

Learning Objectives

Chapter 1: Biochemistry an Introduction

1) The six chemical elements primarily in biomolecules (H, C, O, N, P, S)

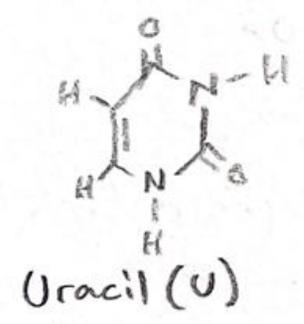
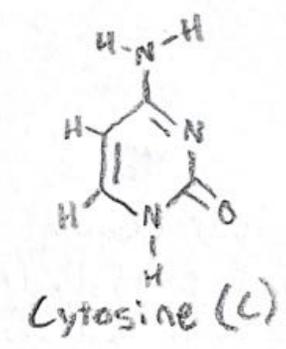
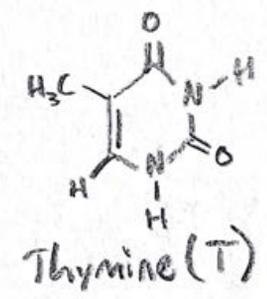
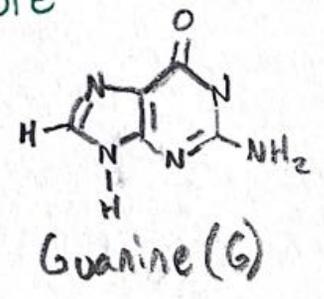
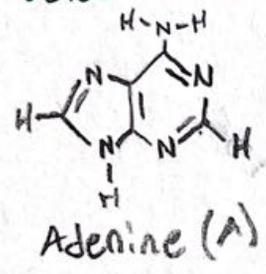
2) Functional groups

$R-OH$ alcohol	$R-\overset{O}{\parallel}C-H$ aldehyde	$R-\overset{O}{\parallel}C-R'$ ketone	$R-\overset{O}{\parallel}C-OH$ carboxylic acid	$R-NH_2$ amine	$R-\overset{O}{\parallel}C-NH_2$ amide	$R-SH$ thiol	$R-\overset{O}{\parallel}C-O-R'$ ester	$R-C=C-R$ alkene
$R-\overset{O}{\parallel}S-R$ sulfone	$R-\overset{O}{\parallel}S-R$ sulfoxide	$R-S-R'$ sulfide	$R-\overset{O}{\parallel}C-X$ acyl halide	$R_1-\overset{O}{\parallel}C-O-\overset{O}{\parallel}C-R_2$ acid anhydride	$R-O-R$ ether	$R-X$ haloalkane	$R-\text{C}_6\text{H}_5$ arene	$R-C\equiv C-R_2$ alkyne

3) Major classes of Biological molecules: Proteins, sugars, lipids, nucleotides

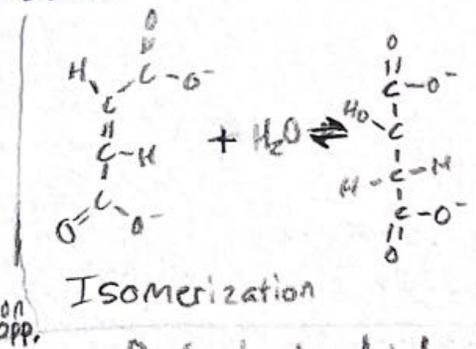
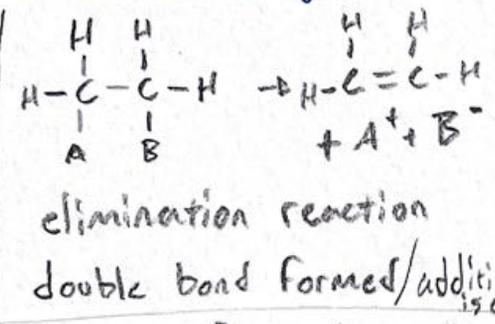
small molecule	Polymer	General Functions
Amino acids	proteins	Catalysts and structural elements
Sugars	Carbohydrates	Energy sources & structural elements
Fatty acids	N.A.	Energy sources & structure of lipid molecules
Nucleotides	DNA, RNA	Genetic information, protein synthesis

Nucleotide structure



4) Common Reaction Types found in biological processes

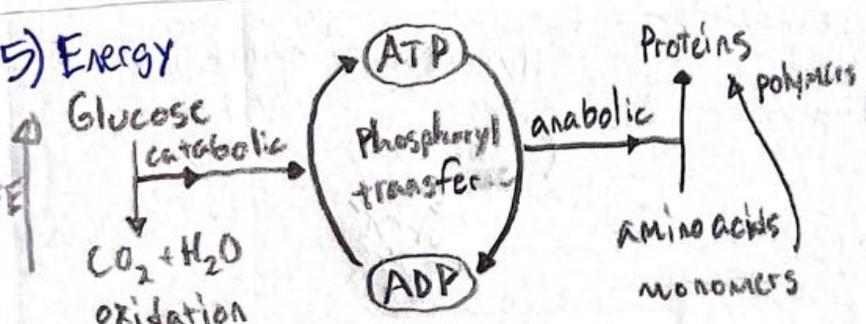
$A^- + B-X \rightarrow A-B + X^-$
nucleophilic substitution
Nucleophiles = negatively charged
Electrophiles: electron deficient
Hydrolysis $\xrightarrow{H_2O}$ | Condensation $\xrightarrow{H_2O}$



Oxidation Reduction Oxidation Loses e^- , Reduction gains e^- , Reduction is higher E state

Math: Valence - nonbonding
 $\begin{matrix} H \\ | \\ H-C \\ | \\ H \end{matrix} \rightarrow \begin{matrix} H \\ | \\ H-C-OH \\ | \\ H \end{matrix}$ $4 - 8 = -4$ $[C^{-4}, 4H^+]$

Reduced ← → Oxidized



anabolic: small molecules assembled into large polymers
 Catabolic: large molecules broken down into small monomers
 Anabolic requires energy
 Catabolic releases energy

Chapter 2: Living Cells

1) Human Microbiota: the digestive system + the bacteria that carry out specialized pathways

2) Structural Elements of Prokaryotes and Eukaryotes

Prokaryotes Main Lecture notes

Very small - vol about 1 μ l
 High concentrations of proteins = up to 300 mg/ml
 Nucleoid - containing circular DNA

Eukaryotes

Cells about 5-10x bigger, many internal components
 Nucleus - containing DNA, Histones, RNA
 Endoplasmic Reticulum - forms ribosomes
 Mitochondria - produces ATP from reduced carbon

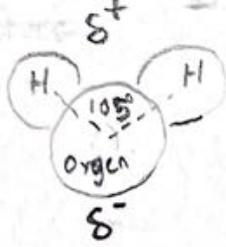
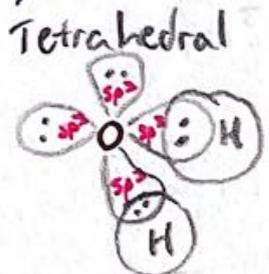
Size comparison: atoms < molecules < antibodies < ribosomes < viruses < genes < bacterial cells
 atoms bond: $\sim 1 \text{ \AA}$ (10^{-10} m), small molecules: $\sim 10 \text{ \AA}$, proteins 5-10 nm, complexes (25-400 nm) (10^{-7} m)
 visible light: 400-700 nm, Bacteria/organelles 3-6 μ microns (10^{-6} m), whole cells $\sim 10 \mu$ microns

3) Cell Fractionation: cell component separation by differential centrifugation

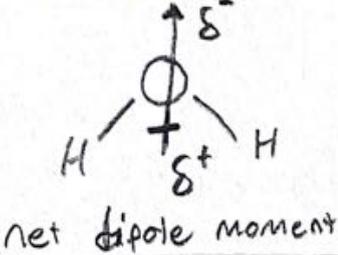
1) Blend: Suspend broken cells containing fragments $\xrightarrow[10 \text{ min}]{800 \times g}$ Nuclei Sediment $\xrightarrow[10 \text{ min}]{15000 \times g}$ Mitochondria, lysosomes, & Sediment $\xrightarrow[60 \text{ min}]{100000 \times g}$ Membrane & ER sediment $\xrightarrow[3 \text{ hrs}]{200000}$ cytosol

Chapter 3: Water, the matrix of life

1) Lewis structure & geometry



2) Dipole moment



3) Coulomb's law

$$F \propto \frac{Q_1 Q_2}{d^2}$$

mag of charges
 distance between them
 $Q = \text{an. of dots}$

5) properties of water

Maximum # of H bonds form when H_2O is frozen into ice
 Open - less dense structure

4) Types of non covalent bonds: non covalent interactions are electrostatic, weak individually

Bond type	Bond strength (kJ/mol)
Covalent	> 210
Ionic interactions	4-80
Van der Waals forces	$< 11 - 11.3$
Hydrogen bonds	12-29

Ionic interactions: occur between charged atoms or groups are **non directed**, felt uniformly in space
Hydrogen Bonds: covalent bonds between lone pairs and hydrogen atoms, needs O or N due to significant polarity to create δ^- strong enough to pull e^- away from hydrogen atom

Van der Waals forces

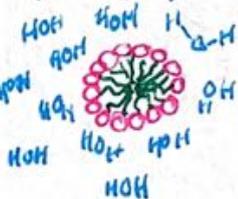
- 1) Dipole - Dipole interactions: occur between molecules containing electronegative atoms
- 2) Dipole induced dipole interactions: Permanent dipole induces transient dipole in nearby molecule
- 3) Induced Dipole Induced Dipole interactions: momentary shift in e^- density on a molecule that causes electrostatic force on nearby molecule (must be nearby) also called London forces

6) Solvent Properties of Water

Hydrophilic
 Polar
 Ionic Bonds
 Sugars
 ex: salts, Ions

Hydrophobic
 non polar
 lipids
 hydrocarbons
 ex: Fats, oils

8) Amphipathic



Colligative Properties

Vapor pressure lowering
 boiling point elevation
 freezing point depression
 Depends on # of particles
 not type of particle

9) Osmotic pressure

$$\pi = MRT$$

$\pi = \text{osmotic pressure}$
 $M = \text{Molarity (moles/L)}$
 $R = \text{gas constant } (0.082 \frac{\text{L atm}}{\text{K mol}})$
 $T = \text{temp (K)}$

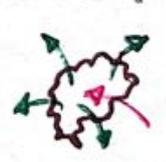
Isotonic solutions do not change cell volume



Hypotonic solutions cause cell rupture



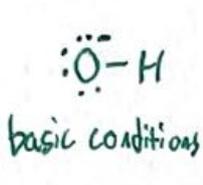
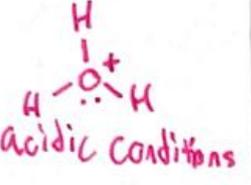
Hypertonic solutions cause cell shrinkage (crenation)



ACID-BASE CHEMISTRY

Brønsted-Lowry Definition

Acid donates H^+ Base accepts H^+



$$\begin{aligned}
 pH &= -\log[H_3O^+] \\
 [H_3O^+] &= 10^{-pH} \\
 pOH &= -\log[OH^-] \\
 [OH^-] &= 10^{-pOH}
 \end{aligned}$$

$$\begin{aligned}
 pH + pOH &= 14 \\
 14 - pOH &= pH \\
 14 - pH &= pOH \\
 K_w &= [H_3O^+] \times [OH^-] \\
 &= 1 \times 10^{-14}
 \end{aligned}$$

The 7 strong acids 100% dissociation
 HCl, HBr, HI, HNO₃, HClO₃, HClO₄, H₂SO₄
 HF is not a strong acid
 note: concentration of strong acid [SA] = [H₃O⁺]

acid ionization constant

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

Percent ionization

$$\% \text{ ionization} = \frac{[H_3O^+]_{eq}}{[HA]_0} \times 100\%$$

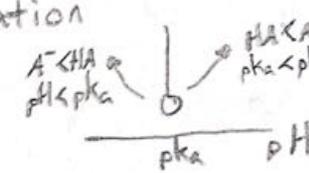
$$\begin{aligned}
 pK_a &= -\log K_a \\
 pK_b &= -\log K_b \\
 pK_a + pK_b &= 14
 \end{aligned}$$

$$\begin{aligned}
 K_a \times K_b &= 14 \\
 K_b &= \frac{[HB^+][B^-]}{[B]}
 \end{aligned}$$

6 possible outcomes of mixing an acid and a base

A) Excess strong ACID
 $pH = -\log[H_3O^+]$
 However much acid is added that is = to [H₃O⁺] then solve for pH

B) Weak ACID Alone
 $[H_3O^+] = \sqrt{K_a \cdot [HA]_{initial}}$
 This equation is reworking of ICE table to avoid quadratic equation

C) Buffer Region (partially neutralized WA)
 Henderson-Hasselbach equation
 $pH = pK_a + \log\left(\frac{[A^-]}{[HA]}\right)$
 weak acid will be at pK_a before acid/base neutralization


D) Weak BASE Only
 $[OH^-] = \sqrt{K_b \cdot [B]_{initial}}$
 this is reworking of ICE table to avoid quadratic

E) Excess Strong BASE
 $pOH = -\log[OH^-]$
 However much base is added that is = to [OH⁻] then use 14 - pOH = pH

F) Neutral Salt
 water with no acid/base properties
 pH = 7

Buffer solutions
 $0.1 < \frac{[A^-]}{[HA]} < 10$
 Buffers are made by mixing WA with its conjugate base

Buffer Creation: adding
 $HA + OH^- \rightarrow A^- + H_2O$

I	x	y	z	-
C	-y	-y	+y	
Y	x-y	0	z+y	

Strong BASE (NaOH) to a weak ACID (HA)
 $pH = pK_a + \log\left(\frac{z+y}{x-y}\right)$
 ICE Table used when strong acid or base are used to drive rxn to completion

Body fluids are generally acidic. The most basic the body will be is about pH = 7.4, Blood