Define primary secondary tertiary and quaternary structure of proteins

Distinguish organic molecules from inorganic. Identify the 4 main molecular components of biomass. Combine every biological macromolecule with the type of construction block subunitus and the link that connects the subunes in polymers. Identify the main cellular functions for each type of macromolecule. Stand up between DNA and RNA. Identify the 4 levels of protein structure, and such as bonds, forces or interactions are responsible for each level of structure (primary, secondary, tertiary, quaternary). Relaxing as changes in subunits affect the structure and function of macromolecules (in particular proteins). Before starting, we assume that you know these basic chemical concepts: atoms and periodic table elements of the electron elements of Valenza Chemical oblivity if you are not familiar with them, you should review our web page: chemical context for biology. It is also possible to read a more complete explanation in the OpenStax Biology textbook (free): 2.1 Atoms, isotopes, ions and molecules: construction blocks 1. All living organisms consist of organic molecules. One of the distinctive features of life is that the cells are made of organic compounds and large molecules built by simple organic compounds. Until the beginning of the nineteenth century, scientists thought that only living organisms could produce organic compounds. The organic compounds are all built by carbon atoms, but not all carbon containing molecules are organic. How do we recognize organic molecules? Organic molecules must have c and h, and can have or, n, p, s (a mnemonic handful is chnops for carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur) organic molecules have at least one covalent bond between c and H or between C and C. In the chemical language, the carbon atom in organic molecules must be reduced and not being completely oxidized (has covalent bonds only to oxygen atoms). Carbon dioxide (CO_2; o = c = o) is a inorganic form of carbon because the carbon atom has links only to oxygen atoms, and is therefore completely oxidized. (An exception to the above rules is urea, where carbon has ties to 2 aminoazotas and a double bond with oxygen â € "but we will not ask you to remember this exception; focus on the general rules mentioned above.) Organic molecules can naturally derive from the abiotic synthesis (see Miller-Urey Expt), but in the biosphere, most organic molecules are synthesized by living organisms. The synthesis of organic carbon molecules from inorganic CO2 requires energy and energy of chemical reduction, since carbon atoms in organic molecules are in reduced form. For a revision of oxidation-reduction reactions (redox) from a biology point of view, see this video Khan Academy. In short, it is said that how carbon or oxygen are reduced if they form covalent bonds with an atom with less electronegativeness, such as hydrogen. On the contrary, carbon is oxidized when it forms a covalent bond with an atom with greater electronegativeness, such as oxygen. Let's remember that a covalent bond is formed when two atoms share a oneElectronics. The reduced atom has acquired a majority share of electrons that form the covalent bond and the oxidized atom has only a minority share. 2. The biomass of a cell (organic content, excluding water and inorganic salts) is composed of 3 types of multi-lipid macromolecules. The 3 types of macromolecules (very large molecules) are polysaccharides, nucleic acids (DNA and RNA) and protein. Students should know how the cells make these macromolecules and their structures and basic functions. 3. The small organic molecules are connected in a covalent manner (polymerized) to form the 3 types of large biological macromolecules (polymers); The lipid membranes are self-assembly. A recent study concluded that the cells are composed of 68 distinct organic molecules (Marth 2008) which are assembled in 3 biological polymers more lipid structures (membranes). The polymerization of monomers in polymers occurs from dehydration reactions, chemical reactions that connect two subunits together through a covalent bond while extracting a -OH and a H to create a water molecule: H_2O. Thus dehydration reactions remove a water molecule from the start-up molecules in the formation process of a covalent bond between those start-up molecules. The neckline of polymers returns to monomers occurs from hydrolysis reactions, where a water molecule is divided (hydrolyzed) to -oh and h. Hydrolysis reactions break the bonds linking two subunitors. This is exactly the opposite of a dehydration reaction. See the charts below on glycoside bonds and peptide links to see how the water molecules in these reactions are created or used. Lipids, by definition, are insoluble organic molecules of water. Lipids in water can spontaneously aggregate through hydrophobic interactions to form the membranes of the lipid bilayer. The hydrophobic interactions derive from non-polar molecules that avoid water - having all the non-palate molecules associated with the minimum of their interaction with water. How can we predict if an organic molecule will be hydrophobic (a lipid) or hydrophilic? If the molecule has charged atoms negatively or positively (it is ionized), or has a high percentage of polar ties (C-O or C-N), the molecule is hydrophilic. If the molecules predominantly non-polar bonds (C-H or C-C), therefore it is hydrophobic. Below are the descriptions of the 3 types of macromolecules and lipid membranes: a. Polysaccharides are polymers made by connecting the monosaccharides using glycoside bonds (see figure below). Examples are starch, cellulose and chitin. Monosaccharides are organic molecules with composition $[CH_2O]$ N, where n is usually 3-6. For example, glucose is a 6-carbon sugar with the $C_6H_{12}O_6$ formula. Other examples include 5 carbon sugars as a ribose. The term carbohydrates can monosaccharides of the composition $[CH_2O]$ n, or polysaccharides. Complex carbohydrates often have branched structures. B. Nucleic acids (RNA and DNA) are polymers made by joining nucleotides (5-carbon sugar-phosphate + nitrogen base) in a to aConnection. Hydrogen bonding between coupled bases (A:T and G:c) stabilizes the secondary structures of DNA and the secondary structures of RNA that are formed by coupling the intramolecular base (A:U and G:c). C. Polypeptides (proteins) are polymers of amino acids, joined together by peptide bonds. The peptide bonds are formed between the carboxyl group (carbon with 2 oxygen atoms attached to it) of an amino acid and the amino group (nitrogen with 2 hydrogen atoms) of the next amino acid. All amino acids have a nitrogen, an alpha-carbon with a side chain (the R group in the diagram below: the 20 different amino acids differ in their r groups) and a carbon carboxyl. Nitrogen carbons, alpha-carbon and carboxyl carboxyl form the peptide backbone of a polypeptide chain. Figures of protein structures often show only the spine of the peptide, leaving out the R groups with side chain. How the proteins â bend into their overall three-dimensional structures and interact with each other to form larger multi-protein complexes, they are determined by various bonds and interactions, as described below (Section # 6). Students should be able to distinguish between these macromolecules and identify the monomers that make up any kind of macromolecule. D. Living organisms also contain lipid bilayer membranes made of phospholipids. Phospholipids adapt spontaneously in water to form bilayer membranes through hydrophobic interactions. Phospholipid bilayers create boundaries and a hydrophobic environment that separates the internal aqueous environment of the cytosol from the outside of the cell, and also separates the distinct compartments of distinct intracellular organelles in eukaryotic cells. Membranes make it easier for cells to create and maintain large differences in ion concentrations that drive cellular energy metabolism, to regulate the transport of materials and water in and out of the cell, and to receive and perceive extracellular signals. 4. Cells use different classes of biological macromolecules in different ways. a. Polysaccharides are primarily used for energy conservation (glycogen, starch) and static structures (such as cellulose, chitin), but they can also play important roles in the recognition/adhesion and signaling of cellular cells. B. Proteins are primarily used for enzymatic activities, signalling and dynamic structural components. C. Nucleic acids are used for storage of genetic information (DNA or RNA) and retrieval (mRNA). Some RNAs reproduce key catalytic roles in information processing (RNA splicing, protein synthesis). D. Lipids are used to define the cellular boundary, compartmentalize the cell (in eukaryotes), for energy conservation (triglycerides: and oils) and signaling (steroids and other lipid hormones). 5. The cells have two types of nucleic acids: DNA and RNA, which differ in the key modes of DNA has based A, C, G, and T, deoxiriboso and two wires that form a duplex through hydrogen bonds between the bases On a wire and complementary bases on the partner row. The primary function of DNA is the conservation and transmission of hereditary hereditary The RNA has A, C, G and U bases, ribose and a filament that can form internal duplexes (called secondary RNA structure) folding on itself. In cells, RNA works in the expression of genetic information in DNA to produce proteins (mRNA, tRNAs, rRNAs and other small RNA molecules), but it can also serve for the storage of hereditary information in many viruses (e.g. influenza, HIV, Ebola). Summary table: Main components of biomass Subunit Primary elementary composition* Main Functions Hydrocarbon Lipids C, H Energy Storage Membranes Carbohydrates monosaccharides C, H, O Energy Storage Static Structures Cell Adhesion Amino Acid Proteins C, H, O, N, S Dynamic Structures Nucle nucleotides C, H, O, N, P Elementary Memorization and Processing of hereditary Information *Any of these molecules may have modifications or be connected to other molecules 6. Protein structures can be described at 4 levels Among all biological macromolecules, proteins have the most complex and dynamic structures. Many proteins consist of one polypeptidic chain. Many other proteins consist of two or more polypeptide chains that must be assembled correctly to form a functional complex. The function of a protein is determined by its structure; a change in protein activity involves a change of some aspects of protein structure. What, then, determines a protein structure? Each polypeptide is assembled as a linear chain of amino acids linked in a covalent way by peptide bonds. While this chain is assembled (any subsequent amino acid is linked to the free carboxy-terminal of the nascent polypeptide chain), the polypeptide chain begins to fold. The biologists distinguish 4 levels of protein structure. Students should be able to identify the four levels of protein structure and molecular forces or interactions responsible for stabilizing each level of the structure. Four levels of protein structure Primary structure "the linear sequence of amino acids, held together by covalent peptide bonds. Secondary structure "alpha propellers" and beta sheets, stabilized by hydrogen bonds between groups of amino acids of the peptide spine and carboxylic groups of amino acids within the same polypeptidic chain, but not immediately close to each other. Note that the side chain R groups are not involved in bonds that stabilize secondary structures. Tertiary structure "Total 3D shape of the folded polypeptidic chain, which can be described as the spatial relationships of the secondary structural elements linked by rings. Stabilized by various types of side chain interactions(Group R), including: Hydrophobic interactions and van der Waals, hydrogen bonds, ion ties, covalent bonds disulfide between cysteine residues and interactions with solvent water molecules. Quaternary structure Assembly of two or more polypeptides bent in a functional protein unit. Stabilized stabilized Hydrophobic and van der waals interactions, hydrogen bonds, ionic bonds and covalent disulphide bonds between cysteine residues on different polypeptide chains. proteins that consist of a single polypeptidic chain have no quaternary structure; only proteins that have two or more polypeptide chains have quaternary structure. 7. changes in the amino acid sequence (primary structure) of a protein can change the structure of the protein and its functioning. examples of cases: hemoglobin: the classic case exploring the structure of the protein is hemoglobin. The functional hemoglobin is a tetramer, consisting of two alpha-globin polypeptide chains and two beta-globins. Hemoglobin also requires a cofactor, heme (also called a prosthetic group,) containing an iron atom that binds oxygen. questions to answer after seeing the video above: What levels of protein structure does hemoglobin exhibit? the most common falciform mutation changes a glutammic acid (an amino acid loaded negatively) in beta-globin in valine (a hydrophobic amino acid.) where you would expect more commonly to find amino acid loaded like glutammic acid, inside the folded protein, or on the surface, which interacts with solvent water molecules? which of the following changes do you think can cause falcyform anemia? glutamic acid is transformed into aspartic acid, another amino acid negatively charged glutamic acid is transformed into lisin, an amino acid positively charged glutamic acid is transformed into a triptophan, amino acid hydrophobic acid glutamic acid is transformed into a serine, an aminophenyl amino acid The absence of this phenylalanine, which has a large hydrophobic side chain, causes the protein to bend badly. Most mis-folded protein is recognized by the cellular quality control system and sent to the cellular recycling center (the proteosoma;) only about 1% of the cftr mis-folded protein arrives at the correct destination, the plasma membrane. my case study is published as blog post: cystic fibrosis: a case study for membranes and extreme transport: Microbes living in extreme environments of temperature, salt and ph have proteins that adapt to structural stability in these extreme environments. questions forfurther research and reflections: Do all living organisms synthesize organic molecules from inorganic molecules? What processes have created organic molecules before the birth of life? In what environments? Whyhave enzymatic activities, but generally not polysaccharides or nucleic acids? Are carbon atoms in their most reduced form in which type of organic molecules «carbohydrate», lipids, proteins or nucleic acids? What macromolecules do branch structures often have? If you heat a cell extract up to almost boiling for a few minutes, what will be the effect on the 3 types of organic polymers (polysaccharides, proteins and nucleic acids)? Think of the ties responsible for the structure of these molecules. That's what happens when you cook food! By expanding the Q#6 above, how will changes in pH or saline concentrations affect solutions of any kind of macromolecule? People kept vinegar and salt before refrigeration became available. The Powerpoint slides for the videos of this page are in this file: B1510_module3_1a_biomolecules B1510_module3_1a_biomolecules Works Citated Marth, J.D. 2008. A unitary vision of the bricks of life. Natura Cell Biology 10:1015.