On the Observation of Nonlinear Asymptotic Membrane Conductance Relations

Dear Sir:

In a continuing series of articles in this Journal (1, 2), we have treated the problem of stationary ion flow through membranes. Our work has led to the prediction of nonlinear asymptotic membrane conductance relations. We have shown in particular (2) that an asymptotic cube law, in which the current varies directly with the third power of the applied transmembrane potential difference, should hold under conditions of high level bipolar flow.

TABLE I

POINTS TAKEN FROM GRAPHICAL DATA OF LÄUGER, LESSLAUER, MARTI AND RICHTER

V	I	V	I	V	I
mv	*μA/cm²*	*mv*	*μA/cm²*	*mv*	*μA/cm²*
10	1.5	91	20	149	90
32	5.0	113	36	162	121
52	9.0	129	56	174	144

It is in this connection that we wish to call attention to a recently published study by Läuger, Lesslauer, Marti, and Richter (3), of the electrical properties of biomolecular phospholipid membranes. We believe that their work provides a convincing demonstration of the applicability of the cube law to one case.

As part of their presentation Läuger and his coworkers exhibit a current-voltage curve of a dioleyl phosphatidyl choline membrane separating aqueous phases consisting of 10^{-2} M KI solutions (see Fig. 3 on p. 26 of their paper.) They take note of the pronounced deviation of the I-V characteristic from linearity which sets in at applied voltages in excess of 30 mv. Their choice of linear voltage and current scales permits an effective demonstration of this point. For our purpose, however, a plot of log I vs. log V is most appropriate. We have therefore measured the nine points presented on their graph, listed them in Table I, and displayed them on a log-log plot of current density vs. voltage as Fig. 1. This graph clearly displays the ohmic range at low voltage levels, a transition region, and a range at higher voltage levels over which a cube law is followed. We note that the transition region cannot be closely fit by simple addition of the linear and cubic terms. The admixture of a term dependent upon the square of the applied voltage and having a negative coefficient, which can be justified theoretically (2) would undoubtedly improve the fit in the transition region without significantly affecting the linear and cube law ranges. This complication has, however, been omitted.

In this analysis we have not sought to answer specific questions raised by Läuger and his coworkers, such as that relating to the charge transport mechanism which operates within the

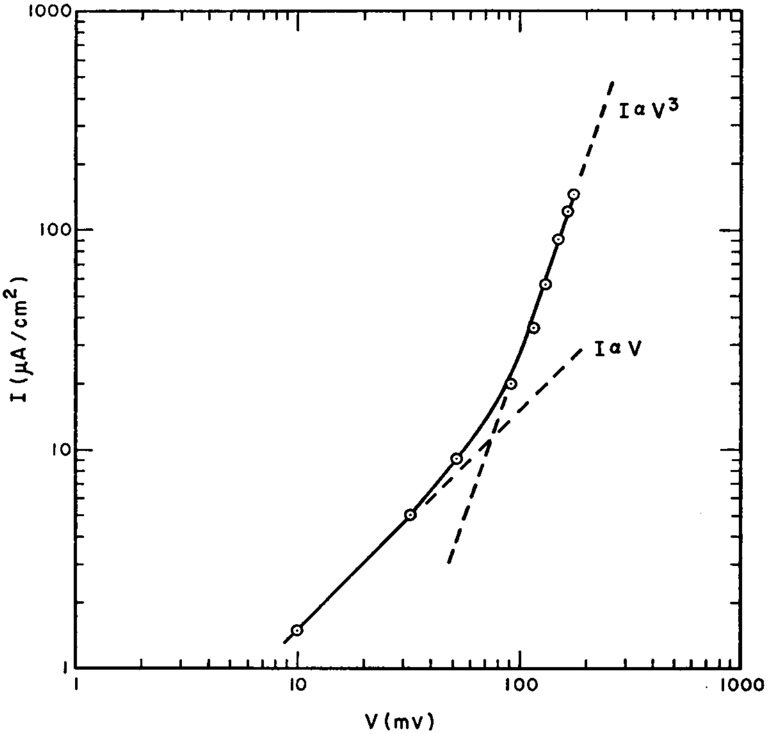

FIGURE 1 A log-log plot of the voltage-current characteristic of a dioleyl phosphatidyl choline membrane in 10^{-3} M KI. This plot, based upon data of Läuger, Lesslauer, Marti, and Richter, illustrates the applicability of the asymptotic cube law at high levels of voltage and current density.

membrane. It is hoped, however, that the observations made above will stimulate further interest in the study of nonlinear membrane conductance.

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