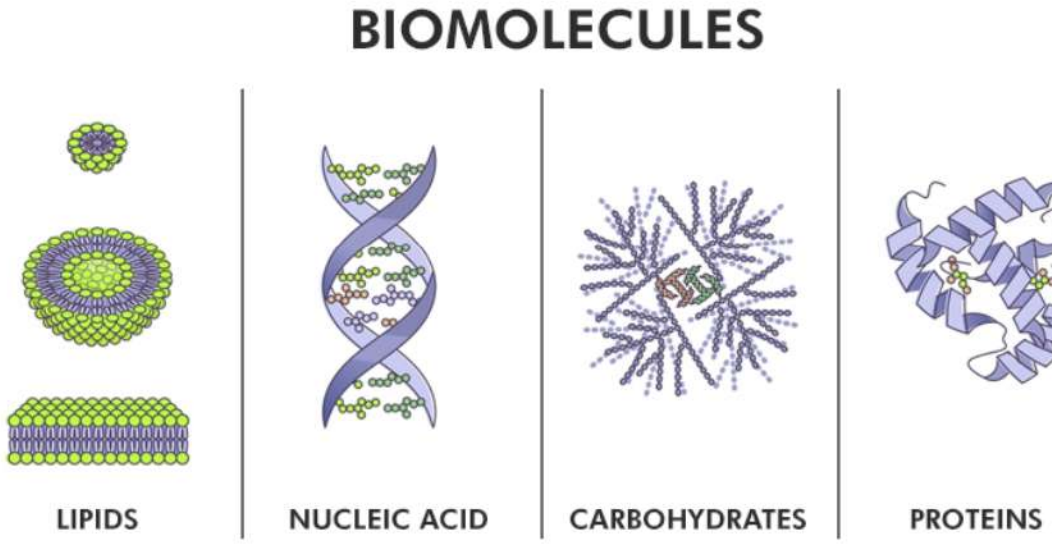
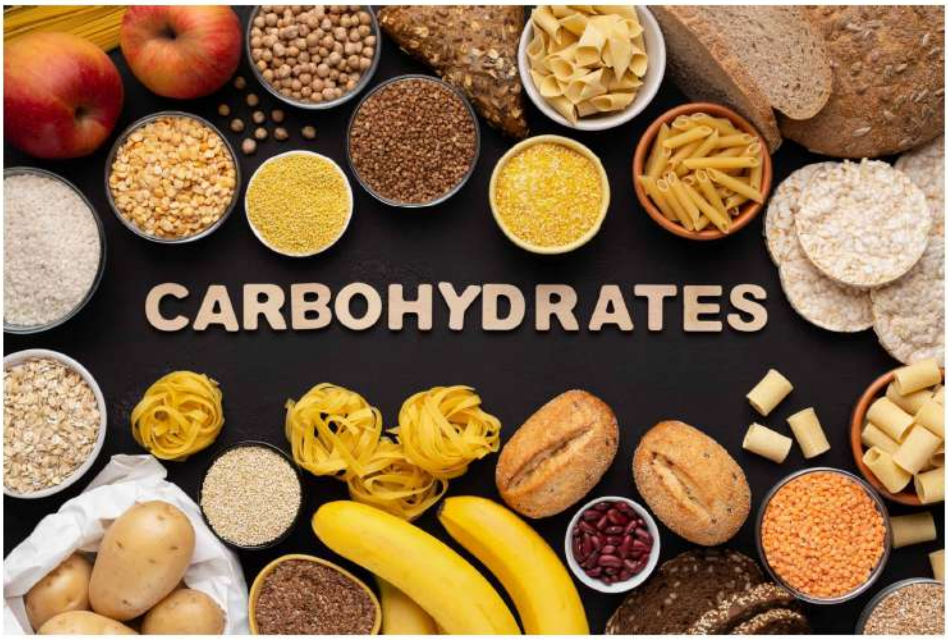
Biological Molecules

Biological molecules are essential compounds that form the building blocks of all living organisms. These include carbohydrates, proteins, lipids, water, and enzymes. Each type of molecule plays a unique role in maintaining life processes, providing energy, building cellular structures, or facilitating chemical reactions.

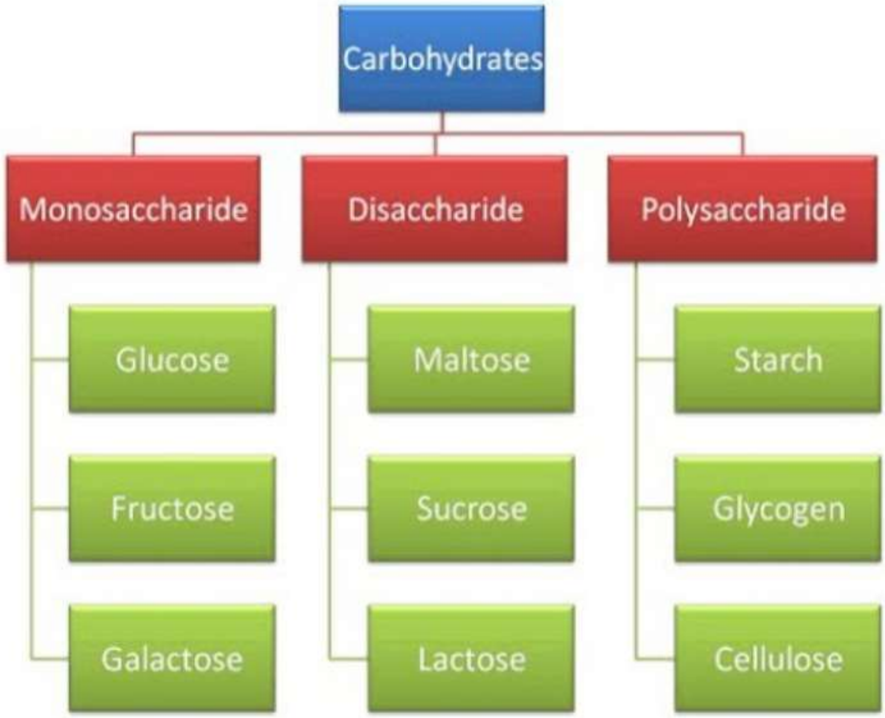


Carbohydrates

Carbohydrates are organic compounds made of carbon, hydrogen, and oxygen, often in a 1:2:1 ratio.



Types of Carbohydrates



Monosaccharides: Simple sugars like glucose, fructose, and galactose. Glucose is vital for cellular respiration and is a quick energy source.

Disaccharides: Formed by joining two monosaccharides, e.g., sucrose (glucose + fructose), lactose (glucose + galactose), and maltose (glucose + glucose).

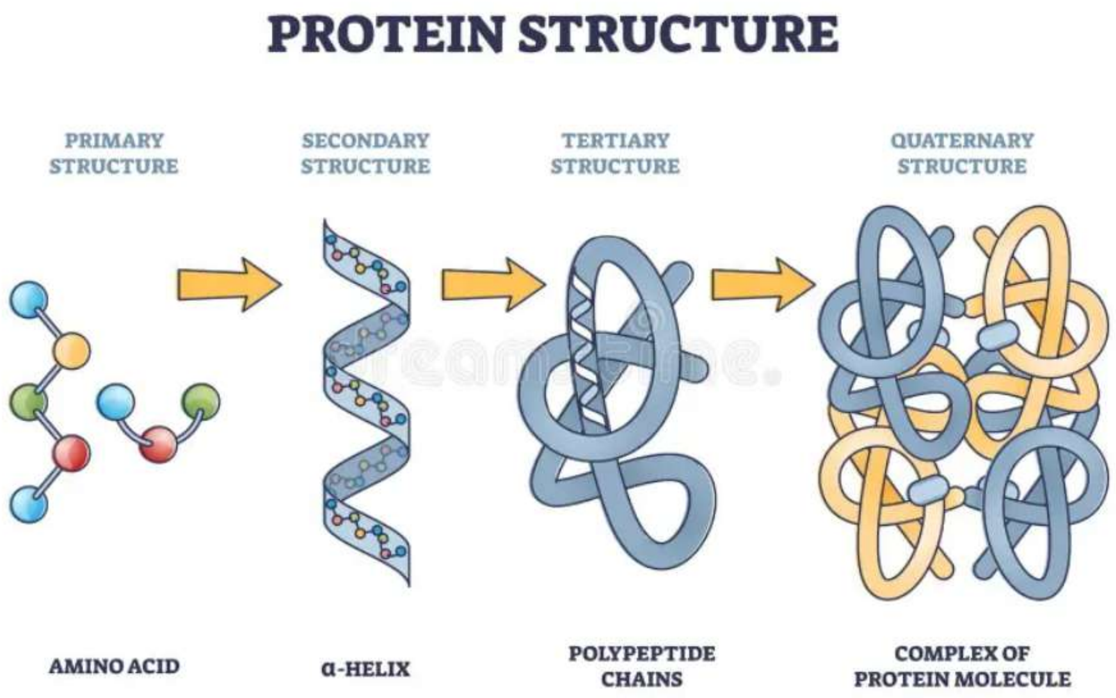
Polysaccharides: Complex carbohydrates formed by long chains of monosaccharides.
Starch: Storage form of glucose in plants, broken down during digestion for energy.
Glycogen: Storage form of glucose in animals, stored in the liver and muscles.
Cellulose: Structural component of plant cell walls, provides rigidity, and is a dietary fiber for humans.

Functions of Carbohydrates
Energy Source: Glucose is the primary energy source for cellular respiration.
Energy Storage: Starch in plants and glycogen in animals.
Structural Role: Cellulose forms plant cell walls, and chitin is used in fungi cell walls and arthropod exoskeletons.
Metabolic Importance: Carbohydrates are broken down through glycolysis and the Krebs cycle to produce ATP, the energy currency of cells.

Proteins

Proteins are complex molecules made of amino acids linked by peptide bonds, containing carbon, hydrogen, oxygen, nitrogen, and sometimes sulfur.

Structure of Proteins



Amino Acids:
There are 20 amino acids, each with a specific structure containing an amino group, carboxyl group, hydrogen atom, and a unique R group.

Levels of Protein Structure:

Primary Structure: The sequence of amino acids in a polypeptide chain.

Secondary Structure: Folding of the chain into alpha-helices or beta-sheets stabilized by hydrogen bonds.

Tertiary Structure: Three-dimensional folding due to interactions between R groups, forming a functional protein.

Quaternary Structure: Combination of multiple polypeptide chains into a single protein complex (e.g., hemoglobin).

Functions of Proteins

Structural Support: Collagen in connective tissues, keratin in hair and nails.

Enzymatic Activity: Enzymes accelerate chemical reactions in cells.

Transport: Hemoglobin transports oxygen; membrane proteins assist in transport across cell membranes.

Communication: Hormones like insulin regulate physiological processes.

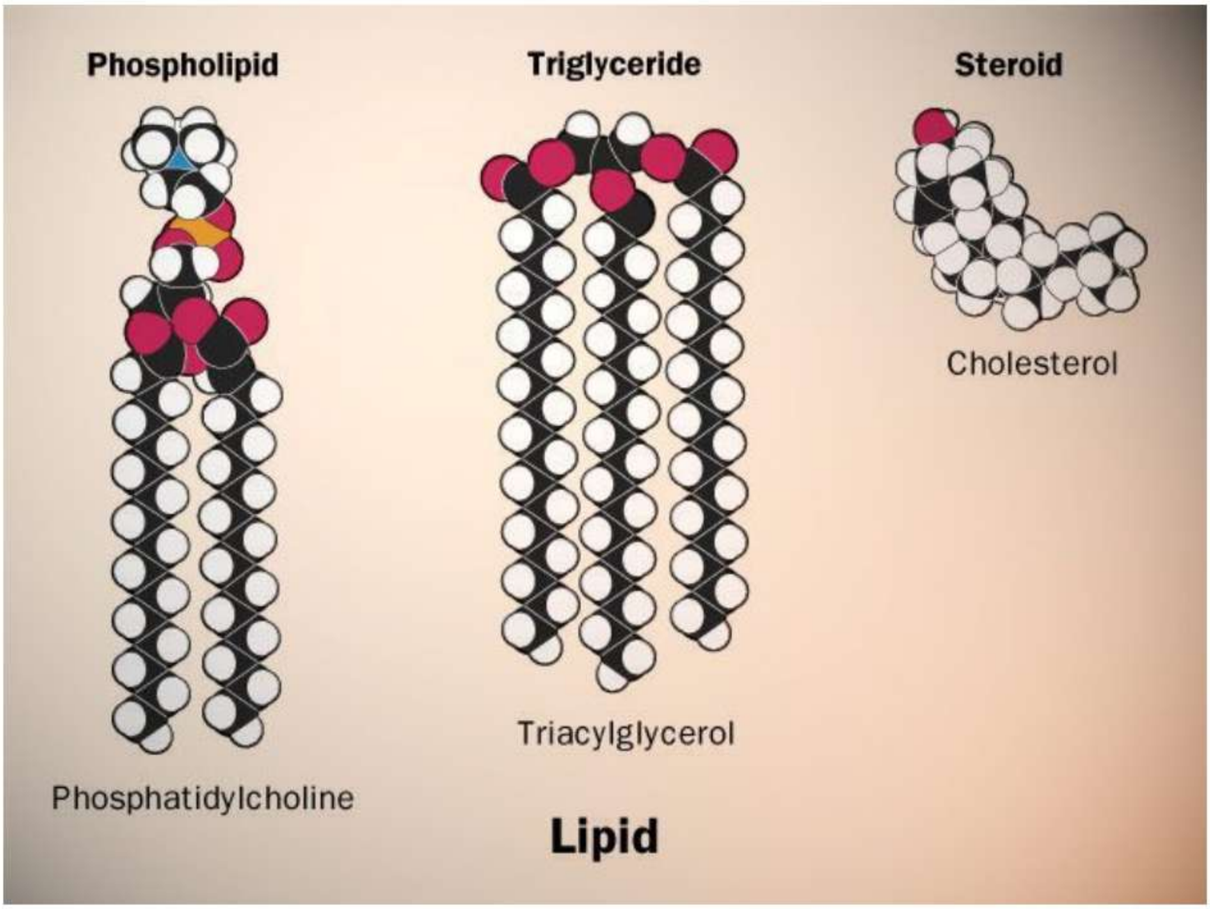
Immune Defense: Antibodies recognize and neutralize pathogens.

Metabolic Importance: Proteins can be used as an energy source when carbohydrates and fats are insufficient, though their primary roles are structural and functional.

Lipids

Lipids are nonpolar molecules, including fats, oils, and steroids, composed mainly of carbon, hydrogen, and oxygen.

Types of Lipids



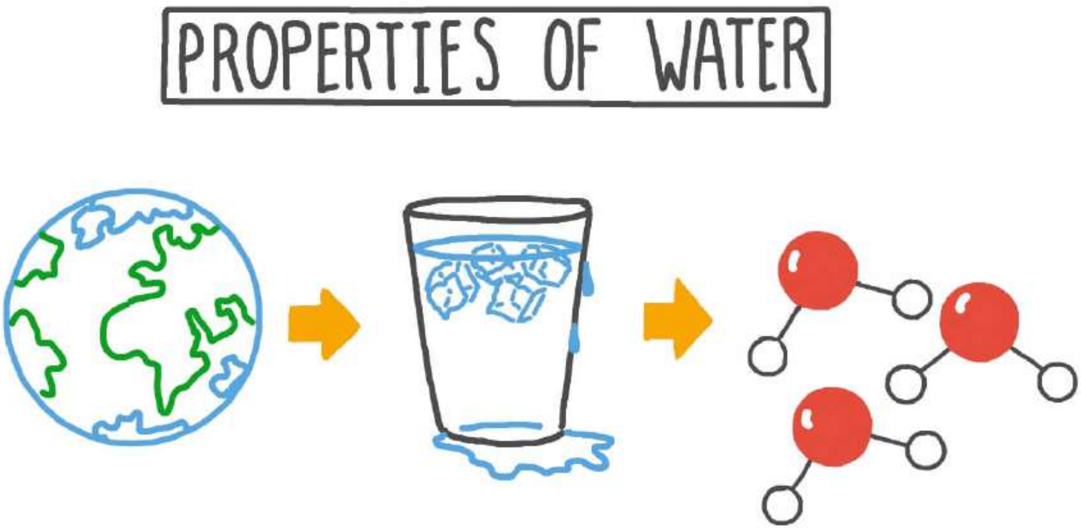
Triglycerides: Made of glycerol and three fatty acids; major form of stored energy in animals.
Phospholipids: Comprise cell membranes, containing a hydrophilic head and two hydrophobic tails.
Steroids: Lipids with a ring structure, such as cholesterol and hormones like estrogen and testosterone.

Functions of Lipids
Energy Storage: Lipids provide a high energy yield per gram, stored as fat in animals.
Cell Membrane Structure: Phospholipids form the bilayer in cell membranes.
Insulation and Protection: Fat provides thermal insulation and cushions organs.

Hormone Production: Steroids act as signaling molecules in various body processes.
Metabolic Importance: Lipids are broken down to fatty acids and glycerol, providing energy when glucose is scarce.

Importance of Water in Biological Systems
Water is a polar molecule crucial for all living organisms, comprising about 70-80% of a cell's mass.

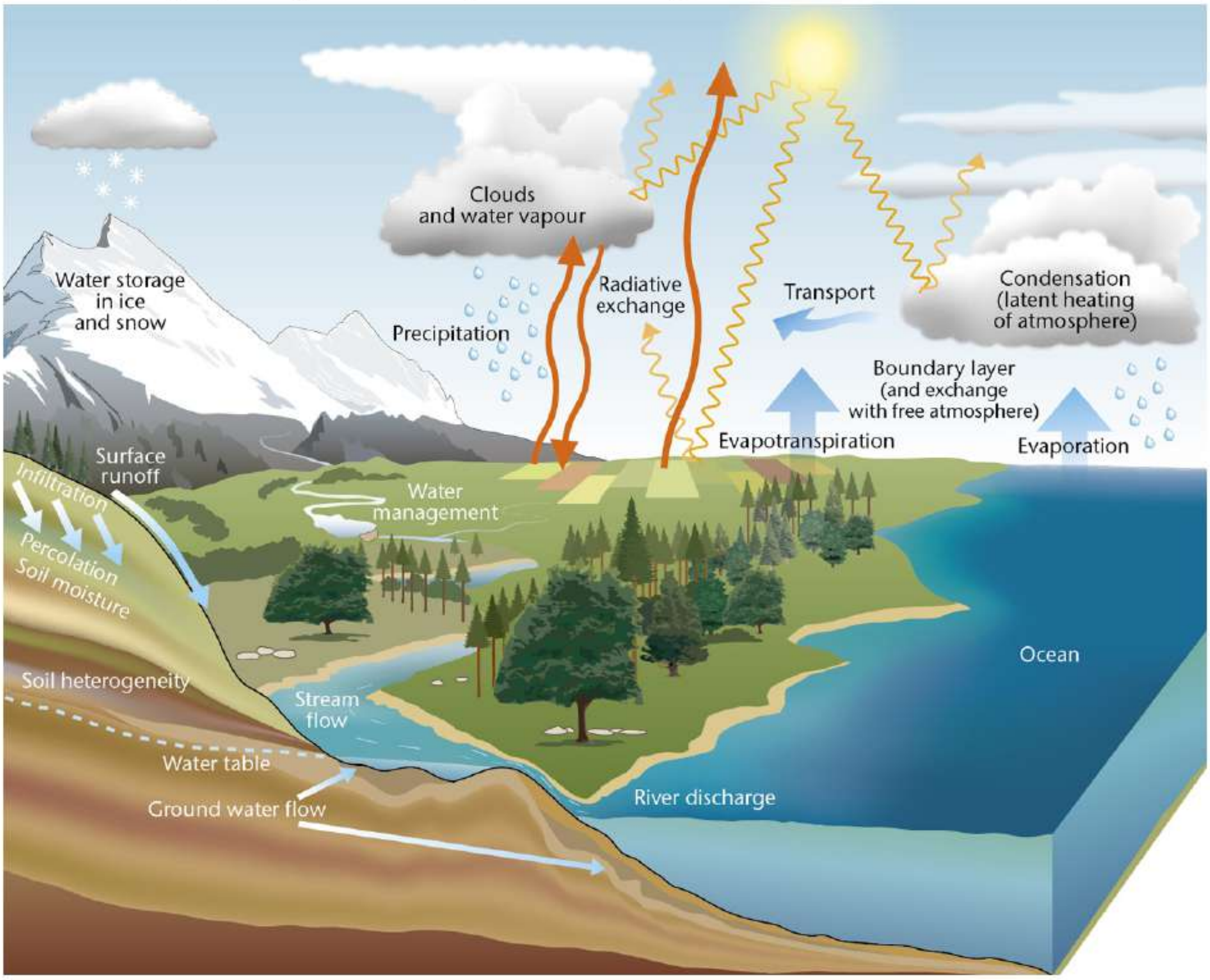
Properties of Water



Cohesion and Adhesion: Water molecules stick together (cohesion) and to other substances (adhesion), aiding in water transport in plants.
Solvent Properties: Water dissolves polar molecules and ions, making it essential for biochemical reactions.
Thermal Stability: Water has a high specific heat, stabilizing temperature changes within organisms and ecosystems.
Density of Ice: Ice is less dense than liquid water, allowing it to float and insulate aquatic life in winter.

Roles of Water in Organisms
Solvent for Chemical Reactions: Facilitates metabolic reactions by dissolving reactants and products.
Transportation Medium: In blood and plant xylem, water transports nutrients, gases, and wastes.
Temperature Regulation: Evaporation of water (sweating, transpiration) helps cool organisms.
Structural Support: Water pressure within cells (turgor pressure) maintains plant rigidity.

Water Cycle in Nature: Water is continuously cycled through ecosystems, essential for nutrient transport, ecosystem stability, and climate regulation.



Enzyme Structure and Function

Enzymes are biological catalysts made of protein, speeding up biochemical reactions without being consumed.

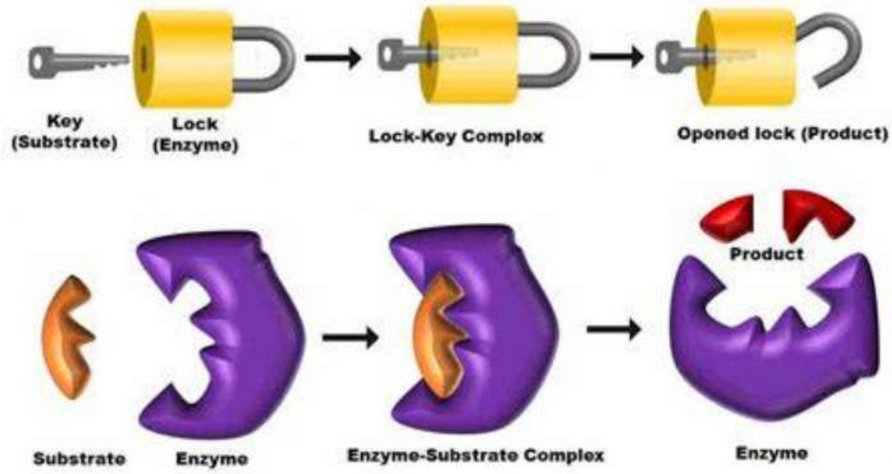
Structure of Enzymes

Enzymes have a unique three-dimensional shape with an active site, where substrate molecules bind.

The shape and chemical environment of the active site are specific to the substrate, similar to a "lock and key."

Mechanism of Enzyme Action

Lock and Key Model: The enzyme's active site is perfectly shaped to fit a specific substrate.



Induced Fit Model: The active site slightly changes shape to accommodate the substrate, ensuring a snug fit.
Enzymes lower the activation energy required for reactions, allowing them to proceed faster at biological temperatures.

Factors Affecting Enzyme Activity

Temperature: Enzyme activity increases with temperature up to an optimum point, after which it denatures.
pH: Each enzyme has an optimal pH. Extremes in pH can alter the enzyme's shape and function.
Substrate Concentration: Higher substrate concentration increases activity until enzyme saturation occurs.
Inhibitors: Molecules that decrease enzyme activity by blocking or altering the active site, e.g., competitive and non-competitive inhibitors.

Enzyme Applications

Biological Processes: Digestion (amylase, protease, lipase), DNA replication (DNA polymerase).
Industrial Use: Enzymes are used in food processing, detergents, and pharmaceuticals.

Conclusion

Understanding biological molecules is crucial for recognizing how life is sustained at the molecular level. Carbohydrates, proteins, and lipids serve as essential building blocks, energy sources, and functional molecules, while water's unique properties make it indispensable for life processes. Enzymes enable biochemical reactions to proceed efficiently, maintaining life processes even under diverse environmental conditions. Mastering these concepts lays a strong foundation for comprehending higher biological processes, cellular mechanisms, and how life operates in diverse conditions and organisms.