A Systems Theoretic Approach to Systems and Synthetic Biology II: Analysis and Design of Cellular Systems

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The complexity of biological systems has intrigued scientists from many disciplines and has given birth to the highly influential field of *systems biology* wherein a wide array of mathematical techniques, such as flux balance analysis, and technology platforms, such as next generation sequencing, is used to understand, elucidate, and predict the functions of complex biological systems. More recently, the field of *synthetic biology*, i.e., *de novo* engineering of biological systems, has emerged. Scientists from various fields are focusing on how to render this engineering process more predictable, reliable, scalable, affordable, and easy.

Systems and control theory is a branch of engineering and applied sciences that rigorously deals with the complexities and uncertainties of interconnected systems with the objective of characterising fundamental systemic properties such as stability, robustness, communication capacity, and other performance metrics. Systems and control theory also strives to offer concepts and methods that facilitate the design of systems with rigorous guarantees on these properties. Over the last 100 years, it has made stellar theoretical and technological contributions in diverse fields such as aerospace, telecommunication, storage, automotive, power systems, and others. Can it have, or evolve to have, a similar impact in biology? The chapters in this book demonstrate that, indeed, systems and control theoretic concepts and techniques can have a significant impact in systems and synthetic biology.

Volume II contains chapters contributed by leading researchers in the field of systems and synthetic biology that concern modeling physiological processes and bottom-up constructions of scalable biological systems. The modeling problems include characterisation and synthesis of memory, understanding how homoeostasis is maintained in the face of shocks and relatively gradual perturbations, understanding the functioning and robustness of biological clocks such as those at the core of circadian rhythms, and understanding how the cell cycles can be regulated, among others. Some of the bottom-up construction problems investigated in Volume II are as follows: How should biomacromolecules, platforms, and scalable architectures be chosen and synthesised in order to build programmable *de novo* biological systems? What are the types of constrained optimisation problems encountered in this process and how can these be solved efficiently?

As the eminent computer scientist Donald Knuth put it, "biology easily has 500 years of exciting problems to work on". This edited book presents but a small fraction of those for the benefit of (1) systems and control theorists interested in molecular and cellular biology and (2) biologists interested in rigorous modelling, analysis and control of biological systems.

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