Biological macromolecules are large molecules essential for life, composed primarily of carbon atoms along with hydrogen, oxygen, nitrogen, sulphur, and phosphorus. These molecules are crucial for the structure, function, and regulation of living organisms. There are four main classes of biological macromolecules:

1. Carbohydrates:

- **Composition:** Carbohydrates are composed of carbon (C), hydrogen (H), and oxygen (O) atoms in a ratio of approximately 1:2:1.
- **Functions:** They serve as a primary source of energy (e.g., glucose) and as structural components (e.g., cellulose in plant cell walls).
- **Examples:** Monosaccharides (e.g., glucose, fructose), disaccharides (e.g., sucrose, lactose), polysaccharides (e.g., starch, glycogen, cellulose).

2. Lipids:

- **Composition:** Lipids are diverse in structure but are predominantly composed of carbon (C), hydrogen (H), and oxygen (O).
- **Functions:** They serve as energy storage molecules (e.g., fats, oils), structural components of cell membranes (e.g., phospholipids), and signaling molecules (e.g., steroid hormones).
- **Examples:** Fats (triglycerides), phospholipids, steroids (e.g., cholesterol), waxes.

3. Proteins:

- **Composition:** Proteins are composed of amino acids, each containing a central carbon atom (C), an amino group (NH2), a carboxyl group (COOH), and a side chain (R group) that varies among different amino acids.
- **Functions:** Proteins serve as structural components (e.g., collagen in connective tissues), enzymes that catalyse biochemical reactions, transport molecules (e.g., hemoglobin), and signaling molecules (e.g., hormones).
- **Examples:** Enzymes, antibodies, hemoglobin, keratin, collagen.

4. Nucleic Acids:

- **Composition:** Nucleic acids are composed of nucleotides, each consisting of a nitrogenous base (adenine, thymine, cytosine, guanine in DNA; adenine, uracil, cytosine, guanine in RNA), a five-carbon sugar (ribose in RNA, deoxyribose in DNA), and a phosphate group.

- **Functions:** They store and transmit genetic information, serve as templates for protein synthesis, and participate in cellular energy transfer (e.g., ATP).
- **Examples:** DNA (deoxyribonucleic acid) and RNA (ribonucleic acid).

Biological Macromolecules in Action:

- **Digestion and Metabolism:** Carbohydrates are broken down into simple sugars (e.g., glucose) for energy, while lipids provide a concentrated source of energy. Proteins are broken down into amino acids, which are used for growth and repair.
- **Cellular Structure:** Lipids form the lipid bilayer of cell membranes, providing a barrier between the cell and its environment. Proteins embedded in membranes serve as channels, receptors, and transporters.
- **Genetic Information:** DNA stores genetic information in sequences of nucleotide bases, which are transcribed into RNA. RNA, in turn, directs the synthesis of proteins through a process called translation.

Understanding the structure, function, and interactions of biological macromolecules is essential for understanding the complexities of life processes, from molecular interactions within cells to the functioning of entire organisms. Advances in biochemistry and molecular biology continue to reveal new insights into these fundamental components of life.