

Swasti Dhagat
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N. S. Sampath Kumar
Chinmaya Mahapatra *Editors*

Recent Advances in Bioprocess Engineering and Bioreactor Design

 Springer

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Preface

In the current scenario, where the demand for innovations in bioprocess engineering is high, the book *Recent Advances in Bioprocess Engineering and Bioreactor Design* provides a comprehensive tool for the cutting-edge technologies in this discipline. This book explores all the areas of bioprocess technology, upstream and downstream processing, metabolic engineering, enzyme-catalyzed reactions, kinetics of microbial growth, bioreactor configurations, economics of bioprocesses, etc. The chapters are structured to provide a thorough understanding of each aspect, making it an invaluable resource for students, researchers, and professionals in the field.

Chapter 1 explores the stages in bioprocess technology—ranging from upstream processing, which includes inoculum development, media design, and bioreactor operation, to downstream processing, unraveling the complexities of product recovery and purification. Chapter 2 provides an insight into metabolic engineering, explaining the steps for the production of metabolites. Techniques such as pathway analysis, overexpression of key genes, and in silico metabolic engineering are meticulously discussed. Chapter 3 addresses the increasing importance of biofuels. From the types of preprocessing of lignocellulosic materials to in silico metabolic engineering, the chapter provides a comprehensive overview of strategies to enhance lipid synthesis, incorporating technological and computational advancements. Chapter 4 explores the fundamental concepts and applications of enzyme-catalyzed reactions, highlighting the versatility of enzymes in various industries. The chapter not only details the mechanisms of enzyme catalysis but also explores the emerging field of artificial enzymes, offering a glimpse into the future of biocatalysis.

From microbial growth assays to whole cell immobilization, Chap. 5 navigates through the various phases of microbial growth and the reactors employed in microbial cultivation. In-depth discussions on production kinetics and factors affecting microbial growth add depth to the understanding of this critical bioprocess aspect. Chapter 6 provides an exhaustive exploration of bioreactor configurations for fermentation processes. From traditional stirred tank bioreactors to advanced single-use bioreactors and novel photobioreactors, the chapter elucidates the design principles and control systems that drive these systems.

Chapter 7 ventures into downstream processing, unraveling the historical background and different stages involved. With a focus on integrated downstream processing unit operations, the chapter navigates through the complexities of separating and purifying diverse bioproducts, offering a comprehensive perspective on this crucial aspect of bioprocessing. Chapter 8 focuses on principles of basic and advanced techniques for the purification of enzymes. From traditional techniques like centrifugation to advanced chromatographic methods, the chapter details the isolation and extraction of enzymes, emphasizing their industrial applications. Chapter 9 delves into bioprocess strategies for the production of short-chain organic acids from microbial cells. With a focus on biosynthesis, strategies to improve production, and the role of metabolic engineering, the chapter sheds light on the challenges and prospects in this domain. The next two chapters are mainly dedicated to bioprocess strategies for plant cells. Chapter 10 explores metabolic burden analysis in in vitro culture of plants. By examining the kinetic parameters influencing cell stress, the chapter provides insights into optimizing plant cell cultures, offering a unique perspective on the intersection of plant biology and bioprocess engineering. Chapter 11 focuses on advances in bioreactor design for plant cell culture. The chapter explores the historical context, basic requirements, and various morphological forms relevant to plant cultivation in bioreactors, providing a comprehensive overview of this specialized field. Chapter 12 widens the scope to the role of nanotechnology and artificial intelligence (AI) in waste management. Covering nanomaterials, catalysts, and the application of AI across the waste management process, the chapter highlights the potential of these technologies to revolutionize the sustainability landscape. Chapter 13 focuses on the economics of fermentation processes. The chapter presents the factors affecting the cost of bioprocesses, offering insights into the estimation, optimization, and strain improvement strategies to maximize production while minimizing costs.

The book *Recent Advances in Bioprocess Engineering and Bioreactor Design* is a complete guide that connects basic principles with the latest technologies in the field. Each chapter reflects the combined knowledge of experts, offering readers a detailed insight into various aspects of bioprocess engineering. It reveals ways to innovate in the future, making it a guide for the upcoming generation of bioprocess engineers and researchers.

Acknowledgments

This book is a result of guidance and support of many people and organizations. The book editors want to express their thanks to everyone who helped with this project, especially the authors and reviewers. The book would not have been possible without their support.

Firstly, a big thank you to all the authors for their contributions. The editors appreciate the time and expertise that each chapter's authors dedicated to this book.

Secondly, the editors want to recognize the reviewers for their valuable contributions. The reviewers played a crucial role in enhancing the quality, coherence, and presentation of the chapters.

The editors express their gratitude to National Institute of Technology Raipur and Vignan's Foundation for Science, Technology and Research for providing the editors with the protected academic time and resource to pursue those goals.

Contents

1	Introduction to Bioprocess Technology	1
	Fariya Khan, Shadma Andleeb Khan, Gauresh Sharma, Reena Vishvakarma, Alvina Farooqui, Mohammed Haris Siddiqui, and Archana Vimal	
2	Understanding the Metabolic Pathways to Increase the Product Yield	25
	Surender Jangra, Soumita Paul, and Kongara Hanumantha Rao	
3	Metabolic Engineering of Lipid Biosynthesis Pathway to Enhance the Oil Content in Microalgae	37
	Zainab Mahmood, Mohit Nigam, and Lalit Kumar Singh	
4	Basic Concepts and Applications of Enzyme-Catalyzed Reactions for Biotechnology	65
	Kongara Hanumantha Rao, Somnath Sahoo, and Jeena Gupta	
5	Kinetics of Microbial Growth, Substrate Consumption, and Product Formation	75
	Smita Gupta and S. K. Sundar	
6	Bioreactor Configurations for Fermentation Processes	115
	Pritam Bajirao Patil and Angana Sarkar	
7	Downstream Processing for Bio-product Recovery and Purification	139
	Kumari Shanu, Sahdev Choudhary, Shalini Kumari, Kumari Anu, and Sarita Devi	
8	Principles of Basic and Advanced Techniques Used for the Purification of Enzymes of Industrial Importance	171
	Kongara Hanumantha Rao and S. Haseena	

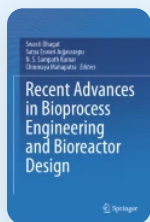
9	Bioprocess Strategies for the Production of Short-Chain Organic Acids from Microbial Cells	185
	Pratiksha Pundir, Harsha Shabhanani, and Amarchand Chordia Murugan	
10	Metabolic Burden Analysis in In Vitro Culture of Plants: A Bioprocess Strategy for Efficient Process Design	233
	Utkarsha Srivastava and Ashwani Mathur	
11	Advances in Bioreactor Design for Plant Cell Culture	251
	Tripti Singh and Ashwani Mathur	
12	Role of Nanotechnology and Artificial Intelligence (AI) in Waste Management	263
	N. Satya Vijaya Kumar, I. Sai Meghana, P. Pavani, N. S. Sampath Kumar, and Anjani Devi Chintagunta	
13	Economics of Fermentation Processes	287
	Swasti Dhagat and Satya Eswari Jujjavarapu	

[Home](#) > [Recent Advances in Bioprocess Engineering and Bioreactor Design](#) > Chapter

Introduction to Bioprocess Technology

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| pp 1–23 | [Cite this chapter](#)



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Abstract

Bioprocess technology is the amalgamation of technology with bioprocess which is the use of any living cell (microorganism or merely its enzymes) or one of its components with defined nutritive supplements and under controlled conditions to obtain a specific desirable product that is useful for mankind. Bioprocess technology is the alteration of significant processes to create value-added products. It deals with designing and developing equipment and processes for products such as food, chemicals, feed, nutraceuticals, amino acids, polymers, or abundantly required and useful pharmaceuticals such as antibiotics, viral vaccines, etc. The use of these processes can be traced back to as old as the ancient Egyptian period where unknowingly they employed this technology for the production of beers, wines, bread, cheese, yogurts, and fermented