7.014 Problem Set 1

Please print out this problem set and record your answers on the printed copy.

Problem sets will not be accepted late.

Question 1

a) Describe the conditions of the atmosphere on prebiotic earth and how these conditions differ from what is found today.

b) Describe the proposed first organism as it compares to modern organisms; include the type of genetic material and the source of energy it may have used.

c) Describe the process that led to an O_2 atmosphere on earth and how this change in atmospheric conditions influenced the course of evolution.

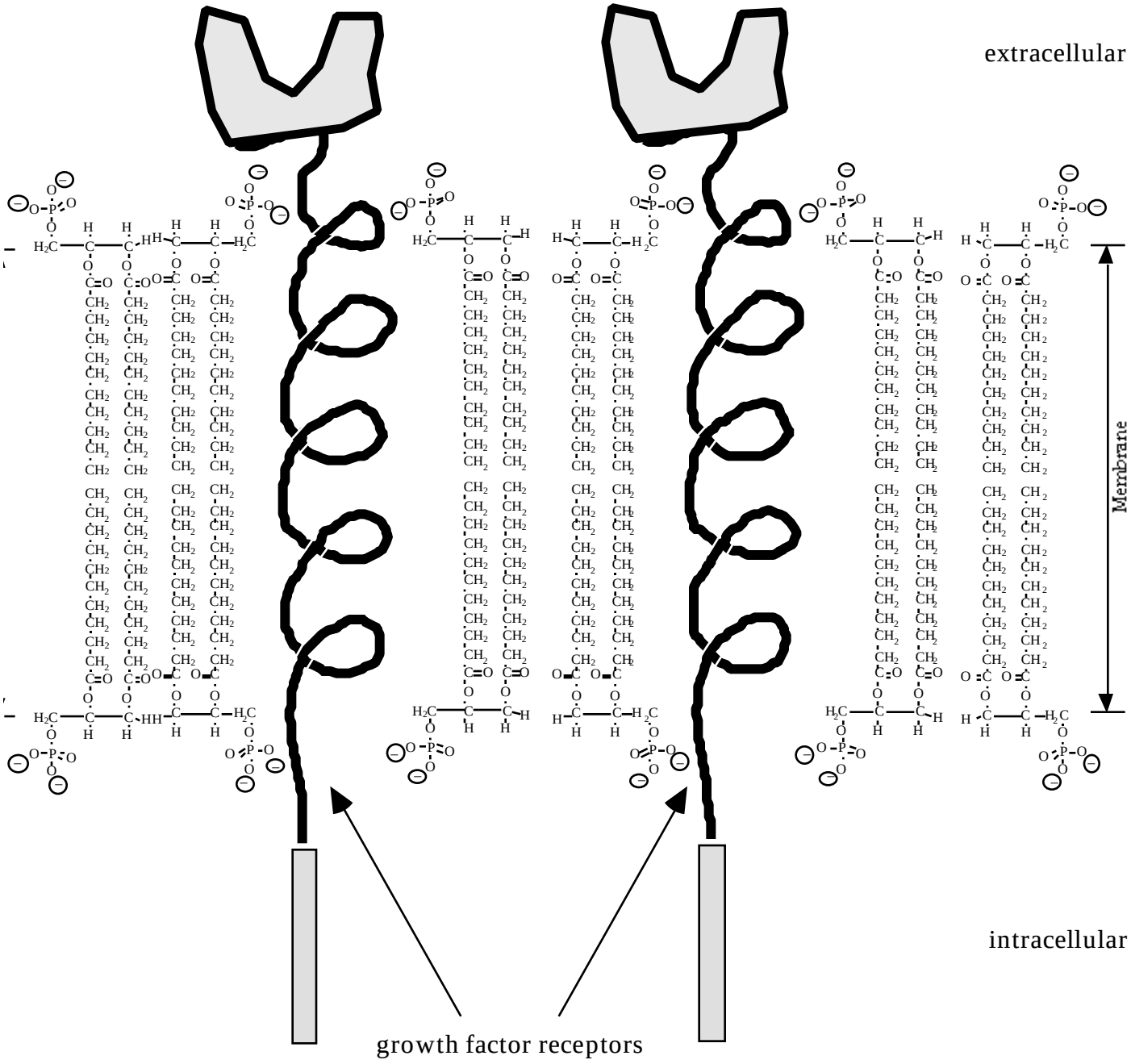
Question 2

You are given four test tubes, each contains cells from a different organism. One tube contains bacterial cells, one contains yeast cells (eukaryotic), one contains human cells and the last contains dinosaur cells.

Can you identify the cells from each tube if you are given a light microscope? Explain your answer.

Question 3

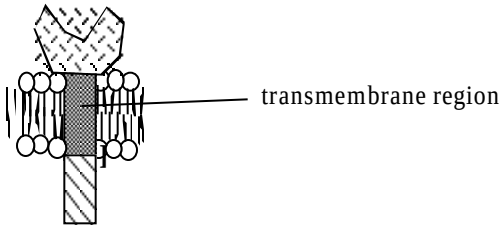
Growth factor receptors (shown below) are transmembrane proteins found on the cell surface.



a) The molecules that form the above membrane belong to what class of macromolecules?

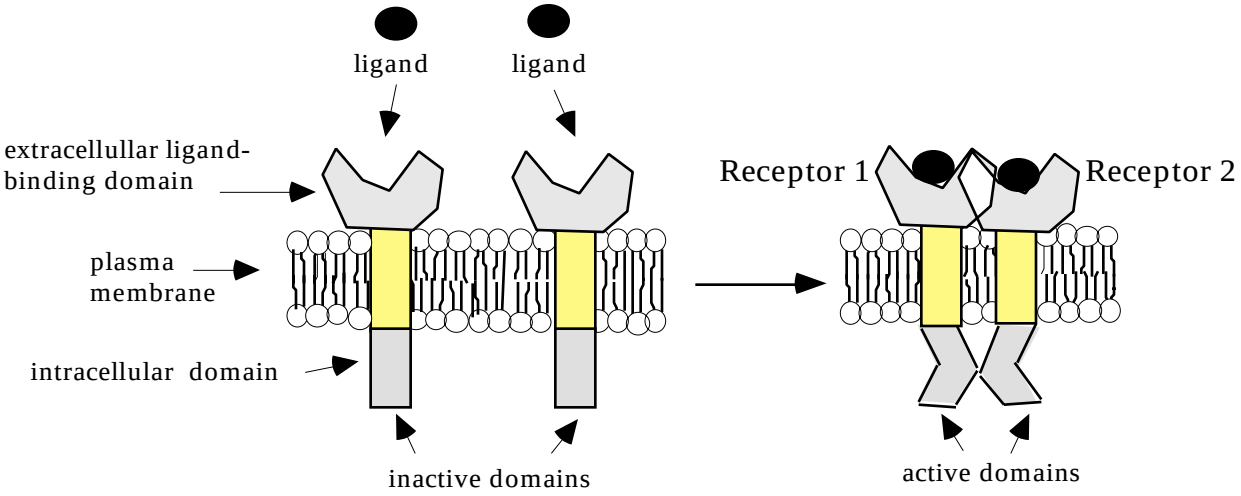
Explain the important qualities / properties of these molecules that allow them to form membranes.

A smaller schematic of the growth factor receptor is shown here.



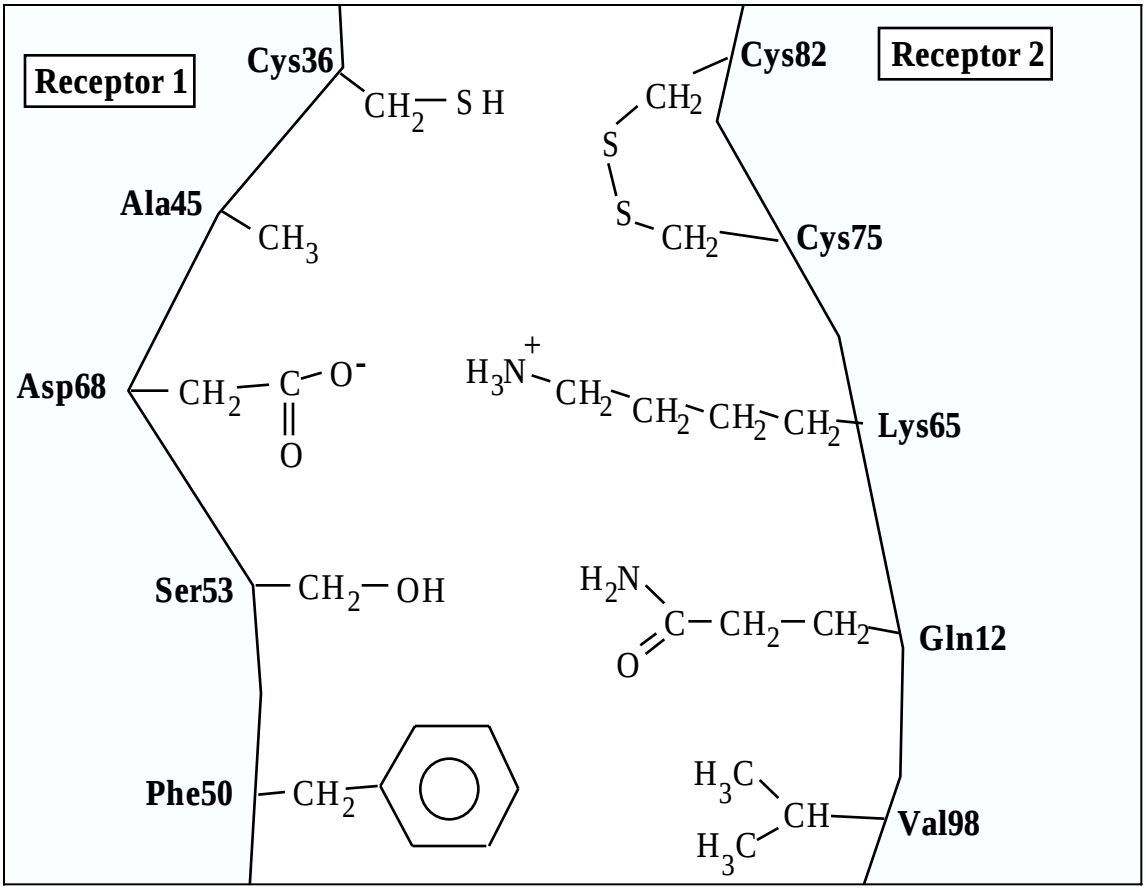
b) Which amino acids would you expect to find in the transmembrane region of the receptor?

When a signaling molecule, called the ligand, binds to the extracellular domain of the receptor, a conformational change occurs in the receptor. Growth factor binding causes dimerization of two adjacent receptors in the cell membrane. Upon dimerization, the intracellular domains of the receptors become activated. See schematic below.



Question 3, continued

c) Regions of the two receptors that interact upon dimerization shown below. In parts (i - iv) below, name the strongest type of interaction (choose from; **hydrogen bond**, **ionic**, **covalent**, **van der Waals**) that occurs between the side chains of the amino acids indicated.



Interacting Side chains	Type of interaction
i) Cys75 : Cys82	
ii) Asp68 : Lys65	
iii) Ser53 : Gln12	
iv) Phe50 : Val98	

d) Explain how Gln12 and Val98, which are far apart in the primary sequence of the protein, can be close to each other in the region of the protein diagrammed above.

Question 4

You have discovered a new enzyme, enzyme E, which breaks down proteins by cleaving peptide bonds after tyrosine or phenylalanine.

a) Enzyme E is the product of gene G that encodes a protein with the molecular weight of 50 kilodaltons (50 kD). Upon purification of enzyme E, only the expected 50 kD polypeptide is present. Interestingly, the molecular weight of the active enzyme E is 250 kD, not 50 kD

i) Why might active purified enzyme E be larger than the product encoded by gene G?

ii) Define primary, tertiary, and quaternary structure.

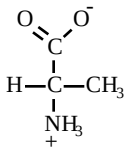
iii) Is the primary structure of the 50 kD protein the same or different than the primary structure of the 250 kD protein? Explain briefly.

iv) Is the tertiary structure of the 50 kD protein the same or different than the tertiary structure of the 250 kD protein? Explain breifly.

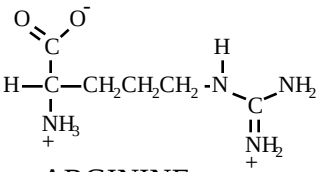
v) Is the quaternary structure of the 50 kD protein the same or different than the quaternary structure of the 250 kD protein? Explain breifly.

b) You test the ability of enzyme E to break down a large protein. This large protein is not broken down by enzyme E. You then treat the large protein with DTT (a compound that disrupts disulfide bonds) and test the enzyme E activity again. This time the large protein is broken down by enzyme E.
Why was enzyme E able to cleave the large protein only after the substrate was treated with DTT?

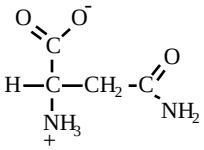
STRUCTURES OF AMINO ACIDS at pH 7.0



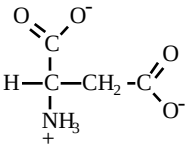
ALANINE
(ala)



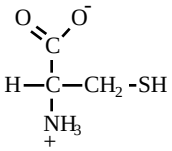
ARGININE
(arg)



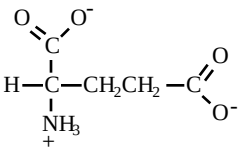
ASPARAGINE
(asn)



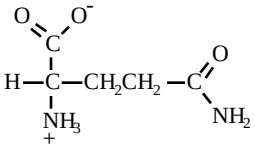
ASPARTIC ACID
(asp)



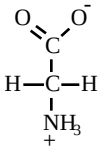
CYSTEINE
(cys)



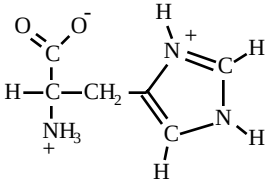
GLUTAMIC ACID
(glu)



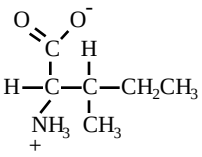
GLUTAMINE
(gln)



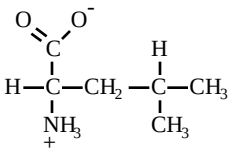
GLYCINE
(gly)



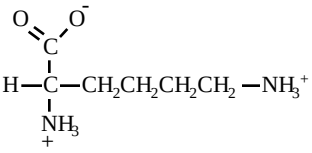
HISTIDINE
(his)



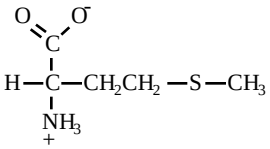
ISOLEUCINE
(ile)



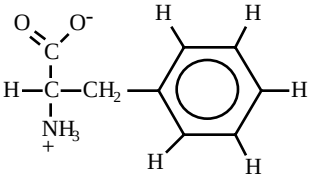
LEUCINE
(leu)



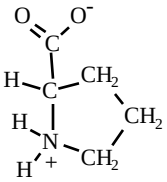
LYSINE
(lys)



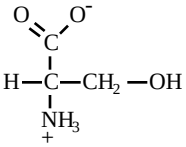
METHIONINE
(met)



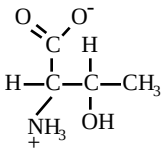
PHENYLALANINE
(phe)



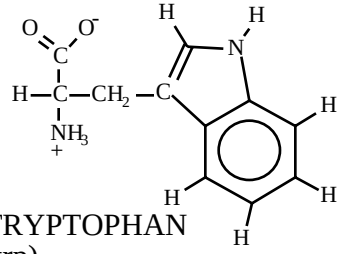
PROLINE
(pro)



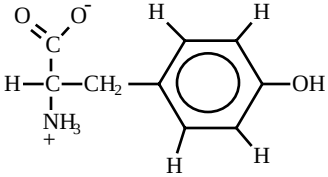
SERINE
(ser)



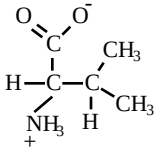
THREONINE
(thr)



TRYPTOPHAN
(trp)



TYROSINE
(tyr)



VALINE
(val)