# Introduction to Biochemistry

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| Anatomy of an atom:  An atom has a nucleus (with neutrons, protons) and electrons  Electronegativity of an atom:  Electronegativity is a measure of an atom's attraction for electrons in a bond.  Hydrogen Bond:  Electropositive hydrogen partially shared with two electronegative atoms  Hydrophobic forces:  pushing nonpolar surfaces out of hydrogen-bonded water network |

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| *Atomic composition of four building-block elements:*   |  |  | | --- | --- | | Carbon | * Form backbones of organic molecules * Can form four bonds with other atoms | | Nitrogen | * Component of all proteins and nucleic acids | | Oxygen | * For Cellular respiration * Found in most organic compound   + Food (Be more specific: Glucose) | | Hydrogen | * Presence in all organic compounds * For acid-base balance |   These four elements that make up the human body. |

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| *Some Elements / Ion our human body*   |  |  | | --- | --- | | Na | * Major cation in tissue fluid 🡪 Vital for **fluid balance** * Vital for **conduction of nerve impulses** | | Mg | * **Needed in Blood** * Needed in other body tissue * Vital as a **co-enzyme** | | P | * Part of **nucleic acids** * **Structural part of Bone and Cell walls** * Vital in **energy transfer** | | S | * Part of **Most proteins** * **Activation of Enzymes** | | Cl | * Major anion in tissue fluid * **Vital for fluid balance** * Part of NaCl and **gastric juice** | | K | * Vital in **nerve function** * Affect **muscle contraction** * Fluid and Electrolyte Balance |      |  |  | | --- | --- | | Ca | * Structural Component of Bones and Teeth * Acid-base balance * **Muscle Contraction** * **Nerve Impulse** * **Blood Clotting** | | F | * **Incorporated into the tooth enamel & bone structure** | | Cr | * **Maintain blood sugar level /** (Insulin) | | Mn | * It is a co-factor for enzymes 🡪 found in liver, kidney and mitochondria * **maturation of red blood cells** | | Zn | * needed in saliva for the taste buds * vital for growth 🡪 sexual development * Vital in protein synthesis and cell division | | I | * Part of thyroid hormones |   *Although those elements are less common in our body, they are essential for body functions and metabolisms* |

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| *Major feature of Chemical Reaction:*   * Energy is conserved by first law of **Thermodynamic**   + Energy cannot be created or destroyed 🡪 Total Energy of a system and its surroundings is constant   + For any cyclic reaction is no net change in the reaction  |  | | --- | | Some Example of Important Reaction:   * First reaction in glycolysis is a coupled reaction to ATP conversion to ADP.   + Glucose 🡪 Glucose-6-phosphate, at the same time ATP is converted into ADP + Phosphate Group   Some Example of Hydrolysis reaction:   * Proteins/Polypeptide are hydrolyzed to amino acids * Fats are hydrolyzed to fatty acids and glycerol * Starch and complex sugars (glycogen) are hydrolyzed to simple sugar (glucose/galactose) * Anions of weak acids dissolve in water to give basic solution. |  * Kinetic of a reaction = Rate of the reaction   + Enzymes/Catalyst can change the rate of the reactions 🡪 Speed up reaction     - For Positive Enzymes/Catalyst: It can lower the activation energy of the reaction * Classification of Chemical Reaction:   + By Type of reactants:     - Redox reaction     - Acid-base reaction       * **The Bronsted-Lowry theory**: *An acid is defined as a proton donor and a base as a proton acceptor*       * The Arrhenius theory       * The Lewis theory   + By the reaction outcome:     - Condensation 🡪 Water is formed during combination of the reactants       * Combining 2 molecules (either the same or different) with the elimination of a stable small molecule     - Hydrolysis 🡪 Water is used to break the bond |

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| *Introduction to Water:*   * The two hydrogen atoms each share a pair of electrons with the oxygen by covalent bonding   + Uneven distribution of electron density 🡪 Water is polar  |  |  | | --- | --- | | Oxygen atom in water molecule | Partial negative charge | | Hydrogen atom in water molecule | Partial positive charge |  * + Hence, the partial positive charge Hydrogen can be attracted by the neighboring partial negative charge oxygen atom. 🡪 Hydrogen Bond is formed due to the electrostatic attraction * When dissolving a solute (e.g: NaCl) into water:   + Hydration shells surrounding anions and cation     - Na+ and Cl- are hydrated * When dissolving a solute (e.g: Alcohol) into water:   + Alcohol form hydrogen bond with the water molecule. * Unique Physical Properties of water is due to the hydrogen bonding:   + High heat of vaporization / Specific Heat   + Strong Surface tension   + A near universal solvent   + Hydrophobic effect   + Ionization of water, pH = pOH = 7 * Important information of solution and solute:   + A liquid mixture in which minor solute is uniformly distributed within the solvent. * Important information of suspension:   + Particles are dispersed throughout the bulk of a fluid.     - Example: Blood |

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| *Building Blocks of Life:*   |  |  |  |  | | --- | --- | --- | --- | | Lipid | Sugar | Nucleic Acid | Proteins |   *Introduction to Lipids:*   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | Common Type of Lipids:   |  |  | | --- | --- | | Triglyceride 🡪 3 Fatty Acids and Glycerol | * For long term storage (@Adipose Tissue) * For Making Cholesterol | | Phosphoacylglycerols | * cell membrane (Phospholipids) | | Sphingolipids | * Enriched in the Central Nervous System (CNS) * Tissue development * Cell recognition * Adhesion (黏附) * Act as receptors for toxins | | Steroid (a cyclical chemical) ***Derived from Cholestrol*** | * Energy metabolism * Reproduction (Sex Hormone) * Homeostasis |   Difference between Oil and Lipid:   |  |  | | --- | --- | | Fat | * Saturated or fewer double bond * Fewer cis structure [No Trans structure] 🡪 High MP | | Lipidc | * A large number of double bond 🡪 Unsaturated * A large number of cis structure 🡪 Low MP |   Introduction to Phospholipids |   *Introduction to Sugar (Monosaccharides and Disaccharides):*   |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | * Definition of Monosaccharides:   + Monosaccharides, which cannot be hydrolyzed to simpler compounds, generally have three to six carbons with a carbonyl group at either the terminal carbon or the carbon adjacent to it. Generally, all other carbons have OH groups bonded to them * More about Monosaccharides:      * + Triose = Monosaccharides has 3 Carbons:     - *L-glyceraldehyde* and *D-glyceraldehyde*, and *dihydroxyacetone*,   + Tetrose = Monosaccharides has 4 Carbons:     - *D-Erythrose*, *D-Threose* and *D-Erythrulose*   + Pentose = Monosaccharides has 5 Carbons:     - ***Ribose*** (Oxyribose / a Pentose / 核糖) is a constituent of RNA.   + Hexoses = Monosaccharides had 6 Carbons:     - Hexoses acts as building blocks of other compounds such as starch.     - Hexoses can form dihexose (like sucrose) by a condensation reaction that makes **1,6-glycosidic bond**. * Common Example of Monosaccharides:  |  |  |  | | --- | --- | --- | | D-Glucose | D-Galactose | D-Fructose |  * Common Example of Disaccharides:  |  |  |  | | --- | --- | --- | | Lactose | * Galactose Ring + Glucose Ring * Lactose is not appreciably sweet * 2 six-membered Ring * Joined by 1🡪4-β-glycosidic bond |  | | Sucrose | * The Disaccharide found in sugarcane * Most common in nature * One Six-membered and one five membered rings * Bonded by 1,6-glycosidic bond |  | |     *Introduction to Sugar (Polysaccharides):*   |  | | --- | | * Glycogen:   + A polymer of glucose containing α-glycosidic bonds   + As a storage of energy in Liver and **Skeletal-Muscle**   + Has an **extensive branched structure**     - Glucose units are hydrolyzed from the ends of glycogen 🡪 Metabolism 🡪 Energy * Cellulose / As a Digestive Fiber for human:   + Provide Support and rigidity to wood, plant stems and grass   + Unbranched Polymer (repeating glucose by 1🡪4-β-glycosidic linkage)   + Cannot be digested by human * **Amylose** / A type of Starch:   + Has an unbranched skeleton of glucose molecules with 1→4-α-glycoside bonds   + Numerous of OH groups ⇒ leading to greater water solubility than cellulose. * Amylopectin / A type of Starch   + Similar to **Amylose**   + Contains Branching along the chain. |   *Introduction to Protein:*   |  |  |  | | --- | --- | --- | | *General Structure of Amino Acid & Peptide Bond*   * Do Notice that: One end is and one end is   + By Condensation: A water is removed, and Peptide bond is formed. (Whole compound is neutral.)     *Primary structure of Proteins – Only one poly peptide chain*   * Definition:   + **Particular sequence of amino acids that is joined together by peptide bond** * Focus on the structure of Amide Bond   *Secondary Structure Proteins – 2 Polypeptide Chains*   |  |  | | --- | --- | |  |  |  * **α-helix and β-pleated sheet** * Focus on the NH Bond and CO Double Bond * The Secondary Structure of Proteins is **formed by the hydrogen bond. Def: The three-dimensional arrangement of localized regions of a protein**   *Tertiary Structure of Proteins – 3 Polypeptide Chains*   * Many kinds of intramolecular forces that stabilize polypeptide chains.   + Including: London Dispersion Forces (Van de Waal’s force)     Example:   * Amino acids that contain hydroxyl (OH) and amino groups (NH2) in their side chains ⇒ Hydrogen Bond * Nonpolar C-C and C-H bonds are stabilized by VDW.   *Quaternary Structure of Proteins - More than 3 Polypeptide Chains*   * The shape adopted when two or more folded polypeptide chains come together into one protein complex. Def: **Association of protein Subunits**   Example: Hemoglobin |   *Introduction to Protein Complex (Quaternary Structure of Proteins):*   |  |  | | --- | --- | | **Globular** | * Coiled into compact shapes * The surface is hydrophilic * Enzymes and Transport Proteins are in this shape   + Thus, soluble in blood | | Fibrous | * Long, Linear, Compacted Polypeptide Chain   + Rod / Sheet Shape * Insoluble in Water * Provide Strength and Protection to tissue or cells | |

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| *Introduction to RNA (Nucleic Acid):*   * Single Strands 🡪 Less stable than DNA * RNA can form secondary structure   + Hairpin Loops   + 3D Structure     *Some common type of RNA:*   |  |  | | --- | --- | | mRNA (Messager RNA) | ★Corresponds to the genetic sequence of a gene  ★Read by a ribosome (rRNA) ⇒ synthesizing a protein. | | rRNA (Ribosomal RNA) | ★Non-coding RNA ⇒ Carries out protein synthesis in ribosomes  ★Essential to all cells | | tRNA (Transfer RNA) | ★Carry an amino acid to ribosome | |

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| *Nucleic Acid – Introduction to Nucleoids and DNA:*   * Component of Nucleic Acid      * Basic Structure of Nucleotides in DNA      * The Bases of Nucleotides (Nitrogenous Group):  |  |  |  |  |  | | --- | --- | --- | --- | --- | | A | T (Only in DNA) | C | G | U (Only in RNA) | | Adenine | Guanine | Cytosine | Thymine | Uracil |   Introduction to the relationship between the Nucleoids and the DNA/RNA   * + Nucleotides (monomer) ⇒ linked in linear manner ⇒ a strand of DNA / RNA   + Two strands of DNA/RNA ⇒ A double helix structure   + **DNA would always interact with another strand of DNA to form double helix**.   + RNA may not interact with another strand to from double helix structure. * The Complementary base Pairing of DNA / RNA   + For DNA: A-T, C-G. Adenosine must pair with thymine **(Paired/Bonded by 2 Hydrogen Bonds)** Cytosine must pair with guanine **(Paired/Bonded by 3 Hydrogen Bonds)**   + For RNA: A-U, C-G Adenosine must pair with Uracil Cytosine must pair with guanine |

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| *Major Classes of dietary fuels:*   |  |  |  |  | | --- | --- | --- | --- | | Major Fuels from food:   |  |  |  | | --- | --- | --- | | Carbohydrate | Proteins | Fats |   How ATP is used:    *The energy - generating pathways are shown in red;*  *The energy -utilizing pathways in blue* |   *Different Forms of Body Fuel Stores:*   |  |  | | --- | --- | | Fats = (Glycerol +3Fatty Acids)  [Fatty Acid] : *A Long Hydrocarbon Chain with Carboxyl Group at the End* | * Major Fuel Store * Store in Adipose tissues * Accumulate in hips, thighs and abdomens | | Carbohydrates | * Smaller fuel stores * Stores as Glycogen in liver and skeletal-muscle | | Proteins | * From Large muscle masses in particular * Used when we are fasting |   *Introduction to metabolism:*   |  | | --- | | Metabolism = all chemical reactions involved in maintaining the living state of the cells and the organism.  There are two type of metabolism: **Catabolism** and **Anabolism**   * Catabolism   + To break down molecules * Anabolism   + To build up molecules from building blocks | |