# Ion Channels: Devices that Control Biological Function

Ion channels are proteins with a hole down their middle that allow the movement of ions across the otherwise impermeable cell membrane and thereby control an enormous range of biological function, from signalling in the nervous system, to coordination of contraction, particularly in the heart, to transport in most cells and organelles. Channels are machines rather like the devices that are linked on a chip to make a computer. Indeed, we have shown that channels follow mathematical laws quite similar to semiconductor devices.

Channels come in a great variety, as do other devices and machines, and (together with their close cousins, transporters) take up a substantial fraction (~1/3) of the genome. The widespread role of channels as controllers of biological function make them natural targets for medication and many drugs of the greatest importance work on channels, directly or indirectly. Most channels are selective, allowing one or another type of ion (e.g., sodium, potassium, calcium, or chloride) to move. My colleagues and I have shown that such selectivity can arise from simple physical laws combining the electrostatics of semiconductor devices with the properties of crowded spheres.

In this view, and perhaps in reality, the channel protein acts rather the way the engine block does in an automobile engine: it provides the mechanical strength and structural organization absolutely needed for function. Channels are an attractive object for physical investigation because of their relative simplicity and many physical scientists have started using their tools to understand channel function. Very little of the world is stereotyped and simple enough to allow prediction by mathematics. But that part of the world is responsible for most of our standard of living.

Our dream is that ion channels will prove to be a part of biology that can be understood by engineering, physics, chemistry, and mathematics and will show us how to understand much protein function in a physical way. If even part of that dream is realized, the practical consequences for daily life are likely to be extraordinary, in both medicine and technology, changing what we do hour to hour as much as electricity has.