Biology 5357

Chemistry & Physics of Biomolecules

Examination #3

Glycobiology, Membranes
& Membrane Proteins Module

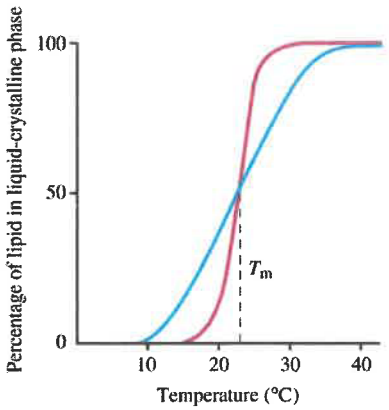
December 9, 2019

Answer Key

6. Cholesterol is an important component of biological membranes (8 points total):

(a) What class of lipid is cholesterol (1 point)?

sterol lipid



(b) What is the proportion of cholesterol in the endoplasmic reticulum vs. plasma membrane (2 points)?

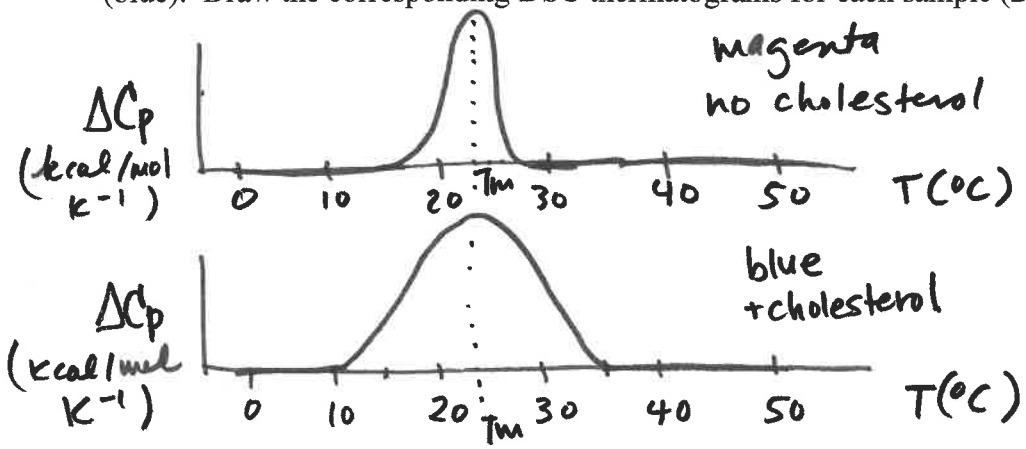
ER: chol/PL = 0.15 (chol is ~10%)

PM: chol/PL = 1.0 (chol is 50%)

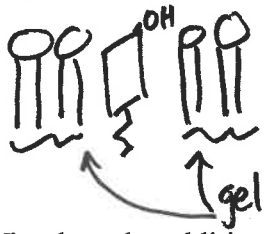
(c) What does cholesterol do to the membrane thickness (1 point)?

increases membrane thickness

(d) Figure 1 shows results from a differential scanning calorimetry (DSC) experiment of membranes with pure phospholipids (magenta) and phospholipids + cholesterol (blue). Draw the corresponding DSC thermatograms for each sample (2 points).



(e) Why does the addition of cholesterol increase membrane fluidity at 15 °C (1 point)?



cholesterol disrupts chain packing & VDW interactions in gel phase.

(f) Why does the addition of cholesterol decrease membrane fluidity at 30 °C (1 point)?

cholesterol orders chains and elongates neighbors promoting VDW interactions in fluid phase

7. Describe how the following factors affect the free energy of micelle formation, and provide an explanation why (6 points total):

(a) Increasing the chain length (2 points)

- increases micelle size and tail interactions
- decreases CMC and free energy (stabilizing)

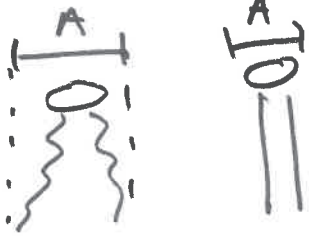
(b) Increasing the salt concentration (2 points)

For ionic detergents & amphiphiles:
- reduces headgroup repulsion
- decreases CMC and free energy (stabilizing)

(c) Increasing the temperature (2 points)

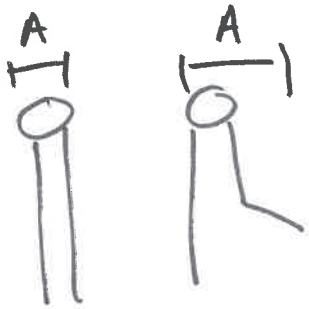
For nonionic detergents/amphiphiles up to cloud point:
- increases micellar size
- decrease CMC and free energy (stabilizing).

8. Describe how the following factors affect the lipid area in a fluid bilayer. Provide an explanation why (8 points total):



(a) Increasing chain length for saturated chains (2 points)

- decreases lipid area.
- due to increas in chain interactions favoring elongation

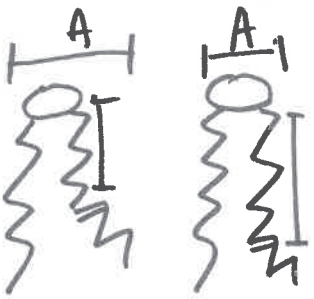


(b) Saturated vs. unsaturated (2 points)

- unsaturation increases area compared to saturated chains
- double bond fixes the chain angle and prevents elongated chains.

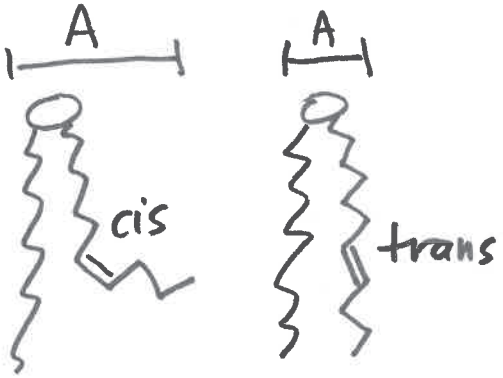
(c) For unsaturated chains, moving the position of the double bond (2 points)

- moving the double bond position towards the end of the chain reduces lipid area.
- increases chain contacts favoring elongation



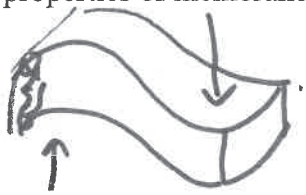
(d) Cis vs. trans unsaturation (2 points)

- cis double bonds increase lipid area compared to trans.
- trans locks chain into extended configuration promoting packing

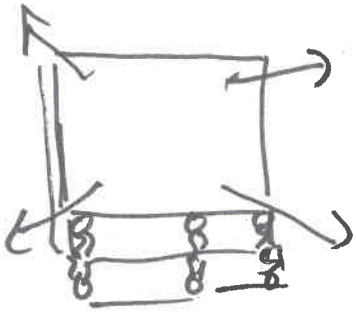


9. What are four material properties of membranes (4 points total)?

bend

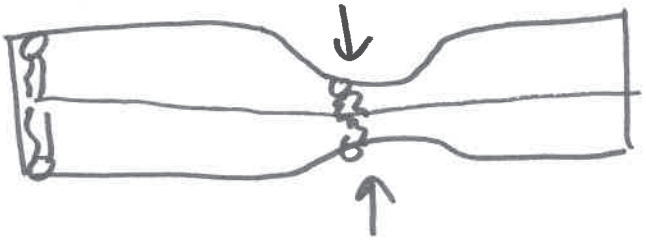


stretch



shear

thichness change.



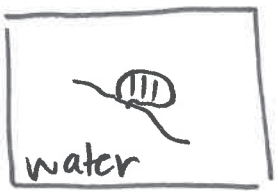
10. Consider the 5 different amino acid partitioning scales that were discussed in class: (i) Radzika, (ii) Wimley, (iii) Moon, (iv) Hessa and (v) MacCallum (20 points total).

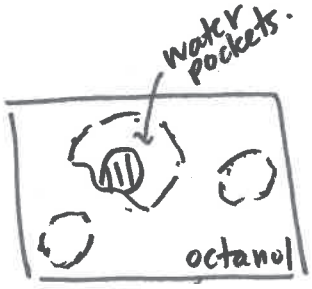
(a) Describe the setup of each experiments/calculation. Draw a cartoon depicting the change in states from water to the "lipid" model (10 points).

Radzicka

- experiment
- partitioning from isotropic water to isotropic non-polar solvent.

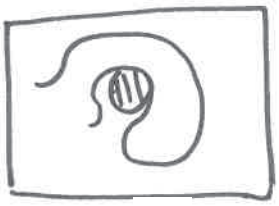
Wimley (octanol) pentapeptide

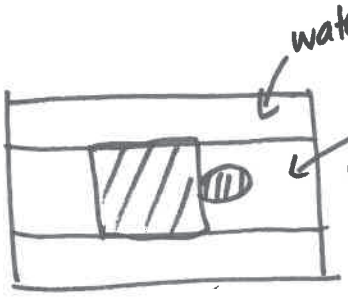




- experiment
- partitioning from water to hydrophobic environment w/ hydrophilic pockets.

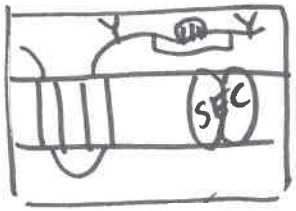
Moon & Fleming

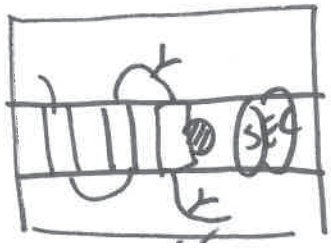




- experiment - from free energy of folding
- partitioning into membrane core.

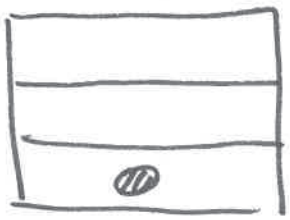
Hessa (translocon)

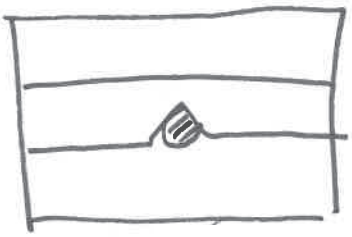




- experiment
- partitioning in cells via transloco
- glycosylation marks water vs. transmembrane.

MacCallum & Tieleman





- computational
- free energy calculation of partitioning from water to lipid bilayer
- molecular defects in membrane structure stabilize charged aas.