

Chapters 4 and 5

Week 2 Workshop Questions

1. The role of a certain cell in an organism is to secrete a protein. Trace the production of that protein from the nucleus through all of the necessary organelles to the point of release from the cell.

Starting at the nucleus, the mRNA leaves through the nuclear pore complex, meets up with a ribosome, is transported to the ER, leaves the ER in a vesicle, goes to the *cis* Golgi, exits on the *trans* side of the Golgi in a vesicle which then fuses with the cell membrane.

2. Organelles that contain their own DNA are all enclosed in double lipid bilayers. Relate this observation to the endosymbiont hypothesis.

See figure 4.18 in the text for a good explanation of the origin of double membrane bound organelles.

3. Vacuoles in plants hold waste material. Why do you think that plants tend to retain cellular wastes whereas animal cells do not?

The presence of a cell wall implants limits what can be expelled outside of plant cells. Holding wastes in an isolated area (the vacuole) circumvents this problem.

4. There are several structural similarities between mitochondria and chloroplasts. Using the idea that form follows function, why are there similarities in these two organelles.

Both mitochondria and chloroplasts are involved in energy-transformation activities that require many enzymes. The stacking or folding of membrane provides enzymatic activity centers for these reactions.

5. Compare and contrast the cell wall of prokaryotic cells with the cell wall of plant cells.

Prokaryotic Cell Wall

Functions in protection and support
Composed of peptidoglycans
Located outside the cell membrane
Influences cell shape

Plant Cell Wall

Functions in protection and support
Composed of cellulose
Located outside the cell membrane
Influences cell shape

6. Cooking oil is composed of lipids that consist of long hydrocarbon chains. These are not amphipathic molecules. Would you expect these lipids to spontaneously form membranes? Why or why not? Describe, on a molecular level, how you would expect these lipids to interact with water. Your answer should explain the saying, "oil and water don't mix."

Non-amphipathic cooking oil lipids would not spontaneously form membranes, because they have no polar end to interact with water. Instead, these lipids would collect together and float on the surface of water, or collect together in droplets suspended in water, reducing their interaction with water to a minimum. This is the reason for the saying "oil and water don't mix."

7. Ethanol, the active ingredient in alcoholic beverages, is a small, polar and uncharged molecule. Would you predict that this molecule crosses cell membranes quickly or slowly? Explain your reasoning.

Ethanol is polar, which is a characteristic that reduces the speed at which it can cross a membrane. But it is also a small molecule, which increases the probability that it could cross a membrane. Water is polar and small and is able to cross a membrane. The ethanol molecule is larger than a water molecule. Conclusion: Ethanol probably crosses a membrane more slowly than water but faster than other larger polar molecules, and much faster than charged molecules.

8. Why can osmosis occur only if a semi-permeable membrane separates solutions?

Osmosis can occur only if a semipermeable membrane separates the solutions because the solutes, which are distributed unequally between the two compartments, must not be able to diffuse. If the solutes are allowed to diffuse freely, they will become evenly distributed

between the two compartments, and equilibrium will be established. No net diffusion of water molecules will occur.

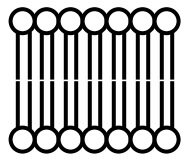
9. Your text claims that the part of the membrane proteins that span the hydrophobic tails of phospholipids is itself hydrophobic. Using the table of amino acids and their properties from chapter 3, make a list of amino acids you would expect to find in these regions of transmembrane proteins.

It makes sense that the part of a membrane protein that spans the hydrophobic tails of a bilayer is itself hydrophobic, because only hydrophobic amino acids will be able to interact with the nonpolar lipid tails. These amino acids are hydrophobic: glycine, alanine, valine, leucine, isoleucine, methionine, proline, phenylalanine, and tryptophan.

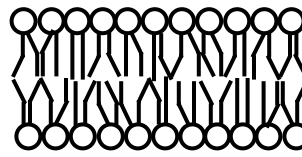
(Polar, uncharged amino acids are serine, threonine, glutamine, asparagine, cysteine, and tyrosine. The following polar amino acids are charged at physiological pH: aspartic acid, glutamic acid, lysine, arginine, and histidine).

10. Unicellular organisms that live in extremely cold habitats have an unusually high proportion of unsaturated fatty acids in their cell membranes. Some of these membranes even contain polyunsaturated fatty acids, which have more than one double bond in the hydrocarbon chain. Researchers have proposed that the lack of saturation helps these membranes maintain a semifluid state at low temperatures instead of becoming semisolid or solid. Draw a picture (cartoon version) of this type of membrane. Using this picture as a resource, comment on the hypothesis that membranes with unsaturated fatty-acid tails function better at cold temperatures. How would you test the hypothesis? Make a prediction about the structure of fatty acids found in organisms that live in extremely hot environments.

Unsaturated hydrocarbon chains have one or more double bonds. Each double bond induces a kink, or bend, in the lipid tail. Saturated hydrocarbon chains lack double bonds, and do not have kinks in their lipid tails. The tails of saturated lipids can interact with each other all along their lengths, and pack tightly together. As temperature decreases, the strong hydrophobic interactions between saturated lipid tails cause them to solidify much more readily than will the hydrocarbon tails of unsaturated lipids, in which the strength of interaction between tails is reduced by the kinks in the chains. Thus an increased number of unsaturated hydrocarbon tails on membrane phospholipids allows the membrane to remain in a fluid state at temperatures that would cause saturated lipid tails to solidify.



Bilayer composed of saturated lipids



Bilayer composed of unsaturated and saturated lipids

11. When biomedical researchers design drugs that must enter cells to be effective, they sometimes add methyl ($-\text{CH}_3$) groups to make the drug molecules more likely to pass through the cell membranes. Conversely, when researchers design drugs that act on the exterior of cell membranes, they sometimes add a charged group to decrease the likelihood that the drugs will pass through membranes and enter cells. Explain why these strategies make sense.

Addition of a methyl group to a drug will make it more hydrophobic, and therefore increase its ability to pass through a lipid bilayer and enter a cell. If a drug is intended to stay outside of cells, addition of a charged group will greatly reduce its ability to pass through the lipid bilayer.

12. Advertisements frequently claim that laundry and dishwashing detergents “cut grease.”

What the ad writers actually mean is that the detergents surround oil droplets on clothing and dishes, making them water-soluble. When this happens, the oil droplets can be washed away. Explain how this happens on a molecular level.

On a molecular level, detergents are amphipathic—they have regions that are polar or charged and therefore are hydrophilic, and they have regions that are nonpolar, and therefore are hydrophobic. The hydrophobic end of the detergent molecule interacts with the grease, and the hydrophilic end of the detergent molecule interacts with water. This forms a bridge between the grease and the water, effectively solubilizing the grease and allowing it to be washed away in water.

13. One characteristic of membranes is their ability to ‘self-seal’. Describe what properties of cell membranes prevent them from rupturing easily.

The nonpolar regions of the fatty acids tend to aggregate together to the exclusion of water. This property leads to ‘sealing’ of ruptures in membranes.

14. A marathon runner has just come into the emergency room suffering from severe dehydration. As her physician, you must decide what type of solution to pump into her veins so that she survives. Your choices are pure H₂O, 0.9% saline, or 5% saline. You can’t remember which solution to use so you treat several blood samples you have prepared on microscope slides with each of the 3 solutions. Describe what you think will happen to the cells under each condition. Which solution should you use to rehydrate this runner?

Take a look at the figure in the text that shows the hypertonic, isotonic and hypotonic solutions and red blood cells (the correct solution is 0.9%)