Foreword by Terrence J. Sejnowski

The exploration of the electrical properties of dendrites pioneered by Wilfrid Rall provided many key insights into the computational resources of neurons. Many of the papers in this collection are classics: dendrodendritic interactions in the olfactory bulb; nonlinear synaptic integration in motoneuron dendrites; active currents in pyramidal neuron apical dendrites. In each of these studies, insights arose from a conceptual leap, astute simplifying assumptions, and rigorous analysis. Looking back, one is impressed with the foresight shown by Rall in his choice of problems, with the elegance of his methods in attacking them, and with the impact that his conclusions have had for our current thinking. These papers deserve careful reading and rereading, for there are additional lessons in each of them that will reward the careful reader.

New techniques have recently allowed direct experimental exploration of mechanisms, such as active membrane currents within dendrites, that previously were only accessible through somatic recordings. The distribution of sodium and calcium currents extends quite widely in the dendritic trees of neocortical and hippocampal neurons. There are still uncertainties in the densities of these ionic currents, and the diversity of their biophysical properties, but it is now clear that the computational repertoire of cortical neurons is far richer than anyone had previously imagined, except perhaps for Rall.

The current work in computational neuroscience has built upon the solid foundations provided by Rall's legacy. Exploring the interplay between the wide range of voltage-sensitive conductances that have been identified, and the spatial interactions within dendrites and between networks of neurons, is now within our grasp. This includes issues such as homeostatic mechanisms for regulating ionic currents in dendrites, the effects of spontaneous activity on dendritic processing, the source of the stochastic variability observed in the spike trains of cortical neurons and role of inhibitory interneurons in synchronizing spike trains in cerebral cortex, and the implications of Hebbian mechanisms for synaptic plasticity. Hidden within dendrites are the answers to many of the mysteries of how brains represent the world, keep records of past experiences, and make us aware of the world.

It would be difficult to imagine the field of computational neuroscience today without the conceptual framework established over the last thirty years by Wil Rall, and for this we all owe him a great debt of gratitude.