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2007 7.013 Problem Set 1

Due before 5 PM on FRIDAY, February 16, 2007.

Turn answers in to the box outside of 68-120.

PLEASE WRITE YOUR ANSWERS ON THIS PRINTOUT.

1. Where in a eukaryotic cell do you think you would find the following proteins residing? Be as specific as you can in terms of subcellular location.

(a) an enzyme whose substrate is DNA

(b) an enzyme that catalyzes protein synthesis

(c) a protein that allows ions to pass in and out of the cell

(d) a protein that acts as a receptor for extracellular cell-cell communication molecules that are large and hydrophilic

(e) a protein that forms a channel through which RNAs can be exported into the cytoplasm

(f) an extracellular matrix protein

(g) a protein that adds carbohydrate groups to proteins destined for the outside of the cell

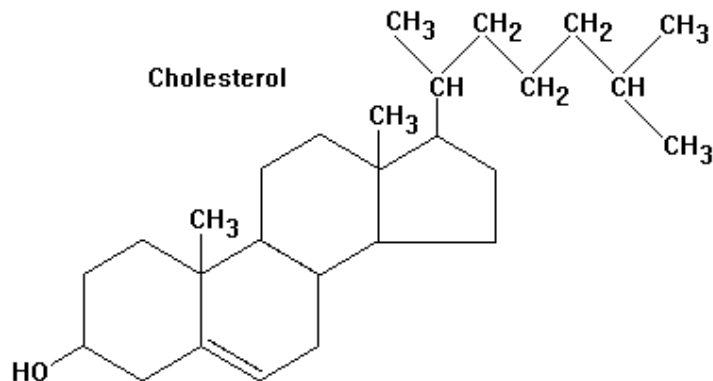
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(h) a protein that synthesizes ATP

(i) the cytoskeletal protein actin

(j) The major cytoskeletal protein actin is translated as a single polypeptide subunit. Many actins associate together to form actin filaments. These filaments can disassemble and reassemble to help cells move and change shape. During these processes, what is the highest level of actin protein structure that is changing? Your choices (from lowest to highest) are: primary, secondary, tertiary, quaternary.

2. Below is a molecule called cholesterol, which is a lipid.



(a) Put a circle around the part of this molecule that is hydrophobic.

(b) Draw a box around the part of this molecule that is hydrophilic.

(c) Cholesterol is transported through your blood. Do you think that cholesterol molecules can be transported in your blood freely, i.e. without requiring any sort of transport protein? Why or why not?

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3. ****For this problem, you will need to use a computer program to view the structure of a protein and of DNA.****

To begin, go to the site:

<http://web.mit.edu/star/biochem/index.html>

and click on **“Click here to start Star Biochem.”**

Once the program Star Biochem has been downloaded onto your computer, go to the site:

<http://web.mit.edu/viz/7.01x/>

This website has several links. Those marked “The Amino Acids,” “The Peptide Bond,” “Secondary Structure,” and “Nucleotides and DNA” contain models of each of these things that will help you understand protein and DNA structure.

To do the graded problem, click on **“7.013 Problems”** and do **“Problem 1 (pdf with live links).”** To help you learn how to use the program, a tutorial is available under **“StarBiochem Tutorial Problem (pdf with live links).”**

If you do not have a computer easily available, or if you would like to do this problem in the presence of technical staff who are familiar with this computer program, there will be staff present on Thursday 2/15/07 from 4-9pm in a room TBA (see the course website).

You are welcome to stop by anytime during that interval to use one of the computers in that room to do the problem, or to ask the staff questions about the program.

Please write your answers to the question entitled “Problem 1” in the space below.

Once you have Star Biochem open, go to “File” and then “Open” and choose the file 1CF7. To begin, go to “Structure” and then to “Quaternary” and click on the box such that there is now a check-mark present in the box. This action will color each chain of either DNA or protein a different color. Now go to “Secondary” and click on the box next to “All Ribbons.” This action will allow you to see the protein as a ribbon diagram. Once you have done this, answer the questions below.

We examine the structure of a segment of DNA bound to a transcription factor (named 1CF7). A transcription factor is defined as a protein that binds to a DNA sequence of a gene and influences whether or not a protein product will be made from that gene. (We will learn more about transcription factors later in the semester, and we will learn about how transcription factors achieve this goal by regulating the process of transcription, i.e. the production of mRNA from DNA.)

(a) The transcription factor shown here is in a complex with the DNA molecule.

(i) Examine the ribbon structure of the protein and the DNA complex. How many protein chains are involved in this complex?

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(ii) List in order the 10 amino acids numbered #16 through #25 in the first protein chain listed, and state which level of protein structure this list represents.

(b) Write out the entire double-stranded DNA sequence (and label the 5' and 3' ends) of the piece of DNA to which this 1CF7 protein complex is bound.

(c) Examine one interaction site by selecting Residues 121 and 122 of chain B.

(i) Which amino acids are residues 121 and 122?

AA#121 =

AA#122 =

(ii) What kind of amino acids are residues 121 and 122 (hydrophobic, polar, acidic or basic)?

AA#121 is (circle one): hydrophobic polar acidic basic

AA#122 is (circle one): hydrophobic polar acidic basic

(iii) With which portion of the DNA (phosphate, deoxyribose, or nitrogenous base) could these amino acids interact so that the DNA and these amino acids were participating in the strongest type of bond possible?

(iv) What is the strongest type of bond in which these amino acids and the DNA could participate (hydrogen, ionic, hydrophobic force, covalent, van der Waals)?

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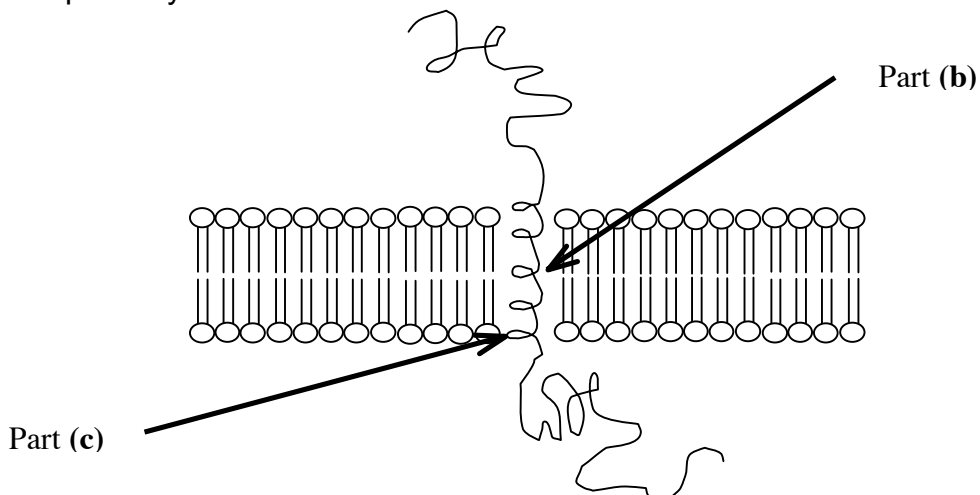
4. (a) Draw the di-peptide “met – tyr” in the form it would be at pH = 7.

(b) Label the N and C termini.

(c) Circle each peptide bond in your drawing above.

(d) Rank the following amino acids from most hydrophobic to least hydrophobic: alanine, arginine, asparagine, phenylalanine.

5. Below is a schematic of a transmembrane protein, which is a protein that crosses a lipid bilayer.



(a) If a protein crosses the membrane, it usually does so using a secondary structure called an alpha helix, as depicted in the diagram above. In an alpha helix, the R groups point out of the helix and the peptide bonds point into the helix. Why do you think the peptide bonds have to be hidden inside an alpha helix, away from the lipids in the membrane?

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(b) Which one of the following amino acids would most likely be found in the portion of an alpha helix that crosses the membrane? (See the arrow labeled part **(b)**.)

alanine

serine

lysine

glutamic acid

(c) Which one of the following amino acids would most likely be found at the very edge of an alpha helix that crosses the membrane? ? (See the arrow labeled part **(c)**.)

alanine

serine

lysine

glutamic acid

6. (a) Draw a G nucleotide triphosphate (dGTP) base-pairing with a C nucleotide triphosphate (dCTP).

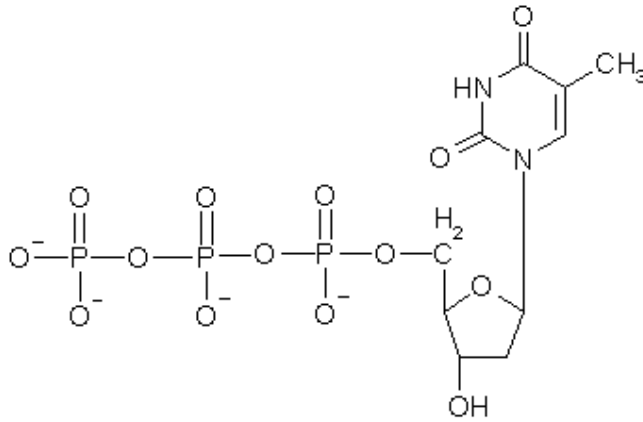
(b) Label all 5' and 3' carbons in your drawing above.

(c) How many phosphodiester bonds are present in your drawing above?

(d) How many hydrogen bonds are present in your drawing above?

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(e) Below is the structure of a nucleotide triphosphate that is used to make DNA. Change this structure in two ways so as to make it into a nucleotide that could be used to make RNA.



(f) Is the overall charge on a DNA double helix at pH7 neutral, negative, positive, or inconclusive?

(g) Is the overall charge on a protein at pH7 neutral, negative, positive, or inconclusive?