

1

Osmosis and the Rate of Diffusion along a Concentration Gradient

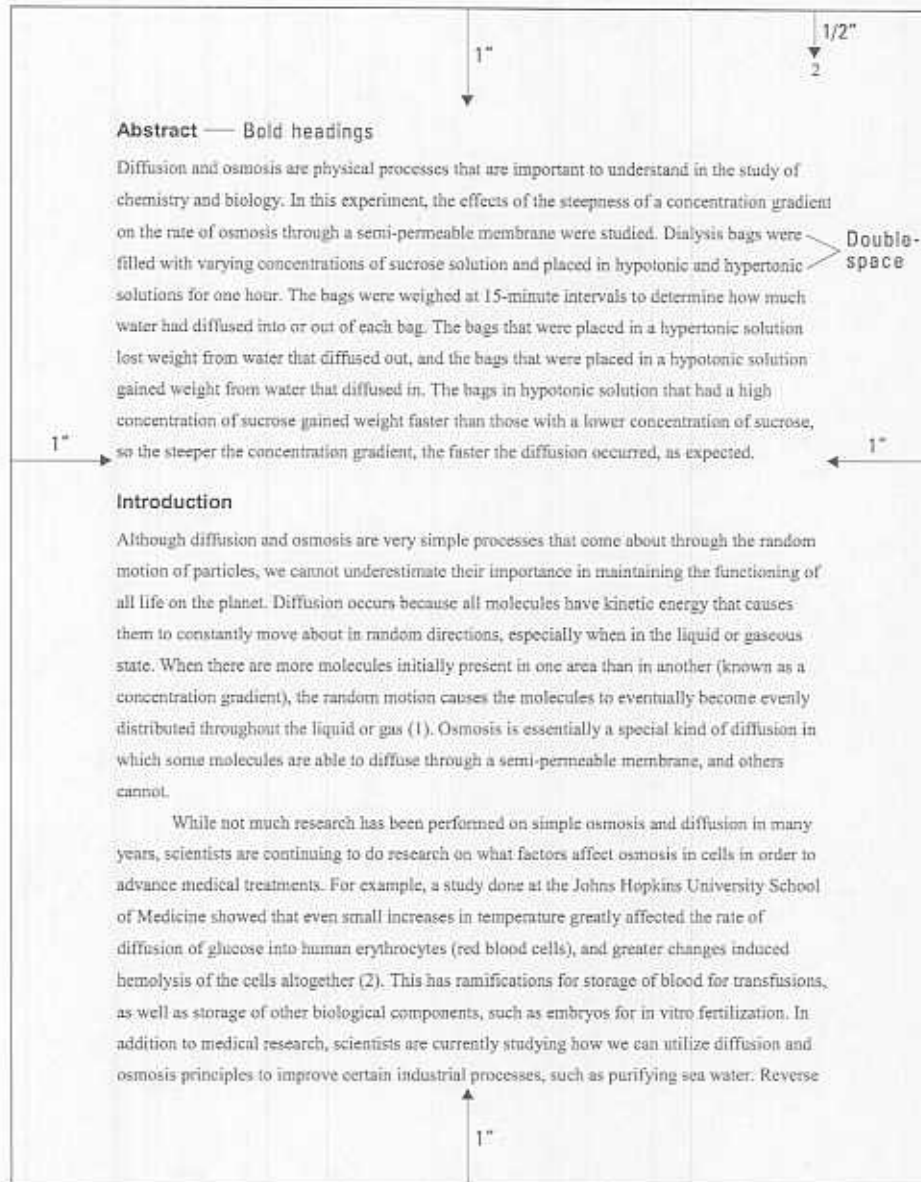
Adrienne E. Dahler
(Sierra West, Lab Partner)

Professor M. Witz
General Biology I
Monroe Community College
23 November 2005

Use 12 pt Times Roman for text

11"

8 1/2"



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 1).

Table I. 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	+0.7 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.

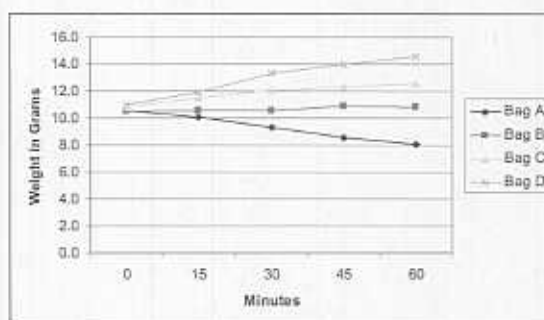


Figure 1. Average weight of bags in solution over a period of one hour

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% sucrose 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 tubing 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

1. Solomon E, Berg L, Martin, D. *Biology*; seventh edition. Belmont (CA): Thomson Learning. 2006.
2. Tsong T, Kingsley, E. Hemolysis of human erythrocyte induced by a rapid temperature jump. *J Biol Chem.* 1975; 250(2):786-789.
3. Ozaki H, Li H. Rejection of organic compounds by ultra-low-pressure reverse osmosis membrane. *Water Res.* 2002; 36:123-130.