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Letter to the Editor

Ionic Diffusion across Biological Membranes

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In a recent publication, Fishman and Volkenstein (*J. Membrane Biol.* **12**:189, 1973) object to the use of the Nernst-Planck equation when the ionic sites can become saturated and they mention a contradiction to this effect in my calculation of the membrane conductance (*see* p. 333 of G. Roy, *J. Membrane Biol.* **6**:329, 1971).

I would like to explain in this letter that there is no contradiction between my calculation and those of Fishman of Volkenstein (1973). The important point of my argument is that the saturation of ions in the membrane does not necessarily mean that all the ionic sites are occupied. It depends if the pore can accept positive and negative charges and if the pore is neutral, negatively or positively charged. For example if the pore is neutral and only positive ions can penetrate, it is obvious that very few ions will remain inside a pore at a time. Because of their mutual repulsion, they will stay far from each other. The number of diffusion sites can be much larger than the maximum number of ions in a pore. If, for example, most of the pores are occupied by no more than two ions and if there are about ten ionic sites along the pore, these two ions could diffuse in the pore by occupying different sites, as long as they are say at least five sites apart. In such a case the concentration of ions in the membrane could be about uniform and independent of the distance across the membrane. Even if it is not uniform, an average maximum value for the concentration can be introduced. Diffusion is still possible and the conductance would be at its maximum and independent of the external concentrations. Such a situation has been found in studies of ionic diffusion across artificial bilayer membranes containing a pore-forming polypeptide, the antibiotic alamethicin (Cherry, Chapman & Graham, *J. Membrane Biol.* **7**:325, 1972). Also, the conductance formulation has been compared to a variety of data from excitable membranes by Hoyt (*J. Cell Comp. Physiol.* **66**:119, 1965) and it was shown that when the concentrations are large (between 0.1 and 0.5 M) the conductance

formulation is more satisfactory. Consequently, a pore could be saturated with ions, without having all its ionic sites occupied. This is a valid hypothesis and it is not in contradiction with the Nernst-Planck electrodiffusion equation.

Guy Roy
Département de Physique
Université de Montréal
Montréal, P.Q., Canada