Membrane Permeability: A Quantitative Approach

Todd M. Bennethum

Department of Biological Sciences
Purdue University, West Lafayette, Indiana 47907-1392

The processes of diffusion and osmosis are vitally important to all living organisms. Most general biology courses include laboratories studying these processes but few of them utilize a truly quantitative approach. This laboratory exercise allows students to use living cells (sheep erythrocytes and *Elodea*) to examine the processes of diffusion and osmosis and collect empirical data. Students then analyze this data to better understand the relationships involving a membrane's permeability to various solutes.

By first placing fresh red blood cells in solutions of varying saline tonicity (e.g., distilled water, 0.15 M NaCl and saturated NaCl), students observe, under the microscope, the effects of osmosis on a typical animal cell. This is also an appropriate opportunity to review concepts such as solution concentration and terms like solute/solvent, hypo-/iso-/hypertonic, plasmolysis/turgor, and hemolysis/crenation.

The relationship between molecular size and solute permeability is easily studied by adding, to test tubes each containing 3 drops of erythrocytes, 5 ml of 0.3 M solutions of nonelectrolytic solutes with differing molecular weights (e.g, water, urea, glycerol, glucose, and sucrose). Students can hold these tubes up to a printed page and count the number of seconds before the tubes clear, allowing them to read the page through the tube. These values can then be graphed, and the relationship between size and permeability of each of the solutes can be determined quantitatively.

Using the principles discussed above, students can use *Elodea* cells to approximate the iso-osmotic concentration of various solutes in the vacuolar sap. First, *Elodea* cells are introduced to varying concentrations of a given solute. A field of 100 or so cells is examined, and the number of plasmolyzed and normal cells is counted. Plasmolyzed cells (i.e., % cells plasmolyzed) is graphed versus solute concentration (in M); the subsequent solute concentration which corresponds to 50% plasmolysis is roughly equivalent to the iso-osmotic concentration of that solute in the plant's vacuolar sap. Graphical comparisons of these values can be made for a variety of solutes (e.g., electrolytes vs. nonelectrolytes, electrolytes of differing valence, nonelectrolytes of varying molecular size) to better understand the principles of membrane permeability and how different solutes affect the rates of diffusion/osmosis in living cells.

Bennethum, T. M., J. A. Chiscon, M. O. Chiscon, C. R. Carlin, R. H. Shippee, and J. W. Vanable, Jr. 1992. Laboratory manual for *Biology the Basic Concepts.* Department of Biological Sciences, Purdue University. [pages 9–15]