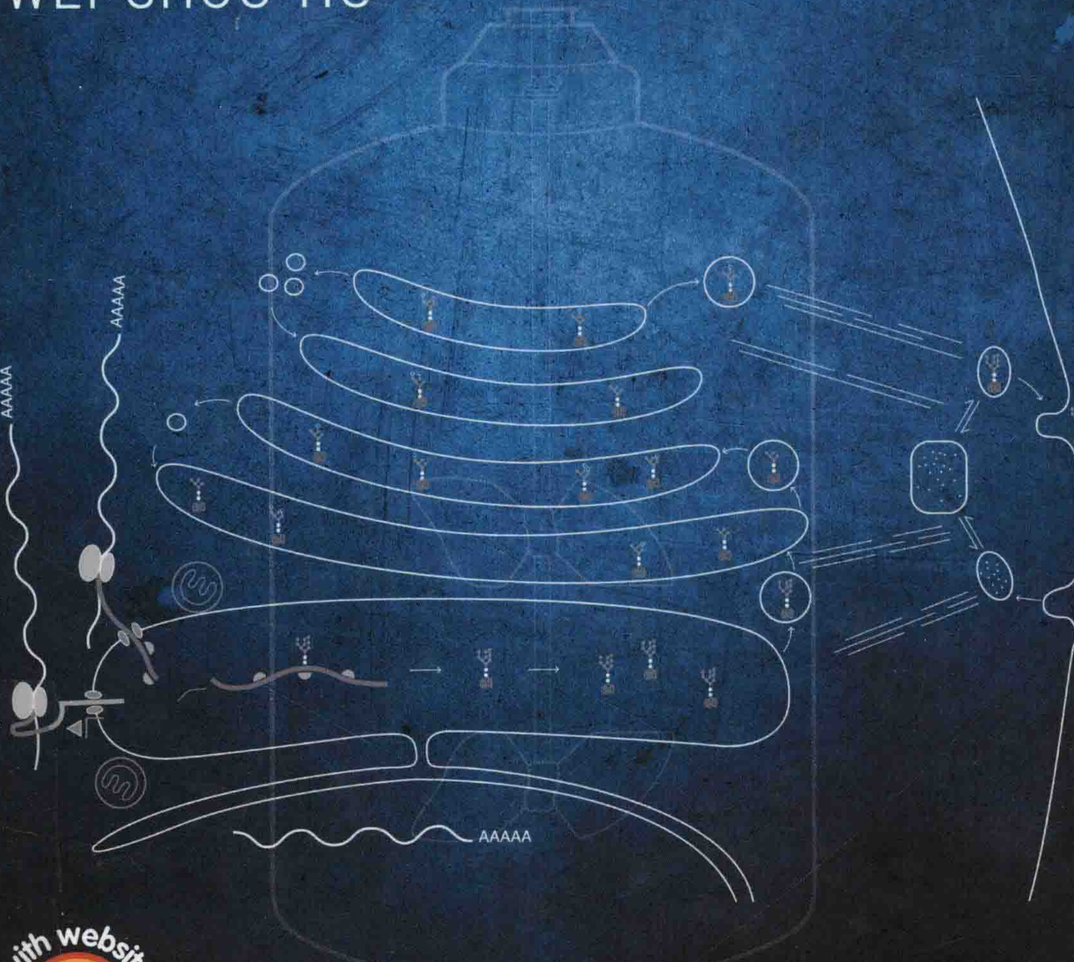
ENGINEERING PRINCIPLES IN BIOTECHNOLOGY

WEI-SHOU HU



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Engineering Principles in Biotechnology

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Engineering Principles in Biotechnology

This book is dedicated to Jenny, Kenny, and Sheau-Ping.

Preface

Bioprocesses use microbial, plant, or animal cells and the materials derived from them, such as enzymes or DNA, to produce industrial biochemicals and pharmaceuticals. In the past two decades, the economic output from bioprocesses has increased drastically. This economic growth was the result of the translation of numerous discoveries to innovative technologies and manufactured products. The success has brought together numerous scientists and engineers of different disciplines to work together to break new ground. The task of taking biotechnological discoveries to a successful product or process requires a multidisciplinary team consisting of engineers and chemical and biological scientists to work synergistically. The success of a project, a team, or even a company in biotechnology often hinges on the ability of scientists and engineers of different specialties to work effectively together. This book has been written with this important characteristic of the bioprocess industry in mind. A major goal of the book is to give students the necessary vocabulary and critical engineering knowledge to excel in bioprocess technology.

This textbook is based on a biochemical engineering course that has been offered at the University of Minnesota for a number of years. The contents are intended for a semester course of about 14 weeks of three lecture-hours a week. Although the majority of the students taking this course are senior undergraduate and graduate students from chemical engineering and bioengineering, nearly one-third are graduate students from a life science background. An emphasis of the content and writing of the book is thus the fundamental engineering principles, the quantitative practice, and the accessibility of analysis for students of different backgrounds. The target audience of the book is not only students taking the biochemical engineering or bioprocess engineering courses given in chemical engineering or bioengineering programs but also students in biotechnology programs that are outside of the chemical engineering disciplines, especially in countries outside North America.

In writing this book, I assumed that the students have had at least one biology course, and have fundamental knowledge of carbohydrates, DNA, RNA, proteins, and other biomolecules, as is the case for most engineering students nowadays. Nevertheless, students from both engineering and life science backgrounds will encounter new vocabulary and new concepts that will help them in cross-disciplinary communication once they join the biotechnology workforce.

Chapters 1 and 2 give an overview of organisms, cells and their components, how they become the product, and what the bioprocesses that produce them look like. Chapters 3 and 4 use basic biochemical reactions, especially the energy metabolism pathways, to familiarize engineering students with analysis of biochemical systems and to introduce the concepts of material balance and reaction kinetics to students with a life science background. For all students, these chapters introduce them to kinetic analysis of binding reactions, gene expression, and cellular membrane transport.

Chapters 5 and 6 cover the quantitative description of cell growth and the steady-state behavior in a continuous bioreactor. This paves the way for dealing with different types of bioreactors. Chapters 7, 8, and 9 are the core of bioreactor engineering, dealing with subjects important to process development. These chapters draw upon extensive practical interactions with industry to make them more relevant to bioprocess technology.

The next three chapters – 10, 11, and 12 – discuss three segments of bioprocesses. Cell culture processes, the subject of Chapter 10, currently produce goods valued over US$100 billion per annum. After introducing cell culture processes, the evolution of biomanufacturing and its life cycle is discussed. Chapters 11 and 12 look to the future on cell-based therapy and on the technologies arising from synthetic biology. In dealing with stem cells, the kinetic description of cellular differentiation is also introduced, and in discussing synthetic pathways the importance of using a stoichiometric relationship to determine the maximum conversion yield is reiterated. The last two chapters, 13 and 14, highlight the bioseparation processes. The overall strategy and the key concepts of various unit operations in bioseparation are covered briefly in Chapter 13. Chapter 14 focuses on the basic quantitative understanding of chromatography.

Writing this book has been a long undertaking. Many of my former and current graduate students have helped in formulating the problem sets and the examples. In preparing the book, I also took ideas from many textbooks on biochemical engineering, especially *Bioprocess Engineering: Basic Concepts* by Shuler and Kargi; *Biochemical Engineering Fundamentals* by Bailey and Ollis; *Fermentation and Enzyme Technology* by Wang, Cooney, Demain, Dunnill, Humphrey, and Lilly; and *Biochemical Engineering* by Aiba, Humphrey, and Millis. I extend my gratitude to my colleagues at the University of Minnesota, especially Arnold G. Fredrickson, Friedrich Srienc, Edward Cussler, Ben Hackel, Kechun Zhang, Samira Azarin, Efie Kokkoli, Yiannis Kaznessis, and Prodromos Daoutidis, for their stimulating discussion that helped shape the book. Finally, I thank Kimberly Durand for her editorial devotion to this book.

About the Companion Website

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www.wiley.com/go/hu/engineering_fundamentals_of_biotechnology

There you will find valuable material designed to enhance your learning, including:

- Panels in PowerPoint

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