Osmosis Lab

Pre-Lab Exercise **Name** _______________________________

1. Define and give an example of "diffusion."

2. Define "osmosis."

3. Describe the strategy of how you will measure osmosis in today's lab

4. Based on today's experiments, state the hypothesis you will be testing.

5. If your hypothesis from Question 4 is correct, what results do you expect to see?

Osmosis Lab
Work in groups of four

INTRODUCTION

Probably everyone has observed that a small amount perfume will spread rapidly in a room, even without air currents carrying it. Likewise a drop of food coloring in a glass of water will spread through the water and eventually create an even coloration throughout.

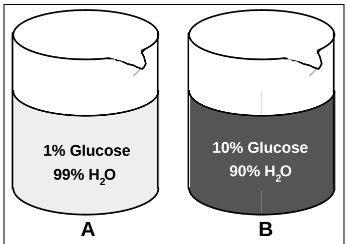


FIGURE 1. Beakers of different solute and solvent concentrations.

This phenomenon, the even spreading of particles within a medium, is called diffusion. It is the result of the random motion of the molecules or particles involved. The process of diffusion obeys the Law of Mass Action which states: *there will be a net movement of molecules from an area of higher concentration to an area of lower concentration until the distribution of molecules within the system is equal.*

The process of diffusion plays an important role in the movement and distribution of materials in living systems. At the cellular level, gas exchange, absorption of many nutrients, waste elimination and intracellular transport are dependent upon diffusion.

The closely related phenomenon of osmosis may be defined in terms of diffusion. Osmosis is the diffusion of water through a semi-permeable membrane in response to a concentration gradient.

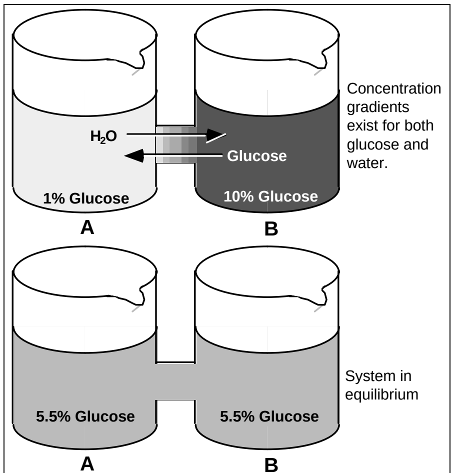


FIGURE 2. Diffusion of solute and solvent from higher concentration to lower concentration.

To understand these two processes and their differences, consider the situation in Figure 1: beaker A contains a solution of 1% glucose and beaker B contains a solution of 10% glucose. Obviously beaker B contains a more concentrated solution of solute (glucose in this case). But if one considers the concentration of water (solvent) in the two beakers, one would have to say that beaker A is more concentrated in water (99% water in A as opposed to 90% water in B).

If the two beakers are joined by a tube as in Figure 2, the Law of Mass Action predicts a net movement of each molecular species (water and glucose) from an area of higher concentration to areas of lower concentration until the concentration of glucose and water in both beakers is equal (Fig. 2).

The movement of glucose and water in this example is due to the molecules obeying the *Law of Mass Action*. When there no longer is net movement of molecules from one beaker to another, we say the system is in equilibrium. This doesn't mean that molecular movement has stopped. Rather, it means the movement of glucose from beaker B to beaker A is equal to its movement in the opposite direction. This is because a concentration gradient no longer exists. The same reasoning applies to the movement of water molecules.

In Figure 3 a membrane or filter which allows free passage of water molecules but prevents the movement of glucose molecules is inserted between the beakers. Thus, the glucose molecules cannot respond to the Law of Mass Action and move down their concentration gradient.

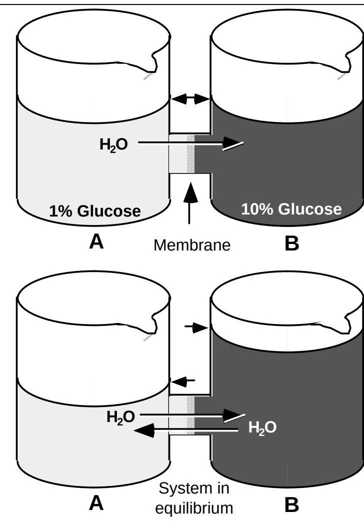


FIGURE 3. A membrane impermeable to Glucose is inserted between the beakers. Only water molecules can respond to their concentration gradient.

Since the filter does not present a barrier to the water molecules, they will move down their concentration gradient (99% → 90%). Because there is a net movement of water from beaker A to beaker B, the volume of A decreases while that of B increases (Fig. 3). This is the process of Osmosis: a net movement of water through a semi-permeable membrane (filter) in response to a concentration gradient.

Theoretically, osmosis should continue as long as a concentration gradient for water exists. Examination of the system in Figure 3 shows, however, that the net water movement into beaker B creates a higher fluid pressure in that beaker. This pressure tends to force water molecules back into chamber A.

Initially, when the levels of solutions in each column are equal, both chambers are exerting equal fluid pressure against the semipermeable membrane. As osmosis proceeds, a pressure gradient is created equal to the weight of the water moved into chamber B. It is this pressure gradient which tends to force water molecules back into beaker A.

Equilibrium is established when the net movement of water molecules into beaker B in response to the Concentration Gradient (osmosis) is equal to the net movement of water in the reverse direction in response to the pressure gradient. In other words, you observe a net movement of water from beaker A to Beaker B which gradually decreases the concentration gradient. At the same time, the increase in volume in beaker B gradually increases the pressure gradient which tends to force the water molecules back into beaker A. At equilibrium the flow of water in each direction is equal.

The process of osmosis has profound effects on living organisms. Cells are enclosed by a plasma membrane which is freely permeable to water, but selectively permeable to most other molecules. Cells contain a weak solution of dissolved proteins, carbohydrates and ions which are not freely permeable.

STRATEGY FOR MEASURING OSMOSIS

In this exercise, you will make bags that have walls of a semi-permeable material (dialysis tubing). You will place sucrose solutions of different strengths into the bags and then place the bags in a beaker of pure water. The walls of the bags are impermeable to sucrose molecules, but do allow water to move through. You will follow the movement of water by weighing the bags. If a bag loses weight during the course of the experiment, you know it is losing water. If it gains weight, it is gaining water.

MEASURING OSMOSIS

MAKE THE SUCROSE DILUTIONS

1. Keep all solutions away from the computer!
2. Set up and label 5 test tubes in the rack. Labels should be: 1.5; 1.0; 0.5; 0.25; H_2O.
3. Using the 1.5M stock sucrose solution, make 15ml of the following dilutions: 1.0M; 0.5M; 0.25M. Note that this is not a dilution series. Use the $\mathbf{C_1 \times V_1 = C_2 \times V_2}$ relationship to make dilutions.

4. Place 10ml of the 1.5M stock in the tube labeled 1.5.
5. Obtain five strips of the dialysis tubing and prepare them by moistening and tying off one end. It is very important that the ends be tied off to prevent the flow of water. To do this, twist the end and double it over before tying off.
6. Label each bag with a small piece of tape folded back on itself on the end of one of the strings. Labels should be: 1.5; 1.0; 0.5; 0.25; H_2O.
7. Add approximately 750ml of deionized water (DI H_2O) to a 1000 ml beaker.
8. Pour 10ml of the following solutions into the appropriately labeled bag: 1.5M; 1.0M; 0.5M; 0.25M; and deionized water. Squeeze any air out of the bags and securely tie off the end of the bag and gently place on a paper towel on your bench. There must be room left in the bag for expansion.

WEIGH THE BAGS AT 10 MINUTE INTERVALS

Table 1. Osmosis Data

		Time (Minutes)			
Conc. Grad.		0	10	20	30
0.00 M	Measured Weight				
	Cumulative Weight	0			
0.25 M	Measured Weight				
	Cumulative Weight	0			
0.50 M	Measured Weight				
	Cumulative Weight	0			
1.00 M	Measured Weight				
	Cumulative Weight	0			
1.50 M	Measured Weight				
	Cumulative Weight	0			

9. When all the bags are filled weigh each bag and place it in the beaker of water. This is the initial weight at time zero for each bag.
10. Record your data in Table 1.
11. Be sure to keep track of the order in which you weigh the bags, and use the same order in subsequent weighings.
12. Repeat the weighing process for each bag at exactly 10 minute intervals over 30 minutes. You should end up with 4 weights for each bag. Record each weight in the appropriate "Measured Weight" row in Table 1.
13. After the last measurement, puncture each bag and flush the sugar solution down the sink. Dispose of the empty bags in the trash.
14. Be sure to rinse and dry the weighing pan from the balance and clean up any spilled sugar solution.

ANALYSIS OF OSMOSIS DATA

Each bag in the beaker of water represents a different concentration gradient of water across a semi-permeable membrane. For simplicity, the solute concentration gradients will be used to describe each. Thus, the 0.5M sucrose solution bag in the beaker of water is said to have a 0.5M concentration gradient.

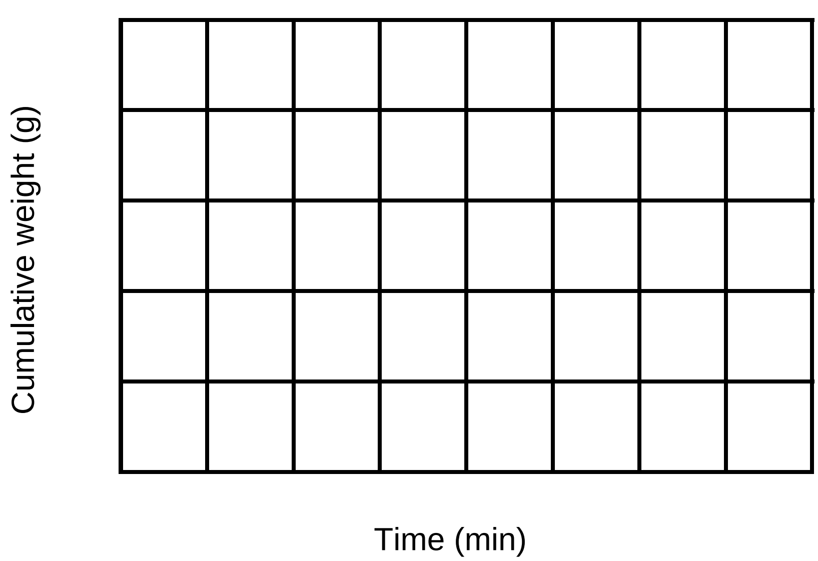
Weight change in the bags represents the gain or loss of water. By examining your data, you should be able to determine whether or not osmosis occurred and in which direction the water moved.

The bag containing water serves as a control. The change in weight observed in it is due to experimental error. One can expect small fluctuations in either direction due to water adhering to the bag or inconsistencies in weighing the bags.

CALCULATE THE CUMULATIVE WEIGHTS

1. The "Cumulative Weight" rows in Table 1 are for showing the weight the bags accumulate over the 30 minute experimental period. Note that at time 0, the accumulated weight is 0 because the bag hasn't had a chance to gain or lose water.
2. To calculate the "Cumulative Weights," subtract the "Measured Weight" at time 0 from the "Measured Weight" of time 10, 20 and 30. For example, if the "Measured Weight" at time 0 is 17 g, and the “Measured Weight" at time 20 is 19 g, the “Cumulative Weight" for time 20 is 2 grams (the weight accumulated over the 20 minute period is 2 grams).
3. Calculate the cumulative weights for your all bags and time samples and enter the values in the appropriate spaces in Table 1.
4. Graph your data in the space below. You will have 5 lines; one for each concentration. Use a different color or pattern for these 5 lines and fill in the “legend” below.

Legend
0.0 M
0.25 M
0.5 M
1.0 M
1.5 M



QUESTIONS FOR YOUR REPORT

1. (2pts) Hand in your data table and graph.
2. Explain the purpose of the dialysis bag containing pure water. Did yours gain or lose weight during the experiment. If so explain.
3. Describe the relationship between weight accumulation in your bags and time.
4. Describe the relationship between concentration gradient and the rate of osmosis.
5. Given enough time, you would observe that the rate of osmosis in each bag would begin to decrease, even though the bag is not full. Explain.
6. Pretend that one of your lab partners made a bag that became rigid and stopped gaining weight at the 20 minute mark. What experimental error(s) did your partner do to cause this?
7. Why do grocery stores constantly spray water on their leafy vegetables in the produce section? Use principles of osmosis in your answer.
8. Saline solutions used in eye drops are said to be isotonic. Explain what isotonic means and why this is important for your eyes.
9. Give a specific example of how an organism adapts to changes osmotic pressure.