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Membrane Channels

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One of the simplest ways living cells store and dissipate free energy for useful purposes is through the use of the cell membrane as an electrical capacitor. Energy is stored across the membrane in the form of electrochemical gradients set up by the action of ATP-dependent ion pumps. Ion channels are passive conductors of the ions: they spend the energy to accomplish tasks for the cell. Among these tasks ion channels make the electrical system of living cells. By conducting ions selectively they generate a voltage across the membrane. This voltage can change its value depending on which kinds of channels open, Na^+ or K^+, and the change can propagate as an impulse rapidly for long distances. This is how a message travels from your brain to your muscles when you move, or between the cells in your brain when you think.

The electrical impulse is possible because the cell membrane voltage is able to feed back on itself through the action of voltage-dependent Na^+ and K^+ channels. ‘Voltage-dependent’ means the probability of channel opening depends on the value of the membrane voltage. In this sense these are electrical transistors – and very good ones – with the ability to switch between opened (conductive) and closed (non-conductive) states over the very narrow range of a few hundredths of a volt. How does an exquisitely sensitive transistor made of protein embedded in a liquid crystal capacitor (the cell membrane) work? This will be the main focus of my presentation. Structural and functional studies with a prokaryotic voltage-dependent K^+ channel have led to many new advances on this mechanism.