Biology 5357

Chemistry & Physics of Biomolecules

Examination #3

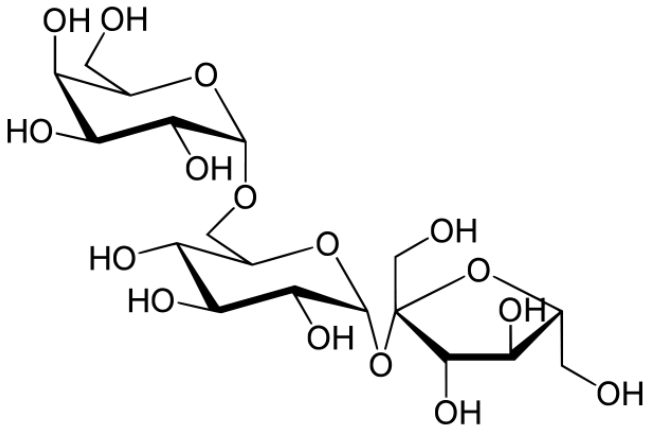
Glycobiology, Membranes
& Membrane Proteins Module

December 10, 2021

Name: _____

Question 1. (12 points, A-C, 4 points each) Raffinose is a trisaccharide composed of the monosaccharides galactose (Gal), fructose (Fru) and glucose (Glc) found in beans, broccoli and other vegetables. It is generally of low nutritional value due to its indigestibility by most animals, including humans.

(A) Label the galactose, fructose and glucose residues on the raffinose structure shown below.



(B) Write the full trisaccharide name of raffinose, including the numbers of the sites of connection, and anomeric form of the linkages.

(C) Is raffinose a "reducing" sugar? Explain.

Question 2. (12 points; A-D, 3 points each) In a couple of sentences, briefly describe or define each of the following terms, and its importance in glycobiology.

(A) Anomeric Effect

(B) Dolichol

(C) Glycocalyx

(D) Lectin

Question 3. (8 points; A & B, 4 points each)

(A) Briefly compare and contrast the steps in the *N*-glycosylation of a secreted protein that occur in the endoplasmic reticulum *vs.* the Golgi apparatus.

(B) The uncatalyzed formation of a typical glycosidic bond, a β1-4 lingage between Gal and Glc residues has a $\Delta G = +3.4$ kcal/mol. Since hydrolysis of ATP to ADP and phosphate has $\Delta G = -7.3$ kcal/mol, it would seem hydrolysis of a single ATP would be sufficient to drive glycosidic bond formation. However, two ATPs are required in forming each glycosidic bond. Explain.

Question 4. (6 points; A & B, 3 points each)

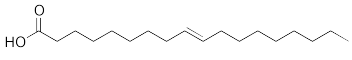
(A) What specific information about glycan structure can be obtained by permethylation, followed by hydrolysis, and subsequent analysis of mass spectrometry fragmentation patterns? Explain.

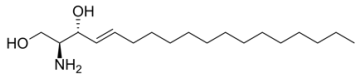
(B) Why is tandem MS/MS useful in analysis of glycan structure? Which structural features can and cannot be determined via this method?

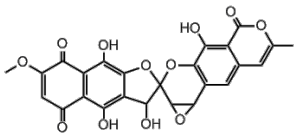
Question 5. (9 points) You are a scientist who has set up a lab on Mars and you discovered a pond of water that is teeming with life! Equipped with your handy light microscope, you see the organism appears unicellular, compartmentalized by some unknown mechanism. Since it is not yet known whether this organism is related to those on earth, you ask yourself the question – are these cells bounded by fluid lipid bilayer membranes? You have every piece of equipment you can imagine, and many chemical reagents, but the electron microscope is broken and the technician is coming on the next SpaceX Starship. Describe three different types of experiments that you will conduct in the meantime to test your hypothesis that these alien organisms have fluid, lipoidal and bilayer membranes.

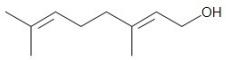
Question 6. (16 points; A & B, 8 points each)

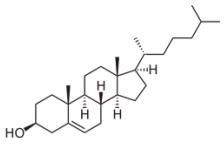
(A) For each of the eight molecules below, name the lipoidal class it comes from.

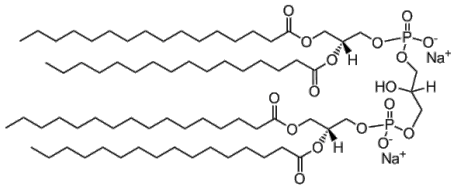


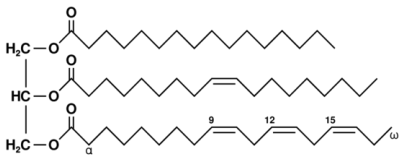


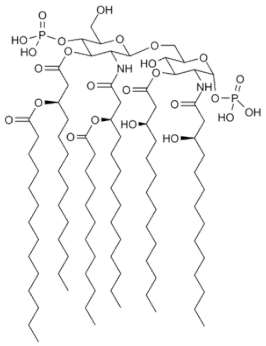




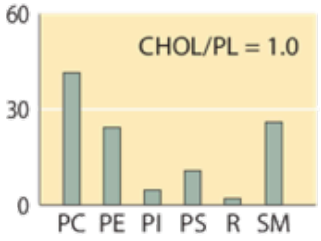


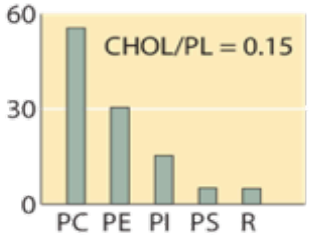


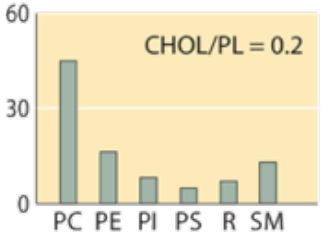


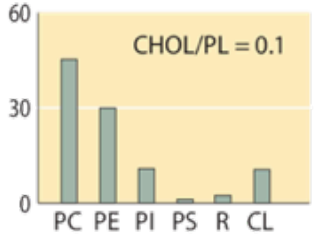


(B) Label the following four plots according to which type of cellular membrane they correspond to.









Question 7. (9 points) How does the self-assembly phase change when the amphiphiles have a critical packing parameter of: (a) CPP < 1/3, (b) CPP = 1, and (c) CPP > 1. Give an example of an amphiphile for each type.

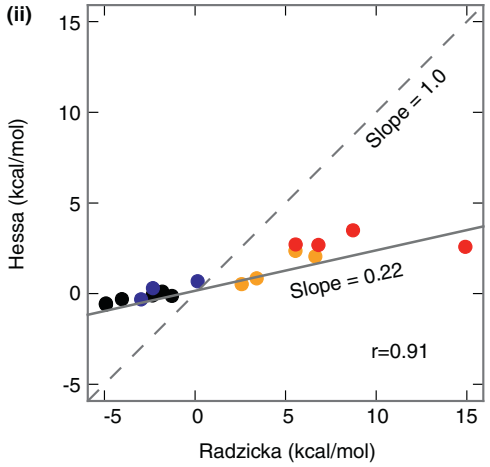
Question 8. (8 points; A & B, 4 points each)

(A) Draw a plot of membrane fluidity *vs*. temperature for a pure lipid bilayer and then one that contains cholesterol. Label the T_m.

(B) You are purifying a membrane protein and testing out new detergents to find out which one provides you with a stable sample for your experiments. What is the most important quantity to consider when working with detergents? Explain. Describe one way of measuring this quantity experimentally.

Question 9. (8 points; A & B, 4 points each)

(A) The following plot compares two amino acid hydrophobicity partitioning scales. Explain why the Hessa scale reports lower partitioning free energies compared to the Radzicka scale.



(B) Consider the results from the reversible folding studies of the β-barrel membrane protein OMPLa in membranes, *i.e.*, the Moon-Fleming hydrophobicity scale. They showed that there is minimal energetic penalty for partitioning an arginine into the center of the membrane if another arginine is already there. Explain why this cooperativity occurs.

Question 10. (6 points) List the structural features in a potassium ion channel that facilitate diffusion limited ion permeation with high selectivity through a lipid bilayer.

Question 11. (6 points) Describe three different mechanisms of membrane transport. Give an example of each mechanism. For each one, describe the driving force for transport/permeation and a feature that makes this type of transport distinct from the other types.

BONUS! **(5 points)** What do you think is the most important membrane protein in biology and why?