Preface

One of the major challenges for post-genomic biology is to understand how genes, proteins, and small molecules interact to form cellular systems. It has been recognized that a complicated living organism cannot be completely understood by merely analyzing individual components, and that interactions between these components or biomolecular networks in terms of structures and dynamics are ultimately responsible for an organism's form and functions. To elucidate the essential principles or fundamental mechanisms in cellular systems, study of structures and dynamics of biomolecular networks in cells is increasingly attracting much attention from biology, mathematics, and engineering communities. In particular, there are many complicated but interesting phenomena generated from the biomolecular networks due to their specific structures and nonlinear dynamics such as switching behavior and collective rhythms of biological systems which are ubiquitous in living organisms.

This book will cover contents and topics on modeling biomolecular networks and analyzing their nonlinear dynamics in a comprehensive manner, especially stressing the viewpoints of systems and engineering. Attention will be focused on deriving general theoretical results and revealing the essential principles of biological systems on the basis of nonlinear dynamical and control theories. In particular, we will describe how to model a general molecular network in a single cell; how to construct a molecular network with specific functions or structures, such as gene switching networks and gene oscillating networks in individual cells at the molecular level; how to model a general multicellular system with the consideration of external fluctuations and intercellular coupling of signal molecules; how to design a synthetic molecular network from the viewpoint of forward engineering; and how to analyze and further control the nonlinear phenomena of living organisms at the molecular level, such as switching behavior, cooperative dynamics, and synchronization of biological oscillators in multicellular systems.

This book will provide upper-level undergraduate students, graduate students, and researchers in the areas of mathematics, engineering, computer science, and biology with a computational or theoretical background in both academia and industry, e.g., fields of systems biology, bioinformatics, and synthetic biology. The book assumes little knowledge of molecular biology with each chapter covering the necessary material. Biologists would find the book useful if they have a strong computational background or training in systems biology or computational biology. Readers are assumed to have undergraduate-level backgrounds in mathematics, engineering, and basic biology. This book will introduce readers to the challenges in life sciences: from the understanding of individual molecules to system-level analysis, and from the static interactions between molecules to dynamical networks, in the hope that the readers will build on them to make new discoveries of their own. Designing and constructing synthetic molecular networks from the perspectives of both synthetic biology and engineering are also described in the book. Unlike traditional books on systems biology and bioinformatics, this book aims to show engineers and biologists the essentials of biomolecular networks with emphasis on structures and dynamics by presenting cutting edge research topics and methodologies, which will be vital for their future careers.

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