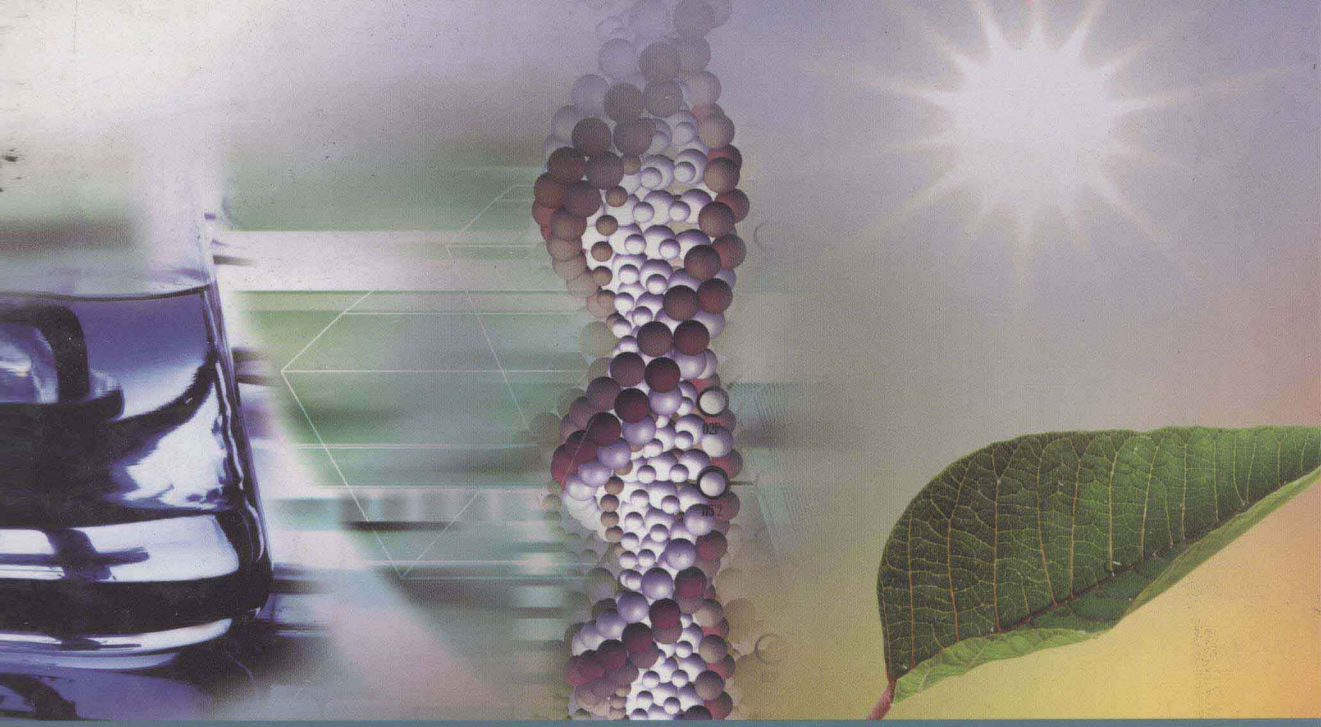

Modern Biotechnology

Connecting Innovations in Microbiology and Biochemistry to Engineering Fundamentals

NATHAN S. MOSIER MICHAEL R. LADISCH

WILEY

MODERN BIOTECHNOLOGY

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MODERN BIOTECHNOLOGY

PREFACE

Biotechnology has enabled the development of lifesaving biopharmaceuticals, deciphering of the human genome, and production of bioproducts using environmentally friendly methods based on microbial fermentations. The science on which modern biotechnology is based began to emerge in the late 1970s, when recombinant microorganisms began to be used for making high-value proteins and peptides for biopharmaceutical applications. This effort evolved into the production of some key lifesaving proteins and the development of monoclonal antibodies that subsequently have provedn to be effective molecules in the fight against cancer. In the late 1980s and early 1990s biotechnology found further application in sequencing of the human genome, and with it, sequencing of genomes of many organisms important for agriculture, industrial manufacture, and medicine.

The human genome was sequenced by 2003. At about the same time the realization developed that our dependence on petroleum and other fossil fuels was beginning to have economic consequences that would affect every sector of our economy as well as the global climate. Modern biotechnology began to be applied in developing advanced enzymes for converting cellulosic materials to fermentable sugars. The process engineering to improve grain-to-ethanol plants and the rapid buildout of an expanded ethanol industry began. This provided the renewable liquid fuels in small but significant quantities.

Thus biology has become an integral part of the engineering toolbox through biotechnology that enables the production of biomolecules and bioproducts using methods that were previously not feasible or at scales previously thought impossible. We decided to develop this textbook that addresses modern biotechnology in engineering. We started with the many excellent concepts described by our colleagues by addressing bioprocess engineering and biochemical engineering from a fundamental perspective. We felt that a text was needed to address applications while at the same time introduce engineering and agriculture students to new concepts in biotechnology and its application for making useful products. As we developed the textbook and the course in which this textbook has been used, the integration of fundamental biology, molecular biology, and some aspects of genetics started to become more common in many undergraduate curricula. This further expanded the

utility of an application-based approach for introducing students to biotechnology. This book presents case studies of applications of modern biotechnology in the innovation process that has led to more efficient enzymes and better understanding of microbial metabolism to redirect it to maximize production of useful products. Scaling up biotechnology so that large quantities of fermentation products could be produced in an economic manner is the bridge between the laboratory and broader society use.

Our textbook takes the approach of giving examples or case studies of how biotechnology is applied on a large scale, followed by discussion of fundamentals in biology, biochemistry, and enzyme or microbial reaction engineering. Innovations in these areas have occurred at an astounding rate since the mid-1990s. The current text attempts to connect the innovations that have occurred in molecular biology, microbiology, and biochemistry to the engineering fundamentals that are employed to scale up the production of bioproducts and biofuels using microorganisms and biochemical catalysts with enhanced properties.

The approach that we take treats microorganisms as living biocatalysts, and examines how the principles that affect the activity of microorganisms and enzymes are used in determining the appropriate scaleup correlations and for analyzing performance of living and nonliving biocatalysts on a large scale. Our textbook will hopefully provide the basis on which new processes might be developed, and sufficient background for students who wish to transition to the field and continue to grow with the developments of modern biotechnology industry. While we cannot hope to teach all the fundamentals that are required to cover the broad range of products that are derived using biotechnology, we do attempt to address the key factors that relate engineering characteristics to the basic understanding of biotechnology applied on a large scale.

October 7, 2008 NATHAN MOSIER AND MICHAEL LADISCH

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One of the authors (Michael Ladisch) wishes to convey his appreciation to the heads of the Agricultural and Biological Engineering Department and Weldon School of Biomedical Engineering at Purdue University for facilitating a partial leave of absence that is enabling him to work as Chief Technology Officer at Mascoma Corporation. As CTO, he is a member of the team building the first cellulose ethanol plant. It is here that some of the lessons learned during the teaching of this material are being put into practice.

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