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Computational and Electronic Analog Implementation of the Hodgkin-Huxley Model of Action Potentials in Neurons[1] PETER SMITH, JUSTIN LINK, Xavier University — Alan Loyd Hodgkin and Andrew Huxley's mathematical model of action potential initiation and propagation in neurons is one of the greatest hallmarks of biophysics. Two techniques for implementing the Hodgkin-Huxley model were explored: computational and electronic analog. Computational modeling was done using NEURON 7.1. NEURON is a free, robust, and relatively user friendly simulation environment that enables quantitatively accurate computational modeling of neurons and neural networks. An analog electronic circuit was built using field-effect transistors (FETs) to simulate the non-linear, voltage-dependent (sodium and potassium) conductances that are responsible for membrane excitability. While the electronic analog qualitatively reproduces many of the key features of the action potential including overall shape, inactivation period, and propagation, it was difficult to quantitatively reproduce the Hodgkin-Huxley model. In addition, while the relative cost to build circuits equivalent to small membrane patches is minimal (∼$50), implementation of larger cells or networks would prove uneconomical. Still, both techniques are viable avenues toward introducing interdisciplinary research into either a computational or electronics lab setting at the undergraduate level.

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