Chapter 4
Sustainable and Eco-Friendly Nanomaterials: Innovation for Eco-Friendly Green Healthcare Solutions

Anita Restu Puji Raharjeng
https://orcid.org/0000-0002-8308-4574
Universitas Islam Negeri Raden Fatah Palembang, Palembang, Indonesia

Evika Sandi Savitri
Universitas Islam Negeri Maulana Malik Ibrahim, Malang, Indonesia

Ruqiah Ganda Putri Panjaitan
https://orcid.org/0000-0002-2194-8808
Tanjungpura University, Pontianak, Indonesia

ABSTRACT

This book chapter elucidates key concepts such as the molecular mechanisms of life, biomolecular synthesis, bioenergetics, and chemical interactions within biological systems. This integrated approach is designed to support a science curriculum that meets contemporary needs, emphasizing the exploration of real-world phenomena through laboratory experiments, digital simulations, and cutting-edge technological applications. This book chapter also highlights the importance of global issues such as climate change, waste management, and public health in the context of biology and chemistry. With a research-driven methodology and problem-based learning approaches, it offers practical guidance for educators, students, and researchers to effectively apply molecular science in various academic and industrial contexts. Through educational innovation and cross-disciplinary integration, Molecular Revolution aims to inspire transformation in science teaching and learning, build-

DOI: 10.4018/979-8-3373-1305-4.ch004

ing a strong foundation for future generations to address global challenges with knowledge and empathy.

1. INTRODUCTION

The need for sustainable innovations has gained widespread attention in recent decades due to growing environmental challenges. The healthcare industry, while primarily focused on improving human health and well-being, has a significant environmental footprint that cannot be ignored. Traditional healthcare systems contribute to a range of environmental issues, including the generation of large amounts of hazardous medical waste, high consumption of non-renewable resources, and significant greenhouse gas emissions (Hamad et al., 2014; Stoner, 1986). Hospitals, for instance, are energy-intensive institutions that produce vast quantities of waste, including disposable medical tools, pharmaceutical byproducts, and single-use plastics (McGain, 2015). Furthermore, the carbon footprint associated with the global supply chain of medical devices, pharmaceuticals, and healthcare infrastructure compounds the environmental burden.

These challenges call for a fundamental transformation of how healthcare services are designed and delivered. Sustainability in healthcare requires innovative solutions that minimize environmental impact while maintaining or improving patient outcomes. One of the most promising areas of innovation is the use of sustainable and eco-friendly nanomaterials. Nanotechnology, with its ability to manipulate materials at the atomic and molecular levels, offers revolutionary possibilities for creating solutions that are not only efficient but also environmentally conscious (Malik et al., 2023). Nanomaterials exhibit unique properties, such as high surface area, tunable chemical and physical characteristics, and biocompatibility, making them ideal candidates for addressing a wide range of healthcare needs (Kyriakides et al., 2021).

The application of eco-friendly nanomaterials holds immense potential in redefining healthcare practices (Aithal et al., 2021a). For instance, nanomaterials can enhance the delivery and efficacy of drugs, allowing for targeted therapies that reduce dosage requirements and minimize side effects (A. P. Singh et al., 2019). Biodegradable nanomaterials can replace conventional non-degradable plastics in medical devices, reducing the accumulation of medical waste (Kothawade et al., 2024). Similarly, nanotechnology can be used to develop antimicrobial coatings for surgical instruments and hospital surfaces, minimizing the risk of healthcare-associated infections while reducing the need for chemical disinfectants that can harm the environment (Alhmoud, 2024a).