

Modeling Neuron Energy Efficiency and Consumption Using Hodgkin-Huxley Equations With Analysis and Application

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In the human brain, high amounts of metabolic energy are required to maintain neural activity. A large fraction of this energy is expended in the generation and firing of action potentials, as each requires an ATP-driven ion pump to restore the ionic concentration gradient. This project analyzes the biophysical accurate Hodgkin-Huxley (H-H) model as an energy model to evaluate the metabolic energy consumption of an isolated neuron. A MATLAB-based simulation of an H-H neuron's derived voltage and ionic currents at various external inputs is created. Using this model, the ATP supply and total energy consumption are measured. Then, various parameters, such as the conductances, temperature, and external currents, are optimized to minimize energy consumption and improve the neurons' energy efficiency. Studying neurons' energy consumption and efficiency provides greater insight into diseases associated with impaired brain energetics, such as Alzheimers and Parkinsons disease. This project aims to use the results of minimized energy calculations for applications in understanding and creating targeted treatments for these disorders.