بسم ألله الرحمن الرحيم

{يَا أَيُّهَا النَّاسُ قَدْ جَاءتْكُم مَّوْعِظَةٌ مِّن رَّبِّكُمْ وَشِفَاء لِّمَا فِي الصُّدُورِ وَهُدًى وَرَحْمَةٌ لِّلْمُؤْمِنِينَ}.

صدق ألله العظيم

(سورة يونس - الآية 57)

Biological Molecule

"Biomolecule"

By

Dr. Inas Saad

University of Technology - Biomedical Engineering Department –

Biomechanics Branch

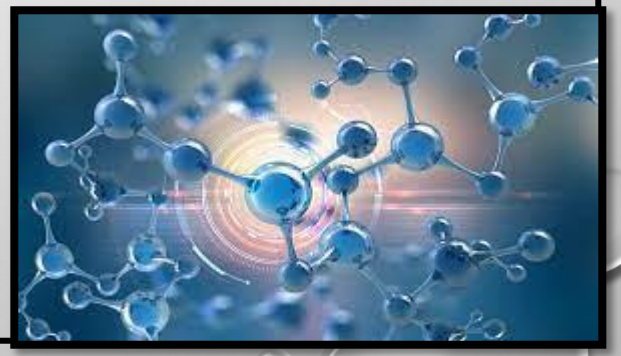
- **Biomolecule,** also called **biological molecule**: any of numerous substances that are produced by **cells** and **living organisms**.
- **Biomolecules** have a wide range of sizes and structures and perform a **wide array** of functions.
- **The four** major types of biomolecules are **carbohydrates, lipids, nucleic acids**, and **proteins.**
- **Biological molecule** : The large molecules necessary for life that are built from smaller organic molecules are called biological macromolecules.
- **Combined, these molecules** make up the majority of a cell's mass.
- **Biological macromolecules** are organic, meaning that they contain carbon (with some exceptions, like carbon dioxide).
- **In addition**, they may contain hydrogen, oxygen, nitrogen, phosphorus, sulfur, and **additional** minor elements.
- **All biomolecules** share in common a fundamental relationship between structure and function, which is influenced by factors such as: the **environment** in which a given biomolecule occurs.

I. Example:

- Lipid are hydrophobic (water-fearing); in water, many spontaneously arrange themselves in such a way that the hydrophobic ends of the molecules are protected from the water, while the hydrophilic ends are exposed to the water.
- This arrangement gives rise to lipid bilayers, or two layers of phospholipid molecules, which form the membranes of cells and organelles.

II. In another example:

- DNA, which is a very long molecule in humans, the combined length of all the DNA molecules in a single cell stretched end to end would be about 1.8 meters (6 feet).
- Whereas the cell nucleus is about (6 μm) in diameter has a highly flexible helical structure that allows the molecule to become tightly coiled and looped.
- This structural feature plays a key role in enabling DNA to fit in the cell nucleus, where it carries out its function in coding genetic traits.



Q: What are biomolecules made of?

- All of the biomolecules that make up our cells are made up of strings of monomers. For example: proteins are made up of strings of amino acids and nucleic acids are strings of nucleotides.. The term for a long string of monomers is a polymer.
- The biomolecules, proteins, carbohydrates and nucleic acids are all polymers.

Q: Are biomolecules organic or inorganic?

Most biomolecules are organic compounds, and just four elements: oxygen, carbon, hydrogen, and nitrogen, make up 96% of the human body's mass.

Q: Is water a biomolecule?

- Water is not a passive solvent in biology, but plays an active role in many biomolecule and cell processes.
- It can be regarded as a kind of biomolecule in its own right, adapting its structure and dynamics to the biological macromolecules and other cell solutes that it accommodates.
- The essential constituent of biomolecules are carbon and hydrogen, and water does not contain carbon ,hence, it can not be considered as a biomolecule

Fundamental properties (Characteristic) of biological substances

a. Size.
b. Molecular weight.
c. Diffusivity.
d. Sedimentation coefficient.
e. Osmotic pressure.
f. Electrostatic charge.
g. Solubility.
h. Partition coefficient.

Biological molecules functions

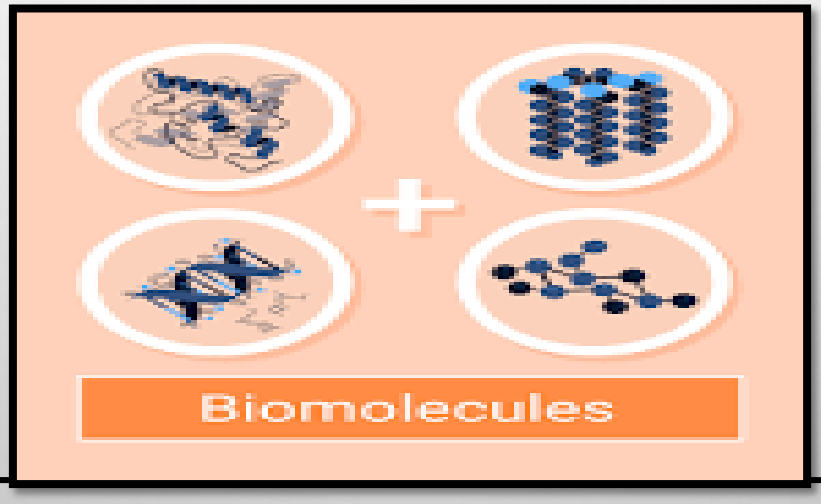
The biomolecules may involve several processes such as: energy storage (carbohydrates), catalyzing the biochemical reactions (hormones), storing/transmitting the genetic codes (RNA/DNA), or altering biological and neurological activities (neurotransmitter/hormones).

Importance of biomolecules:

- **Biomolecules are vital** for life as it aids organisms to grow, sustain, and reproduce.
- **They are involved** in building organisms from single cells to complex living beings like humans, by interacting with each other.
- **The diversity** in their shape and structure provides diversity in their functions.

Is DNA a biomolecule?

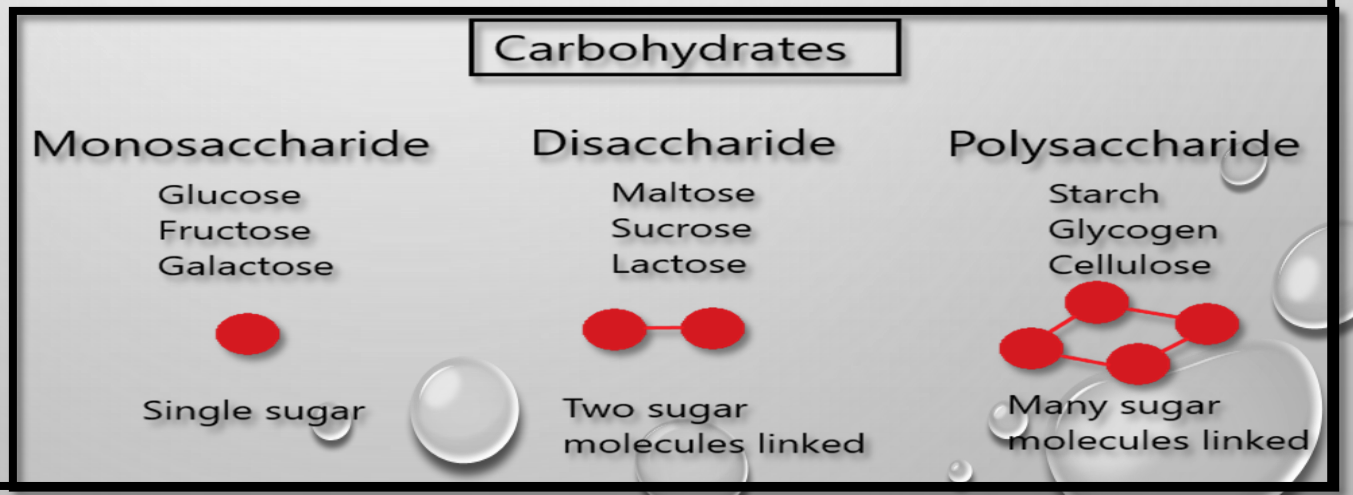
A biomolecule refers to any molecule that is produced by living organisms. As such, most of them are organic molecules. The four major groups of biomolecules include: polysaccharides, proteins, nucleic acids (DNA and RNA), and lipids.



Biomolecule

1- Carbohydrates:

- Carbohydrates, which are made up primarily of molecules containing atoms of: carbon, hydrogen, and oxygen.
- Carbohydrates can be represented by the formula $(CH_2O)_n$, where *n* is the number of carbon atoms in the molecule.
- Carbohydrates provide energy to the body, particularly through glucose, a simple sugar (essential energy sources and structural components of all life).
- Carbohydrates also have other important functions in humans, animals, and plants.
- They are among the most abundant biomolecules on Earth.
- They are built from four types of sugar units: monosaccharides, disaccharides, and polysaccharides.



2- Lipids:

- ✓ Lipids are hydrophobic (water-fearing), or insoluble in water, because they are nonpolar molecules. This is because they are hydrocarbons that include only nonpolar carbon-carbon or carbon-hydrogen bonds.
- ✓ Another key biomolecule of living organisms.
- ✓ Lipids perform many different functions in a cell, including: serving as a source of stored energy and acting as chemical messengers called fats. They also form membranes, which separate cells from their environments and compartmentalize the cell interior, giving rise to organelles, such as: the nucleus and the mitochondrion, in higher (more complex) organisms.
- ✓ Lipids also provide insulation from the environment for plants and animals. For example, they help keep aquatic birds and mammals dry because of their water-repelling nature.
- ✓ Lipids are also the building blocks of many hormones and are an important constituent of the plasma membrane.
- ✓ Lipids include: fats, oils, waxes, phospholipids, and steroids.

3- Proteins:

- Proteins are one of the most abundant organic molecules in living systems and have the most diverse range of functions of all macromolecules.
- Changes in temperature, pH, and exposure to chemicals may lead to permanent changes in the shape of the protein, leading to a loss of function or denaturation.
- Proteins may be structural, regulatory, contractile, or protective; they may serve in transport, storage, or membranes; or they may be toxins or enzymes.
- Each cell in a living system may contain thousands of different proteins, each with a unique function.
- Their structures, like their functions, vary greatly. They are all, however, polymers of amino acids, arranged in a linear sequence.
- The functions of proteins are very diverse because there are 20 different chemically distinct amino acids that form long chains, and the amino acids can be in any order. For example, proteins can function as enzymes or hormones.
- Proteins have different shapes and molecular weights; some proteins are globular in shape whereas others are fibrous in nature. For example, hemoglobin is a globular protein, but collagen, found in our skin, is a fibrous protein.

A- Enzymes:

- which are produced by living cells, are catalysts in biochemical reactions (like digestion) and are usually proteins.
- Each enzyme is specific for the substrate (a reactant that binds to an enzyme) upon which it acts.
- Enzymes can function to break molecular bonds, to rearrange bonds, or to form new bonds.
- An example of an enzyme is salivary amylase, which breaks down amylose, a component of starch.

B- Hormones:

- Which are chemical signaling molecules, usually proteins or steroids.
- Secreted by an endocrine gland or group of endocrine cells that act to control or regulate specific physiological processes, including growth, development, metabolism, and reproduction.
- For example: insulin is a protein hormone that maintains blood glucose levels.

Note: Amino acids are the monomers that make up proteins. Each amino acid has the same fundamental structure, which consists of a central carbon atom bonded to an amino group (–NH2), a carboxyl group (–COOH), and a hydrogen atom.

4- Nucleic Acids

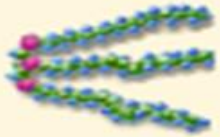
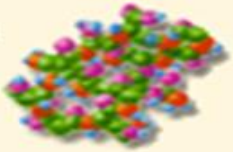
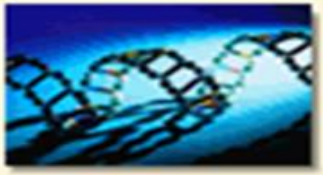
- Nucleic acids are key macromolecules in the continuity of life.
- They carry the genetic blueprint of a cell and carry instructions for the functioning of the cell.
- The two main types of nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).
- DNA is the genetic material found in all living organisms, ranging from single-celled bacteria to multicellular mammals.
- The other type of nucleic acid: RNA, is mostly involved in protein synthesis.
- The DNA molecules never leave the nucleus, but instead use an RNA intermediary to communicate with the rest of the cell. Other types of RNA are also involved in protein synthesis and its regulation.
- DNA and RNA are made up of monomers known as nucleotides.

- The nucleotides combine with each other to form a polynucleotide, DNA or RNA.
- Each nucleotide is made up of three components:

i. a nitrogenous base.

ii. a pentose (five-carbon) sugar.

iii. a phosphate group.

Macromolecules	Monomers	Functions	Examples
Carbohydrates 	Sugar	Store Energy Structural Material	 Potato
Lipids 	Fatty acid	Store Energy Form Membrane Steroids	 Fat cells
Proteins 	Amino acid	Enzymes Stuctural Material Peptides	 Hair
Nucleic Acids 	Nucleotide	Store genetic information	 DNA

DNA Double-Helical Structure:

- DNA has a double-helical structure.
- It is composed of two strands, or polymers of nucleotides.
- The strands are formed with bonds between phosphate and sugar groups of adjacent nucleotides.
- The strands are bonded to each other at their bases with hydrogen bonds, and the strands coil about each other along their length, hence the "double helix".
- The alternating sugar and phosphate groups lie on the outside of each strand, forming the backbone of the DNA.
- The nitrogenous bases are stacked in the interior, like the steps of a staircase, and these bases pair; the pairs are bound to each other by hydrogen bonds.

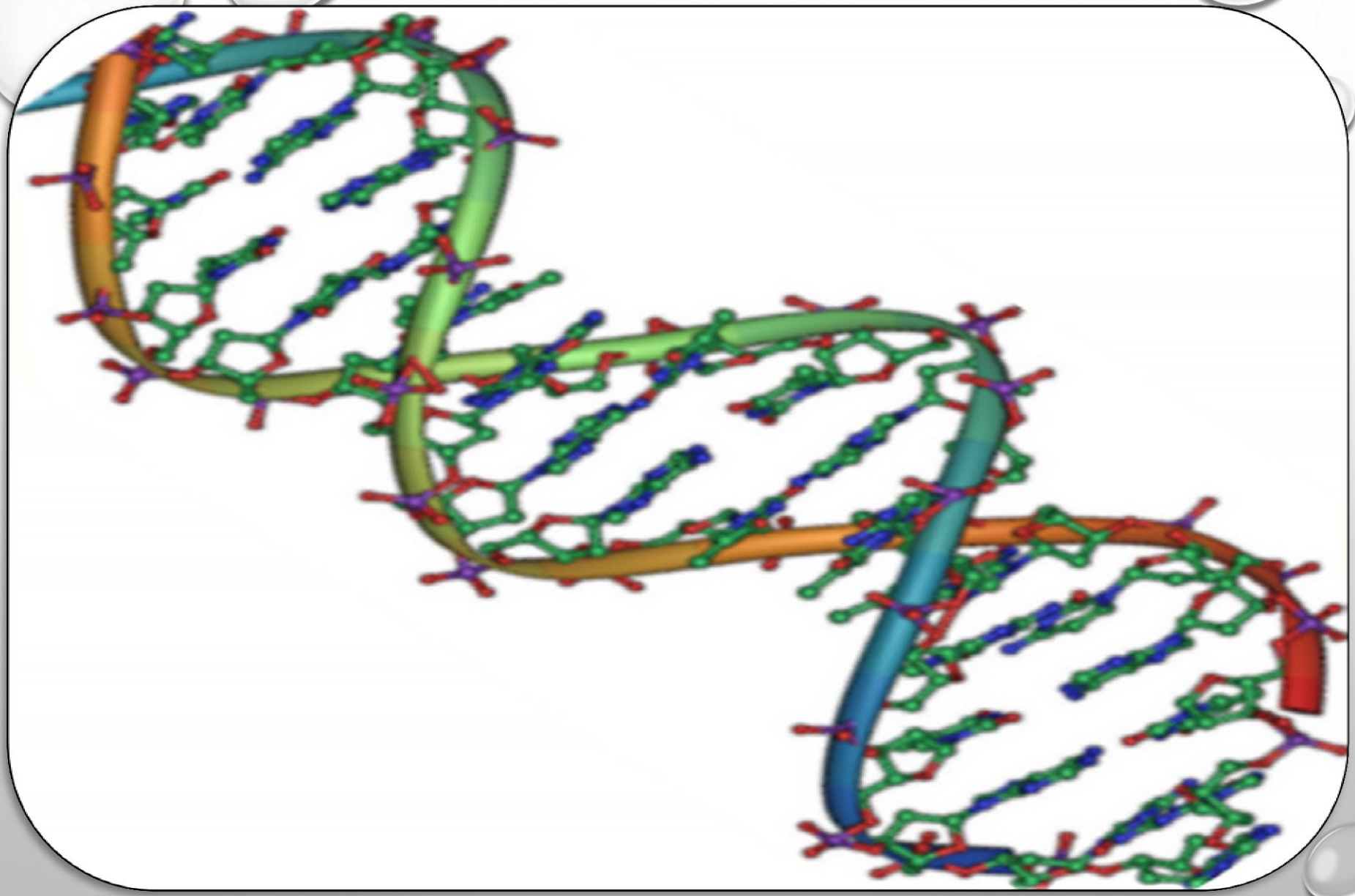


Figure: The double-helix model shows DNA as two parallel strands of intertwining molecules.


THANK YOU