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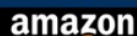


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Emerging Trends in Biotechnology

EMERGING TRENDS IN BIOTECHNOLOGY



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Emerging Trends in Biotechnology

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Preface

Biotechnology stands at the forefront of scientific innovation, transforming the way we understand and interact with living systems. From advancements in genetic engineering and molecular diagnostics to breakthroughs in sustainable agriculture, environmental management, and personalized medicine, the field continues to evolve at an unprecedented pace. The present volume, *Emerging Trends in Biotechnology*, thoughtfully edited by Dr. Imran Hussain and Dr. Sujeet Pratap Singh, brings together diverse perspectives and cutting-edge developments that reflect the dynamic nature of this discipline.

This book offers a comprehensive overview of contemporary research areas, including synthetic biology, bioinformatics, nanobiotechnology, and translational research. It highlights not only the scientific progress achieved in recent years but also the practical applications that address global challenges such as food security, climate change, and human health. By integrating theoretical insights with real-world applications, this volume serves as a valuable resource for students, researchers, and professionals alike.

Dr. Imran Hussain has meticulously curated contributions that emphasize interdisciplinary approaches and innovation-driven research. The chapters presented in this book underscore the

importance of collaboration between academia, industry, and policy frameworks in advancing biotechnology for societal benefit. Moreover, the inclusion of emerging tools such as artificial intelligence and omics technologies reflects the future direction of the field.

I am confident that this book will inspire readers to explore new ideas, foster critical thinking, and contribute to the advancement of biotechnology. It is a timely and significant contribution that will undoubtedly serve as a reference for years to come. I congratulate Dr. Imran Hussain for his dedicated efforts in bringing together this important work and extend my best wishes for its success.

Editors:
Dr. Imran Hussain &
Dr. Sujeet Pratap Singh

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Polyhydroxybutyrate (PHB): Microbial Production, Properties, Extraction and Biomedical Applications

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Abstract

Polyhydroxybutyrate (PHB), a member of the polyhydroxyalkanoate (PHA) family, is a biodegradable and biocompatible thermoplastic polymer synthesized by a diverse range of bacteria under nutrient-limiting conditions. This chapter explores the structural characteristics, physicochemical properties, biosynthesis pathways, physiological roles, and microbial sources of PHB. The ability of both Gram-positive and Gram-negative bacteria to produce PHB from various carbon sources makes it a promising alternative to petrochemical plastics. The metabolic pathways involved in PHB synthesis and degradation, including key enzymes such as PhbA, PhbB, and PhbC are discussed. Furthermore, the chapter examines the multifunctional role of PHB in microbial stress tolerance and its potential in biomedicine, particularly in tissue engineering and drug delivery. Different methods for PHB extraction, including solvent and surfactant-based techniques, are evaluated for their efficiency and environmental impact. With its wide range of applications, PHB stands at the forefront of sustainable materials research and development.

Keywords: Biodegradable polymer, Bioplastics, Polyhydroxybutyrate, Polyhydroxyalkanoates, Biosynthesis, Metabolic pathway, Microbial production, PHB extraction

1. Introduction

Plastics have become an integral part of modern life, permeating nearly every facet of human activity—from food and beverage containers to medical devices such as prosthetics. Despite their utility, the widespread use of conventional plastics, primarily derived from petrochemical sources, poses a significant environmental threat due to their persistence and resistance to natural degradation processes (Verma et al., 2020). Synthetic polymers like polystyrene, synthesized from styrene monomers, are particularly noted for their physical attributes—transparency, thermal resistance, chemical inertness, and mechanical strength—which contribute to their widespread use (Antonietti et al., 2011). However, these same properties also render them non-biodegradable, leading to critical issues in waste management and ecological sustainability.

In light of these challenges, the development of biodegradable alternatives has become a global imperative. Bioplastics, synthesized from renewable biomass such as corn starch, pea starch, vegetable oils, and microbial sources, offer a promising alternative. Unlike petroleum-derived plastics, bioplastics are designed to degrade under natural environmental conditions, thereby reducing the long-term accumulation of plastic waste and its associated carbon footprint (Mishra et al., 2010; Sen et al., 2011). Many of these materials can be broken down via aerobic or anaerobic microbial processes, making them more environmentally benign. Key biopolymeric constituents include starch, cellulose, proteins, and aliphatic polyesters such as polyhydroxyalkanoates (PHAs) (Mohanty et al., 2020).