

Chapter 5- The Structure and Function of Macromolecules

(Key Concepts are Underlined)

Polymer Principles

Most macromolecules are polymers

Macromolecule

Polymer

Monomer

Condensation Reaction (a.k.a. dehydration rx.)- binds monomers by forming water; one contributes -OH and other -H (enzyme controlled)

Hydrolysis- water used to split monomers of polymers

Significance: digestion

An Immense variety of polymers can be built from a small set of monomers

Variation due to arrangement (40 to 50 common monomers of life)

Carbohydrates- Fuel and Building Material

Sugars, the smallest carbohydrates includes both sugars and their polymers

Carbohydrates- include simple sugars and their polymers

Monosaccharides- single sugars (empirical formula = CH_2O); contain many hydroxyl groups; aldose and ketose sugars (depends on location of carbonyl); 3 to 7 carbons long; most have -ose endings (e.g. hexose sugar called glucose); major fuel in cellular work; their carbon skeletons are used to form other organic molecules

Disaccharides- two monosaccharides joined by glycosidic linkages (e.g. sucrose- used in transport in plants)

Polysaccharides, the polymers of sugars, have storage and structural roles

Polysaccharides- polymer of a few hundred to few thousand monosaccharides joined by glycosidic linkages; energy storage and structural material

Starch- food storage; consists of glucose monomers with mostly 1-4 linkages; plants store starches (helical) in plastids; animals store glycogen (branched) in liver and muscle cells

Cellulose- structural; β glucose polymer (hydroxyl on carbon 1 is above the plane of the ring), where the glucose molecules alternate in a “up” and “down” position; they are linear, which allows these molecules to hydrogen bond by lying parallel to one another and form strong microfibrils; special enzymes required to hydrolyze; important for healthful diet; most abundant organic compound on earth

Chitin- structural polysaccharide used by arthropods and many fungi

Lipids- Diverse Hydrophobic Molecules

Fats store large amounts of energy

Lipids- relatively large and varied molecules (not exactly polymers); large hydrocarbon regions making them hydrophobic

Fats (a.k.a. triglycerides)- made up of glycerol and 3 fatty acids (usually 16 to 18 carbons long and have a carboxylic acid “head” and hydrophobic tail), bonded by ester linkages; saturated and unsaturated fats (one or more double bonds in one or more of the fatty acid chains); saturated fatty acids are linear and unsaturated fatty acids are kinked due to double bonds; most saturated fats are animal fats (solid at room temperature), while many

unsaturated fats come from plants (liquid at room temperature)- due to packing; primary function is energy storage (twice the amount of energy of carbohydrates by weight), and padding and insulation are other functions

Phospholipids are major components of cell membranes

Phospholipids- similar to fats, but only 2 fatty acids (the third hydroxyl is attached to phosphate group); the phosphate group (being polar) can be linked to other small polar molecules to form different types of phospholipids; hydrophobic and hydrophilic regions; form micelles in water (phospholipid spheres)

Significance: Phospholipid bilayer

Steroids: lipids with four fused rings and vary in terms of their functional groups;

Significance: Cholesterol (precursor to many steroids)

Proteins- The Molecular Tools of Life

Proteins- used for support, storage, transport, signaling, movement, defense, and reaction catalysis; more than 50% dry weight of most cells; polymers (or **polypeptides**) made up of 20 possible amino acid monomers

Conformation- unique 3-D shape of protein

A polypeptide is a polymer of amino acids connected in a specific sequence

Amino acids- organic molecules containing both carboxyl and amino groups; center contain an asymmetric carbon attached to a hydrogen, carboxyl group, amino group, and a side chain (or R group); R groups differentiate the amino acids and give them unique physical and chemical properties (i.e. nonpolar, polar, acidic, and basic); amino acids are adjoined when the carboxyl group of one and an

amino group of another come together to form a **peptide bond** via dehydration; resulting polypeptides have different lengths and amino acid sequences, which means an immense variety of proteins are possible

A protein's function depends on its specific conformation
-proteins are polypeptides, which have been precisely twisted, folded, and coiled into an unique shape (or conformation); conformation is driven and maintained by bonding between parts of the polypeptide chain, which is ultimately dependent on its amino acid sequence (or primary structure)

Primary structure- unique sequence of amino acids, which is determined by DNA sequencing; even the slightest alteration of this sequence may effect the protein's conformation, thus function (e.g. sickle-cell anemia)

Secondary Structure- coils and folds resulting from hydrogen bonding (e.g. hydrogen bonding between the nitrogen and oxygen atoms within peptide bonds along regular intervals of the polypeptide chain); include **alpha (α) helices** and beta **pleated sheets** (where parts of chain lie parallel)

Tertiary Structure- irregular contortions, superimposed on patterns of secondary structure from bonding between R groups (side chains) of various amino acids [i.e.

hydrophobic interactions, disulfide bridges (covalent bond between two sulfhydryl groups), **ionic bonding**]

Quaternary Structure- overall protein structure resulting from the aggregation of polypeptide subunits (e.g. collagen and hemoglobin)

denaturation- when a protein loses its native conformation due to environment (i.e. pH, salt concentration,

temperature, solvent type; usually permanent within the cell (too crowded)

- protein folding is quite complex and not completely understood

Nucleic Acids- Informational Polymers

Gene- unit of inheritance consisting of a nucleic acid polymer called DNA

Nucleic acids store and transmit hereditary information

DNA (deoxyribonucleic acid- no oxygen on number 2 carbon) is a very long molecule (hundreds to thousands of genes) containing the information for all cellular activities; codes for proteins by synthesizing **RNA (ribonucleic acid)**, which transfers the genetic code to protein synthesizing sites

A nucleic acid strand is a polymer of nucleotides

Nucleotides- comprised of a **nitrogenous base**, **pentose sugar**, and **phosphate group**; monomeric unit of nucleic acids

Pyrimidine- six-membered ring of carbon and nitrogen (cytosine, thymine, and uracil)

Purines- six-membered ring fused to a five-membered ring (adenine and guanine)

Nucleoside- nitrogenous base and pentose sugar

- the DNA code lies in the nitrogenous base sequence, which specifies an amino acid sequence (primary structure) of a protein (which specifies the proteins conformation and function)

Inheritance is based on replication of the DNA double helix
- in 1953, James Watson and Francis Crick first proposed the DNA molecule was a **double helix**; sugar-phosphate backbones on the outside of the helix and nitrogenous bases paired in the interior via hydrogen bonds (and Van der Waals attractions between the stacked bases)
- strands are complimentary (A – T and G – C) and serve as templates during replication

We can use DNA and proteins as tape measures of evolution

- evolutionarily speaking, closely related species share greater proportion of their DNA and protein sequences