Preface

Even though fermentation processes have been carried out since the beginning of the 20th century, biochemical engineering was first established as a field during the development of the industrial penicillin fermentation process. Before this process was implemented the fermentation industry was based on relatively primitive bioreactors and many new developments were necessary in connection with establishing a large-scale process for the production of the first pharmaceutical derived from a fermentation process. In particular, the requirements for large volumes of sterile air and for large power inputs led to completely new bioreactor designs. Later there were many developments in design of an optimal fermentation strategy, and biochemical engineers contributed significantly to the large increase in productivity and yield obtained over the years, e.g., through introducing advanced fed-batch fermentation. All these developments led to the establishment of biochemical engineering as a separate discipline. At this time, a biochemical engineer was traditionally a chemical engineer that received some training in the life sciences.

In the 1970s there was a rapid development in life sciences; many new enzyme processes were developed, many biochemical engineers started to construct detailed mathematical models for the biocatalyst, and biological waste water treatment was introduced extensively. At this time Springer started the book series *Advances in Biochemical Engineering* (*/Biotechnology* was added later), and in the first volume in 1971, Fiechter and Ghose (the founding editors) stated, "Biochemical engineering is concerned with the effective practical application of the knowledge amassed by the biological sciences." Along these lines, the first volume contained chapters on (1) the nature of fermentation fluids; (2) cell separation; (3) enzyme kinetics; (4) production and application of enzymes; (5) overproduction of microbial metabolites and enzymes; (6) production of biomass from hydrogen and CO_2; and (7) production of single-cell protein from hydrocarbons. The editors expressed a hope that the book series would assist in the development of the "yet to emerge hybrid discipline of biochemical engineering."

Since then we have realized a biological revolution. Over the years there has been a shift in focus among biochemical engineers from development of new unit operations towards the use of engineering principles to understand the molecular mechanisms governing a given process and to use this knowledge

for improving the process. This has particularly been manifested in the design of new enzymes through protein engineering and in the design of new cell factories for the production of a wide range of compounds. Thus, biochemical engineering today encompasses a wide range of activities and it would not be possible to include all aspects of modern biochemical engineering in one volume. However, the essence of biochemical engineering is basically the same as defined in 1971, namely *quantitative analysis of biological processes and use of this information for design of new molecules, cells, unit operations or complete processes.*

One area that has attracted much attention is the use of cell factories for the production of a wide range of chemicals. This area illustrates very well the definition of biochemical engineering specified above, and it has therefore been chosen as the focus of this volume. The use of cell factories for production of chemicals dates back to the production of penicillin, ethanol, acetone–butanol, glycerol and further to enzymes and other antibiotics. All these products were traditionally produced by cell factories that naturally produce these compounds. With the introduction of genetic engineering it has, however, become possible to combine traits from different organisms into a single cell factory, and thereby obtain a better production process – an approach referred to as metabolic engineering. This approach has been further supported by developments in genomics, which has enabled gaining much more detailed insight into the function of living cells at the systems level. This volume therefore contains chapters on concepts of metabolic engineering (by Stephanopoulos and coworkers), on detailed modeling of cellular systems (by Reuss and coworkers), on the use of plant cells for production of natural products (by Zhong and coworker), on the production of chemicals through the use of enzyme catalysis (by Bornscheuer), on the production of chemicals through the use of microbial cell factories (by Nielsen and coworkers), and finally on the control of fermentation processes through advanced monitoring techniques (by Ulber and coworkers). I hope you will enjoy reading the chapters and actively contribute to the further advancement of biochemical engineering in the future.

Lyngby, May 2005 Jens Nielsen