Solution key - 7.012 Recitation 1 - 2010

<u>Questions:</u>

1. Oil is fluid at room temperature but butter is solid. Which types of fat do you think predominates in oil and butter (saturated/unsaturated)?

Butter is comprised of saturated fatty acids that only have single bonds, which allow close packing. In comparison, oil is comprised of unsaturated fatty acids that have one or more double bonds that hinder close packing.

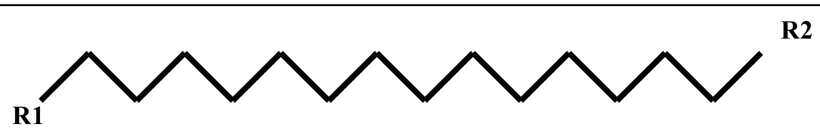
2. Each cell in an organism has a plasma membrane that defines its boundaries, however the plasma membranes of different cell types show different fluidity. What factors determine the fluidity of the plasma membrane?

This is defined by lipid composition and temperature. Fluidity of the membrane increases proportionately with an increase in the unsaturated fatty acids, short chain fatty acids or phospholipids. It also increases with an increase in temperature. Membrane fluidity is also know to decrease with an increase in the amount of cholesterol in the membrane.

3. When biomedical researchers design drugs that must enter cells to be effective, they often add methyl ($-CH_3$) groups, which make the drugs more likely to enter the cells. Why does this work?

Plasma membrane is comprised of lipid bilayer with proteins embedded in it. Adding nonpolar, hydrophobic methyl groups ($-CH_3$) to the drug enhances the chances of the drug (which may otherwise be hydrophilic and hence incompatible for the hydrophobic atmosphere provided by the lipid bilayer) to cross the lipid bilayer and enter the cell to mediate its action.

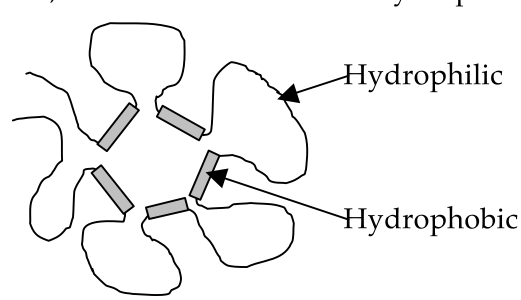
4. There are some rare organisms that do not have lipid bilayers, but instead have lipid monolayers. The structure of one lipid they can use to make up their monolayers is shown below. Why would you not need a bilayer (i.e. but instead could use a lipid monolayer) if you used this specific kind of lipid to make up your cell membrane?



Note: R1 & R2 represent charged groups and "∧" represents bonds between C and H atoms.

A cell membrane is comprised of lipid bilayer with proteins embedded in it. The hydrophobic tails of the lipid molecules face each other and remain hidden in the non-aqueous interior of the lipid bilayer whereas the polar, hydrophilic heads of the lipid molecules form the extracellular or cytosolic surface of the lipid bilayer. Since the molecule shown in the schematic above has polar R1 and R2 groups at the two ends and a hydrophobic chain in between, it can assemble with similar molecules to form a lipid monolayer that will have a hydrophobic interior and hydrophilic exterior, as is observed in a cell membrane.

5. A certain protein has this structure, where a line indicates a hydrophilic region and a box represents a hydrophobic region.



i. Why do you think the protein might fold this way when dissolved in salt water?

The boxed hydrophobic regions try to hide in the non-aqueous interior away from the surrounding hydrophilic environment of the salt water. In comparison, the hydrophilic regions, shown by the lines, remain exposed to the salt water and may form hydrogen bonds and / or ionic bonds with the molecules in the surrounding environment.

ii. How do you think the protein might fold differently if it were dissolved in cooking oil?

The folding will be reversed. The boxed hydrophobic regions will be exposed and may undergo hydrophobic interaction with the surrounding hydrophobic environment whereas the hydrophilic regions, shown by the lines, will be hidden in the interior away from the surrounding hydrophobic environment. Please note; if the foldingor 3D-conformation of the protein is altered then the protein becomes non-functional.

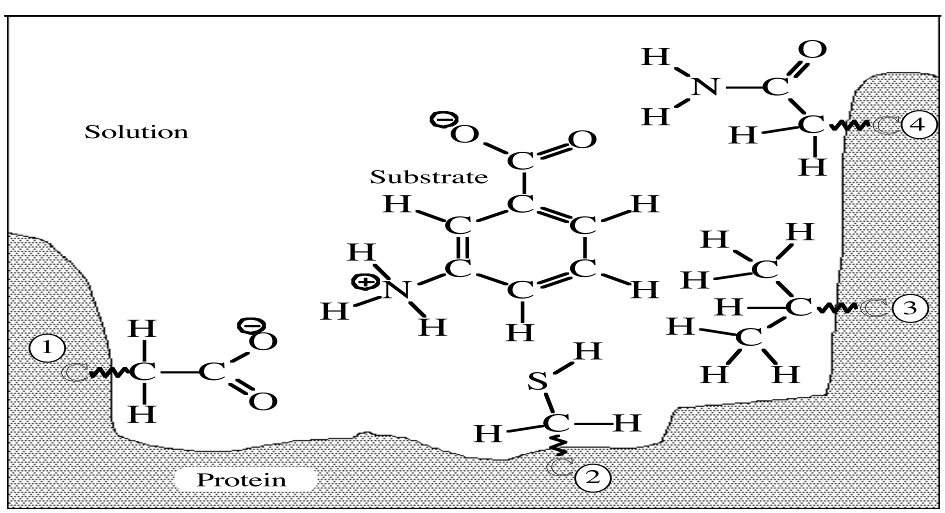
6. You are studying a protein that functions in your gut. If you boil this protein, you will disrupt hydrogen bonds and ionic bonds, but not covalent bonds. If this protein is most active (100% active) in the cytoplasm of the gut cells, what percentage of activity do you predict it will have:

i. At 100°C *A temperature of 100℃ will disrupt the hydrogen bonds and ionic bonds (but not covalent bonds) thereby disrupting the three dimensional conformation of the enzyme that is essential for its activity. It is note worthy that at this temperature, the primary structure of the protein will remain unchanged since the covalent peptide bonds are not disrupted. If the protein is brought back to its normal temperature conditions, the protein may or may not fold back on itself to acquire the normal three-dimensional conformation that it needs for its activity.*

ii. After protease treatment *Protease treatment will cleave the covalent peptide bonds that hold the amino acids of the proteins one after the other to form its primary structure. The effect of such treatment is irreversible since the primary structure of the protein is disrupted.*

iii. If it is suddenly exposed to the acidic environment of the lysosomes.*On exposure to the acidic environment, the noncovalent bonds will be disrupted and therefore the active three dimensional conformation of the protein will not be maintained. So the protein will be nonfunctional. If the protein is brought back to its cytosolic pH of 7.4, the protein may fold back on itself to acquire the normal three-dimensional conformation that it needs for its activity.*

7. The following diagram represents a substrate molecule bound to the active site of a protein. The R groups from the amino acids in the protein's substrate-binding region are shown. Each of the four R groups from the protein that interacts with the substrate is numbered on the figure below.



i. What are the identities of the four amino acids involved in this enzyme binding its substrate?

AA#1 = *Aspartic acid* AA#3 = *Valine*
AA#2 = *Cysteine* AA#4 = *Asparagine*

ii. For each side chain, state the strongest type of interaction it could have with the substrate in the configuration shown below. *Your choices are: Covalent, Hydrophobic, Ionic, Hydrogen, and Van der Waals.* Also classify each R group as *hydrophobic, polar or charged*.

R Group	Interaction(s) of R Group with Substrate	Classification of R Group
(1)	*Ionic, (Hydrogen bonding also possible)*	*Charged, polar, hydrophilic*
(2)	*Hydrophobic / Van der Waals*	*Polar, hydrophilic*
(3)	*Hydrophobic / Van der Waals*	*Nonpolar, hydrophobic*
(4)	*Hydrogen bonding*	*Polar, hydrophilic*

Note: For (2) and (3) if a clear hydrophobic environment was provided as a part of the question you would then select hydrophobic as the strongest interaction instead of hydrophobic / van der Waals as stated in the rows above.