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A Short Note

A NEW THEORY OF THE WATER CONTENTS OF LIVING CELLS IN SOLUTIONS CONTAINING DIFFERENT CONCENTRATIONS OF PERMEANT SOLUTES

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Previous work has suggested that living cells may acquire and then maintain different water contents, and hence volume, in solutions containing different concentrations of solutes that are permeant to the cell membrane. Toward better understanding of this phenomenon, two hypotheses were introduced: one hypothesis is based on the membrane-pump theory; another represents an extension of the polarized multilayer theory of cell water, a part of the association-induction (AI) hypothesis.

The first hypothesis is qualitative. The second hypothesis is more quantitative and is described by the following equation:

$$\log\left[1 + \frac{(1-q)n_2}{n_1}\right] = K_1 K_3^{a} + K_4 , \qquad (1)$$

where a is the water content of the cells in units of grams of water per 100 grams of cell proteins. n_2 is the molal concentration of the solute and n_1 is 55.51, the number of moles of water in which n_2 moles of the solute are desorbed. q is the equilibrium distribution coefficient of the solute in the cell water. K_1, K_3, and K_4 are all constants under specified conditions.

To test the different predictions of these hypotheses, the water contents of frog muscle equilibrated at 25°C in solutions of different concentrations of seven pentoses, seven hexoses, seven dissacharides, two trisaccharides, and six sugar alcohols were determined.

In equimolal solutions of different sugars and sugar alcohols, the equilibrium water contents of the muscles increased with decreasing molecular weights of these solutes.

In equimolal solutions of different sugars and sugar alcohols, the equilibrium water contents of the muscles were the same with solutes of the same molecular weights.

The water contents of muscles, equilibrated in solutions of different sugars and sugar alcohols, are positively correlated with the equilibrium distribution coefficients (or q-values) of the sugar and sugar alcohols in the muscle cell water with a linear correlation coefficient of +0.973.

The relationship between the equilibrium water contents of muscles (in solutions containing different concentrations of different sugars and sugar alcohols) and the concentrations of these sugars and sugar alcohols agree in general contours with that predicted by Equation 1.

The experimental findings described above do not agree with the prediction based on the membrane-pump hypothesis; they do agree with the predictions of Equation 1 based on the polarized multilayer theory of cell water.