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BIOMOLECULES

All the carbon compounds that we get from living tissues can be called ‘biomolecules.

Elemental analysis gives elemental composition of living tissues in the form of hydrogen, oxygen, chlorine, carbon etc. while analysis for compounds gives an idea of the kind of organic and inorganic constituents present in living tissues.

we shall classify them into amino acids, nucleotide bases, fatty acids etc

Amino Acids

Amino acids are organic compounds containing an amino group and an acidic group as substituents on the same carbon i.e., the α-carbon. Hence, they are called α-amino acids.

They are substituted methane’s.

There are four substituent groups occupying the four valency positions. These are hydrogen, carboxyl group, amino group and a variable group designated as R group.

The R group in these proteinaceous amino acids could be a hydrogen (the amino acid is called glycine), a methyl group (alanine), hydroxy methyl (serine), etc.

The chemical and physical properties of amino acids are essentially of the amino, carboxyl and the R functional groups.

Based on number of amino and carboxyl groups, there are acidic (e.g., glutamic acid), basic (lysine) and neutral (valine) amino acids.

There are aromatic amino acids (tyrosine, phenylalanine, tryptophan).

A particular property of amino acids is the ionizable nature of $-NH_2$ and $-COOH$ groups.

Fatty Acids

A fatty acid has a carboxyl group attached to an R group. The R group could be a methyl ($-CH_3$), or ethyl ($-C_2H_5$) or higher number of $-CH_2$ groups (1 carbon to 19 carbons).

Fatty acids could be saturated (without double bond) or unsaturated (with one or more C=C double bonds).

Glycerol which is trihydroxy propane is another simple lipid.

Many lipids have both glycerol and fatty acids. Here the fatty acids are found esterified with glycerol.

They can be then monoglycerides, diglycerides and triglycerides

Some lipids have phosphorous and a phosphorylated organic compound in them. These are phospholipids. They are found in cell membrane. Lecithin is one example.

Nucleosides

Nitrogen bases carbon compounds in which heterocyclic rings can be found. are – adenine, guanine, cytosine,

uracil, and thymine. When found attached to a sugar, they are called nucleosides

Adenosine, guanosine, thymidine, uridine and cytidine are nucleosides.

Nucleotides

carbon compounds in which heterocyclic rings can be found If a phosphate group is also found esterified to the sugar, they are called nucleotides.

Adenylic acid, thymidylic acid, guanylic acid, uridylic acid and cytidylic acid are nucleotides.

Nucleic acids like DNA and RNA consist of nucleotides only.

PRIMARY AND SECONDARY METABOLITES

A metabolite refers to any substance involved in metabolism. It is often regarded as the immediate by-product of a metabolic process.

The metabolites can be grouped into two major types: primary and secondary.

Primary metabolites are those that are directly involved in the growth, development, and reproduction of an organism whereas secondary metabolites are those that are not.

Thus, primary metabolites are critical to the survival and the fecundity of an organism. Secondary metabolites may not be as crucial but the lack or insufficiency could lead to the impairment of the organism.

Examples of primary metabolites are ethanol, glutamic acid, aspartic acid, 5′ guanylic acid, acetic acid, lactic acid, glycerol, etc. Examples of secondary metabolites are pigments, resins, terpenes, ergot, alkaloids, antibiotics, naphthalene's, nucleosides, quinolones, peptides, growth hormones, etc.

BIOMACROMOLECULE

Biomacromolecules are biomolecules that have an enormous size of 800 to 1000 Daltons, high sub-atomic loads and complex designs.

They are natural polymers of various basic or monomeric units. Instances of Biomacromolecules are Proteins, Nucleic Acids (DNA and RNA), Carbohydrates and lipids.

PROTEINS

Proteins are polypeptides. They are linear chains of amino acids linked by peptide bonds.

Each protein is a polymer of amino acids. there are 20 types of amino acids (e.g., alanine, cysteine, proline, tryptophan, lysine, etc.), a protein is a heteropolymer and not a homopolymer.

Proteins carry out many functions in living organisms, some transport nutrients across cell membrane, some fight infectious organisms, some are hormones, some are enzymes. etc.

Collagen is the most abundant protein in animal world and Ribulose bisphosphate Carboxylase-Oxygenase (RuBisCO) is the most abundant protein.

POLYSACCHARIDES

Polysaccharides are long chains of sugars. They are threads containing different monosaccharides as building blocks.

For example, cellulose is a polymeric polysaccharide consisting of only one type of monosaccharide i.e., glucose.

Cellulose is a homopolymer.

In a polysaccharide chain, the right end is called the reducing end and the left end is called the non-reducing end.

Starch forms helical secondary structures. In fact, starch can hold I_2 molecules in the helical portion. The starch-I_2 is blue in colour. Cellulose does not contain complex helices and hence cannot hold I_2.

There are more complex polysaccharides in nature. They have as building blocks, amino-sugars and chemically modified sugars (e.g., glucosamine, N-acetyl galactosamine, etc.).

NUCLEIC ACIDS

These are polynucleotides. Together with polysaccharides and polypeptides these comprise the true macromolecular fraction of any living tissue or cell.

For nucleic acids, the building block is a nucleotide. A nucleotide has three chemically distinct components.

One is a heterocyclic compound, the second is a monosaccharide and the third a phosphoric acid or phosphate.

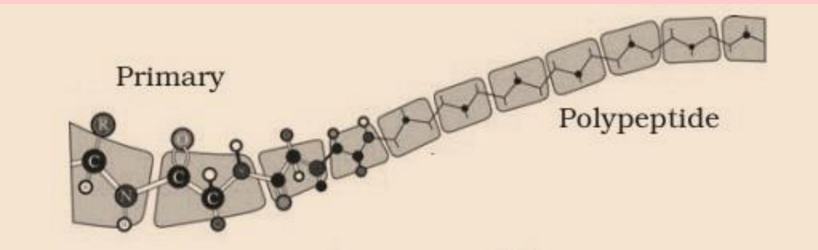
the heterocyclic compounds in nucleic acids are the nitrogenous bases named adenine, guanine, uracil, cytosine, and thymine. Adenine and Guanine are substituted purines while the rest are substituted pyrimidines. The skeletal heterocyclic ring is called as purine and pyrimidine respectively.

STRUCTURE OF PROTEINS

Primary structure

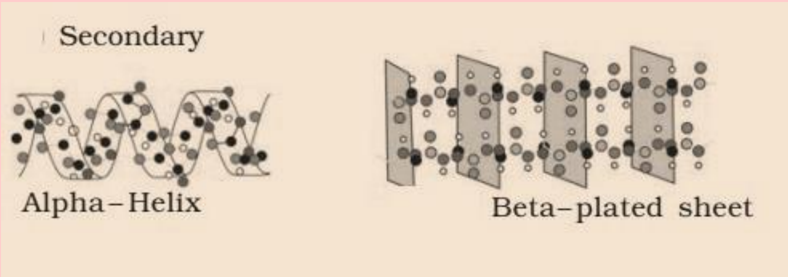
The sequence of amino acids i.e., the positional information in a protein – which is the first amino acid, which is second, and so on – is called the primary structure of a protein

A protein is imagined as a line, the left end represented by the first amino acid and the right end represented by the last amino acid. The first amino acid is also called as N-terminal amino acid. The last amino acid is called the C-terminal.



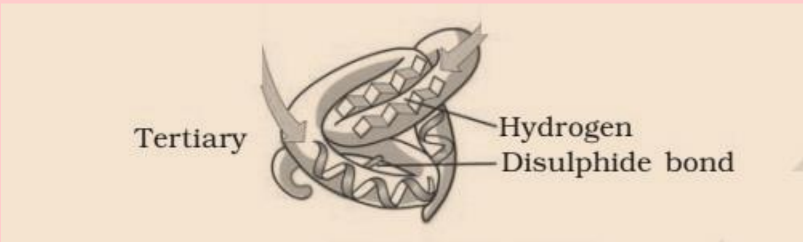
Secondary structure

only some portions of the protein thread are arranged in the form of a helix. In proteins, only right-handed helices are observed. Other regions of the protein thread are folded into other forms in what is called the secondary structure



Tertiary structure

In addition, the long protein chain is also folded upon itself like a hollow woollen ball, giving rise to the tertiary structure. This gives us a 3-dimensional view of a protein. Tertiary structure is absolutely necessary for the many biological activities of proteins.



Quaternary structure

Some proteins are an assembly of more than one polypeptide or subunits. The manner in which these individual folded polypeptides or subunits are arranged with respect to each other.

ENZYMES

One can depict an enzyme by a line diagram. An enzyme like any protein has a primary structure, i.e., amino acid sequence of the protein. An enzyme like any protein has the secondary and the tertiary structure.

In tertiary structure the backbone of the protein chain folds upon itself, the chain criss-crosses itself and hence, many crevices or pockets are made. One such pocket is the ‘active site’. An active site of an enzyme is a crevice or pocket into which the substrate fits.

Inorganic catalysts work efficiently at high temperatures and high pressures, while enzymes get damaged at high temperatures

Chemical Reactions

when bonds are broken and new bonds are formed during transformation, this will be called a chemical reaction.

Rate of a physical or chemical process refers to the amount of product formed per unit time. It can be expressed as

$$\text{rate} = \frac{\delta P}{\delta t}$$

Rate can also be called velocity if the direction is specified. Rates of physical and chemical processes are influenced by temperature among other factors.

Nature of Enzyme Action

Each enzyme (E) has a substrate (S) binding site in its molecule so that a highly reactive enzyme-substrate

complex (ES) is produced. This complex is short-lived and dissociates into its product(s) P and the unchanged enzyme with an intermediate formation of the enzyme-product complex (EP).

In catalytic cycle of an enzyme

the substrate binds to the active site of the enzyme, fitting into the active site

The binding of the substrate induces the enzyme to alter its shape, fitting more tightly around the substrate.

The active site of the enzyme, now in close proximity of the substrate breaks the chemical bonds of the substrate and the new enzyme- product complex is formed.

The enzyme releases the products of the reaction and the free enzyme is ready to bind to another molecule of the substrate and run through the catalytic cycle once again.

Factors Affecting Enzyme Activity

Temperature and pH

Each enzyme shows its highest activity at a particular temperature and pH called the optimum temperature and optimum pH.

Concentration of Substrate

The activity of an enzyme is also sensitive to the presence of specific chemicals that bind to the enzyme. When the binding of the chemical shuts off enzyme activity, the process is called inhibition and the chemical is called an inhibitor.

When the inhibitor closely resembles the substrate in its molecular structure and inhibits the activity of the enzyme, it is known as competitive inhibitor.

Classification and Nomenclature of Enzymes

Enzymes are divided into 6 classes each with 4-13 subclasses and named accordingly by a four-digit number.

Oxidoreductases/dehydrogenases:

Enzymes which catalyse oxidoreduction between two substrates S and S'

Transferases:

Enzymes catalysing a transfer of a group, G (other than hydrogen) between a pair of substrate S and S'

Hydrolases:

Enzymes catalysing hydrolysis of ester, ether, peptide, glycosidic, C-C, C-halide or P-N bonds.

Lyases:

Enzymes that catalyse removal of groups from substrates by mechanisms other than hydrolysis leaving double bonds.

Isomerases:

Includes all enzymes catalysing inter-conversion of optical, geometric or positional isomers.

Ligases:

Enzymes catalysing the linking together of 2 compounds, e.g., enzymes which catalyse joining of C-O, C-S, C-N, P-O etc. bonds.

Co-factors

Enzymes are composed of one or several polypeptide chains. However, there are a number of cases in which non-protein constituents called cofactors are bound to the the enzyme to make the enzyme catalytically active.

Three kinds of cofactors may be identified: prosthetic groups, co-enzymes and metal ions.

Prosthetic groups are organic compounds and are distinguished from other cofactors in that they are tightly bound to the apoenzyme.

Co-enzymes are also organic compounds but their association with the apoenzyme is only transient, usually occurring during the course of catalysis.