جامعة المستقبل
AL MUSTAQBAL UNIVERSITY

كلية العلوم

قســـم الادلة الجنائية

المحاضرة الثانية

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المادة : الخلية The Cell

المرحلة : الأولى

اسم الاستاذ: د.عماد هادي الطائي

The Structure and Function of Macromolecules

Within all cells, small organic molecules are joined together to form larger molecules. **All living things are made up of four main classes of macromolecules:**

- Carbohydrates,
- Lipids,
- Proteins,
- Nucleic acids.

These large macromolecules may consist of thousands of covalently bonded atoms, some with mass greater than 100,000 daltons. **Most macromolecules are polymers, built from monomers. Three of the four classes of macromolecules** carbohydrates, proteins, and nucleic acids—form chain-like molecules called polymers. A **polymer** is a long molecule consisting of many similar or identical building blocks linked by covalent bonds. **The repeated units are small molecules called monomers.**

The chemical mechanisms that cells use to make and break polymers are similar for all classes of macromolecules. Despite the great diversity in organic macromolecules, members of each of the four major classes of macromolecules are similar in structure and function.

Carbohydrates

Serve as fuel and building material. Carbohydrates include sugars and their polymers.

- **The simplest carbohydrates are** monosaccharides, or simple sugars.
- **Disaccharides, or double sugars, consist of** two monosaccharides joined by a condensation reaction.
- **Polysaccharides are** polymers of many monosaccharides.

• **Monosaccharides** generally have molecular formulas that are some multiple of the unit CH_2O. For example, glucose has the formula $C_6H_{12}O_6$. Most names for sugars end in -*ose* such as glucose, an aldose, and fructose, a ketose, are structural isomers. Monosaccharides are also classified by the number of carbon atoms in the carbon skeleton.

  - The carbon skeleton of a sugar ranges from three to seven carbons long.
  - Glucose and other six-carbon sugars are hexoses. For example, glucose and galactose, both six-carbon aldoses, differ only in the spatial arrangement of their parts around asymmetric carbons.

- **Polysaccharides, the polymers of sugars, have storage and structural roles.**
  - **Polysaccharides** are polymers of hundreds to thousands of monosaccharides joined by glycosidic linkages.
    - **Some polysaccharides serve for** storage and are hydrolyzed as sugars are needed.
    - Other polysaccharides serve as building materials for the cell or the whole organism.
    - **Starch is** a storage polysaccharide composed entirely of glucose monomers.
    - Plants store surplus glucose as starch granules within plastids, including chloroplasts,
    - **Animals store glucose in** a polysaccharide called glycogen.

Lipids: are a diverse group of hydrophobic molecules. Unlike other macromolecules, lipids do not form polymers. The unifying feature of lipids is that they have little or no affinity for water because they consist of mostly hydrocarbons, which form nonpolar covalent bonds.

Fats: store large amounts of energy. **A fat is constructed from** two kinds of smaller molecules: glycerol and fatty acids.

Phospholipids: are major components of cell membranes.

- **Phospholipids** have two fatty acids attached to glycerol and a phosphate group at the third position.

  ○ The phosphate group carries a negative charge.

  ○ Additional smaller groups (usually charged or polar) may be attached to the phosphate group to form a variety of phospholipids.

- The interaction of phospholipids with water is complex.
- **Phospholipids are arranged** as a bilayer at the surface of a cell.
- The hydrophilic heads are on the outside of the bilayer, in contact with the aqueous solution, and the hydrophobic tails point toward the interior of the bilayer.
- The phospholipid bilayer forms a barrier between the cell and the external environment.
- Phospholipids are the major component of all cell membranes.

Proteins: have many structures, resulting in a wide range of functions.

• **Proteins account for more than** 50% of the dry mass of most cells. They are instrumental in almost everything an organism does.

• **Protein functions include** structural support, storage, transport, cellular signaling, movement, and defense against foreign substances.

• **Most important, protein enzymes function** as catalysts in cells, regulating metabolism by selectively accelerating certain chemical reactions without being consumed.

* **Proteins** are the most structurally complex molecules known.

○ Each type of protein has a complex three-dimensional shape.

- All protein polymers are constructed from the same 20 amino acid monomers.
- Polymers of proteins are called polypeptides.
- A protein consists of one or more polypeptides folded and coiled into a specific conformation.

Amino acids: are the monomers from which proteins are constructed. Amino acids are organic molecules with both carboxyl and amino groups.

Nucleic acids: store and transmit hereditary information**.**

- The amino acid sequence of a polypeptide is programmed by a unit of inheritance known as a **gene.**
- A gene consists of DNA, a polymer known as a **nucleic acid. There are two types of nucleic acids: RNA** and **DNA.**

- **The two types of nucleic acids** are ribonucleic acid (RNA) and Deoxyribonucleic acid (DNA).

- RNA and DNA are the molecules that enable living organisms to reproduce their complex components from generation to generation.
  o DNA provides directions for its own replication.
  o DNA also directs RNA synthesis and, through RNA, controls protein synthesis.
- Organisms inherit DNA from their parents.
- **Each gene along a DNA molecule directs the synthesis of a specific type of** RNA called messenger RNA (mRNA). mRNA functions as an intermediary, moving information and directions from the nucleus to the cytoplasm.

A nucleic acid strand is a polymer of nucleotides

- **Nucleic acids are polymers made of** nucleotide monomers organized as polynucleotides.
- **Each nucleotide consists of three parts:** a nitrogenous base, a pentose sugar, and a phosphate group.
- **The nitrogenous bases are rings of carbon and nitrogen that come in two types:** purines and pyrimidines.

○ **Pyrimidines** have a single six-membered ring of carbon and nitrogen atoms.
- There are three different pyrimidines: cytosine (C), thymine (T), and uracil (U).
- Thymine is found only in DNA and uracil is found only in RNA.

○ **Purines** have a six-membered ring joined to a five-membered ring. The two purines are adenine (A) and guanine (G).

Micro molecules

Micro molecule, a word refers to a small molecule of low molecular weight and is often referred to as a monomer. Monomers are combined together through different biochemical reactions to form a macromolecule, which is known as a polymer. **The most essential micro molecules in cells are** nucleotides, amino acids, monosaccharides, fatty acids, and glycerol (organic micro molecules).

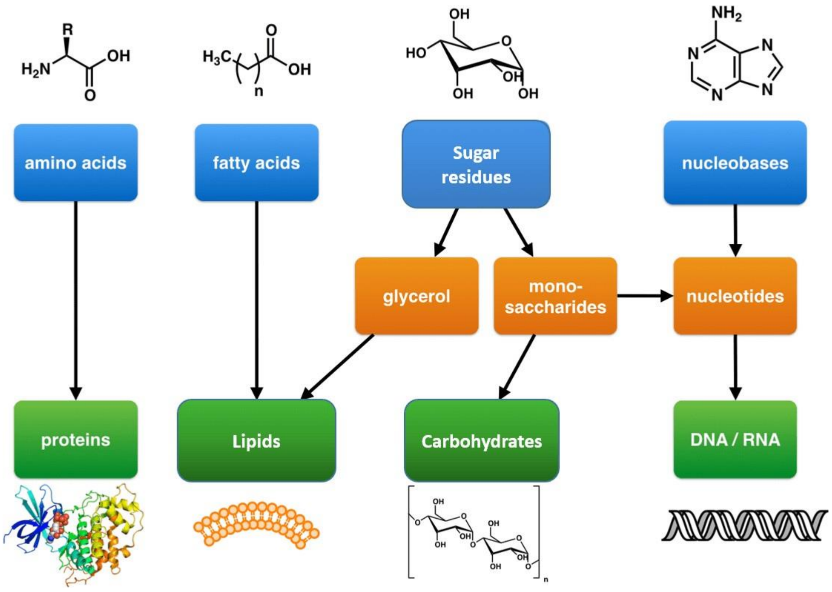


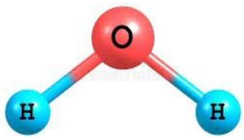
Figure 1: Micromolecules are combined together in the form of linkage to form macromolecules or polymers. Amino acid micromolecules form proteins, fatty acids micromolecules form lipids, sugar micromolecules form glycerol and carbohydrates, while nucleobases micromolecules form DNA and RNA, as mentioned previously.

Other inorganic essential micro molecules are water and minerals. Micromolecules are combined together forming macromolecules by different types of reactions:

1. addition reactions where micro molecules are added one by one.
2. condensation reaction where a water molecule is lost from two micro molecules after combination.

Water

Water is an inorganic micro molecule. It is found in its free form. Water contains two hydrogen atoms and one oxygen atom only.



Water is essential for every living organism since most of the bodyweight is made up of water. **It has various important functions :**

1. It helps maintain shape and structure of the cell by creating a pressure that opposes external forces.
2. Water allows everything inside cells to have the right shape at the molecular level
3. Water also contributes to the formation of membranes surrounding cells, which are formed by two layers of molecules called phospholipids. The bilayer surrounds cells are selectively allowing substances like salts and nutrients to enter and exit the cell without disrupting. Without water, cell membranes would lack structure, and without proper membrane structure, cells would be unable to keep important molecules inside the cell and harmful molecules outside the cell.

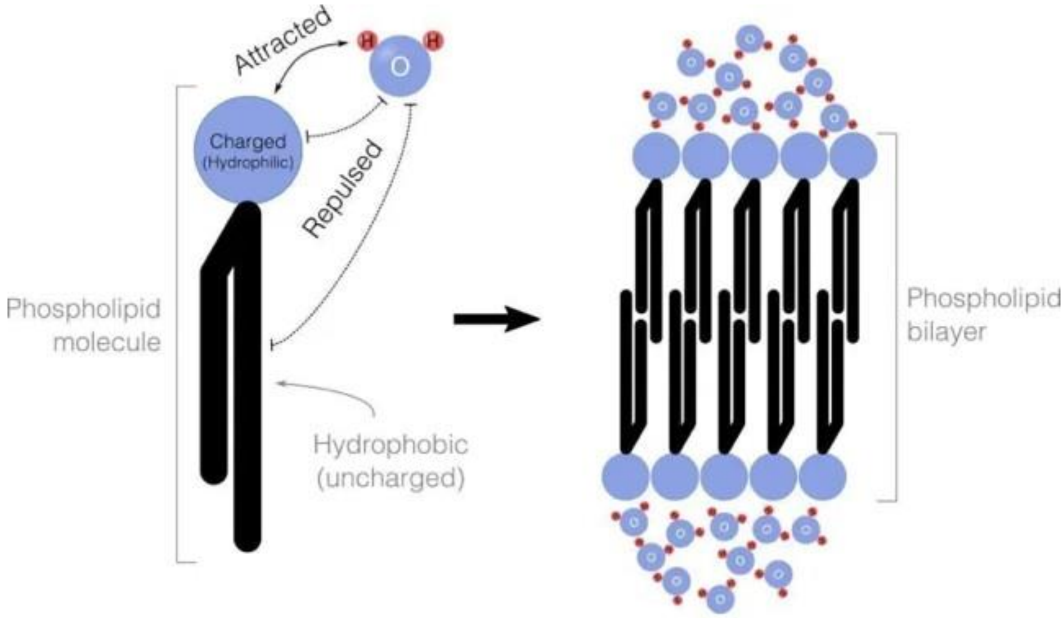


Figure: **Phospholipid bilayers.** Phospholipids form bilayers surrounded by water. The polar heads face outward to interact with water and the hydrophobic tails face inward to avoid interacting with water.

Minerals

Minerals are another example of inorganic essential of micro molecules that needed by the cell. Elements such as iron, zinc, and selenium are essential components of enzymes where they attract or subtract molecules and facilitate their conversion to specific end products. Few elements donate or accept electrons in redox reactions, which results in generation and utilization of metabolic energy and have an impact on the structural stability and to import certain biological molecules.

Iron is involved in the binding, transporting, and release of oxygen in higher animals.

Magnesium and Potassium are both essential for the function and integrity of ribosomes.

Calcium is required as a constituent of Gram-positive cell walls, but not for Gram- negative bacteria.

Sodium ions are needed by many marine organisms for their growth.