>

Water

Water makes up around 80% of the total mass of the cell.

A molecule of water consists of a positive end and a negative end. This is called a dipole.

This property of water makes it an excellent solvent.

The hydrogen bonding between water molecules also affects its

physical properties.

Below are the properties that make water an excellent compound for living organisms.

Water As A Solvent

Water has two ends. Thus, when NaCl is dissolved in water it breaks into Na⁺ and Cl⁻. Na⁺ makes a bond with OH⁻ and Cl⁻ makes a bond between H⁺.

In the same way, other ionic compounds can dissolve in water. Thus, water is considered as a universal solvent.

This property of water helps in the transport of a large number of molecules in living organisms.

Thermal Properties Of Water

High Specific Heat Of Capacity

As water contains a large number of hydrogen bonds it requires a lot of energy to break them. Thus, it needs a lot of energy to raise the temperature of the water. The body comprises a huge amount of water thus it makes it a stable internal environment.

High Latent Heat Of Evaporation

Water needs a high amount of heat to evaporate. This is due to a large number of hydrogen bonds. Thus, when water evaporates it absorbs a large heat from surrounding making it an efficient cooling process.

That is how the body uses sweat to cool down the temperature.

Freezing Property

Water shows an unusual behavior because the ice formed is less than water

(liquid). Thus, oceans and seas freeze in a way that ice remains at the top while the liquid water is present below it. The top layer of ice prevents heat loss from below.