Preface

This volume presents a wide range of perspectives on synthetic biology, presented by leaders in the field. But what is "synthetic biology"? This is a rapidly evolving field of research, whose definition is addressed by the authors of several chapters in this book. Terminology is important and useful, but the name of a new field is largely a linguistic and philosophical issue, not a biological one. The name of a new area of research is not a driver of innovation but rather a retrospective attempt to describe the emergence of a new research community. Nonetheless, the editors cannot resist the opportunity to present a perspective on "synthetic biology."

With the advent of methods for the chemical synthesis of DNA, synthetic DNA gradually became a more powerful part of the toolkit of molecular biology. As DNA synthesis methods improved, it became possible to synthesize whole genomes of small viruses, and eventually complete bacterial genomes, as well as some eukaryotic chromosomes. Presumably, the complete synthesis of a whole eukaryotic genome is now not far off. This line of work, often called "synthetic genomics," may be simply defined and includes the design, synthesis, and testing of complete genomes and chromosomes. "Synthetic biology" includes "synthetic genomics" but is not restricted to completely synthetic genetic elements. In practice it has become a more up-to-date term for "genetic engineering." In current usage "synthetic biology" involves the design and assembly of biological systems for either practical purposes or basic research. Synthetic DNA, recently developed genome-editing methods, computational design tools, and other recent innovations are hallmarks of the field. An engineering perspective is often quite explicit, complete with design–build–test cycles and, all too frequently, milestones.

Another, more pragmatic, definition of synthetic biology is "those things presented at synthetic biology conferences." This volume includes a diverse set of 15 such chapters that we grouped into five topics as follows.

1. *Design, synthesis, and manipulation of genomes:* Three chapters deal with chemical synthesis of DNA, minimal cellular genomes, and enzymatic methods for genome editing.
2. *Modifying the central dogma:* Two chapters discuss synthetic alternatives to the conventional Watson–Crick DNA structure and altering the genetic code to expand the repertoire of amino acids encoded.
3. *Experimental and computational approaches to the design and improvement of biological processes:* Three chapters cover the use of cell-free systems to develop genetic circuits, the engineering of modified cellular organization, and automation of the design process in synthetic biology.
4. *Applications to small molecule production:* Two chapters describe integrated approaches to metabolic engineering and engineering microbial systems for the production of natural products.
5. *Applications to higher organisms:* This is the longest section of the book. It consists of five chapters, covering engineering gene circuits for mammalian cells; applying synthetic biology methods to engineer organs for transplantation; engineering the morphogenesis of tissues and organs; the use of synthetic biology to engineer plants; and the use of synthetic biology methods to engineer bacteriophage for fighting bacterial infections in humans.

As you can see, this book covers a broad range of topics. These include method development, the application of synthetic biology in basic biological research, and also practical applications. These applications include the development of microbial factories for production of high-value molecular products. Medical applications based on the engineering of cells and tissues and of microbes that interact with humans are also discussed.

Synthetic biology is still a young field and will likely be a hot topic for some years. But, because of its great power, it may eventually be destined to permeate all areas of biology and to therefore disappear as a distinct discipline.

Daniel G. Gibson
Clyde A. Hutchison III
Hamilton O. Smith
J. Craig Venter