1
Introduction and Overview

John Villadsen

COPYRIGHTED MATERIAL

Bioengineering is a relatively new addition to a long list of terms starting with "bio." It is broadly defined as "the application of engineering principles to biological systems." Bioengineering can include elements of chemical, electrical and mechanical engineering, computer science, materials, chemistry and biology. The systems that are analyzed range from cell cultures and enzymes applied in the bio-industry and in bioremediation to prosthetics, construction of models for organs such as liver, drug-delivery systems and numerous other subjects in biomedical engineering, all requiring an understanding of transport phenomena (mass, heat, and momentum transfer) and kinetics, combined in often large mathematical models. Besides a working knowledge of these core chemical engineering disciplines, a successful study of a problem in bioengineering requires an insight into the core disciplines of biology and biochemistry, specifically in human physiology when the goal is, for example, to construct a new cancer drug delivery system.

In this volume, coauthored by nine scientists, mostly working in academic institutions or in the bio-industry, the focus is on application of bioengineering in the emerging "white biotechnology" industry. The design of bioremediation systems closely follows the principles of analysis and design of industrial bioprocesses. This text will also prove valuable for environmental engineers. The biomedical applications of the text are, however, also quite obvious. Thus, the important but complex application of mesenchymal stem cells to treat osteoporosis is based on an optimal growth strategy of the cell culture on a scaffold at the right liquid flow with the right oxygen and nutrient availability. Here, kinetics and transport phenomena are coupled to basic biology and biochemistry, and design of the system is based on a complex model for the interaction between scaffold, cells, and nutrients.

In Chapters 5, 6, and 8, the reader will find self-contained accounts of the tools that together make it possible to understand the behavior of cell cultures and enzymatically catalyzed reactions: The interaction of metabolic network reactions in steady state and during transients, analyzed by mathematical models and solved by state-of-the-art computer software.

Fundamental Bioengineering, First Edition. Edited by John Villadsen.
© 2016 Wiley-VCH Verlag GmbH & Co. KGaA. Published 2016 by Wiley-VCH Verlag GmbH & Co. KGaA.

In Chapter 16, a structural framework for successful scale-up of bioreactions from laboratory scale to large industrial scale is presented. In Chapter 17, the sequence of management decisions that may lead to new business ventures in the bio-industry is discussed.

The analyses of cultures on the level of the cell are authored by three leading European scientists. Each author gives - as far as possible - a complete account of his subject, illustrated with examples and with sufficient detail to give readers, both in industry and in graduate classes at universities, a fair chance to understand and *utilize* the very powerful analytical tools presented in the three chapters.

The two Chapters 16 and 17 on large-scale bioreactors and on the business opportunities in the bio-industry are written by leading experts from two major bio-industrial companies, DSM in the Netherlands and Novozymes in Denmark. These chapters could serve as guidelines for prospective business ventures in the industry.

Although the focus of this book is on the bioreactor, Chapters 12 and 13 cover further processing of the effluent from the bioreactor. The author, a distinguished Indian bioscientist, gives a short introduction to the subject of downstream processing. Also, a survey of measuring, monitoring, and control of bioreactions is included. In Chapter 14, a leading expert on chemical analysis to capture key fermentation variables and on using the experimental data in analysis of fermentation broths gives an easy-to-read but largely complete survey of the subject. In Chapter 15, a young expert in control of chemical processes, discusses control problems in bioreactors, specifically addressing the challenges of bio-system control.

Finally, the content of the book is tied together by seven chapters (2, 3, 4, 7, 9, 10, and 11) written by the editor of this work. These chapters introduce a common nomenclature for the whole book, with introductory material on stoichiometry, kinetics, thermodynamics, and design of ideal and real bioreactors. It is hoped that the introductory chapters, illustrated with many simple examples, will make it easier to read the advanced chapters, especially since there are frequent cross references between introductory and advanced chapters.