PREFACE

A major goal of synthetic biology is to engineer artificial gene circuits with some desired behaviors or products. One useful analogy to conceptualize the part of synthetic biology is the electronic engineering hierarchy. At the bottom of the hierarchy of synthetic biology are DNA, RNA, and proteins, analogous to the physical layer of transistors, capacitors, and resistors in analog electronics. The next layer, the device layer, comprises biochemical reactions that regulate the flow of information and manipulate biochemical process, equivalent to engineered logic gates to perform computations. At the module layer, synthetic biologists use a diverse library of biological devices to assemble complex pathways that function like the integrated circuits (ICs) for filter, amplifier and computer.

However, these biological devices and modules are not independent biological objects but with biological context and within cellular environments. In this book, the synthetic genetic circuits are modeled by nonlinear stochastic systems *in vivo,* i.e., the biological genetic systems suffer from intrinsic random fluctuation due to random genetic variations and random environmental disturbance due to changes in the cellular context in host cells. Therefore, our design purpose is to engineer a genetic circuit to achieve a desired behavior or product despite intrinsic random fluctuation and random environmental disturbance.

For the systematic design of synthetic genetic circuits, we first construct several promoter-RBS component libraries according to the promoter-RBS regulatory strengths based on the regulatory model of promoter-RBS components and the experimental data. After constructing promoter-RBS component libraries, based on system dynamic model we could design a synthetic genetic circuit to achieve some prescribed design (user-oriented) specifications by selecting an adequate set of promoter-RBS components from the corresponding promoter-RBS libraries.

In this book, based on stochastic system model and promoter-RBS libraries, we design biological filter for signal detection, biological transistor for signal amplification, biosensor for signal processing, genetic lysis circuit for population control, genetic transmitter and receiver for cell-cell communication to meet the prescribed design (user-oriented) specifications through the proposed library-based searching method. Finally, these synthetic genetic circuits are implemented by experiments to confirm their design performances. We find these synthetic genetic circuits based on the proposed synthetic method could fit these design specifications so that we could save much trial times by the conventional methods. In future, system designers should cooperate with synthetic biologists to produce more complex genetic circuit. In this situation, the development of systematic design methods is an important topic for synthetic biology. Therefore, the proposed systematic biology methods in this book have much potential applications to systems synthetic biology in future.