A Hodgkin-Huxley Model for Cerebellar Resurgent Sodium Current

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The nervous system relays messages throughout the body using ionic currents that form action potentials. The Purkinje neurons of the cerebellum, which regulate motor function, exhibit a unique action potential distinguished by a resurgent sodium current. This resurgent current results from the relief of an open-channel blocking mechanism that prevents the usual inactivation of sodium channels, while also generating its own current after repolarizing voltage steps. Animal models provide evidence for a requirement for resurgent current for proper motor control. To relate resurgent current to patterns of action potentials that contribute to cerebellar function, we have developed a computer simulation of resurgent current. Although models simulating resurgent current have been previously designed, they have either failed to represent the physical mechanism of the resurgent current or are too computationally intensive for wide use in studies. Ideally, an effective model will mimic experimentally recorded currents, reflect what is known about the physical mechanism of open channel block, and permit testing the hypotheses that are too complex to study experimentally. To create a more effective resurgent current model, we have expanded the canonical Hodgkin-Huxley representation of voltage-gated sodium channels to simulate the physical mechanism of the additional current component. Because of the simple, yet meaningful, nature of a Hodgkin-Huxley simulation, the new model will be an effective tool to reconstruct the neuronal excitability that governs our cerebellum function.