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Artificial Intelligence in Genomics and Proteomics: Advancing Multi-Omics Integration for Precision Medicine and Drug Discovery

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ABSTRACT

Biomedical research, clinical diagnostics, and pharmaceutical innovation are all changing as a result of the confluence of high-throughput omics technology with artificial intelligence (AI). Genomics and proteomics provide complementary insights into biological systems, although when analysed in isolation they fail to represent the complexity emerging from post-transcriptional regulation, post-translational alterations, and dynamic molecular interactions. Integrative approaches, particularly AI-driven Multiomics are gradually overcoming this gap by enabling holistic interpretation from DNA sequence to protein structure and function. This review synthesises recent advances in AI applications across genomics, proteomics, and their integration, highlighting the roles of machine learning and deep learning in variant detection, biomarker discovery, protein structure prediction (e.g., Alpha Fold), and functional annotation. We further reviewed the impact of AI on drug discovery and development; including target identification, lead optimisation, generative molecular design, formulation optimisation, and smart manufacturing. Practical applications of next-generation sequencing (NGS) in research, diagnostics, oncology, infectious illnesses, and forensics are presented alongside developing AI frameworks such as transformer-based models, graph neural networks, and generative biology platforms. Critical issues like as data heterogeneity, bias, the restricted interpretability of complex models, computational limitations, and ethical and legal concerns around data privacy and clinical deployment still exist despite significant advancements. Overall, the integration of AI with genomes and proteomics has considerable promise for increasing precision medicine, expediting drug discovery, and determining the future of predictive and preventative healthcare.

Keywords: *Artificial intelligence, Deep learning, Genomics, Next-generation sequencing, Drug discovery*

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