Title: NEURON for multiscale simulations: reaction-diffusion meets electrophysiology

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The feats of the mind -- from walking and talking to calculus -- are the result of interactions between dynamical systems spanning multiple spatial and temporal scales. Ion channels in specific locations of individual cells open and close in milliseconds both in response to input from some subset of the brain's approximately one hundred billion neurons and in response to highly localized chemical concentrations. The coincidence of action potentials themselves lasting milliseconds can trigger structural changes encoding memories that are preserved for years. Numerous tools have been developed to study these interactions, including the NEURON simulator, which has long allowed the simulation of large networks of spatially extended neurons with realistic ion channel based dynamics. In NEURON 7.3, we introduced enhanced support for deterministic one-dimensional reaction-diffusion dynamics to facilitate the study of how large-scale subcellular chemical dynamics, such as intracellular calcium waves, affect and are affected by network dynamics. These types of subcellular dynamics need a higher spatial resolution but can work with a larger time step. We present experimental reaction-diffusion support developed since the 7.3 release, including prototypes of stochastic and three-dimensional simulations. We discuss our strategies for interaction across different temporal scales, between stochastic and deterministic processes, and between one- and three-dimensional data.