The Propagating Action Potential On the Squid Giant Axon

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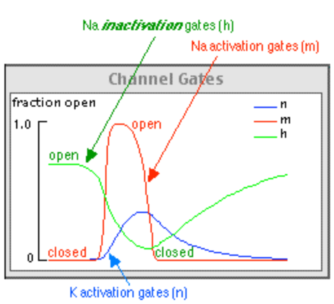
In the 1940s and 1950s, Alan Hodgkin and Andrew Huxley conducted extensive experiments in order to produce a mathematical model to represent a nerve cell during excitation. It was already known that ions controlled the electrical current flow, namely sodium ion and potassium ion. Previous to their efforts, the mechanisms which controlled the influx of these ions was not precisely modeled. The two revolutionized the way we look at action potential propagation, and it was done without the aid of computers. Using their equations, and the help of computers, I have produced a model of a propagating action potential with respect to both space *and* time. With this model I show the relationship between cytoplasmic resistance and propagation velocity.

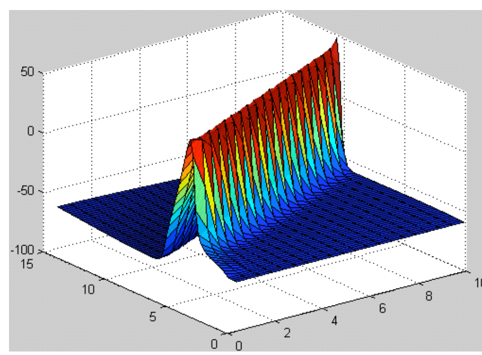
As we all hopefully know from physiology, the nervous system communicates through neurons which fire electrical signals called action potentials. Sodium rushes into the cell and Potassium rushes out to depolarize the cell and then switch to repolarize.

In the 1850s, Lord Kelvin developed Cable Theory to help explain the behavior of current and signal decay through submarine telegraphic cables. This focuses not only on the geometry of the cable, but the properties of the cable itself. We can apply this same principle to electrical propagation in nerve cells. However, this does not prove to be very accurate since the regulation of the electrical properties depends on channels physically opening and closing, which themselves are dependent on the voltage of the cell membrane. This makes modeling nerve cell propagation a bit more complicated.

Through grueling experiments and calculations, Hodgkin and Huxley produced equations to govern the opening and closing of the channels to allow Na^- and K^+ into and out of the cell. The three gates to represent this action are the h, m, and n gates, and the basis for the equations is on the probability of them being open at a particular voltage. All of those equations are derived from purely experimental values.



Using the Cable Equation, The HH Equations, and the Diffusion Equation, my goal was to produce an accurate computer model to represent the voltage across the membrane of a nerve cell as an action potential passes, and be able to hold valid for all points along the axon and all time. Most applications of the HH Model show the membrane voltage with respect to time at a particular location. This is useful; however it does not shed any light on the *propagation velocity*. That is exactly the focus of my experiment. While changing the cytoplasmic resistance of the axon, results show that propagation velocity decreases as resistance increases.



Websites:

http://alford.bios.uic.edu/teaching/hh%20equations.html

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