INHIBITION ON DENDRITIC SPINES AND THIN DENDRITES MAY BE INEFFECTIVE BECAUSE OF IONIC CONCENTRATION CHANGES.

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The Nernst-Planck equation for electro-diffusion was applied to axons, dendrites and spines. For thick processes (greater than 1 micron) the results of computer simulation agreed accurately with the cable model for passive conduction and for propagating action potentials. For thin processes and spines, however, the cable model may fail during transient events such as synaptic potentials. First, ionic equilibrium potentials assumed to be constant in the cable model can change and alter the driving forces for movement of ions across the membrane. Second, longitudinal diffusion, not considered in the cable model, may dominate over electrical forces when ionic concentration gradients become large. In particular, our model predicts that inhibition is effective only on cell bodies or large processes, but not on small structures such as spines and thin processes (less than 0.1 micron). Large inhibitory input on a spine head may in fact give an excitatory response, because of the shift of the reversal potential caused by large concentration changes. We suggest modifications to the cable model that lead to better agreement with the electro-diffusion model.

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