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**Title**: Energetics based spike generation of a single neuron: simulation results and analysis

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**Abstract**:
The onset of great advances in computational capability, coupled with the moral dilemma often faced with traditional brain research has prompted a non-invasive approach towards understanding the brain. Significant effort at WARFT has been routed towards capturing the spike activity of the neuron as a function of its intracellular parameters (Venkateswaran, et al). Our voltage spike - energetics model assumes a lumped nature of the mitochondria and other intracellular organelles, and doesn’t consider the individual contributions of the mitochondrial cloud inside the soma and the spatial communication across the intracellular organelles. It localizes the energy budget of the neuron to a single global mitochondrion and does not consider mechanisms such as ATP communication and transportation across the organelles such as nucleus, ER, peroxisomes, and the golgi apparatus with a commensurate level of biological accuracy. In this poster, we propose a novel distributed model of intracellular organelles, which analyzes the energetics in a three-dimensional environment, with emphasis laid on the spatial distribution of various organelles and the associated inter-dependencies across them.

The Three-Dimensional framework for the voltage-spike energetics model is set up by dividing the total mitochondria (and hence the energy budget) in a neuron among the various energy consuming entities (organelles). The plane containing these organelles is divided into infinitesimally small segments on which the mitochondria are localised. Stochastic equations are developed to model the transition of mitochondria across various “states” which represent its physical coordinates along the segment. The solution of this system of equations gives the probability distribution of mitochondria which is used to model mechanisms such as ATP consumption, restoration of ionic gradient and neurotransmitter packing. The developed energetics model for the organelles is distributed as hyper-nodes in a graph with the inter-dependencies optimised to simulate a distributed neuron. This has prompted the development of a generic framework which can analyse the commonalities present in biochemical signalling mechanisms such as the phosphorylation-dephosphrylation switch, diffusion and docking of vesicles in a simulation environment. Parallel research at WARFT is aimed at establishing a relationship across functions defined by the various regions of the visual cortex and morphological properties of the neurons in a specific layer. The morphological model provides the crucial link between functionality and energetics in the central nervous system and this highly integrated morphology-functionality-energetics model will
lead to a more comprehensive understanding of the visual cortex.