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Abstract - Bold headings

Diffusion and osmosis are physical processes that are important to understand in the study of chemistry and biology. In this experiment, the effects of the steepness of a concentration gradient on the rate of osmosis through a semi-permeable membrane were studied. Dialysis bags were filled with varying concentrations of sucrose solution and placed in hypotonic and hypertonic solutions for one hour. The bags were weighed at 15-minute intervals to determine how much water had diffused into or out of each bag. The bags that were placed in a hypotonic solution lost weight from water that diffused out, and the bags that were placed in a hypotonic solution gained weight from water that diffused in. The bags in hypotonic solution that had a high concentration of sucrose gained weight faster than those with a lower concentration of sucrose, so the steeper the concentration gradient, the faster the diffusion occurred, as expected.

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Introduction

Although diffusion and osmosis are very simple processes that come about through the random motion of particles, we cannot underestimate their importance in maintaining the functioning of all life on the planet. Diffusion occurs because all molecules have kinetic energy that causes them to constantly move about in random directions, especially when in the liquid or gaseous state. When there are more molecules initially present in one area than in another (known as a concentration gradient), the random motion causes the molecules to eventually become evenly distributed throughout the liquid or gas (1). Osmosis is essentially a special kind of diffusion in which some molecules are able to diffuse through a semi-permeable membrane, and others cannot.

While not much research has been performed on simple osmosis and diffusion in many years, scientists are continuing to do research on what factors affect osmosis in cells in order to advance medical treatments. For example, a study done at the Johns Hopkins University School of Medicine showed that even small increases in temperature greatly affected the rate of diffusion of glucose into human erythrocytes (red blood cells), and greater changes induced hemolysis of the cells altogether (2). This has ramifications for storage of blood for transfusions, as well as storage of other biological components, such as embryos for in vitro fertilization. In addition to medical research, scientists are currently studying how we can utilize diffusion and osmosis principles to improve certain industrial processes, such as purifying sea water: Reverse

osmosis has been used to purify sea water in the past, and this process involves high pressures and great energy expenditure. Recently, an ultra-low-pressure reverse osmosis membrane has been developed that has been found effective in removing many low-concentration and low-molecular-weight compounds from water (3). Ozaki and Li found that a multi-layer membrane whose surface was covered with certain negatively charged groups increased the resistance to the contaminating organic compounds while still allowing water through at low pressures.

The purpose of this experiment was to observe simple osmosis in action and determine if the steepness of the concentration gradient affects the rate of diffusion across the membrane.

Materials and Methods

In each group, four dialysis tubing bags were obtained and labeled A-D. These dialysis bags allow water to diffuse through their membranes, but do not allow larger molecules such as sugars to diffuse through. Each bag was filled with 10 mL of varying concentrations of sucrose solution, sealed shut, and weighed to the nearest tenth of a gram. Bag B, the control group, was filled with a 1% sucrose solution and immersed in a 1% solution. Bag A was filled with a 1% sucrose solution and immersed in a 25% sucrose solution. Bag C was filled with a 10% sucrose solution and immersed in a 1% sucrose solution. Bag D was filled with a 25% sucrose solution and immersed in a 1% sucrose solution. At 15 minute intervals, the bags were removed from their respective solutions simultaneously, gently blotted dry, and weighed again to the nearest tenth of a gram. This procedure was performed four times over the period of one hour, and the weights and changes in weights were recorded.

Results

Although all dialysis bags started out at approximately the same weight, the experimental bags changed dramatically in weight by the end of the fourth 15-minute time interval as water diffused in and out of the bags. Bag A lost weight, while bags C and D gained weight. The control group, bag B, maintained a fairly consistent average weight throughout the experiment, deviating only slightly from the initial weight (Table I).

Table L Average change in weight of bags in solution during each time interval

	0-15 minutes	15-30 minutes	30-45 minutes	45-60 minutes	Overall (0-60 minutes)
Bag A	-0.5 g	-0.8 g	-0.7 g	-0.5 g	-2.5 g
Bag B	+0.1 g	0.0 g	+0.3 g	-0.1 g	+0.3 g
Bag C	70.7 g	+0.6 g	+0.3 g	+0.2 g	+1,8 g
Bag D	+0.9 g	+1.4 g	+0.7 g	+0.6 g	+3.6 g

All experimental bags gained or lost weight rapidly over the first 30 minutes (Figure 1). During the last 30 minutes, Bag C's weight gain tapered off while bags A and D continued to lose and gain (respectively) relatively steadily.

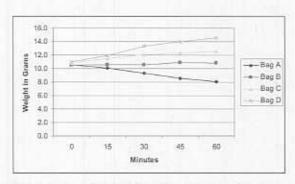


Figure 1. Average weight of bags in solution over a period of one hour

Discussion

The experimental bags lost or gained weight based on their concentration gradients relative to the solutions they were placed in. Bag A lost weight because it was placed in a hypertonic solution: the surrounding solution contained a lower concentration of water than the solution in the bag. Therefore water diffused down its concentration gradient from an area of higher concentration (inside the bag) to the area of lower concentration (the surrounding solution). Bags C and D gained weight because they were placed in a hypotonic solution: the surrounding solution contained a higher concentration of water than the solution in the bag. Therefore water diffused into the bags, going from an area of higher concentration to one of lower concentration.

Bag D gained more weight overall and gained weight faster than bag C because the concentration gradient was steeper. Although both bags were placed in a 1% socrose solution, bag C was filled with a 10% sucrose solution while bag D was filled with a 25% sucrose solution. More water had to diffuse into bag D in order for the concentrations of water inside and outside the bag to come to equilibrium. In addition, bag D continued to steadily gain weight, indicating that water was still diffusing into the bag even after the full hour had passed. Bag C's average weight gain leveled off over the last time interval, indicating that the concentration of water inside the bag had nearly reached equilibrium with the concentration of water in the surrounding solution.

Although bags A and D had the same concentration gradient (25% to 1%), they did not lose and gain the same amount of weight, respectively. Bag D gained on average a full 1.1 grams over bag A. This can be explained by the amount of solution present on each side of the concentration gradient. Bag D enclosed a very small amount of 25% sucrose solution, relative to the large amount of 1% sucrose solution it was placed in. Bag A, on the other hand, enclosed a very small amount of 1% sucrose solution, relative to the large amount of 25% sucrose solution it was placed in.

It was noted that the average weight of bag B did increase by 0.3 grams from the initial average weight, but this can be explained by the groups being unable to blot all excess liquid from the bags. Due to the nature of securing the ends of the tuhing with rubber bands, it was inevitable that some outside solution would get trapped in the folds, causing the bags to weigh slightly more during the course of the experiment than at the initial weighing.

References

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