WORLD'S #1 ACADEMIC OUTLINE

BROADER CHEMICAL PRINCIPLES

A. Intermolecular Forces
1. Electrostatic: Strong interaction between ions; for charges $q_1$ and $q_2$ separated by $r_{12}$ and solvent dielectric constant, $\varepsilon$; water has large $\varepsilon$ stabilizes zwitterion formation
2. Polarizability, $\alpha$: Measures distortion of electron cloud by other nuclei and electrons
3. Dipole moment, $\mu$: Asymmetric electron distribution gives partial charge to atoms
4. London forces (dispersion): Attraction due to induced dipole moments; force increases with $\mu$
5. Dipole-dipole interaction: The positive end of one dipole is attracted to the negative end of another dipole; strength increases with $\mu$
6. Hydrogen bonding: Enhanced dipole interaction between bonded $H$ and the lone-pair of neighboring $O$, $N$ or $S$; gives “structure” to liquid water; solubilizes alcohols, fatty acids, amines, sugars, and amino acids

B. Types of Chemical Groups
1. Hydrophobic = Lipophobic: Repelled by polar group; insoluble in water; affinity for non-polar Examples: alkane, arene, alkene

2. Hydrophilic = Lipophilic: Affinity for polar group; soluble in water, repelled by nonpolar Examples: alcohol, amine, carboxylic acid
3. Amphipathic: Polar and nonpolar functionality; common for most biochemical molecules: fatty acids, amino acids and nucleotides

C. Behavior of Solutions
1. Miscible: 2 or more substances form 1 phase; occurs for polar + polar or non-polar + non-polar
2. Immiscible: 2 liquids form aqueous and organic layers; compounds are partitioned between the layers based on chemical properties (acid/base, polar, nonpolar, ionic)

3. Physical principles:
   a. Colligative properties depend on solvent identity and concentration of solute; a solution has a higher boiling point, lower freezing point and lower vapor pressure than the pure solvent
   b. Biochemical example: Osmotic pressure - Water diffuses through a semi-permeable membrane from a hypotonic to a hypertonic region; the flow produces a force, the osmotic pressure, on the hypertonic side

Osmotic Pressure

1. Henry’s Law: The amount of gas dissolved in a liquid is proportional to the partial pressure of the gas
2. Carbon dioxide dissolves in water to form carbonic acid
3. Oxygen is carried by hemoglobin in the blood
4. Pollutants and toxins displace in bodily fluids; react with tissue and interfere with reactions

Examples: Sulfur oxides and nitrogen oxides yield acids; ozone oxidizes lung tissue; hydrogen cyanide

ACADEMIC OUTLINE

ACADEMIC

BIOCHEMISTRY

CHEMICAL CONCEPTS

Key Elements in the Body
8. Oxygen   20. Calcium  34. Selenium
11. Sodium  25. Manganese  50. Tin
13. Aluminum  27. Cobalt

GLUCOSE

DNA

TRIGLYCERIDE
A. Bonding Principles
1. Most bonds are polar covalent; the more electronegative atom is the + end of the bond.
Example: For >C=O, O is negative, C is positive.
2. Simplest Model: Lewis Structure: Assign valence electrons as bonding electrons and non-bonding lone-pairs; more accurate bonding models include valence-bonds, molecular orbitals and molecular modeling.
3. Resonance: The average of several Lewis structures describes the bonding.
Example: The peptide bond has some >C=N< character.

B. Molecular Structure

<table>
<thead>
<tr>
<th>Atom</th>
<th>sp²</th>
<th>sp³</th>
<th>sp³⁺</th>
</tr>
</thead>
<tbody>
<tr>
<td>C 4 e⁴ bonds</td>
<td>-C-C-</td>
<td>&gt;C=C&lt;</td>
<td>-C=C-C-</td>
</tr>
<tr>
<td>N 5 e³ bonds, 1 lone pair</td>
<td>&gt;N-</td>
<td>R=N-</td>
<td>-C=N</td>
</tr>
<tr>
<td>O 6 e² bonds, 2 lone pairs</td>
<td>-O-</td>
<td>&gt;R=O</td>
<td></td>
</tr>
</tbody>
</table>

1. Geometries of valence electron hybrids:
   - sp²: planar, sp³: tetrahedral, sp: linear
2. Isomers and structure
   a. Isomers: same formula, different bonds
   b. Stereoisomers: same formula and bonds, different spatial arrangement
   c. Chiral: optically active
      - Produces + or - rotation of plane-polarized light
   d. D: Denotes dextrorotatory based on clockwise rotation for glyceraldehyde
   e. L: Denotes levorotatory based on counter-clockwise rotation for glyceraldehyde; insert (-) or (+) to denote actual polarimeter results
   f. D/L: Denotes structural similarity with D or L glyceraldehyde
   g. Chiral: Not identical with mirror image
   h. Achiral: Has a plane of symmetry
   i. Racemic: 50/50 mixture of stereoisomers is optically inactive; + and - effects cancel
   j. R/S notation: The four groups attached to the chiral atom are ranked a,b,c,d by molar mass
      - The lowest (d) is directed away from the viewer and the sequence of a-b-c produces clockwise (R) or counter-clockwise (S) configurations
   k. Nomenclature: Use D/L (or R/S) and +/- in the compound name.
      - Example: D- (lactic acid)

1. Fisher-projection: Diagram for chiral compound
2. Molecular implication: All molecules exhibit structural variation due to free rotation about C-C single bond; depict using a Newman diagram
3. Alkene: cis and trans isomers; >C=C< does not rotate; common in fatty acid side chains

C. Common Organic Terminology
1. Saturated: Maximum # of Hs (all C-C)
2. Unsaturated: At least one >C=C<
3. Nucleophile: Lewis base; attracted to the + charge of a nucleus or cation
4. Electrophile: Lewis acid; attracted to the electrons in a bond or lone pair

KINETICS: RATES OF REACTIONS

A. Determination of Rate
For a generic reaction, A + B => C:
1. Reaction rate: The rate of producing C (or consuming A or B)
2. Rate-law: The mathematical dependence of the rate on [A], [B] and [C]
3. Multiple-step reaction: Focus on rate-determining step - the slowest step in the mechanism controls the overall rate

B. Simple Kinetics
1. First-order: Rate = k₁[A]
   - Examples: SN1, E1, aldose rearrangements
2. Second order: Rate = k₂[A][B]
   - Examples: SN2, E2, acid-base, hydrolysis, condensation

C. Enzyme Kinetics
1. An enzyme catalyzes the reaction of a substrate to a product by forming a stabilized complex; the enzyme reaction may be 10⁴-10⁹ times faster than the uncatalyzed process
2. Mechanism:
   - Step 1: E + S = k₁ ES
   - Step 2: ES = k₂ => E + S
   - Step 3: ES = k₃ => products + E
3. Michaelis-Menten Equation:
   - \[ v = \frac{V_{max} \cdot [S]}{K_m + [S]} \]
   - \[ K_m = \frac{(k_3 + k_1)k_2}{k_2} \]
4. Practical solution: Lineweaver-Burk approach: 
\[
1/v = \frac{K_m}{V_{\text{max}}} + \frac{1}{V_{\text{max}}} 
\]
The plot “1/v vs. 1/[S]” is linear
Slope = \( -\frac{1}{K_m} \)
y - intercept = \( \frac{1}{V_{\text{max}}} \)
x - intercept = \( -\frac{1}{K_m} \)
Calculate \( K_m \) from the data

D. Changing Rate Constant (k)
1. Temperature increases the rate constant:
Arrhenius Law: \( k = Ae^{-E_a/RT} \)
   a. Determining \( E_a \): Graph “ln(k) vs. 1/T”; calculate \( E_a \) from the slope
2. Catalyst: Lowers the activation energy; reaction occurs at a lower temperature
3. Enzymes
   a. Natural protein catalysts; form substrate-enzyme complex that creates a lower energy path to the product
   b. In addition, the enzyme decreases the Free Energy of Activation, allowing the product to more easily form
   c. Enzyme mechanism is very specific and selective; the ES complex is viewed as an “induced fit” lock-key model, since the formation of the complex modifies each component

E. Energetic Features of Cellular Processes
1. Metabolism: The cellular processes that use nutrients to produce energy and chemicals needed by the organism
   a. Catabolism: Reactions which break molecules apart; these processes tend to be exergonic and oxidative
   b. Anabolism: Reactions which assemble larger molecules; biosynthesis; these processes tend to be endergonic and oxidative
2. Anabolism is coupled with catabolism by ATP, NADPH and related high-energy chemicals
3. Limitations on biochemical reactions
   a. All required chemicals must either be in the diet or be made by the body. If chemicals in the diet; harmful waste products must be detoxified or excreted
   b. Cyclic processes are common, since all reagents must be made from chemicals in the body
   c. Temperature is fixed; activation energy and enthalpy changes cannot be too large; enzyme catalysts play key roles

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**ORGANICS & BASES**

<table>
<thead>
<tr>
<th>Acid</th>
<th>Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrhenius</td>
<td>aqueous ( \text{H}_2\text{O}^- )</td>
</tr>
<tr>
<td>Bronsted-Lowry</td>
<td>proton donor</td>
</tr>
<tr>
<td>Lewis</td>
<td>electron-pr receptor</td>
</tr>
</tbody>
</table>

**A. Amphoterism**
1. A substance that can react as an acid or a base
2. The molecule has acid and base functional groups; Example: amino acids
3. This characteristic also allows amphoteric compounds to function as single-component buffers for biological studies

**B. Acids**
1. \( K_a = \frac{[\text{A}^-][\text{H}^+]}{[\text{HA}]} \)
2. Strong acid: Full dissociation; \( \text{HCl}, \text{H}_2\text{SO}_4 \) & \( \text{HNO}_3 \)
3. Weak acid: \( K_a < 1 \), large \( pK_a \)
4. Key organic acid: \( \text{RCOOH} \)

**Examples**
- Fatty acid: \( \text{RCOOH} \) from the hydrocarbon chain; Vitamin C is ascorbic acid; nucleic acids contain acid phosphate groups

**Common Acids & \( pK_a \)**

<table>
<thead>
<tr>
<th>Acid</th>
<th>( pK_a )</th>
<th>( pK_b )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic</td>
<td>4.75</td>
<td>5.35</td>
</tr>
<tr>
<td>Formic</td>
<td>3.75</td>
<td>4.35</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>8.35</td>
<td>10.33</td>
</tr>
<tr>
<td>( \text{H}_2\text{PO}_4^- )</td>
<td>7.21</td>
<td>( 12.32 )</td>
</tr>
<tr>
<td>( \text{HPO}_4^{2-} )</td>
<td>2.16</td>
<td>9.25</td>
</tr>
</tbody>
</table>

**C. Organic Bases**
1. \( K_b = [\text{OH}^-][\text{B}^-]/[\text{BOH}] \)
2. Strong base: Full dissociation; \( \text{NaOH}, \text{KOH} \)
3. Weak base: \( K_b < 1 \), large \( pK_b \)
4. Organic Amines & derivatives
   - Examples: \( \text{NH}_3 \) (\( pK_b = 4.74 \)), hydroxylamine (\( pK_b = 9.97 \)) and pyridine (\( pK_b = 5.25 \))
5. Purine: Nucleic acid component: adenine (6-aminopurine) & guanine (2-amin-6-hydropurine)

**D. Buffers**
1. A combination of a weak acid and a salt of a weak acid: equilibrium between an acid and a base that can shift to consume excess acid or base
2. Buffer can also be made from a weak base and salt of weak base
3. The \( pH \) of a buffer is roughly equal to the \( pK_a \) of the acid, or \( pK_b \) of the base, for comparable amounts of acid/salt or base/salt
4. Buffer \( pH \) is approximated by the Henderson Hasselbalch equation
   - Note: This is for an acid/salt buffer

**Henderson Hasselbalch Equation:**
\[
pH = pK_a + \log \left( \frac{[\text{base}]}{[\text{acid}]} \right)
\]

**Common Buffers**

<table>
<thead>
<tr>
<th>Buffer composition</th>
<th>approx. ( pH )</th>
</tr>
</thead>
<tbody>
<tr>
<td>acetic acid + ( \text{acetate salt} )</td>
<td>4.8</td>
</tr>
<tr>
<td>ammonia + ammonium salt</td>
<td>9.3</td>
</tr>
<tr>
<td>carbonate + bicarbonate</td>
<td>6.3</td>
</tr>
<tr>
<td>diacid salt + monoacid salt</td>
<td>7.2</td>
</tr>
</tbody>
</table>

**E. Amino Acids**

1. **Amino acids** have amine (base) and carboxylic acid functionality; the varied chemistry arises from the chemical nature of the R-group:
   - Essential amino acids: Must be provided to mammals in the diet
   - Polymers of amino acids form proteins and peptides
   - Natural amino acids adopt the L-configuration
2. **Zwitterion**: self-ionization; the “acid” donates a proton to the “base”
   - Isoelectric point, \( pI \): \( pH \) that produces balanced charges in the Zwitterion

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**TYPES OF ORGANIC COMPOUNDS**

<table>
<thead>
<tr>
<th>Type of Compound</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkane</td>
<td>( \text{C}<em>n\text{H}</em>{2n} ), ethene ( \text{C}_2\text{H}_4 )</td>
</tr>
<tr>
<td>Alkene</td>
<td>( \text{C}<em>n\text{H}</em>{2n+2} ), unsaturated fatty acids</td>
</tr>
<tr>
<td>Aromatic ring</td>
<td>benzene - ( \text{C}_6\text{H}_6 ), phenylalanine</td>
</tr>
<tr>
<td>Alcohol</td>
<td>( \text{R}-\text{OH} ), \text{MeOH}, \text{glycerol} (3-OH)</td>
</tr>
<tr>
<td>Ether</td>
<td>( \text{R'}\text{O}-\text{R&quot;} ), \text{EtOH}, \text{diethyl ether}</td>
</tr>
<tr>
<td>Aldehyde</td>
<td>( \text{R}\text{CHO} ), formaldehyde, aldose sugars</td>
</tr>
<tr>
<td>Ketone</td>
<td>( \text{O} ), \text{Me-CO-Me} 2-propanone or acetone ketone sugars</td>
</tr>
<tr>
<td>Carboxylic acid</td>
<td>( \text{O} ), ( \text{RCOOH} ), ethanoic acid or acetic acid</td>
</tr>
<tr>
<td>Ester</td>
<td>( \text{O} ), ( \text{RCOOEt} ), ethyl acetate, \text{Lactone: cyclic ester}, \text{Triglycerides}</td>
</tr>
<tr>
<td>Amines</td>
<td>( \text{N-R} ), \text{Methylamine, R-NH}_2 ), \text{Acetamide Peptide bonds}</td>
</tr>
<tr>
<td>Amide</td>
<td>( \text{O} ), ( \text{R-C-NRR&quot;} ), \text{Acetyl CoA}</td>
</tr>
</tbody>
</table>

**Cyclic Ethers:**

- Pyran
- Furan
**BIOCHEMICAL COMPOUNDS**

**A. Carbohydrates: Polymers of Monosaccharides**

1. **Carbohydrates** have the general formula \((\text{CH}_2\text{O})_n\)

2. **Monosaccharides**: Simple sugars; building blocks for polysaccharides

   - **Hexose**
   - **Pentose**
   - **Triose**

**Common Sugars**

<table>
<thead>
<tr>
<th>Type</th>
<th>Common Name</th>
<th>Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hexose</td>
<td>Glucose</td>
<td>(\alpha)-glucose, (\beta)-glucose</td>
</tr>
<tr>
<td>Pentose</td>
<td>Ribose, Deoxyribose</td>
<td>(\alpha)-ribose, (\beta)-ribose</td>
</tr>
<tr>
<td>Triose</td>
<td>Glyceraldehyde</td>
<td>(\alpha)-glyceric aldehyde</td>
</tr>
</tbody>
</table>

**Common Functional Groups**

- **Aldehyde**: \(\text{CH}_2\text{O} \) (non-polar, cannot be synthesized by animal cells)
- **Ketone**: \(\text{C} = \text{O} \) (polar)
- **Hydroxyl**: \(\text{OH} \) (polar)
- **Amine**: \(\text{NH}_2 \) (polar)
- **Ester**: \(\text{R} \text{CO}_2\text{H} \) (polar)
- **Phosphate**: \(\text{R}_3\text{PO}_4 \) (polar)

**Properties of Common Functional Groups**

- **Aldehyde**: Can be oxidized to carboxylic acid
- **Ketone**: Can be reduced to alcohol
- **Hydroxyl**: Can be oxidized to ketone
- **Amine**: Can be oxidized to amide
- **Ester**: Can be hydrolyzed to acid and alcohol
- **Phosphate**: Can be esterified to form phospholipids

3. **Carbohydrate Reactions**

   - **Hydrolysis**: Breaks the glycosidic bond
   - **Condensation**: Forms a new glycosidic bond
   - **Oxidation**: Forms carboxylic acid or ketone
   - **Reduction**: Forms alcohol or amine
   - **Substitution**: Forms ester or amide

4. **Polysaccharides**

   - **Hexose**: Glucose, fructose, galactose
   - **Pentose**: Ribose, deoxyribose
   - **Triose**: Glyceraldehyde

**B. Fats and Lipids**

1. **Lipid**: Non-polar compound, insoluble in water

   - **Examples**: Steroids, fatty acids, triglycerides

2. **Fatty acid**: \(\text{R-COOH} \)

   - **Essential fatty acids**: Cannot be synthesized by the body: linoleic, linolenic, and arachidonic

3. **Properties and structure of fatty acids**

   - **Saturated**: Side chain is an alkane
   - **Unsaturated**: Side chain has at least one \(\text{C} = \text{C} \) double bond
     - \(\text{C} = \text{C} \) trans isomer forms cis fatty acids
     - \(\text{C} = \text{C} \) cis isomer forms trans fatty acids
   - **Solubility in water**: \(<6 \text{C} \) soluble, \(>7 \text{C} \) insoluble
   - **Formic acid**: \(\text{H}_2\text{CO} \)
   - **Melting point**: Saturated fats have higher melting points

4. **Common fatty acid compounds**

   - **Triglyceride**: Three fatty acids bond via ester linkage to glycerol
   - **Phospholipids**: A phosphogroup bonds to one of three positions of fatty acid/glycerol: R-PO_2^-, R-PO_4^-, or R-PO_2^-

5. **Examples of other lipids**

   - **Steroids**: Cholesterol and hormones
   - **Vitamins**: D, E, K

6. **Lipid reactions**

   - **Triglyceride**: Three-step process of dehydration reaction of fatty acid and glycerol
   - **The reverse of this reaction is hydrolysis of the triglyceride**
   - **Phosphorylation**: Fatty acid + acid phosphate produces phospholipid
   - **Lipase (enzyme)** breaks the ester linkage of triglyceride

**Common Fatty Acids**

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Systematic Name</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic acid</td>
<td>ethanoic</td>
<td>(\text{CH}_3\text{COOH} )</td>
</tr>
<tr>
<td>Butyric acid</td>
<td>butanoic</td>
<td>(\text{C}_4\text{H}_9\text{COOH} )</td>
</tr>
<tr>
<td>Valeric acid</td>
<td>pentanoic</td>
<td>(\text{C}<em>5\text{H}</em>{10}\text{COOH} )</td>
</tr>
<tr>
<td>Myristic acid</td>
<td>tetradecanoic</td>
<td>(\text{C}<em>{14}\text{H}</em>{29}\text{COOH} )</td>
</tr>
<tr>
<td>Palmitic acid</td>
<td>hexadecanoic</td>
<td>(\text{C}<em>{16}\text{H}</em>{33}\text{COOH} )</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>octadecanoic</td>
<td>(\text{C}<em>{18}\text{H}</em>{37}\text{COOH} )</td>
</tr>
<tr>
<td>Oleic acid</td>
<td>cis-9-octadecenoic</td>
<td>(\text{C}<em>{18}\text{H}</em>{36}\text{COOH} )</td>
</tr>
<tr>
<td>Linoleic acid</td>
<td>cis, cis-9, 12 octadecadienoic</td>
<td>(\text{C}<em>{18}\text{H}</em>{30}\text{COOH} )</td>
</tr>
<tr>
<td>Linolenic acid</td>
<td>9, 12, 15- octadecatrienoic (all cis)</td>
<td>(\text{C}<em>{18}\text{H}</em>{28}\text{COOH} )</td>
</tr>
<tr>
<td>Arachidonic acid</td>
<td>5, 8, 11-, 14- eicosatetraenoic (all trans)</td>
<td>(\text{C}<em>{20}\text{H}</em>{34}\text{COOH} )</td>
</tr>
</tbody>
</table>
### C. Proteins and Peptides - Amino Acid Polymers

1. **Peptides** are formed by linking amino acids; all natural peptides contain L-amino acids.
   - **Dipeptide:** Two linked amino acids
   - **Polypeptide:** Numerous linked amino acids

2. The nature of the peptide varies with amino acids since each R-group has a distinct chemical character.
   - a. R-groups end up on alternating sides of the polymer chain
   - b. Of the 20 common amino acids: 15 have neutral side chains (7 polar, 8 hydrophobic), 2 acidic and 3 basic; the variation in R-explains the diversity of peptide chemistry (see table, pg. 6)

3. **Proteins** are polypeptides made up of hundreds of amino acids.
   - a. Each serves a specific function in the organism
   - b. The structure is determined by the interactions of various amino acids with water, other molecules in the cell and other amino acids in the protein

4. **Types of proteins:**
   - a. **Fibrous:** Composed of regular, repeating helices or sheets; typically serve a structural function
   - b. **Globular:** Tend to be compact, roughly spherical; participates in a specific process
   - c. **Oligomer:** Protein containing several subunit proteins

#### Six Classes of Enzymes (Enzyme Commission)

<table>
<thead>
<tr>
<th>Type</th>
<th>Reaction</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Oxidoreductase</td>
<td>Oxidation-reduction</td>
<td>Oxidases: oxidize CH-OH, &gt;C=O or CH-CH; Oxygen acceptors: NAD, NADP</td>
</tr>
<tr>
<td>2. Tranferase</td>
<td>Functional group transfer</td>
<td>Examples: transfer methyl, acyl- or amine group</td>
</tr>
<tr>
<td>3. Hydrolase</td>
<td>Hydrolysis reaction</td>
<td>Examples: cleave carboxylic or phosphoric ester</td>
</tr>
<tr>
<td>4. Lyase</td>
<td>Addition reaction</td>
<td>Examples: add to &gt;C=C&lt;, &gt;C=O, aldehyde</td>
</tr>
<tr>
<td>5. Isomerase</td>
<td>Isomerization</td>
<td>Example: modify carbohydrate, cis-trans fat</td>
</tr>
<tr>
<td>6. Ligase</td>
<td>Bond formation, via ATP</td>
<td>Examples: form C-O, C-S or C-C</td>
</tr>
</tbody>
</table>

5. **Peptide Structure:**
   - **Primary structure:** The linear sequence of amino acids connected by peptide bonds
   - **Secondary structure:** Describes how the polymer takes shape
   - **Tertiary structure:** The overall 3-dimensional conformation

### Common Protein

<table>
<thead>
<tr>
<th>Examples</th>
<th>Mol Wt</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>fibrinogen</td>
<td>450,000</td>
<td>Physical structures</td>
</tr>
<tr>
<td>hemoglobin</td>
<td>68,000</td>
<td>Binds O₂</td>
</tr>
<tr>
<td>insulin</td>
<td>5,500</td>
<td>Glucose metabolism</td>
</tr>
<tr>
<td>ribonuclease</td>
<td>13,700</td>
<td>Hydrolysis of RNA</td>
</tr>
<tr>
<td>trypsin</td>
<td>23,800</td>
<td>Protein digestion</td>
</tr>
</tbody>
</table>

### QuickStudy

1. Quaternary structure: The conformation of protein subunits in an oligomer
2. Chemical reactions of proteins:
   - a. Synthesis of proteins by DNA and RNA
   - b. Peptides are dismantled by a hydrolysis reaction breaking the peptide bond
3. Denaturation: The protein structure is disrupted, destroying the unique chemical features of the material
4. Enzymes are proteins that function as biological catalysts
5. Nomenclature: Substrate + -ase

#### Examples:
- **Enzyme** that acts on phosphoryl groups (R-P-O₄) is called **phosphatase**
- **Enzymes** are highly selective for specific reactions and substrates

### Chargaff’s Rule for DNA:
- **The polypeptide component**
- **Nucleic Acids:** Polymers of Nucleotides

<table>
<thead>
<tr>
<th>Nucleic Acid Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
</tr>
<tr>
<td>adenine</td>
</tr>
<tr>
<td>guanine</td>
</tr>
<tr>
<td>cytosine</td>
</tr>
<tr>
<td>uracil</td>
</tr>
<tr>
<td>thymine</td>
</tr>
</tbody>
</table>

### Additional Phosphates:
- a. A nucleotide can bond to 1 or 2 additional phosphate groups
- b. AMP + P ⇄ ADP - Adenosine diphosphate
- c. ATP - Adenosine triphosphate
- d. ADP and ATP function as key biochemical energy-storage compounds

### Glycosidic bond:
- Linkage between the sugar and base involve the anomeric carbon (carbon #1) >C=O (sugar) + >NH (base) linked sugar - base

### Linking Nucleotides:
- The polymer forms as each phosphate links two sugars; #5 position of first sugar and #3 position of neighboring sugar

### Types of nucleic acids:
- Double-stranded DNA (deoxyribonucleic acid) and single-stranded RNA (ribonucleic acid)

### Components of a nucleotide:
- Sugar: ribose (RNA) or deoxyribose (DNA)
- Bases: purine (adenine and guanine) and pyrimidine (cytosine, uracil (RNA) and thymine (DNA))

### In DNA, the polymer strands pair to form a double helix; this process is tied to base pairing

### Chargaff’s Rule for DNA:
- a. Adenine pairs with thymine (A-T) and guanine pairs with cytosine (C-G)
- b. Hydrogen bonds connect the base pairs and supports the helix
- c. The sequence of base pairs along the DNA strands serves as genetic information for reproduction and cellular control

### DNA vs RNA:
- DNA: uses deoxyribosyl, RNA uses ribose; DNA uses the pyrimidine thymine, RNA uses uracil

### DNA & RNA in protein synthesis
- a. DNA remains in the nucleus
- b. Messenger-RNA (m-RNA): Enters the nucleus and copies a three-base sequence from DNA, termed a **codon**.
- c. Transfer-RNA (t-RNA): Carries a specific amino acid to the ribosomal-RNA (r-RNA) and aligns with the m-RNA codon
- d. Each codon specifies an amino acid, STOP or START; a protein is synthesized as different amino acids are delivered to the ribosome by t-RNA, oriented by m-RNA and r-RNA, then chemically connected by enzymes
### COMMON AMINO ACIDS

<table>
<thead>
<tr>
<th>Amino acid</th>
<th>MW</th>
<th>pK&lt;sub&gt;a&lt;/sub&gt;</th>
<th>pK&lt;sub&gt;b&lt;/sub&gt;</th>
<th>pK&lt;sub&gt;α&lt;/sub&gt;</th>
<th>R-pK&lt;sub&gt;α&lt;/sub&gt;</th>
<th>R-pK&lt;sub&gt;b&lt;/sub&gt;</th>
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<tbody>
<tr>
<td>Alanine</td>
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<td>3.23</td>
<td>9.71</td>
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<td>H₂C=</td>
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<td>9.00</td>
<td>10.76</td>
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<td>Aspartagine e 132.12</td>
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<td>O⁻</td>
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<td>Glycine 75.07</td>
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<td>N=CH²⁻</td>
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<td>6.02</td>
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<td>H₃N⁻CH₂=CH₂CH₂CH₂⁻</td>
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<tr>
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<td>9.52</td>
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<td>hydrophobic</td>
<td>CH₃=</td>
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</table>

**Note:** Source - CRC Handbook of Chemistry & Physics

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### Amino Acid pK Values

- **pH**: 119.12, 8.96
- **pH**: 149.21, 9.08
- **pH**: 131.18, 9.60
- **pH**: 115.13, 10.47
- **pH**: 131.18, 9.58
- **pH**: 181.19, 9.04
- **pH**: 155.16, 9.09
- **pH**: 75.07, 9.58
- **pH**: 147.13, 9.04
- **pH**: 121.16, 9.52
- **pH**: 174.20, 9.00
- **pH**: 89.09, 9.71

### Amino Acid Characteristics
- **Hydrophobic**: yellow
- **Basic**: blue
- **Acidic**: red
- **Polar**: green

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### Amino Acid pK Values

- **115.13**: 10.47
- **131.18**: 9.58
- **146.19**: 9.00
- **135.16**: 6.04
- **149.21**: 9.08

### Amino Acid Descriptions
- **Valine**: 1.95, 6.30, hydrophobic
- **Leucine**: 2.26, 9.60, hydrophobic
- **Isoleucine**: 2.26, 9.60, hydrophobic
- **Phenylalanine**: 2.18, 9.09, hydrophobic
- **Proline**: 1.95, 10.47, hydrophobic

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### Abbreviations Used in Biology & Biochemistry

- **aa** = amino acid
- **Lys** = lysine
- **M** = methionine
- **m** = milli (mL/mole)
- **mm** = millimeter
- **n** = nano (10⁻⁹)
- **p** = pico (10⁻¹²)
- **R** = arginine
- **R** = ribose sugar
- **s** = second (s)
- **T** = treonine
- **U** = uracil - pyrimidine
- **X** = xanthine
- **yr** = year