
Preface

Revolutionary advances in high-throughput bioanalytical technologies have made it possible to shift the focus of biological studies away from a limited number of high-priority processes to those where the organism of interest, be it a bacterium, an infected host cell, a patient, or a multi-scale combination of all can be examined as a “system.” These forms of analyses are the primary focus of the new field of systems biology. Systems biology is a broad term used to describe the study of the interactions of a large number of disparate biochemical processes with the aim of garnering new insights into how organisms respond to different stimuli. Although more and more efforts are being directed toward examining the entirety of biological processes in complex multicellular organisms, the bulk of system-level analyses conducted to date have focused on the biology of microbes.

The purpose of this book is to introduce the reader to some of the established and state-of-the-art technologies that are being used to study microbial systems biology. Although the majority of techniques that have been detailed in this book can easily be accessed by most investigators, some forms of systems biology analyses still require outsourcing to specialized centers. For example, NanoSIMS technology is not widely available and only a handful of labs operate this equipment. Similarly, genetic sequencing is still primarily the work of large specialized centers such as US Department of Energy’s Joint Genome Institute. Therefore, a few of the chapters in this book (Chaps. 4, 13–15) serve rather as an introduction to the capabilities of a tool than as a step-by-step guide to conducting an experiment.

For a long time medicinal goals supplied the major impetus for examining microbiology, but recent concerns about ecological causes such as global climate change, bioremediation of polluted environments, and the need for alternative sources of energy have provided new thrusts for studying microbial biology. Some important microbes cannot be easily grown in laboratory settings and therefore analyses of these cells require either environmental collection or development of nontrivial special laboratory settings. In order to familiarize the reader with some of the challenges associated with such studies, this book includes chapters on sample collection and genetic manipulation of certain cells that grow in distinct and sometimes extreme environments (e.g., Chap. 3).

Computational modeling forms the essential backbone of systems biology analyses. Depending on the size and complexity of the system, modeling methodologies can range from simplified chemical kinetics-based mathematical reconstructions that would account for the transient behavior of key components of the system to static genome-scale models of cellular physiology. Chapters 14–20 of this book introduce the reader to different *in silico* modeling and analysis methodologies. The aim of these chapters is to highlight the difficulties connected with developing such tools and to outline the strengths and shortcomings of each method.

Collectively, the chapters in this book provide an introduction to some of the various tools that are currently available for analysis, modification, and utilization of microbial organisms. Studies in systems microbiology continually result in new advances in various fields of research ranging from development of novel drugs to sequestration of greenhouse gasses and even assessing the causes of ancient pandemics. Hopefully, the information provided by the authors will serve as fodder for new scientific discoveries and developments.

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