Secondary Structure

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Secondary structures are composed of torsion angles which aid in the formation of helices and sheets. Turns, and hydrophobicity additionally affect the secondary structure of a protein resulting in alternative protein structures.

What Causes Secondary Structure?

Figure 1. Depiction of phi (\(\phi\)), psi (\(\psi\)), and omega (\(\omega\)) angles between 2 amino acids. The phi and psi bonds are the torsion bonds connecting the amine and the carboxylic acid groups to the alpha carbon in the center of the amino acid. Phi angles are bond between N and Ca. Psi angles are bond between Ca and C. Omega angles are flat 180 degree angles and occur between peptide bonds. Only phi and psi angles can rotate, and their rotation depends on the steric hindrance caused by the R-group of the amino acid.

Types of Secondary Structure

Figure 2. Image of a Ramachandran plot. This plot identifies the most ideal torsion angles throughout the secondary structure (shown by the darkest areas on the graph). Steric hindrance plays a factor in restricting the angles, meaning different amino acid R-groups can affect the torsion angles. The most ideal angles are denoted on the graph by the darkest areas. Certain degrees of rotation form different types of secondary structures.

Types of Helices

Figure 3. Secondary structures can be separated into two common groups. Alpha Helix:
- phi and psi bonds are both around -60 degrees which cause ideal hydrogen bonds to form between the C=O and N-H. Beta Pleated Sheet:
- phi bonds are around -120 and psi bonds are around +135

Beta Pleated Sheets

Figure 5. Additional substructures exist within the group of beta pleated sheets:
- parallel beta pleated sheet
- anti-parallel beta pleated sheet

Types of Helices

Figure 4. Additional substructures exist within the group of helices:
- Alpha helices (3.6): 100\(^\circ\) turn in helix
- 3.10 helices: 120\(^\circ\) turn in helix
- pi helices: 87\(^\circ\) turn in helix

The various degree turns in the helices additionally affect how tightly the helix is coiled.

Hydrophobicity

Figure 6. Common turns that are used in beta pleated sheets. Each turn uses 4 amino acids. Prolines are common when phi is negative, and glycines are common when phi is positive.

Figure 7. The alpha helix is amphiphatic. The figure depicts the orientation of hydrophilic and hydrophobic amino acids from a top view of the helix. The numbers indicate the position of each of the amino acids, in their optimal positions according to hydrophobicity, from the first amino acid to the last.

Figure 8. Adjacent side chains of a \(\beta\) pleated sheet can be oriented so that one side of the sheet is hydrophilic while the other side is hydrophobic. This aids in creating a boundary between water and oily environments.