Chemistry 1506: Allied Health Chemistry 2

Section 9: Proteins

Biochemical Amides

Outline

Section 9.1 Protein Roles

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

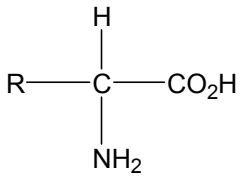
- Movement Proteins
  - Intracellular
  - Cellular
  - Bodies

- 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 = CH_3, Methyl, Alanine, Ala

- R = $CH(CH_3)_2$, Iso-Propyl, Valine, Val

- R = $CH_2CH(CH_3)_2$, Iso-Butyl, Leucine, Leu

- R = $C^*H(CH_3)(CH_2CH_3)$, Sec-Butyl, Isoleucine, Ile

- $HN\{CH_2CH_2CH_2$-ring$\}CH$-CO_2H, Proline, Pro

- R = CH_2-C_6H_5, Aromatic, Phenylalanine, Phe

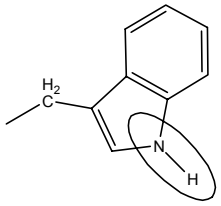
- R = CH_2CH_2-S-CH_3, Thioether, Methionine, Met

- Neutral Polar Amino Acids
  - R = CH_2-OH, 1° Alcohol, Serine, Ser
  - R = $CH(CH_3)$-OH, 2° Alcohol, Threonine, Thr
  - R = CH_2-SH, Thiol / Thioalcohol, Cysteine, Cys
  - R = CH_2-(1,4-C_6H_4)-OH, Phenol, Tyrosine, Tyr

- R = CH_2-C(=O)-NH_2, Amide, Asparagine, Asn

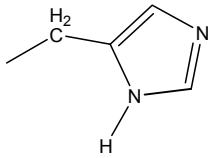
- R = CH_2-CH_2-C(=O)-NH_2, Amide, Glutamine, Gln

- Tryptophan, Trp, Heterocyclic
  - Aromaticity effects on Nitrogen basicity
  - R =



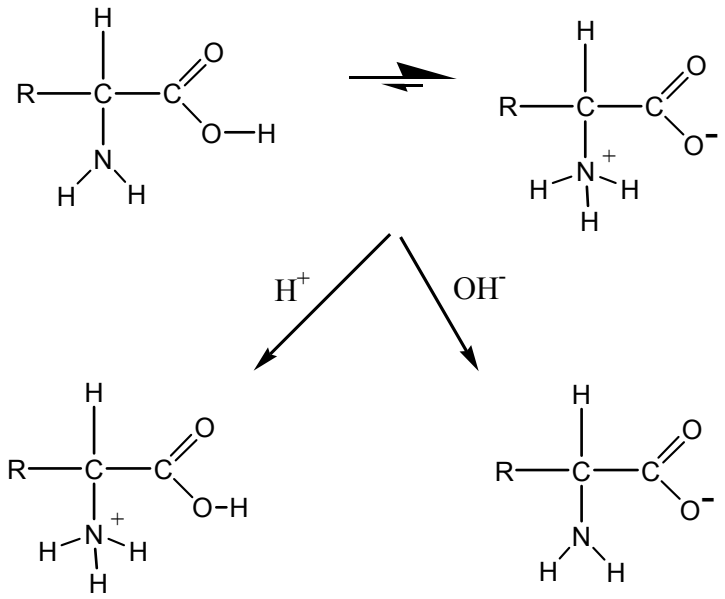
- Acidic Amino Acids
  - Variable Chain Lengths
  - R = CH_2-CO_2H, Aspartic Acid, Asp
  - R = CH_2CH_2-CO_2H, Glutamic Acid, Glu

- Basic Amino Acids
  - Variability
    - Base Distance
    - Base Strength, Lone pairs on Nitrogen
  - R = $CH_2CH_2CH_2CH_2$-NH_2, Lysine, Lys
  - R = $CH_2CH_2CH_2NH$-C(=NH)-NH_2, Arginine, Arg
  - Histidine, His
    - R =



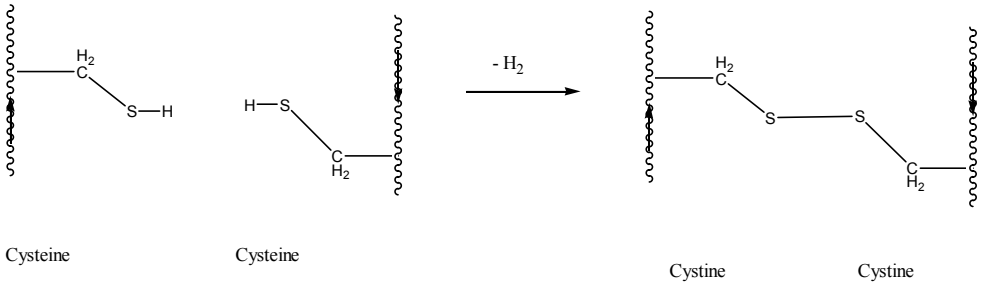
- Zwitterions
  - Molecules that contain both a positive charge and a negative charge

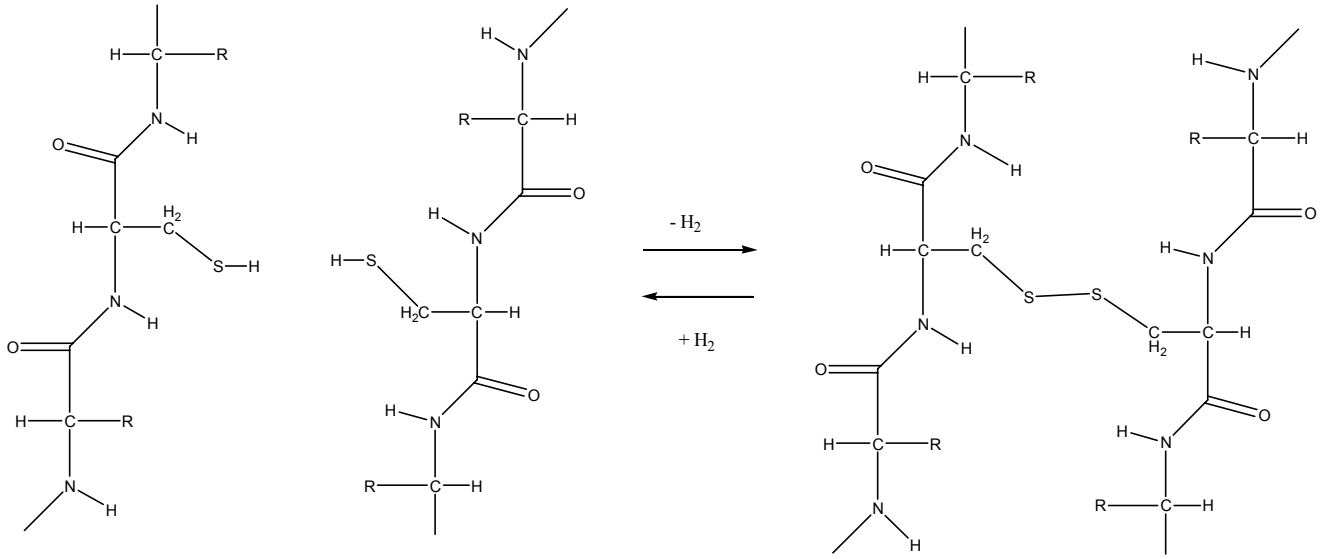
- Intramolecular Acid-Base Chemistry



- Isoelectric Point
  - pH at which Amino Acids are in Zwitterionic form

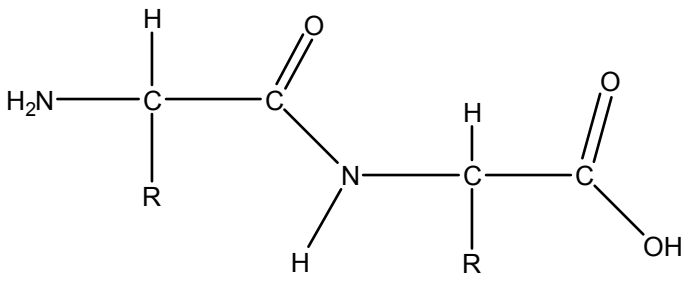
- Cysteine
  - Cysteine ⇒ Cystine
    - Oxidation with loss of H_2
    - Thiols ⇒ Disulfides
    - Reversible Redox (Reduction reverses the reaction)





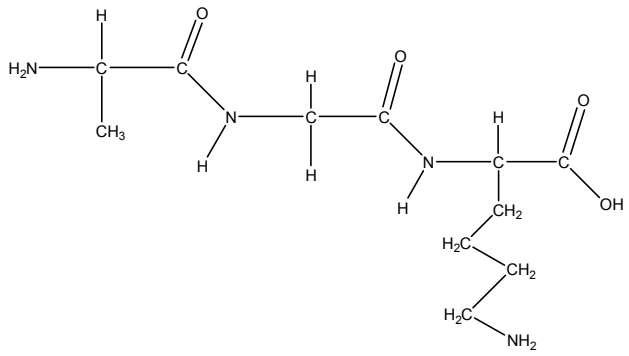
Section 9.3 Peptides and Proteins

- 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 NH_2 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 $\Rightarrow$
    - 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

Index of Topics and Vocabulary