Proteins as Computational Devices

Bob Eisenberg

January, 2002

Computers perform mathematics. The components of computers are devices that execute simple mathematical operations. Nearly all the computers we use in fact follow one set of laws. The Poisson Drift Diffusion equations (*PDD*) describe the movement of quasi-particles through the doped channels of Field Effect Transistors *FETs* embedded in a glass insulator. The insulating membranes of cells are also perforated by 'doped' channels through which ions move to carry current. Several laboratories have shown that the *PDD* equations describe the flow of current through open ion channels, suggesting that these proteins might have the same repertoire of behavior as *FETs.* Ion channels are thus objects of considerable technological promise, although so far their electrical behavior is only as interesting as diodes. The ***electrochemical*** behavior of ion channels is much richer, suggesting that they may find their niche as electrochemical computing elements, able to control selectively the flow of different types of ions, adding the currents of some ions, subtracting those of others, and perhaps controlling (i.e., multiplying) still others. The biological role of channels will be discussed along with the physical origin of their selectivity. It seems that ***the main difference between FET and ion channels is the size of the charge carriers***. Ion channels are ideal candidates to be biological computational elements because they follow the same laws as the computational devices of our technology, but the finite size of ions in channels allows a much greater range of chemical behavior.