

Chemistry 1506: Allied Health Chemistry 2

Section 9: Proteins

Biochemical Amides

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Section 9.1 Protein Roles

- Structural Proteins
 - Cellular
 - Bodies
 - Tendons
 - Muscles
 - Bones

- Movement Proteins
 - Intracellular
 - Cellular
 - Bodies

- Molecular Transport Proteins
 - Within Cells
 - Across Membranes

- Catalysis Proteins
 - Digestion
 - Biochemical Pathways

- Protection Proteins
 - Antibodies

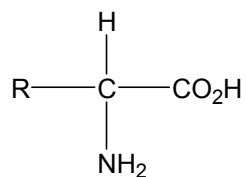
- Hormone Proteins

- Regulation of Cellular Activity Proteins

- Storage Proteins (e.g., Ca^{+2})

Section 9.2 Amino Acids

➤ General Structure



➤ 20 Commonly Occurring Amino Acids

➤ α -Amino Acids

➤ 19 are chiral at α carbons

➤ See Table in Text

➤ Nonpolar Amino Acids

➤ Size

➤ Total Steric Bulk

➤ Distance of bulk from protein backbone

➤ R = H, Glycine, Gly

➤ R = CH₃, Methyl, Alanine, Ala

➤ R = CH(CH₃)₂, Iso-Propyl, Valine, Val

➤ $R = \text{CH}_2\text{CH}(\text{CH}_3)_2$, **Iso-Butyl, Leucine, Leu**

➤ $R = \text{C}^*\text{H}(\text{CH}_3)(\text{CH}_2\text{CH}_3)$, **Sec-Butyl, Isoleucine, Ile**

➤ $\text{HN}\{\text{CH}_2\text{CH}_2\text{CH}_2\text{-ring}\}\text{CH-CO}_2\text{H}$, **Proline, Pro**

➤ $R = \text{CH}_2\text{-C}_6\text{H}_5$, Aromatic, Phenylalanine, Phe

➤ $R = \text{CH}_2\text{CH}_2\text{-S-CH}_3$, Thioether, Methionine, Met

➤ Neutral Polar Amino Acids

➤ $R = \text{CH}_2\text{-OH}$, 1° Alcohol, Serine, Ser

➤ $R = \text{CH}(\text{CH}_3)\text{-OH}$, 2° Alcohol, Threonine, Thr

➤ $R = \text{CH}_2\text{-SH}$, Thiol / Thioalcohol, Cysteine, Cys

➤ $R = \text{CH}_2\text{-(1,4-C}_6\text{H}_4\text{)-OH}$, Phenol, Tyrosine, Tyr

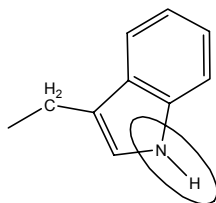
➤ $R = \text{CH}_2\text{-C(=O)-NH}_2$, Amide, Asparagine, Asn

➤ $R = \text{CH}_2\text{-CH}_2\text{-C(=O)-NH}_2$, Amide, Glutamine, Gln

➤ Tryptophan, Trp, Heterocyclic

➤ Aromaticity effects on Nitrogen basicity

➤ $R =$



➤ Acidic Amino Acids

➤ Variable Chain Lengths

➤ $R = \text{CH}_2\text{-CO}_2\text{H}$, Aspartic Acid, Asp

➤ $R = \text{CH}_2\text{CH}_2\text{-CO}_2\text{H}$, Glutamic Acid, Glu

➤ Basic Amino Acids

➤ Variability

➤ Base Distance

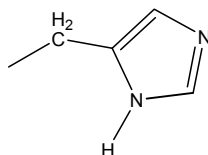
➤ Base Strength, Lone pairs on Nitrogen

➤ R = CH₂CH₂CH₂CH₂-NH₂, Lysine, Lys

➤ R = CH₂CH₂CH₂NH-C(=NH)-NH₂, Arginine, Arg

➤ Histidine, His

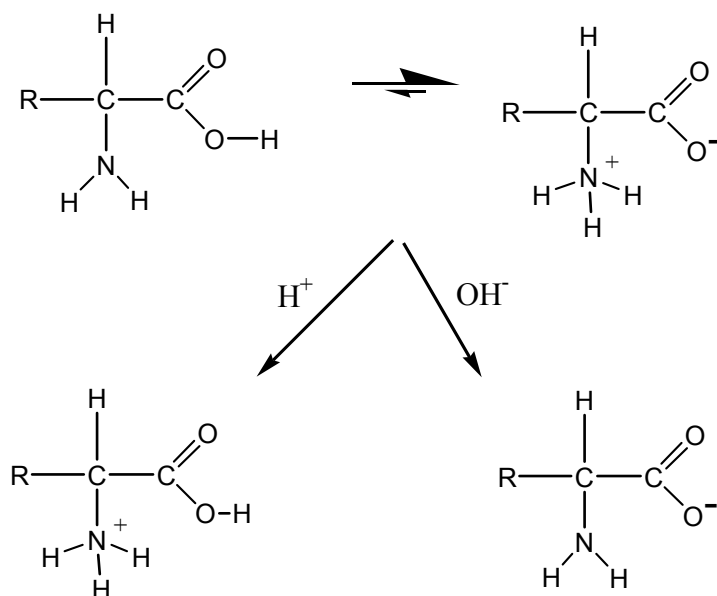
➤ R =



➤ **Zwitterions**

- Molecules that contain both a **positive charge** and a **negative charge**

➤ **Intramolecular Acid-Base Chemistry**



➤ **Isoelectric Point**

- **pH** at which **Amino Acids** are in **Zwitterionic form**

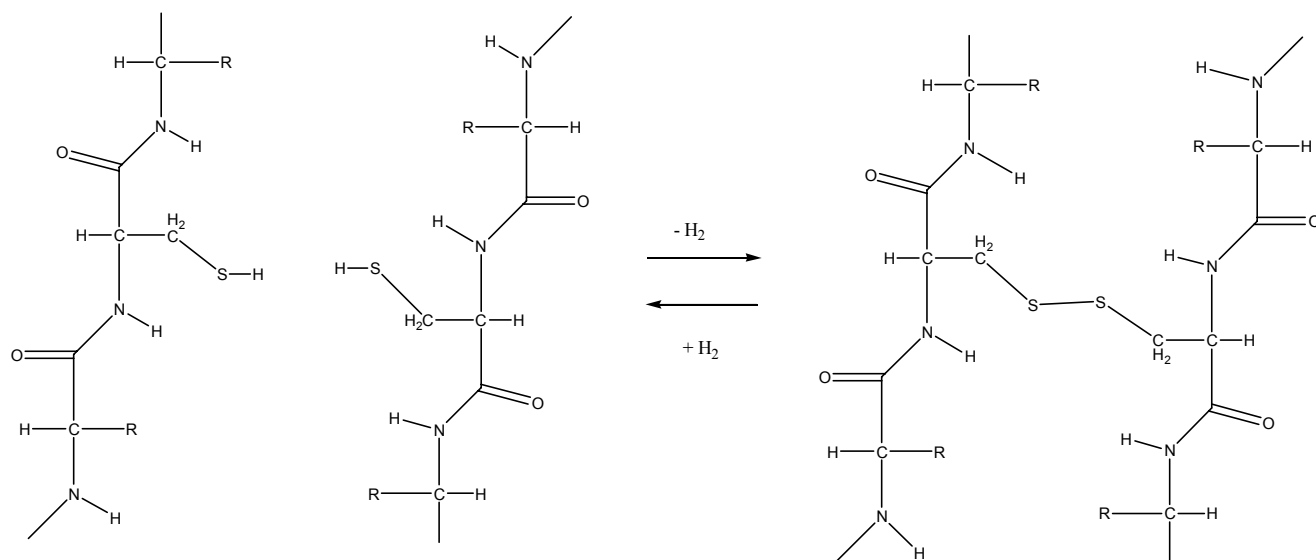
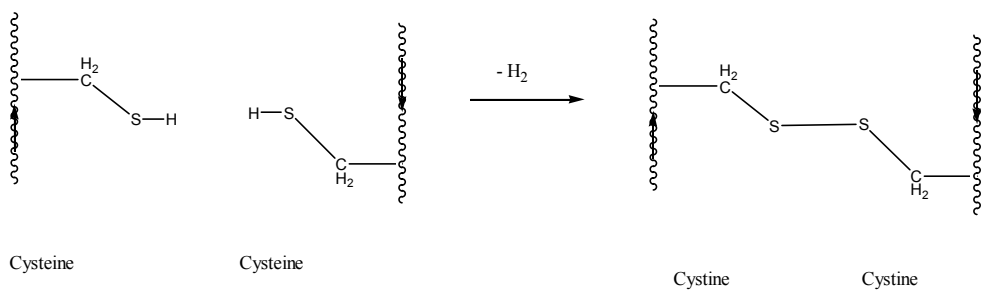
➤ Cysteine

➤ Cysteine \Rightarrow Cystine

➤ Oxidation with loss of H_2

➤ Thiols \Rightarrow Disulfides

➤ Reversible Redox (Reduction reverses the reaction)



Section 9.3 Peptides and Proteins

➤ Peptide (Amide) Bonds

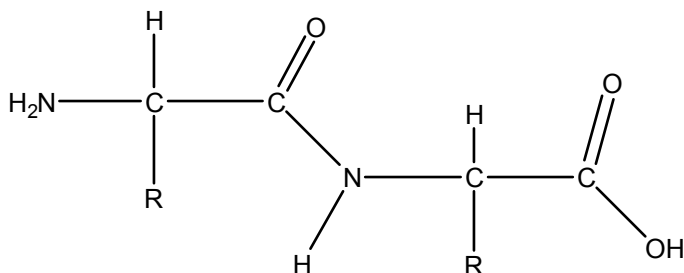
➤ 6 atom unit

➤ rigid

➤ trans arrangement about amide linkage

➤ planar

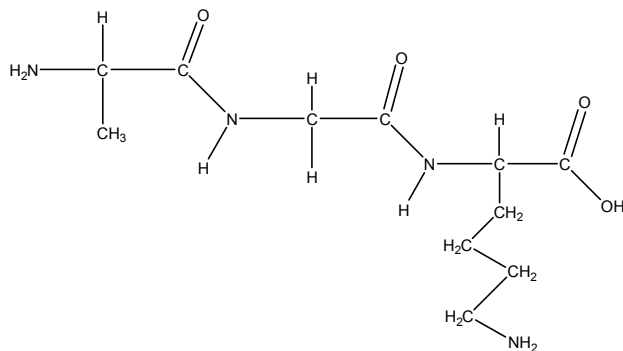
➤ Dipeptide example



➤ Peptide Sizes

➤ Dipeptide, Tripeptide, Tetrapeptide... Polypeptide....Protein

- Structures of peptides and proteins specified with **3 letter codes**
- 1st start from **NH₂ groups on the left**
- Identify side chains
- Join Amino Acids by **peptide bonds**
- Typical Exam Questions
 - Example Ala-Gly-Lys



- Levels of Structure
 - 1°, Primary Structure
 - Sequence of Amino Acids in protein backbone

 - 2°, Secondary Structure
 - α -Helix and β -Pleated Sheets

 - 3°, Tertiary Structure
 - Overall 3D shape/folding of protein chain

 - 4°, Quaternary Structure
 - Multiple separate proteins clustered together

- Typical Positions of Amino Acids in Proteins
 - Core Amino Acid Residues
 - Nonpolar Amino Acids

- Surface Amino Acid Residues
 - Depends on protein position
 - Polar/Hydrogen Bonding/Ionic Residues where touch water
 - Nonpolar residues where in membrane

- Active Site
 - Acid/Basic/Etc. residues to Catalyze reactions
 - Nonpolar and Polar/Hydrogen Bonding/Ionic to hold substrate in Position

- How proteins keep their shapes
 - “Hydrophobic” vs. “Hydrophilic” Interactions

- Types of Bonds Holding Proteins in their Shapes
 - Covalent Bonds, Directional
 - Disulfide linkages, Directional

 - Ionic Bonds, Non-directional

 - Hydrogen Bonds, Directional

 - Dipole-Dipole Interactions, Non-directional

 - Van der Waal's Interactions, Non-Directional
 - Individually weak but strong in total

Section 9.4 Primary Structure

➤ Sequence

➤ Number of Possibilities

➤ (number of Amino Acids)ⁿ

➤ where n is the chain length

➤ Example: 20 AA in mammals ⇒

➤ **dipeptides** have $(20)^2 = 400$ 1° structures

➤ **tripeptides** have $(20)^3 = 8,000$ 1° structures

➤ 1° Structure Determines 2°, 3°, and 4° Structures

➤ Thermodynamics

➤ Kinetics

➤ Types of Structural Variations Found in “the Same” protein

➤ Between **individuals** in a **species**

➤ Between **sub-populations** in a species

➤ Between species

- Effects of Structural Variations
 - Depend on site and nature of substitutions
 - Some changes have no observable effects
 - Some changes have effects
 - On rates
 - On control
 - On **specificities**
 - Some changes kill activity
 - These changes work by changing 2°, 3°, and 4° structures
and hence protein reactivity

Section 9.5 Secondary Structure

- Types of 2° structures
- See Figure in Text
 - α -Helix
 - β -Pleated Sheet
 - Held together by intra-structural Hydrogen Bonds
 - between backbone groups
 - N-H Hydrogen Bonds Donors
 - C=O Hydrogen Bond Acceptors
 - Random coils/chains

Section 9.6 Tertiary And Quaternary Structure

- Bond Types same as on list above for other structural features

- Collagen
 - Found in human **connective tissue**, very strong
 - See Figure in Text
 - Each Collagen molecule is a **triple helix** (of 3 chains)
 - Each chain is an individual molecule made up of an **α -helix**
 - Twisted together like **braiding**

- Chaperones
 - Proteins that assist **folding** to give **thermodynamically preferred structures**

➤ Denaturation and Naturation

➤ Often reversible

➤ Can be artificially induced by heat, solvent, salts, etc.

➤ Denaturation

➤ Loss of native 3D structure

➤ Naturation

➤ Gain of native 3D structure

➤ Glycoproteins

➤ Sugars bonded to protein surfaces

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