Secondary Structure

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What Causes Secondary Structure?

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.

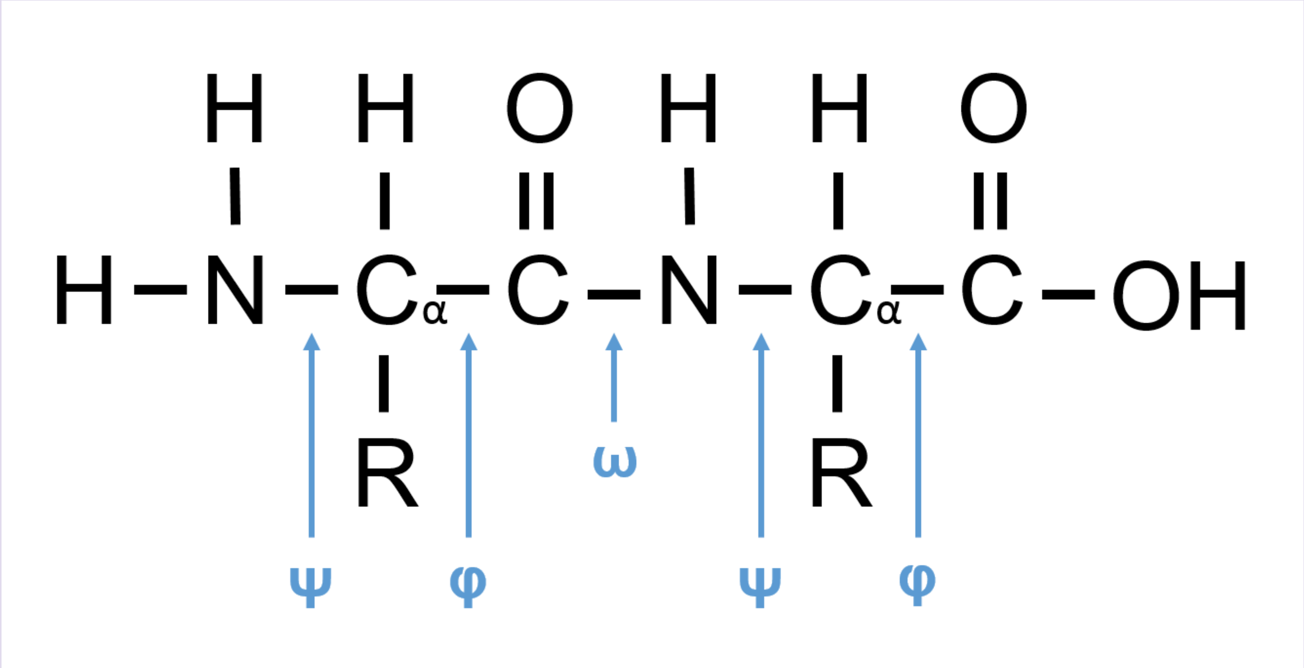
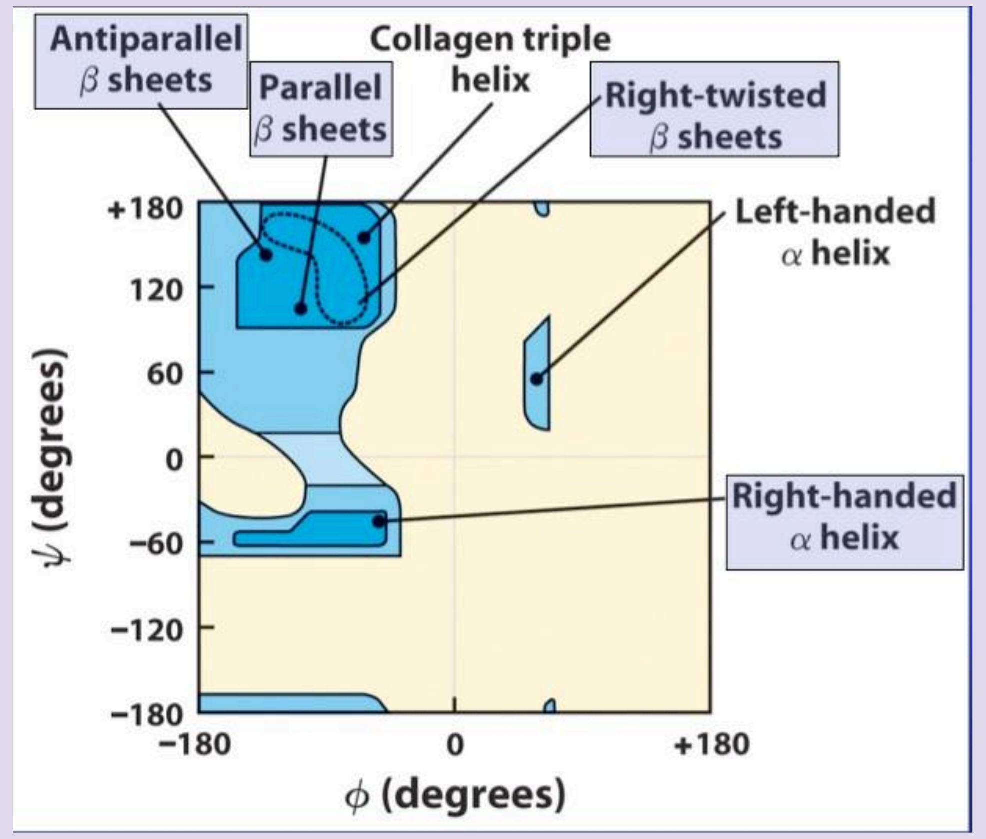


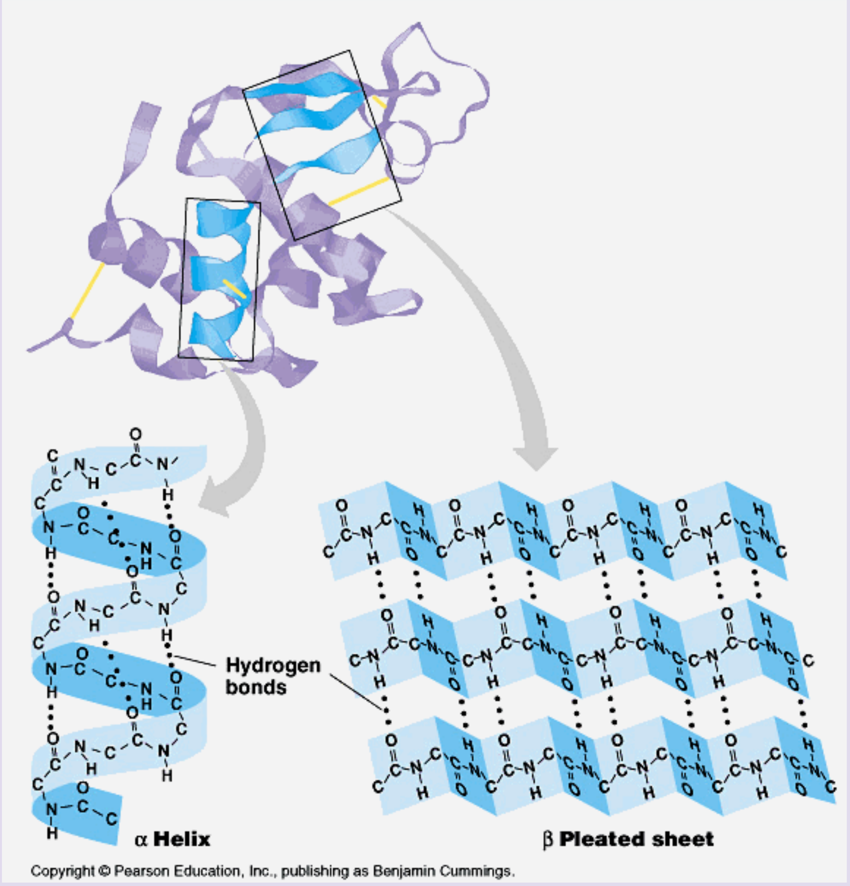
Figure 1. Depiction of phi (ϕ), psi (Ψ), and omega (ω) angles between 2 amino acids. The phi and psi bonds are the torsion bonds connecting the amine and the carboxylic acid groups to the alpha carbon in the center of the amino acid. Phi angles are bond between N and Cα. Psi angles are bond between Cα 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[1].



Nigro, A. *The Three-Dimensional Structure of Proteins*. [PDF document] Retrieved from Western Connecticut State University Web site: http://people.wcsu.edu/nigroa/CHE%20421/Lectures/CHP%204%20Three%20Dimensional%20Structure%20of%20Proteins.pdf

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 the darkest areas. Certain degrees of rotation form different types of secondary structures[1].

Types of Secondary Structure



Campbell, Neil A., and Jane B. Reece. Biology. 7. San Francisco: Pearson: Benjamin Cummings, 2005.

Figure 3. Secondary structures can be separated into two common groups:

Alpha Helix[2]

- phi and psi bonds are both around -60 degrees which cause ideal hydrogen bonds to form between the C,O and H,N.

Beta Pleated Sheet[2]

- phi bonds are around -120 and psi bonds are around +135

Types of Helices

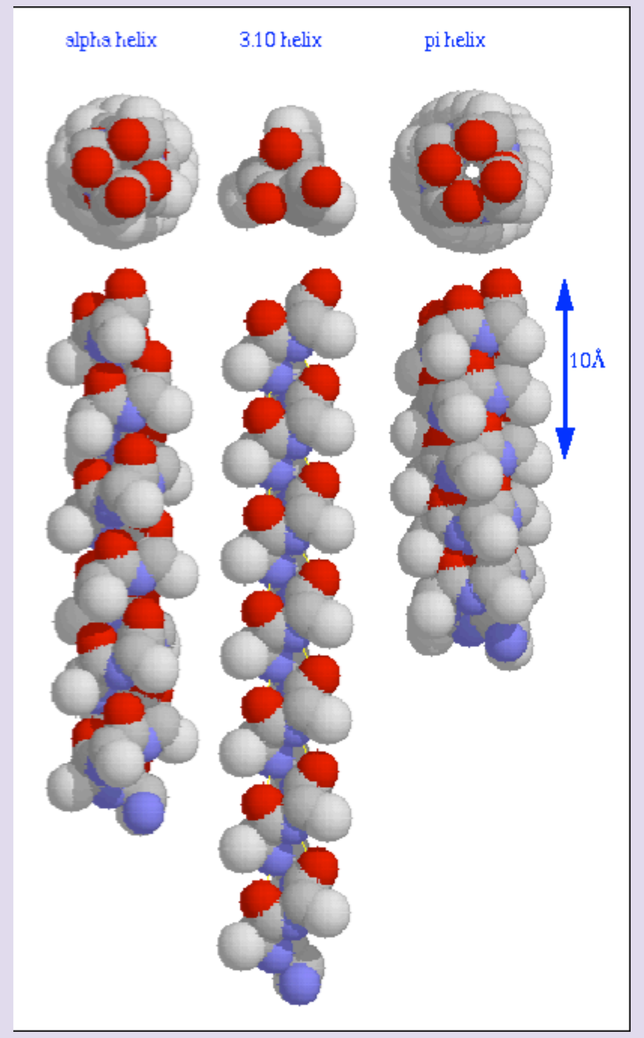


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Figure 4. Additional substructures exist within the group of helices

- Alpha helices (3.6_{13}): 100° turn in helix[3]
- 3.10 helices: 120° turn in helix[4]
- pi helices: 87° turn in helix[5]

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

Bibliography

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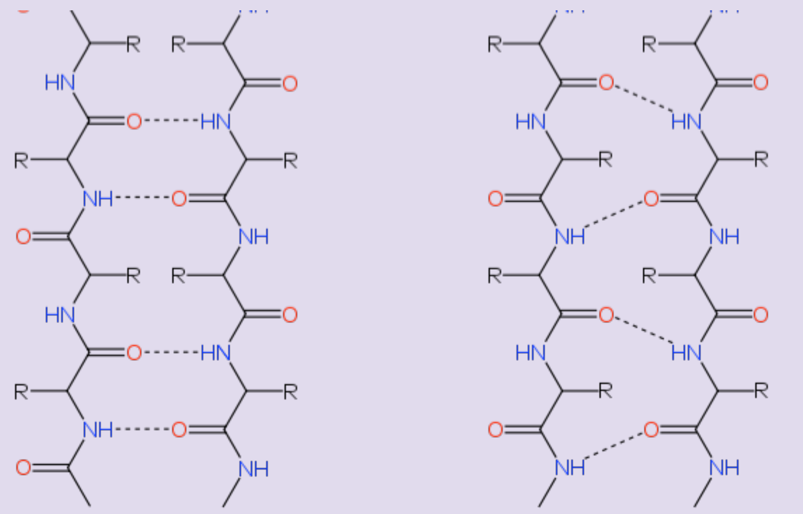
Beta Pleated Sheets

Types

Figure 5. Additional substructures exist within the group of beta pleated sheets[2]

- parallel beta pleated sheet
- anti-parallel beta pleated sheet



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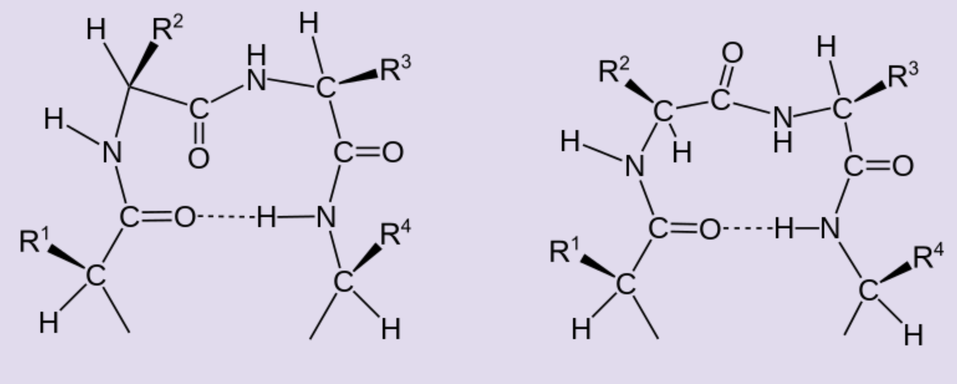
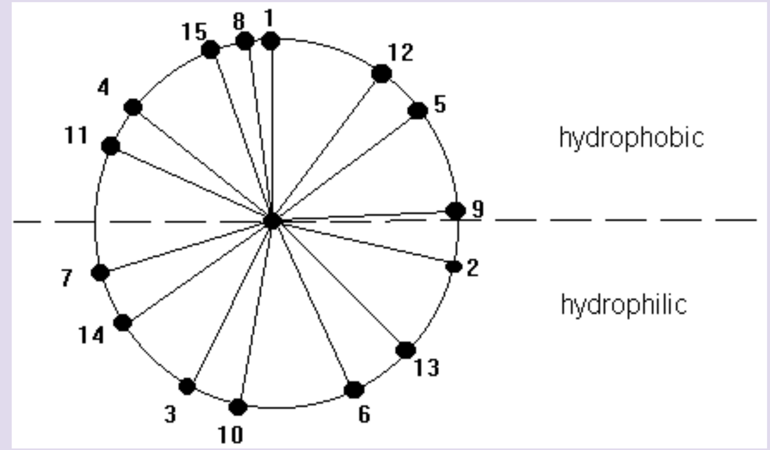
Turns



Turn (Biochemistry). (28 October 2015) Wikipedia. Retreived from https://en.wikipedia.org/wiki/Turn_(biochemistry)

Figure 6. Common turns that are used at 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.[7]

Hydrophobicity



"a-Helix", Protein Structure: a-helix, B-sheet and turns. Retrieved from http://www.whatislife.com/reader/protein/protein.html

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.[7]

Protein structure. (12 February 2010) Wikipedia. Retreived from http://en.citizendium.org/wiki/Protein_structure

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