7.012 Problem Set 1

Please print out this problem set and record your answers on the printed copy. Answers to this problem set are to be turned in at the box by 4:10 Wednesday, September10. Problem sets will not be accepted late. Solutions will be posted on the web September 11, 2003.

Question 1

Bob, a student taking 7.012, looks at a long-standing puddle outside his dorm window. Curious as to what was growing in the cloudy water, he takes a sample to his TA, Brad Student. He wanted to know whether the organisms in the sample were prokaryotic or eukaryotic.

a) Give an example of a prokaryotic and a eukaryotic organism.

Prokaryotic: Eukaryotic:

b) Using a light microscope, how could he tell the difference between a prokaryotic organism and a eukaryotic one?

c) What additional differences exist between prokaryotic and eukaryotic organisms?

Question 2

A new startup company hires you to help with their product development. Your task is to find a protein that interacts with a polysaccharide.

a) You find a large protein that has a single binding site for the polysaccharide cellulose. Which amino acids might you expect to find in the binding pocket of the protein? What is the strongest type of interaction possible between these amino acids and the cellulose?

In the course of your research you discover a small polypeptide that is associated with cellulose. You want to design an enzyme that will bind this small polypeptide. You design the enzyme shown below.

b) In the table below please indicate which amino acid you placed in each position to give the strongest possible interaction between your enzyme and the small polypeptide. For instance, you would choose an amino acid for position D that most strongly interacts with the carboxyl group of the small polypeptide. Also list what interaction occurs at each position (choose from: covalent bond, ionic bond, hydrogen bond, or van der Waals forces).
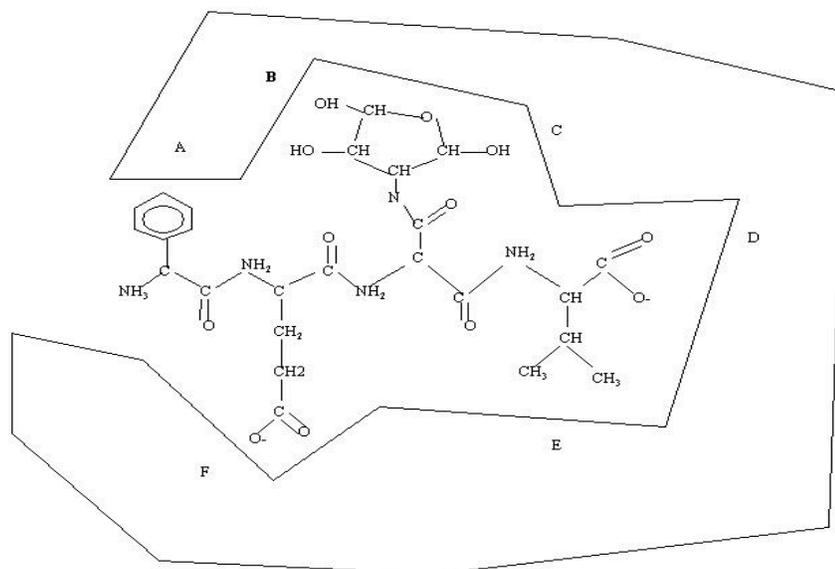
Amino Acid position	Amino Acid	Interaction
A		
B		
C		
D		
E		
F		

Question 3

One of your classmates, Mike, is working on a new science fiction novel. He approaches you with questions regarding cell membranes.

a) Explain the following to Mike.

      i) What are lipids.

      ii) Why are saturated fatty acids more likely to be solid at room temperature than unsaturated fatty acids.

b) On the diagrams below label the hydrophilic and hydrophobic regions of the phospholipids.
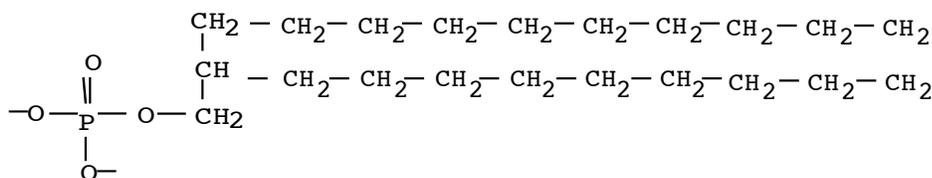
c) Why does the structure of the phospholipid molecule favor the formation of bilayers or membranes?

d) Mike proposes the following structure for the membranes of an alien life form. What conditions would need to exist to make this arrangement possible?
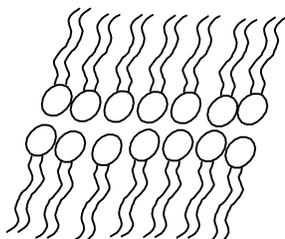
Portion of alien membrane

Question 4

Prions (pronounced pree-ahns) are agents that cause a novel type of fatal brain disease. Bovine spongiform encephalopathy (BSE or mad cow disease), sheep scrapie and Creutzfeldt-Jakob disease (CJD) of humans are examples of prion diseases. Prions enter cells and convert normal proteins found within the cells into prions just like themselves. The normal cell proteins have all the same "parts" as the prions--specifically the same amino acid building blocks--but they fold differently.

a) What is the primary structure of a protein? What force or forces (covalent bonds, ionic bonds, hydrogen bonds, or van der Waals forces) are involved in primary structure?

b) What is the secondary structure of a protein? What force or forces (covalent bonds, ionic bonds, hydrogen bonds, or van der waals forces) are involved in secondary structure?

c) What is the tertiary structure of a protein? What force or forces (covalent bonds, ionic bonds, hydrogen bonds, or van der waals forces) are involved in tertiary structure?

d) Do you expect both the normal and the infectious versions of a prion protein to have the same primary structure? Why or why not.

e) Do you expect both the normal and the infectious versions of a prion protein to have the same tertiary structure? Why or why not.