

Biochemistry/Organic Chemistry

1: Compounds Important to Life

- Biologists classify compounds into organic compounds and inorganic compounds.
 - Organic Compound: a compound that is derived from living things and contains carbon
 - Inorganic Compound: a compound generally derived nonliving things
- Water
 - Water is an inorganic molecule with unique properties that make it one of the most important compounds for living things.
 - In the water molecule (H₂O), the hydrogen and oxygen atoms bond so that the electrical charge is unevenly distributed.
 - The area of the molecule containing oxygen has a slightly negative charge, and the areas containing hydrogen have slightly positive charges.
 - Polar Compound: a compound with one side having a negative charge and the other side a positive charge
 - Hydrogen bonds form between water molecules.
- Six Unique Properties of Water
 1. Universal Solvent: Water is an excellent solvent due to its polarity. When ionic compounds interact with water, the compounds often break apart or dissociate into ions.
 2. Surface Tension: Water's high surface tension is due to the cohesion of its molecules.
 3. Capillary Action: The ability of a liquid to move upward against the force of gravity by molecular attraction to a surrounding surface (adhesion).
 4. Resistance to Temperature Change: When water is heated, most of the heat energy goes into breaking the hydrogen bonds between the molecules. Only after the bonds have been broken will the heat energy increase the motion of the molecules and thus raise the temperature of the water.
 5. High Heat of Vaporization: At 100 °C & 1 atm, it takes 540 cal to change 1 g of water to vapor.
 6. Freezing: The molecules of water move apart to maintain the maximum # of H bonds. Therefore, the density of ice (0.92 g/cm³) is less than the density of water (1.00 g/cm³).
- Carbon Compounds
 - A carbon atom has four electrons in its outer energy level. Carbon readily forms four covalent bonds with other elements.
 - Carbon bonds with other carbon atoms to form straight chains, branched chains, and rings.
 - Because carbon can bond in such a variety of ways, organic compounds exhibit great variability. This variability is responsible for the great variation among living things.
 - Polymer: a compound consisting of repeated linked monomers
 - Monomer: a repeated, single-molecule unit in a polymer
 - Macromolecule: a large biological polymer
- Condensation Reaction: a chemical reaction in which monomers are linked together to form polymers; water is produced
 - Also called dehydration synthesis

- The reactants give off a hydrogen ion (H^+) and a hydroxide ion (OH^-), which in turn combine to produce a water molecule (H_2O)
- Hydrolysis: the splitting of a polymer into monomers through a reaction with water
 - In hydrolysis a water molecule splits into a hydrogen ion and a hydroxide ion. As the polymer breaks apart, the hydrogen and hydroxide ions each combine with one of the monomers.

2: Organic Compounds

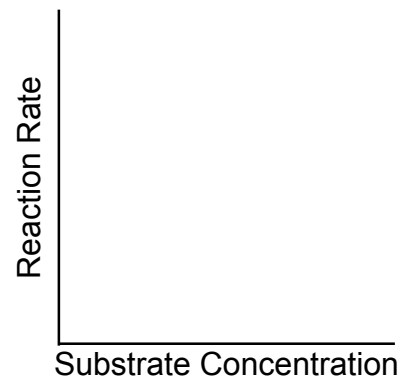
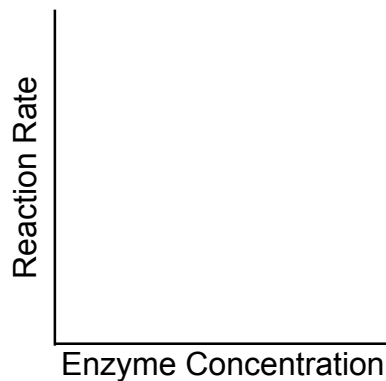
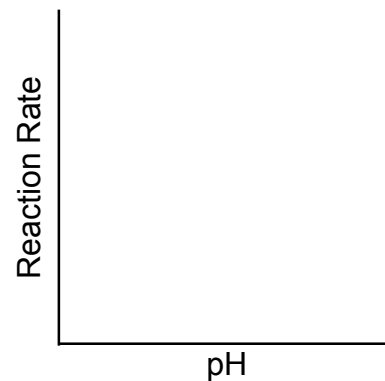
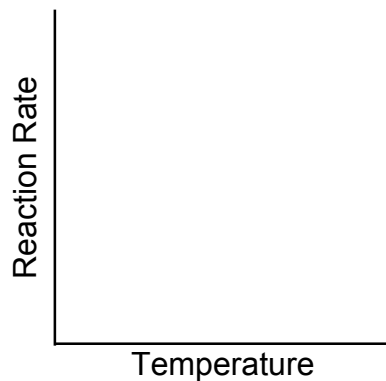
- For all living organisms, four types of organic compounds are essential: carbohydrates, lipids, proteins, and nucleic acids.
- **Carbohydrates:** organic compounds composed of carbon, hydrogen, and oxygen in a ratio of two hydrogen atoms to one oxygen atom
 - **Monosaccharide:** contains carbon, hydrogen, and oxygen in a ratio of one to two to one (simplest carbohydrate)
 - General Formula = $C_nH_{2n}O_n$
 - Examples:
 - Glucose: manufactured by plants during photosynthesis. Main source of energy for both plants and animals and is metabolized during cellular respiration.
 - Fructose: found in fruits and is the sweetest of the monosaccharides
 - Galactose: found in milk and is usually in combination with glucose and fructose
 - Glucose, Fructose, and Galactose have the same molecular formula ($C_6H_{12}O_6$), but not the same structural formulas.
 - Isomers: compounds that differ in structure but not in molecular composition.
 - **Disaccharide:** a double sugar formed from two monosaccharides linked together in a condensation reaction
 - Examples:
 - Sucrose: found in sugar cane and sugar beets (glucose + fructose)
 - Lactose: found in milk (glucose + galactose)
 - Maltose: malt sugar (glucose + glucose)
 - **Polysaccharide:** a complex molecule composed of three or more monosaccharides linked together in a condensation reaction
 - Examples:
 - Glycogen: animals store glucose in the form of glycogen (hundreds of glucose molecules strung together in a highly branched chain)
 - Starch: plants store glucose in the form of starch (2 forms: highly branched chains and long unbranched chains that coil)
 - Cellulose: give strength and rigidity to the plant cell (thousands of glucose monomers are linked in long, straight chains)
- **Lipids:** fatty compounds made up of carbon, hydrogen, and oxygen
 - A lipid molecule has a larger number of carbon and hydrogen atoms and a smaller number of oxygen atoms than carbohydrates do. (Beef fat = $C_{57}H_{110}O_6$)
 - Examples: fats, oils, waxes
 - Lipids are nonpolar and do not dissolve in water.
 - The cell membrane is composed of mainly lipids. The insolubility of lipids in water allows the membrane to form a barrier between the aqueous environments inside and outside the cell.

- Lipids store energy efficiently. Lipids have a relatively large number of C-H bonds which store more energy than C-O bonds.
- Triglyceride: a type of lipid in which the macromolecule is composed of three molecules of fatty acids joined to one molecule of glycerol
 - Each fatty acid molecule combines with the glycerol molecule through a condensation reaction.
 - Fatty acids are long, straight hydrocarbon chains with a carboxyl (COOH) group attached at one end.
 - The carboxyl end of the fatty acid molecule is polar, and the hydrocarbon end is nonpolar.
 - hydrophilic head (attraction to water) and hydrophobic tail (repulsion to water).
 - Oils: triglycerides that are liquid at room temperature (example: vegetable oil)
 - Fats: triglycerides that are solid at room temperature (example: animal fat)
 - Saturated Fats: the fatty acids of these fats do not have double bonds (Examples: lard & butter)
 - Unsaturated Fats: the fatty acids of these fats do have double bonds (Examples: olive oil, peanut oil, corn oil)
- Phospholipid: a type of lipid in which the macromolecule is composed of two molecules of fatty acids and a phosphate group joined to one molecule of glycerol
 - Phospholipids make up the cell membrane.
- Wax: a type of lipid in which the molecule consists of a long fatty acid chain joined to a long alcohol chain
 - Wax is waterproof and forms protective coatings on the outer surfaces of plants
- Steroid: a lipid in which the molecule is composed of four carbon rings
 - Steroids are considered lipids because they do not dissolve in water.
 - Steroids are found in substances such as hormones, nerve tissue, toad venom, and plant poisons.
- **Proteins**: organic compounds formed mainly of hydrogen, oxygen, carbon, and nitrogen
 - Formed from the linkage of amino acids (monomers) in condensation reactions.
 - The covalent bond between amino acids is called a peptide bond.
 - There are 20 amino acids, and they share a common structure. Each amino acid contains a central carbon atom to which four other groups bond.
 - hydrogen atom, carboxyl group (COOH), amine group (NH₂), and an R group
 - The differences between kinds of amino acids result from the structure of the R group.
 - Differing amounts and combinations of amino acids account for the diversity of protein structure.
 - Dipeptide: two amino acids bonded together by a peptide bond through a condensation reaction
 - Polypeptide: a long chain of amino acids
 - Proteins are composed of two or more polypeptides

Enzymes

- Catalysts: substances that speed up chemical reactions without being affected by the reactions themselves.
- Enzyme: a **protein** that increases the rate of reactions by lowering the activation energy.
- Activation Energy: the amount of energy needed to start a chemical reaction
- Substrate: molecule on which an enzyme acts
 - An enzyme binds to a substrate and stresses the bonds of that molecule in a way that makes a reaction more likely to occur.

- The key to an enzyme's activity is its shape.
 - Active Site: location on an enzyme where the substrate binds
 - Each substrate can only bind to one enzyme.
- Temperature, pH, substrate concentration, and enzyme concentration affect reaction rates
 - Each enzyme functions within a certain optimal temperature and pH range (see graphs).
 - Enzymes can become **denatured** when exposed to high temperatures or adverse pH.
 - **Denaturation**: loss of the tertiary structure of a protein (enzyme) through unfolding so that some of its original properties, especially its biological activity, are diminished or eliminated.
 - The rate of an enzyme-catalyzed reaction is also affected by the concentration of the enzyme and the substrate (see graphs).
 - Graphs (drawn in class) & Additional Notes:



-
- **Nucleic Acids**: complex organic molecules that store important information in the cell
 - **Examples**: DNA (stores information that is essential for cell activities, responsible for heredity) and RNA (protein synthesis)
 - **Nucleotides**: nucleic acid monomers consisting of a nitrogenous base, a sugar, and a phosphate group