070926 Quiz 1 Morphology of Complex Materials

1) We discussed in class that many materials can be described as displaying a hierarchy similar to the hierarchy displayed by globular proteins. Consider the polyurea shown in Figure 1.

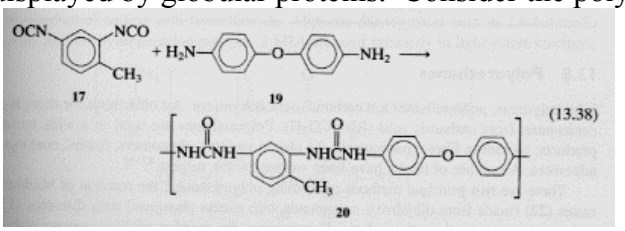


Figure 1 Polyurea (from MP Stevens Polymer Chemistry An Introduction p. 377). The O-C bond is extremely flexible.

a) What parts of this molecule will display rigid planar sheet structure?

b) Sketch the molecule in terms of these sheets indicating where hydrogen bonding is possible.

c) Could this molecule form β-sheet like structures? Sketch how this could look.

d) Could this molecule form helical structures? Explain how this might be possible.

e) Comment on the type of tertiary structure that you might see in a polyurea. Is micro-phase separation possible?

2) Proteins are the seminal model for molecular hierarchy. The primary structure is a sequence of amino acids.

a) Give the generic chemical structure for an amino acid and a protein molecule.

b) Label the α-carbon, the β-carbon and the N and C termini of the protein.

c) Show what parts of the structure are coplanar (sheet-like).

d) Indicate the two bond angles used to make a Ramachandran plot.

e) What values of these angles are forbidden? Why?

3) A folded protein displays 0 conformational entropy since it exists in a single state. The unfolded protein has a high conformational entropy.

a) What causes a protein to spontaneously lose its entropy during folding?

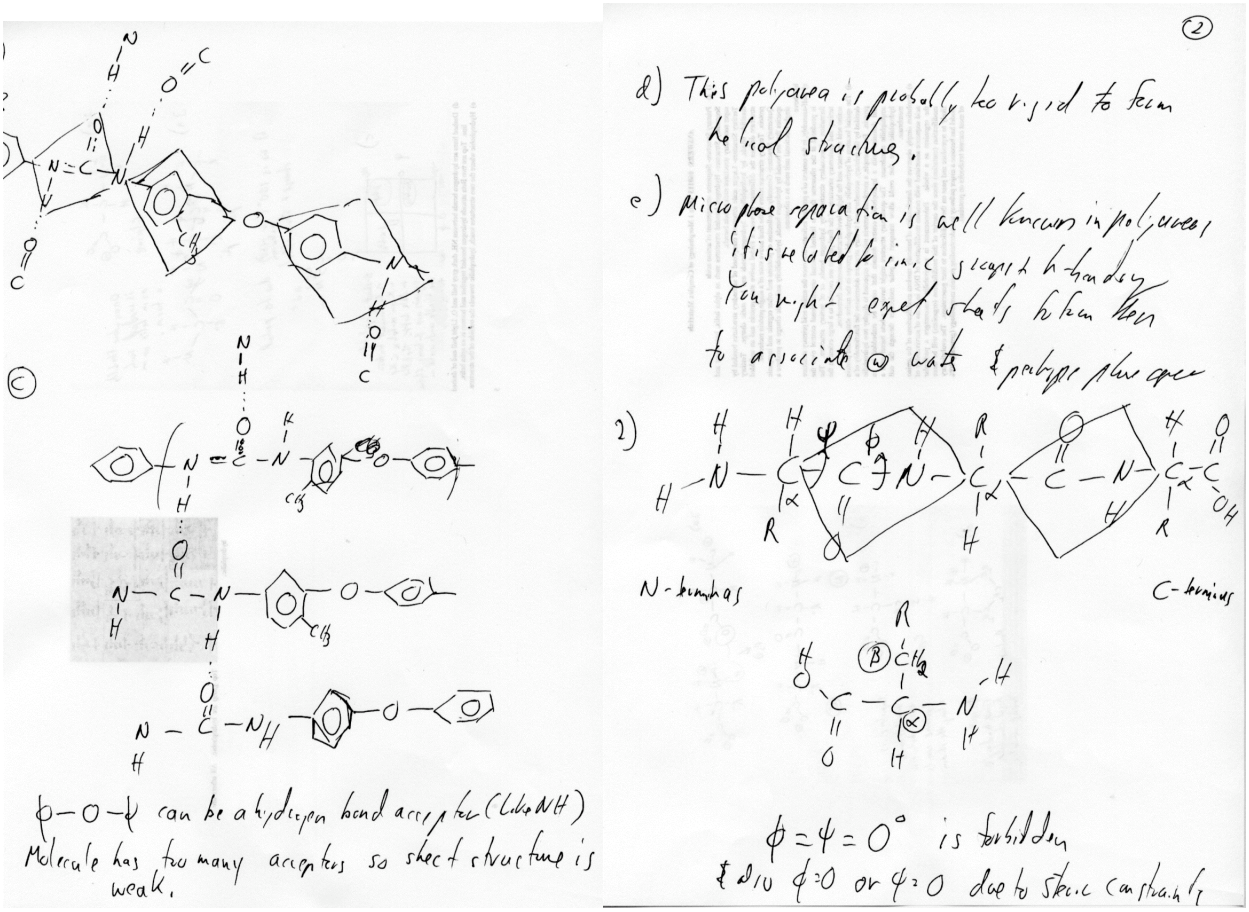
b) Sketch two protein chains showing an anti-parallel β-configuration indicating hydrogen bonding by dashed lines. Indicate the coplanar parts of the two chains. Why is this called a pleated sheet?

c) What is a disulfide bond and which amino acids are involved in this bond?

d) Sketch the structure of the amino acid proline and indicate the importance of proline to β-sheet structure.

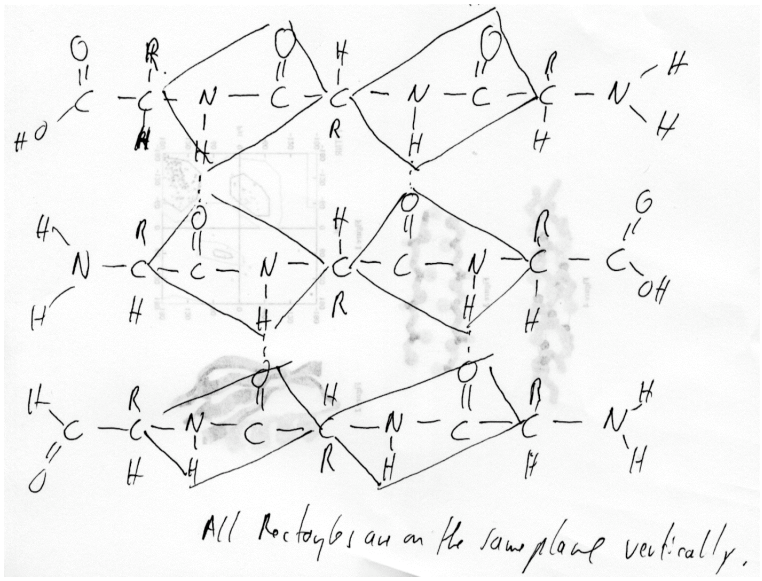
e) Sketch a cell membrane (amphiphilic bilayer) and indicate how a membrane protein can spontaneously embed itself in such a bilayer.

1) a) The aromatic ring and the urea group will display planar structures due to conjugation.



3) a) The protein lowers its overall energy through the formation of hydrogen bonds, disulfide bonds and by reducing the exposure of hydrophobic groups to water and by increasing the exposure of ionic groups to the aqueous environment.

b)



c) A disulfide bond is a bond between two sulfur atoms that is stronger than any other secondary bond in a protein.

c)