# Chapter 4
# From Imaging to Drug Delivery and Treatment: Nano-Biomaterials for the Nervous System Disorders

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## ABSTRACT

*Nano-sized particles, ranging from 1 to 100 nm, uniquely traverse blood vessels and cell membranes, making nano-biomaterials highly promising for treating brain and nervous system disorders. Their small size facilitates efficient drug delivery, enabling them to penetrate the blood-brain barrier as effective nanocarriers. Additionally, nanoparticles play a crucial role in diagnosing various conditions, especially neurological disorders, allowing for non-invasive imaging of the brain and nervous system. Nano-biomaterials can potentially mitigate the irreversible effects of conditions like Alzheimer's and Parkinson's diseases. Various types of nanomaterials, including metal-based nanoparticles (e.g., gold nanoparticles), carbon nanotubes, silicon nanoparticles, nanocrystals, nanodiscs, liposomes, micelles, and polymeric nanoparticles, are applicable to neurological disorders. This chapter aims to explore the applications of nano-biomaterials in the diagnosis and treatment of nervous system disorders, highlighting their innovative contributions to modern medicine.*

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## 1. INTRODUCTION

The nervous system is a complex network responsible for controlling and coordinating body functions and is particularly vulnerable to a variety of debilitating conditions, such as neurodegenerative disorders, traumatic injuries, and congenital abnormalities (García-González et al., 2024; Haikal & Weissert; Ng & Lee, 2019; Palanisamy et al., 2023; Shi et al., 2024). These neurological disorders often cause consequential morbidity and mortality, leading to a major challenge to healthcare systems around the globe (Hubbers, 2022; Lee, 2009; Steinmetz et al., 2024). Although there is continuous advancement in medical science, drug delivery into brain for treat these disorders remains challenging due to the presence of the blood-brain barrier (BBB) (Sheykhhasan et al., 2022). BBB causes limitations in delivering therapeutic agents to the brain whereas the nervous system has limited capacity for self-healing (Furtado et al., 2018; Hersh et al., 2022). To overcome these limitations, nanotechnology has shown promising advances. Nanotechnology, an interdisciplinary field, involves manipulating materials at the nanoscale, typically ranging from 1 to 100 nanometers. At this scale, materials display unique properties that are significantly different from their bulk forms, including enhancement in their electrical, optical, and mechanical characteristics (Rezghi Rami et al., 2024). The convergence of nanotechnology with biology has led to the development of nano-biomaterials, that are designed for specific biomedical purposes, particularly within the nervous system. These materials are engineered to interact with biological systems at the molecular level. This makes them highly potential to promote neural repair and regeneration (Erisen & Uludag, 2024).

Nano-biomaterials have brought significant improvement in nervous system applications by their potential in delivery of different materials in addition to creating a supportive environment for cell growth, differentiation, and imitation of the natural extracellular matrix (ECM). Due to their minute size, these materials can cross biological barriers, making them ideal for drug delivery that aims to target the central nervous system (CNS). Additionally, it is possible to enhance them with bioactive molecules to reduce probable side effects and increase their therapeutic effectiveness. In the case of repairing the nervous system, nano-biomaterials can be utilized to make scaffolds that boost neural tissue regeneration or to deliver neuroprotective agents directly to the injury site. These applications are vital in the treatment of neurodegenerative diseases and injuries that conventional therapies often fall short (Haleem et al., 2023; Logothetidis, 2011; Dur E Nayab et al., 2023). Biomaterials are specially designed substances for the purpose of interacting with biological systems for therapeutic or diagnostic purposes. Unlike biological materials produced by living organisms, biomaterials are synthesized to replace, enhance, or interact with living tissue, making them essential in medical advancements (e.g., drug delivery systems, tissue engineering, and implants). The field of biomaterials has progressed significantly, drawing on disciplines such as physics, biology, chemistry, and engineering to develop biocompatible materials. Biomaterials can be categorized into structural and functional types. Structural biomaterials such as titanium is used in joint replacements to provides physical support (Cao & Ding, 2022; Chen et al., 2020). As technology advances, there is a growing emphasize in developing materials that not only replace damaged tissues but also promote healing and regeneration, offering significant potential specially in the field of nervous system repair. The potential of nano-biomaterials in revolutionizing nervous system disorder treatments continues to expand (De et al., 2022) (Figure 1).