Diffusion and Osmosis

Cell membranes are selectively-permeable by nature and as such, exert some control over substances passing through them into and out of cells. **Diffusion** is the random movement of molecules from an area of higher concentration of those molecules to an area of lower concentration. For example, if one were to open a bottle of hydrogen sulfide (H_2S has the odor of rotten eggs) in one corner of a room, it would not be long before someone in the opposite corner would perceive the smell of rotten eggs. The bottle contains a higher concentration of H_2S molecules than the room does and, therefore, the H_2S gas diffuses from the area of higher concentration to the area of lower concentration. Eventually a dynamic equilibrium will be reached; the concentration of H_2S will be approximately equal throughout the room and no **net** movement of H_2S will occur from one area to the other. Remember that this does not mean that molecular motion stopped.

Water, too, will diffuse through membranes in a process called **osmosis**. Osmosis is the diffusion of water through a selectively permeable membrane (a membrane that allows for diffusion of certain solutes and water) from a region of higher water potential (*i.e.*, low [solute]) to a region of lower water potential (*i.e.*, high [solute]). Water potential is the measure of free energy of water in a solution.

Small solute molecules and water molecules can move freely through a selectively permeable membrane, but larger molecules will pass through more slowly, or perhaps not at all. In medicine, the movement of a solute through a selectively permeable membrane is called **dialysis.** The size of the minute pores in the dialysis tubing determines which substances can pass through the membrane.

By detecting the presence of particular molecules on each side of a piece of dialysis tubing, we can determine which molecules passed through the tubing and which did not.

Part A: Diffusion

Imagine that a solution of glucose and starch is placed inside a bag made of dialysis tubing. Distilled water is placed in a beaker, outside the dialysis bag. Iodine is added to the water in the beaker until it is a faint yellow color and the bag is allowed to sit for 20 minutes. After 20 minutes have passed, the solution inside the dialysis tubing and the solution in the beaker are tested for glucose and starch.

Q. 1 Make a prediction about the movement of glucose and starch.
Q. 2 How could the presence of glucose and starch in the water be detected?

The results are given in Table 1.

Table 1 Initial and final results of Lugol and Clinitest tests on contents of bag and beaker

Initial Contents		Lugol test		Clinitest	
		Initial Color	Final Color	Initial Color	Final Color
Bag	15% glucose/1% starch	purple	purple	orange	orange
Beaker	H_2O + IKI	yellow	yellow	blue	green

Note: Initial means before the 20 minutes; final means after the 20 minutes.

Q. 3 Describe the Lugol test for starch and the use of Clinitest tablets for detecting glucose.
Q. 4 What do the results tell us about the movement of glucose and starch?
Q. 5 Is the membrane selectively permeable? Explain.
Q. 6 Suppose that a bag filled with a 5% starch solution was placed in a beaker filled with a 10% starch

solution. Describe the direction of movement of starch and water.
Q. 7 A single starch molecule may have thousands of atoms, a glucose molecule has 24, and the ions of dissolved salt are the size of single atoms. Using your knowledge of diffusion across selectively permeable membranes, predict what would happen if each of these was placed into separate dialysis tubes and placed in water.
Q. 8. Why is the chemical digestion of starch in your stomach necessary?
Q. 9. Does this investigation show that starch molecules cannot move across living cell membranes? Explain.

Part B: Osmosis

When two solutions have the same concentration of solutes, they are said to be **isotonic** to each other. If the two solutions are separated by a selectively permeable membrane, water will move between the two solutions, but there will be no **net** change in the amount of water in either solution. If two solutions differ in the concentration of solutes that each has, the one with more solute is **hypertonic** to the one with less solute. The solution that has less solute is **hypotonic** to the one with more solute. These words can only be used to compare solutions.

Now consider two solutions separated by a selectively permeable membrane. The solution that is hypertonic to the other must have more solute and therefore less water. The water potential of the hypertonic solution is less than the water potential of the hypotonic solution, so the **net** movement of water will be from the hypotonic solution into the hypertonic solution.

Imagine that six dialysis tubing bags are prepared and filled with: distilled water, 0.2 M sucrose, 0.4 M sucrose, 0.6 M sucrose, 0. 8 M sucrose, and 1.0 M sucrose. The initial mass of each bag is recorded in Table 2. The bags are placed in six separate beakers of distilled H_20 and left for 30 minutes. Afterwards, the final mass of each bag is determined and recorded in Table 2.

Table 2 Initial and final mass of dialysis bags.

Contents of Dialysis Bag	$Mass_{Initial}$	$Mass_{Final}$	Δ_{Mass}	Percent Change in Mass*
a) distilled water	28.0	28.0		
b) 0.2 M	26.9	28.5		
c) 0.4 M	27.0	29.4		
d) 0.6 M	28.4	32.6		
e) 0.8	28.2	32.0		
f) 1.0 M	29.9	34.8		

*To calculate: Percent Change in Mass = [Final Mass - Initial Mass x 100]/ Initial Mass

Q. 10 Graph the percent change in mass versus sucrose concentration. What can we learn from the graph about the movement of water?
Q. 11 Imagine you have a starch solution of unknown concentration. Using what you've learned in this activity, design an experiment that would allow you to determine the concentration of the unknown solution. Make sure you identify the dependent and independent variables in your experiment as well as any controlled variables and a control group.