SHORT COMMUNICATIONS

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Asymmetric polymeric membranes as a possible model of biological membranes

In previous studies of liquori the preparation and electrochemical properties of asymmetrically charged membranes[1] were described, and a system of coupled ion-exchange membranes[2] was proposed as providing a rough model for the electrochemical behavior of muscle or nerve membranes[3].

The possibility of a real correlation between a biological membrane and the above-mentioned model can now be discussed on the basis of some considerations upon the perfusion experiments of BAKER, HODGKIN AND SHAW[4]. Giant squid axon free of its axoplasm was perfused, replacing the original content with solutions of different ionic composition. The effect of internal potassium concentration on the resting potential was investigated.

By plotting the recorded e.m.f. as a function of the internal potassium concentration, HODGKIN and co-workers[4] obtained a curve which is represented by the solid line of Fig. 1. The authors explain this trend in terms of permeability considerations

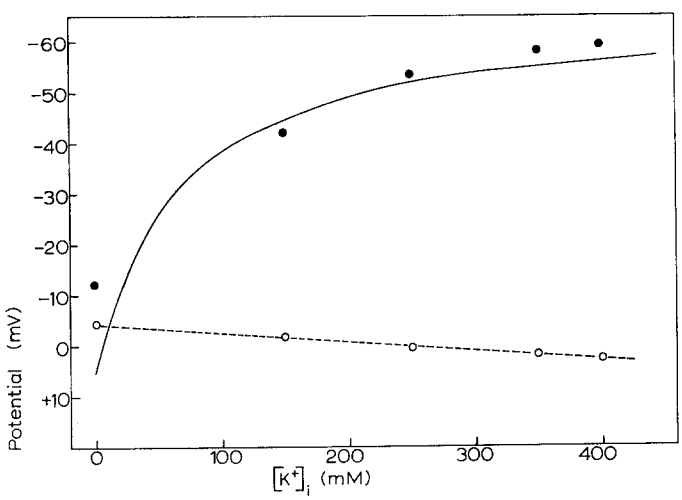

Fig. 1. Potential (mV) *versus* inside K^+ concentrations, $[K^+]_i$. Outside K^+ and Na^+ concentrations of the solution bathing the one side of the membrane are constant. Their values are: $[K^+]_0 = 0.010$ M, $[Na^+]_0 = 0.450$ M. The solid line represents HODGKIN's data. Closed circles are our experimental data obtained with an asymmetric membrane; open circles are data obtained with a symmetric membrane (uniformly charged, $5 \cdot 10^{-1}$ equiv/kg).

and its variation as a function of the increasing resting potential. While in no way underestimating the value of these authors' contribution, which retains its importance in the biological field, we shall approach the whole matter on physicochemical grounds in search of one general explanation; we suggest that an asymmetry potential arising

from a different distribution of fixed charge could be responsible for this phenomenon. We have repeated the experiment carried out by HODGKIN and co-workers, but replacing the biological membrane with an asymmetric charged membrane.

An asymmetric permselective membrane is a membrane whose asymmetry arises from a different distribution of fixed charges within the membrane itself. Such a membrane may generally be prepared by evaporating a mixture of a polyelectrolyte and an uncharged polymer in an appropriate solvent. A fixed charge gradient is obtained by evaporating successive layers of the mixture containing increasing concentrations of the polyelectrolyte. We have employed polystyrene sulphonate embedded in a collodion matrix.

The concentrations of ionizable groups on the two outer layers were $3 \cdot 10^{-4}$ equiv/kg and $5 \cdot 10^{-1}$ equiv/kg. The system can be schematized as follows:

$$\begin{array}{lcl} [K^+]_0 = 0.010\ M & & [K^+]_i = 0.400\ M \\ & \text{Membrane} & \\ [Na^+]_0 = 0.450\ M & & [Na^+]_i = 0.050\ M \end{array}$$

The starting conditions were successively changed by replacing the inside solutions with others, sodium being progressively substituted for potassium. The final condition was a solution where all potassium is replaced by sodium to a final concentration of 0.450 M.

As may be seen in Fig. 1, our recorded results (closed circles) represent behavior which in this respect can be considered at least similar if not identical to that of the nerve membrane; the data follow very closely those of HODGKIN (solid line).

We foresaw that isotonicity and ionic concentration would not play an important limiting role in this case. In other words, the limitations imposed by the experimental conditions in the case of the giant squid axon do not exist when a biological system is replaced by this model. This provided us with the possibility of investigating a larger range of ionic compositions. The results lead us to the conclusion that this behavior is a property of the different distributions of fixed charge of the membrane and, in this respect, of general application. A homogeneously charged membrane does not, of course, show this behavior (open circles and dotted line of Fig. 1). An e.m.f. close to zero results when ionic systems of similar compositions bathe the two faces of such a membrane.

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