



**MULTIDISCIPLINARY
BIOTECHNOLOGY UNIT 1**



Definition, Scope and Milestones in Biotechnology

Biotechnology is a field of science that involves the use of living organisms, cells, and biological systems to develop new products, processes, and technologies that improve human health, food production, and environmental sustainability. The scope of biotechnology is broad and encompasses many different areas, including medical biotechnology, agricultural biotechnology, industrial biotechnology, environmental biotechnology, and many others.

The history of biotechnology can be traced back thousands of years to early human civilizations, which used fermentation to produce food and beverages. However, the modern era of biotechnology began in the mid-20th century with the discovery of the structure of DNA and the development of new techniques for manipulating genetic material. Since then, biotechnology has advanced rapidly, with numerous milestones that have transformed the field and opened up new possibilities for research and development.

Some of the key milestones in biotechnology include:

- Discovery of DNA structure (1953)
- Development of recombinant DNA technology (1970s)
- Creation of the first genetically engineered organism (1973)
- Development of monoclonal antibody technology (1975)
- Approval of the first recombinant DNA drug (1982)
- Completion of the Human Genome Project (2003)
- Development of CRISPR-Cas9 gene editing technology (2012)

Today, biotechnology is a rapidly growing field with numerous applications in healthcare, agriculture, energy, and other industries. It has the potential to transform many aspects of modern life, from the development of new treatments for diseases to the production of more sustainable food and energy sources. As the field continues to evolve and new technologies emerge, the scope and impact of biotechnology are likely to expand even further.

Carbohydrates are one of the four main types of biomolecules, along with proteins, lipids, and nucleic acids. They are made up of carbon, hydrogen, and oxygen atoms, with the general formula $(CH_2O)_n$. Carbohydrates are important sources of energy for living organisms, and they also play a variety of other roles in cellular function.

The basic building blocks of carbohydrates are monosaccharides, or simple sugars, which include glucose, fructose, and galactose. Monosaccharides can be joined together through dehydration synthesis to form larger molecules, including disaccharides (such as sucrose and lactose) and polysaccharides (such as starch, glycogen, and cellulose).

Carbohydrates are organic molecules made up of carbon, hydrogen, and oxygen atoms. The general chemical formula for carbohydrates is $(CH_2O)_n$, where "n" represents the number of carbon atoms in the molecule.

Carbohydrates can be divided into three main categories: monosaccharides, disaccharides, and polysaccharides.

- **Monosaccharides:** Monosaccharides are the simplest form of carbohydrates and are known as simple sugars. They are made up of a single sugar molecule, such as glucose, fructose, or galactose. Monosaccharides can exist in either linear or ring forms, depending on the arrangement of their atoms.
- **Disaccharides:** Disaccharides are formed when two monosaccharides are joined together through a glycosidic bond. Common disaccharides include sucrose (table sugar), lactose (found in milk), and maltose (found in malted grain).
- **Polysaccharides:** Polysaccharides are complex carbohydrates made up of many monosaccharides joined together through glycosidic bonds. They can be further classified into two main types:
 - **Homopolysaccharides:** Homopolysaccharides are made up of a single type of monosaccharide. Examples include cellulose (found in plant cell walls) and glycogen (a storage form of glucose in animals).
 - **Heteropolysaccharides:** Heteropolysaccharides are made up of two or more different types of monosaccharides. Examples include chondroitin sulfate (found in cartilage) and hyaluronic acid (found in connective tissue).

The structure of carbohydrates is determined by the arrangement of their atoms, particularly the location and orientation of hydroxyl (-OH) groups on the sugar molecules. This arrangement affects the physical and chemical properties of carbohydrates, such as their solubility, reactivity, and ability to form hydrogen bonds.

The functions of carbohydrates in living organisms are diverse and include:

- Energy storage: Glucose, a monosaccharide, is a primary source of energy for many organisms. Excess glucose can be stored as glycogen in animals and as starch in plants.
- Structural support: Carbohydrates play an important role in providing structural support to cells and tissues. For example, cellulose, a polysaccharide found in plant cell walls, provides rigidity and strength to plant cells.
- Cell-cell recognition: Carbohydrates on the surface of cells can serve as recognition molecules, allowing cells to identify and communicate with one another.
- Lubrication: Carbohydrates can act as lubricants in the body, helping to prevent damage to tissues and organs.
- Signaling: Carbohydrates can also act as signaling molecules, playing a role in processes such as hormone regulation and cell growth and differentiation.

Overall, carbohydrates are essential biomolecules that play a wide range of roles in cellular function and physiology. Their structural diversity and versatility make them an important focus of study in many areas of biology and biotechnology.

Structure and functions of proteins Proteins are complex molecules made up of long chains of amino acids. The structure of proteins can be described at four different levels: primary, secondary, tertiary, and quaternary.

Primary structure: This refers to the sequence of amino acids in the protein chain. There are 20 different types of amino acids that can be combined in any order to form a protein.

Secondary structure: This refers to the local folding of the protein chain into regular patterns such as alpha helices or beta sheets. These structures are stabilized by hydrogen bonding between the backbone atoms of the amino acids.

Tertiary structure: This refers to the overall 3-dimensional shape of the protein. It is determined by the interactions between the amino acid side chains, including hydrogen bonding, electrostatic interactions, hydrophobic interactions, and disulfide bonds.

Quaternary structure: This refers to the arrangement of multiple protein subunits into a larger, functional protein complex. The subunits can be identical or different, and their arrangement can be symmetric or asymmetric.

The structure of a protein is critical to its function. Changes in the protein's structure can lead to changes in its function, which can have profound effects on the organism or system in which it operates.

Proteins play a critical role in many biological processes and perform a wide range of functions in the body. Some of the key functions of proteins include:

1. Enzymatic catalysis: Many proteins act as enzymes, catalyzing chemical reactions that are essential for life.
2. Structural support: Proteins such as collagen provide structural support for tissues, including skin, tendons, cartilage, and bones.
3. Transport and storage: Proteins such as hemoglobin and myoglobin transport and store oxygen in the body.
4. Signaling: Proteins such as hormones and neurotransmitters act as signaling molecules that transmit messages between cells.
5. Immune defense: Antibodies are proteins that help the immune system recognize and neutralize pathogens such as viruses and bacteria.
6. Muscle contraction: Proteins such as actin and myosin are involved in muscle contraction.
7. Regulation of gene expression: Proteins such as transcription factors regulate gene expression by binding to DNA and controlling the rate at which genes are transcribed into RNA.
8. Metabolism and energy production: Proteins such as enzymes involved in cellular respiration are critical for metabolism and energy production.

These are just some of the many functions of proteins in the body. Different types of proteins perform different functions, and the complex interactions between proteins and other molecules in the body are essential for life.

Structure and functions of Lipids

Lipids are a diverse group of organic compounds that are insoluble in water but soluble in nonpolar solvents such as chloroform, ether, and acetone. They play important roles in the body, including:

- Energy storage: Lipids such as triglycerides are an efficient form of energy storage in the body. When the body needs energy, these lipids can be broken down and used for fuel.
- Cell membrane structure: Phospholipids and cholesterol are key components of cell membranes, providing a barrier between the cell and its environment and regulating the movement of molecules into and out of the cell.
- Signaling: Lipids such as prostaglandins and leukotrienes are involved in signaling pathways that regulate a variety of physiological processes, including inflammation, blood clotting, and fever.
- Insulation and protection: Lipids such as adipose tissue provide insulation to help regulate body temperature and protect organs from damage.
- Hormone synthesis: Lipids such as cholesterol are used in the synthesis of hormones such as testosterone and estrogen.

The structure of lipids varies depending on the specific type of lipid, but they generally consist of a hydrocarbon chain attached to a polar or nonpolar head group. Common types of lipids include fatty acids, triglycerides, phospholipids, and cholesterol.

Overall, lipids are essential for maintaining normal physiological function in the body, and their structure and function are tightly regulated to ensure proper cellular and systemic function.

Structure and functions of Nucleic acids

Nucleic acids are large biomolecules that play a critical role in the storage, transmission, and expression of genetic information. There are two main types of nucleic acids: DNA (deoxyribonucleic acid) and RNA (ribonucleic acid).

The structure of nucleic acids is based on the nucleotide, which is composed of three parts: a nitrogenous base, a five-carbon sugar (either deoxyribose in DNA or ribose in RNA), and a phosphate group. The nitrogenous bases in DNA are adenine (A), thymine (T), guanine (G), and

cytosine (C), while in RNA, thymine is replaced by uracil (U). The nucleotides are joined together by covalent bonds between the sugar and phosphate groups, forming a long chain.

The primary function of nucleic acids is to store and transmit genetic information from one generation to the next. DNA is the genetic material in most organisms, and it carries the instructions for the synthesis of proteins and other biomolecules. RNA plays a key role in the translation of genetic information into proteins by serving as an intermediary between DNA and protein synthesis machinery.

In addition to their role in genetic information storage and transmission, nucleic acids also play a variety of other important functions in the cell. For example, RNA molecules can catalyze chemical reactions, regulate gene expression, and participate in other cellular processes such as RNA splicing and protein synthesis. Nucleic acids also play a role in various signaling pathways, such as in the regulation of the immune response.

Overall, nucleic acids are essential biomolecules that play a critical role in the maintenance of genetic information and the proper functioning of cells and organisms.