Preface

The two decades leading up to this year's twentieth annual Computational Neuroscience conference (CNS) have seen a dramatic upswing in applications of quantitative and analytical methods taken from mathematics, physics, and engineering (among others) to the traditionally more biological approaches to Neuroscience. Much of the progress in the Computational Neurosciences, as in the broader field of Neuroscience, has taken the form of advancements in our understanding of neural systems at two key levels: the cellular processes underlying the dynamic electrical and chemical behaviors of individual neurons and the complex interactions among neurons in networks of varying composition and size, ranging from two reciprocally connected neurons, to detailed local microcircuitry, to large scale networks of thousands or more. One of the most difficult challenges, however, has been (and remains) to bridge the cellular and network levels of computation, i.e., to identify and understand how the properties of individual neurons contribute to the behaviors of functional networks underlying perception, motor performance, memory, and cognition. Given that neurons, like people, communicate with and influence one another through a variety of means, this problem is quite a bit like relating the individual personalities of two or more people to the interactions between them; or more generally, it is like relating the psychology of individuals to the sociology of a community.

One of the most fruitful means of addressing the interface between cellular and network computation has been the application of phase response analysis to neuronal systems. Neuronal phase response curves (PRCs) describe the pattern of shifts in the timing of action potentials (spikes) that are caused by inputs to a neuron arriving at different times within that neuron's spike cycle. The degree to which an input can affect spike timing depends not only on the properties of the neuron but also on the characteristics of the input, and the relationship between the PRCs of individual neurons and the behavior of a neuronal network additionally depends on the connectivity structure within the network. Consequently, many of the complexities of computation at the cellular and network levels are embodied in the variety of applications of phase response analyses to neuronal systems. This book provides a cross section of the considerable body of work by many of the

prominent theoreticians and experimentalists in the Computational Neurosciences which make use of PRCs to further our understanding of neurons and networks, more generally, the brain, and more abstractly, ourselves. Part 1 introduces the theoretical underpinnings of phase response analysis and presents the central concepts and context for the rest of the book; Part 2 surveys techniques for estimating neuronal phase response curves and many of the technical considerations necessary to do so; Part 3 presents many of the key investigations relating the phase response properties of neurons to their cellular characteristics; and finally, the chapters in Part 4 illustrate how phase response curves can be used to understand and predict patterning of network activity in neuronal systems.

To make this text exciting and accessible to a diverse audience, the contributors to this book were asked to write "across the aisle," so-to-speak, such that the more theoretical or "mathy" authors considered more biologically-minded readers in preparing their contributions, and vice versa. Although this text generally proceeds from more theoretical to more applied topics, and major themes are partitioned into the book's four major parts, readers are not expected to move purely linearly through the content from start to finish. Rather, we encourage readers to familiarize themselves with the general concepts and perspectives and then move from one chapter to another as curiosity and perhaps relevance to their own interests dictate.

We, the editors, dedicate this volume to our mentors, in particular among them Drs. Dieter Jaeger, Eve Marder, Jack Byrne, John Clark, Ron Calabrese, and Terry Blumenthal, and to our families.