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A Review on Bioactive Heterocycles for Treating Neurodegenerative Disorders

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Abstract

Neurodegenerative disorders such as Alzheimer’s disease, Parkinson’s disease, Huntington’s disease, and amyotrophic lateral sclerosis represent major challenges to global healthcare due to their progressive nature, complex pathophysiology, and limited availability of effective disease-modifying therapies. Bioactive heterocyclic compounds have attracted considerable attention in medicinal chemistry because of their diverse structural characteristics, favorable biological activities, and potential to interact with multiple molecular targets involved in neurodegeneration. This review provides an overview of the therapeutic potential of biologically active heterocycles in the management of neurodegenerative disorders. Particular emphasis is placed on important heterocyclic scaffolds, including nitrogen-, oxygen-, and sulfur-containing compounds, and their reported neuroprotective, antioxidant, anti-inflammatory, anti-amyloidogenic, and enzyme-inhibitory activities. Several heterocyclic derivatives have demonstrated the ability to modulate targets such as acetylcholinesterase, monoamine oxidase, oxidative-stress pathways, protein aggregation, and neuroinflammatory mechanisms. The review also highlights the structure–activity relationships of selected heterocyclic compounds and discusses how molecular modification can improve potency, selectivity, bioavailability, and blood–brain barrier penetration. Despite promising preclinical findings, challenges remain concerning toxicity, pharmacokinetic properties, metabolic stability, target selectivity, and translation from experimental models to clinical applications. Advances in computational drug design, molecular docking, artificial intelligence, and multi-target-directed ligand strategies may facilitate the development of more effective heterocyclic therapeutics. Overall, bioactive heterocycles represent a valuable and versatile source of lead compounds for neurodegenerative disease research, and continued interdisciplinary investigation may contribute to the discovery of safer and more effective therapeutic agents.

Keywords: Bioactive Heterocycles, Neurodegenerative Disorders, Alzheimer’s Disease, Parkinson’s Disease, Neuroprotection, Antioxidants, Anti-inflammatory Activity, Acetylcholinesterase Inhibitors, Drug Design, Medicinal Chemistry.

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