Significance and History of the Name PNP

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FETs contain channels in which the flow of quasi-particles follow the drift diffusion equations [18, 26, 27, 32, 35, 36] with forces calculated from all the charges present, using Poissonôs equation of the electric field. These equations are called *PNP* in biophysics to emphasize the importance of computing the variable spatial distribution of potential from the much less variable distribution fixed charge, using the Poisson equation with boundary conditions (for bath concentration and potential), as extensively discussed in [3, 5, 8-12, 14, 16, 22, 28].

The name *PNP* for Poisson Nernst Planck [4] was introduced deliberately in a Biophysical Society workshop [13] as a pun to emphasize the importance of computing the electric field (as opposed to assuming it was constant [17, 19, 29], and the analogy with transistors. As in transistors, the electric field of PNP, like the electric field in transistors is not constant as conditions change. Electric forces must be computed as a consistent mathematical solution of the relevant model. Previous work (for example, [1, 6, 7, 21, 24, 25, 31]: references [1, 14, 20] describe much of the earlier work on Nernst-Planck equations but do not cite the relevant astrophysical literature) on Nernst-Planck equations in biology and chemistry did not mention the analogy with transistors; the importance of permanent charge (i.e., ódopingô); and most importantly the crucial role of the ***variable*** shape (i.e., óconformationô) of the electric field and its large changes when bath concentrations or potential is changed (note the title of [14]).

Transistors function by changing the conformation of the electric field produced by doping and boundary conditions. The change in shape of the electric field is crucial for the function of transistors. Drift diffusion without doping, Poisson, or variable shapes of electric fields has a limited range of behaviors. With doping, Poisson, and variable shapes of fields, *PNP* can do everything a transistor and thus everything a computer can do. For example, elementary texts show how a single *FET* can be an amplifier, limiter, switch, multiplier, logarithm or exponentiator [30, 33, 34, 36]. Arrays of *FET*s provide all the logic, memory, and display functions of a computer.

Evolution needs devices as much as engineers do. It seems unlikely that evolution would entirely ignore the devices that (ionic) *PNP* equations allow. It seems likely that evolution uses fields that change shape to help with the function of proteins, channels, transporters, and enzymes [15].

Transistors function by changing the conformation of their electric field without changing the conformation of their masses. It seemed [14, 15]ð and seems [23]ð possible that some functions of proteins customarily attributed to changes in the conformation of mass might actually be produced by changes in the conformation of their electric (and steric) fields.

Transistors are the main active devices in digital technology that make modern technology possible. They use depletion layers to switch currents on and off. Today, we know that depletion zones control some kinds of selectivity (Na^+ vs. K^+ in the DEKA channel: Fig. 6-7 of [2]). Someday, we may find that depletion layers switch biological functions.

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