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Industrial Applications for Bioprocessing and Biomanufacturing

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Chapter 1

An Introduction to Bioprocessing and Industrial Bio- Manufacturing Foundation and Evolution

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ABSTRACT

This chapter highlights the transformative potential of bioprocessing and biomanufacturing as central forces in biotechnology, ecology, and medicine. Bioprocessing is the foundation of modern biotechnology because it actively employs biological systems to produce valuable compounds while simultaneously addressing urgent global challenges. Through carefully designed processes, bioprocessing mitigates climate change, strengthens ecosystem resilience, and responds to the escalating demands of global population growth by enabling sustainable production of food, medicines, and renewable energy. Emphasize that bioprocessing not only creates bio-based

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products but also reshapes industrial practices by reducing dependence on fossil resources and promoting environmentally responsible alternatives demonstrate that bioprocessing and biomanufacturing serve as vital engines of innovation in biotechnology, ecology, and medicine.

INTRODUCTION

Bio-processing is the multidisciplinary science that encompasses technology, engineering, and biology in order to develop products using biological systems. It plays a vital role in businesses such as environmental management, food production, agriculture, and pharmaceuticals.

Definition and Scope of Bioprocessing

Bioprocessing is defined as the process that uses biological systems, such as microorganisms, enzymes, plant or animal cells, and their components to produce valuable products or to induce predetermined biochemical changes, (Abu, Gundersen, & Woodley, 2015). Fundamentally, it integrates biology with engineering to develop, optimize, and scale processes that transform feedstock into a valuable product. Biotechnology applications are interdisciplinary and include upstream processing (i.e. growth and cultivation of biological materials), downstream processing (i.e. recovery, purification, and formulation of products), and process optimization (i.e. efficiency, scalability, and regulations), (Azubuike, Chikere, & Okpokwasili, 2016). The most impact it has had is within the pharmaceutical industry allowing for the mass production of therapeutic proteins, monoclonal antibodies, recombinant therapies and therapies based on gene and cell treatment, (Bailey & Ollis, 2018). Bioprocessing also has applications other than in healthcare. For instance, in the bioenergy sector, it promotes the manufacture of advanced biofuels, such as bioethanol, biodiesel, and biogas, so as to mitigate the dependence on fossil fuels, (Barrangou & Doudna, 2016). In the food and beverage sector, fermentation processes form the basis for the production of essential foodstuffs like bread, cheese, yoghurt, beer, among other modern probiotics and functional foods that promote the health of the gut, (Bhardwaj et al., 2014). Bioprocessing also leads to new bioproducts such as bioplastics, biosensors, and artificial biomolecules with broad applications. Recent innovations in bioengineering and genetic engineering have made it possible to develop stable, high-yield microbial and mammalian cell “factories”, whereas synthetic biology is providing new opportunities for the manufacture of sustainable bio-based materials. It further enables speedy process development, real-time process optimization and quality control, and as a result, bioprocesses are becoming a core technology shaping medicine, food, energy and sustainable industries, (Buchner & Rapp, 1899; Bud, 1994).

History and Evolution of Bioprocessing

Bioprocessing dates back millennia, with early applications of fermentation by ancient societies such as Mesopotamia and Egypt to preserve food, bake bread, and create alcohol, (Butler, 2005). At the time, the important part played by microorganisms was not yet known, but these early processes paved the way for the use of microbes in today's biotechnological food production. The industrial revolution of the 19th century led to a revolution in human microbiology, with Louis Pasteur putting science on a new path when he eventually showed that microbes

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