Preface

We live in the age of networks. For most of us, networks are an integral part of our daily social and intellectual lives, connecting us at an ever accelerating pace and transforming the way we communicate, learn, create, work, and play. The importance of networks has long been realized in the social sciences, resulting in a rich literature that capitalizes on quantitative network analysis to understand the web of social relations, cooperation and conflict among individuals and organizations. More recently, networks have become of central interest in the natural sciences, particularly in the study of complex biological systems, including the brain. Modern network approaches are beginning to reveal fundamental principles of brain architecture and function. This book highlights the many emerging points of contact between neuroscience and network theory.

With this book I wanted to introduce networks to neuroscientists and make neuroscience appealing to all those working on theoretical network models. I also wanted to give a real sense of how broadly and deeply network thinking applies to neuroscience. I attempted to strike a balance between providing a broad overview of the many areas of neuroscience where network approaches have begun to make a difference and exploring at least some of these areas in sufficient detail to illustrate the substance and direction of the field. This balance requires a compromise between breadth and depth. Rather than focusing on a single "model system" or level of analysis, I chose to emphasize how networks connect levels of organization in the brain and how they help us link structure to function. In order to keep the book accessible and focus more of the discussion on the relevance of network approaches to many areas of neuroscience, I opted for an informal and nonmathematical treatment of the subject. Readers interested in the statistical and computational

underpinnings of network science can find more formal and analytic treatments in numerous monographs and review articles.

In each section of the book, I attempted to provide substantial discussion of open research questions, in order to give a sense of the many controversies and uncertainties that still pervade the field. I wanted to document the rapid pace of discovery and innovation in brain networks while also exposing the historical roots of the field. Not all areas of neuroscience have been equally covered. In the past, much of my own work has focused on the structure and dynamics of large-scale brain networks, and thus research in this area is discussed at some length. Other areas—for example, the burgeoning field of cellular network analysis and modeling or exciting developments in the study of invertebrate nervous systems—are not treated in as much detail. While the book contains many scholarly references, they necessarily represent only a selection, and I am afraid that some relevant areas have not been discussed or cited. I sincerely apologize to all who believe that their work has been overlooked.

This book would not have been possible without a network of colleagues and friends. I am deeply grateful to Paul Layer, who many years ago took me on as an undergraduate research assistant and who opened my eyes to the wonders and mysteries of the brain. My PhD advisor, Gerald Edelman, had an enormous impact on my thinking, and it was a privilege to be a part of the unique intellectual environment he created at the Neurosciences Institute in New York and San Diego. Many years of working with Giulio Tononi have been invaluable for developing key ideas about complexity and networks. Interactions with Rolf Pfeifer, Esther Thelen, and Linda Smith sharpened my appreciation of dynamics and developmental change. Working with Barry Horwitz, Randy McIntosh, and Rolf Kötter shaped my ideas about the link between structure and function in the brain. The work of my students Chris Honey and Jeff Alstott was instrumental for formulating many of the key ideas of the book—and I thank them for encouraging me to write it and for cheering me on as I toiled in my office. I also greatly appreciate the many interactions with my colleagues at Indiana University, whose integrative, cross-disciplinary, and forward-looking way of approaching complex scientific questions I admire.

Many friends have given freely of their time to read and critique early drafts of the book. I especially thank Mika Rubinov, who provided significant scientific and editorial input to several chapters. I also thank Dani Bassett, Diarmuid Cahalene, Barb Finlay, Chris Honey, Barry