Osmosis and Dialysis

OBJECTIVES: The goal of this experiment is to investigate the processes of osmosis and dialysis.

SKILLS: Dialysis and osmosis relationships

EQUIPMENT: Dialysis tubing, beakers, test tubes

SAFETY AND DISPOSAL: Samples in today's lab present no special hazards. Liquids can be flushed in the lab sinks and solids discarded in regular trash.

INTRODUCTION: The transfer of water, ions, and small molecules between cells and their environments is critical to an organism's survival. Three closely related mechanisms by which cells maintain the proper concentration of electrolytes are diffusion, osmosis and dialysis.

In diffusion, solute molecules such as chloride ions move from areas of high concentration to areas of low concentration. Provided the solute can pass through the cell membrane, diffusion allows solute molecules to enter or leave the cell.

In osmosis, solvent water flows across a semipermeable membrane separating two solutions. If the two solutions have different solute concentrations, the flow of water will work to equalize the concentrations on either side of the membrane: water will move through the membrane from the solution of lower concentration to the more concentrated solution until an equilibrium develops so that no net transfer of water occurs. The pressure necessary to reach equilibrium is called the osmotic pressure of the system and depends on the difference in solute concentration between the two solutions – the higher the solute concentration the greater the osmotic pressure. Demonstrating this osmotic effect quantitatively is difficult, for it requires that there can be no leaks that will allow water to pass from the more concentrated part of the system. A qualitative demonstration of osmotic pressure is relatively simple and will be seen as part of today's lab.

In dialysis, some small molecules and ions pass through the membrane in addition to solvent molecules. Larger molecules, such as starch and proteins, cannot pass through the pores of the membrane. This selective permeability of membranes is what allows medical dialysis to clear chemical waste from the bloodstream of patients while not removing important macromolecules.

The solution concentration inside human blood cells is comparable to that of a 0.154 M, or 0.9%, NaCl solution. The physiological saline solutions used routinely with hospital patients are 0.9% NaCl in order to be isotonic, or of the same concentration, to the body fluids. Solutions that have a greater concentration than that of the cell, or any other system possessing a semipermeable membrane, are termed hypertonic. Solvent molecules move from the cell to the more concentrated surrounding solution, which results in shrinkage of the cell. A hypotonic solution has a concentration less than that of the cell. The net movement of solvent particles is into the cell, which could eventually cause the cell to burst.

EXPERIMENTAL PROCEDURES

You will be setting up a number of experiments, all of which require time to soak. Read all of the procedures and properly plan and label your work. Multitasking is essential to the timely completion of all parts of the laboratory.

I. Differential permeability of dialysis tubing

Obtain two pieces of cellophane dialysis tubing and moisten by soaking in distilled water for several minutes. Once the tubing has soaked, tie off one end tightly using a rubber band.

Mix together 10 mL of a 1% calcium chloride solution and 10 mL of a 1% starch dispersion. Transfer the mixture to one of the dialysis bags, being careful that none of the mixture contaminates the outside of the tubing, and tie off the open end. If the tubing becomes contaminated, rinse the outside of the bag gently with distilled water. Suspend the system in a beaker of distilled water. Use the remaining solution to test for the presence calcium ions, chloride ions and starch.

Testing for Calcium ions: Add 2-3 drops of 5% $(NH_4)_2C_2O_4$ to 1 mL of the solution. A white precipitate indicates the presence of calcium ions, now in the form of $CaC_2O_4(s)$

Testing for Chloride ions: Add 2-3 drops of 0.1 M $AgNO_3$ to 1 mL of the solution. A white precipitate indicates the presence of chloride ions, now in the form of AgCl(s).

Testing for Starch: Add 1-2 drops of KI/I_2 solution to 1 mL of the solution. If starch is present, the solution will turn a blue-black color.

All of the above are positive controls. Provided the solution was made correctly, the presence of each chemical being tested for is guaranteed and the observations indicate what would be observed for an unknown solution if that chemical were present. A negative control can also be useful, especially when testing for starch. To make a negative control, run the same tests as above using distilled water in place of the solution.

After one hour, test the water *in the beaker* for the presence of calcium ions, chloride ions, and starch using the same tests as above.

II. Dialysis of IV solutions

Set up a second dialysis system in the same manner as in part II, only this time using about 15 mL of IV solution. Again, be careful not to contaminate the outside of the dialysis tubing with IV solution. Note the appearance of the bag and obtain its mass. Dialyze the solution against distilled water for one hour. After dialysis, record the new mass of the bag, carefully blotting off water on the outside surface and note its general appearance. Transfer the solution from the dialysis tubing into a scintillation vial, label and store in your drawer for analysis next week. In a second vial, save 15 mL of non-dialyzed IV solution.

III. Osmosis in cells

Prepare a sugar solution by dissolving about 10 g of sucrose in about 90 mL of distilled water.

Obtain two prunes, two carrot slices and two cucumber slices. Record the mass of each. Place one prune, one carrot slice and one cucumber slice in the sucrose solution. Place the remaining vegetables in a beaker of distilled water. After about one hour, blot the vegetables with a paper towel and find the new masses. Also make and record observations on the appearance, texture and flexibility of all of the vegetables. Determine the percent change in mass, the equation for which is:

$$\%\ change = \frac{New\ value - Old\ value}{Old\ value}$$

IV. Demonstration of osmosis

Gummy bears have been soaking in different solutions for 3-4 days. Compare the size of the soaked gummy bear to the standard gummy bear provided. Rank the bears in terms of size.