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The Role of AI in Advancing Biotechnology: Current Applications & 58 Free AI tools & Future Trends & Implications for Global Health Equity

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Abstract

In the field of biotechnology, the tremendous thrust that AI has unleashed has expedited various aspects such as drug discovery, genomic analysis, optimization of bioprocesses, and agriculture and marine biotechnology. This paper analyzes the state of art of AI applications in biotechnology at present, the future trends, and its possibility to help rapprochement between lower-income and high-income countries. Through the combination of recent literature and case studies, this work points out the ability of AI to fast-track biotechnological innovations while solving essential global issues like health equity. Yet, it also weighs in the danger that AI may further these inequalities unless it is implemented with inclusion and representation. Based on AI in biotechnology, this research offers a multidisciplinary view that advocates solutions tailored at the local level, the building of functional capacities, and the enactment of equitable policies that guarantee the benefits of AI are benefited by all countries. Subsequently, a panoramic review of 58 free-of-charge AI tools and platforms is offered, demonstrating the size and depth of AI impact on the biotechnology arenas and hence is a good resource for researchers, trainers, and policymakers for whom they intend to understand and harness these tools, that are open-source. Although this work is a review, it provides a structured, data-informed synthesis—including a curated list of 58 freely accessible AI tools—intended as a practical resource to support reproducibility, translational research, and strategic integration of AI in experimental biotechnology workflows.

Keywords

Artificial intelligence; biotechnology; drug discovery; genomic analysis; bioprocess optimization; agricultural biotechnology; health equity; free AI tools; low- income countries; high-income countries

1. Introduction

Biotechnology is the use of biological systems and organisms to create technologies for human benefit. With the development of AI, this field has gained a terrific edge. AI computing enables the analysis of large-scale datasets, pattern recognition, and predictive modeling, thereby facilitating significant advancements in drug discovery and agricultural biotechnology [1]. The paper aims to discuss whether AI truly is making a difference in biotechnology and in what areas—presenting detailed examples with the existing applications, development trends, and a view on whether AI could be useful to close the gap between LIC and HICs regarding health issues.

Thus, going beyond technological advancement, the integration of AI in biotechnology poses some very grave matters before humankind, including food security, disease treatment, and environmental sustainability. At one end of the drug discovery spectrum, AI can cut down the time and costs for making new medicines. On the other hand, with agriculture, it promises to achieve high yields, which is crucial for feeding the hungry [2]. Some predict the value generation by AI in the pharmaceutical sector alone could be between \$350 billion and \$410 billion per annum by 2025, that is to say, a considerable influx of innovations across the R&D spectrum [3].

Despite its transformative potential, AI poses considerable risks, particularly the exacerbation of socioeconomic disparities between high-income and low-income countries. Research seems to suggest that unless inclusive strategies are designed, AI matrix of AI investments could be lopsided towards HICs, leaving LICs behind [4]. This paper addresses the utilization of AI to close the gap between different social-economic entities and countries, and determine challenges that need to be tackled to realize equitable development.

The use of AI in biotech is well known, yet a full view that ties tech use, future paths, and deep social effects—mainly for health fairness worldwide—is still broken up. The quick growth of many AI tools makes a hard scene that is difficult for experts and rule makers to get through. Also, the rapid tech jumps can hide the substantial moral and social issues they bring.

This study argues that although AI is accelerating biotechnological innovation and enabling unprecedented tool development, its true benefit to global health depends on addressing ethical concerns and implementing equitable access strategies, particularly in low-resource settings. If not handled well and open to all, the same tech that may heal sickness and feed the world might just make wide gaps deeper.

2. Current Applications of AI in Biotechnology

AI has made big steps into many parts of biotech. It makes processes faster, more accurate, and up to date. Here are main parts where AI is now used, shown by new books and studies.

2.1 Drug Discovery and Development

The conventional method of drug development is lengthy, costly, and fails often. AI is addressing key limitations at multiple stages of the drug development pipeline. At the start, AI programs look over data about genes, proteins, and health to find new targets that might work well as treatments [5]. Organizations such as BenevolentAI utilize machine learning-generated networks linking drugs, diseases, and gene targets to uncover novel therapeutic associations between genes, sickness, and drugs [6].

When they find a target, the job moves to make a new possible drug that can work on it. Here, Google DeepMind's AlphaFold advanced this field. It can guess the 3D shape of proteins from parts of them with great detail. AlphaFold has fixed a complex problem in biology [7]. Its large database of Protein Structures, with over 200 million guesses, gives researchers a huge help in designing drugs based on in-silico simulations, making drug discovery approachable [8]. See in fig 1.

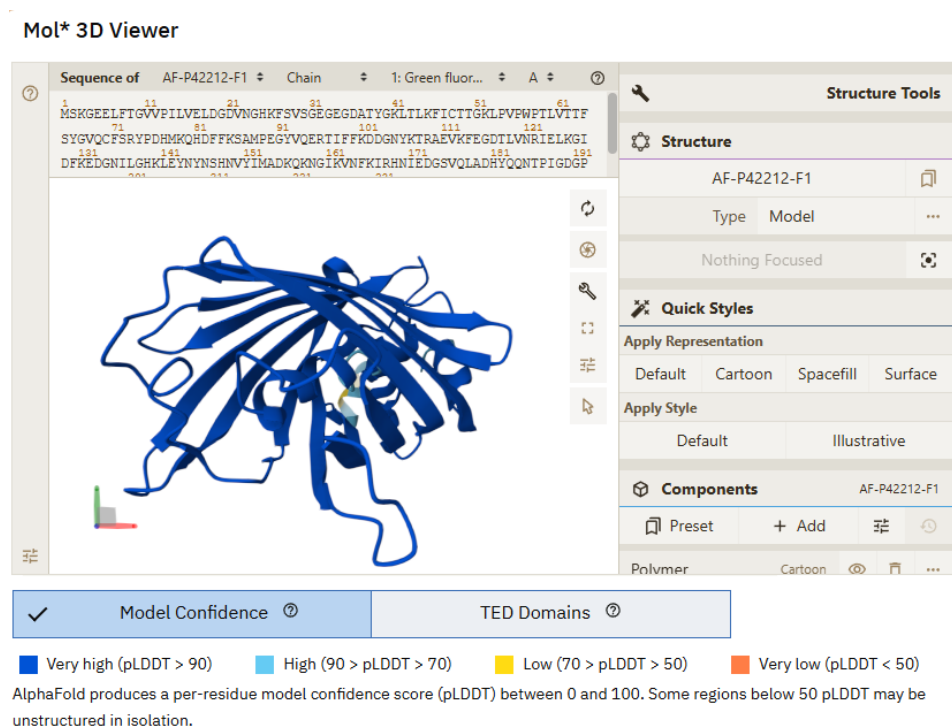


Fig 1. The molecular structure 3D viewer in AlphaFold. Depicted is the 3D structure of green fluorescent protein.

On this point, Companies such as Exscientia and Insilico Medicine are leveraging AI to design novel drug candidates from first principles. Several drug candidates developed using AI

algorithms have entered clinical trial phases, highlighting the technology's growing translational impact [9]. For one, groups like Atomnet use deep AI nets to find drug shapes [10]. Also, groups like Recursion Pharmaceuticals chart life with auto tests & AI to seek new cures [11].

2.2 Genomic Analysis and Personalized Medicine

The advent of next-generation sequencing (NGS) has produced a deluge of genomic data, but its clinical utility depends on our ability to interpret it accurately. AI is proving indispensable for this task. Tools like Google's DeepVariant use deep convolutional neural networks to call genetic variants from sequencing data with superior accuracy compared to traditional methods [12]. This enhanced precision is crucial for identifying disease-causing mutations and informing personalized treatment strategies.

Furthermore, AI is refining the power of gene-editing technologies like CRISPR-Cas9. Designing the guide RNA (gRNA) that directs the Cas9 enzyme to its target is critical for both efficacy and safety. AI models can predict the on-target efficiency and, more importantly, the off-target effects of gRNAs, allowing researchers to select the safest and most effective sequences for therapeutic applications [13]. This synergy between AI and gene editing is accelerating the development of personalized medicines tailored to an individual's unique genetic makeup, with profound implications for treating genetic disorders.

For instance, DeepCRISPR, developed by multiple research groups, is a deep learning tool designed to predict gRNA efficiency and specificity [14]. Similarly, OpenCRISPR-1, developed by Profluent Bio, shown in fig 2, is an AI-generated, open-source gene editor designed for high precision in genetic modifications [15].

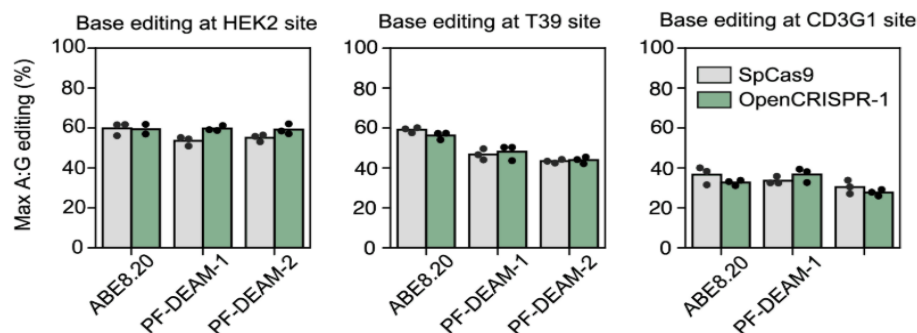


Fig 2: OpenCRISPR-1 enables efficient base editing when paired with the hyperactive deaminase ABE8.20, as well as with the newly developed deaminases PF-DEAM-1 and PF-DEAM-2, demonstrating functionality comparable to SpCas9. (profluent.bio)

2.3 Bioprocess Optimization

Large biopharmaceutical companies utilize advanced AI models to optimize complex bioproduction processes, such as vaccine and biologic manufacturing. AI & learn tech help make these steps work better & make more. For a case, in the growth of CHO cells—a key source for meds—learn tech goes through old facts to find the best way to grow, which boosts the work done [16].

Some firms make "digital twins," which are web forms of real bio-tasks. AI-driven simulations, or 'digital twins', optimize bioprocesses by predicting system requirements and outcomes in advance, thereby reducing experimental costs and time, thus spending less time in development of therapeutics, without the high-cost real tests [17]. Biocellion, as seen in fig 3, has a tech AI that makes & shows how cells act, setting up a digital twin for bio-tasks advancement [18].

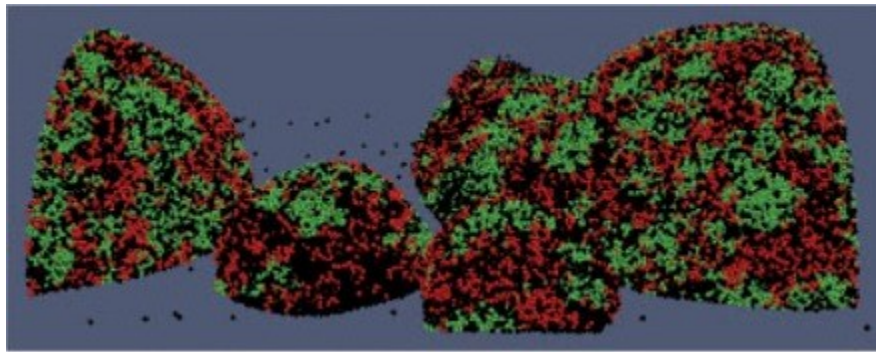


Fig 3. Microbial patterns simulated using Biocellion. The black (R strain) and green (G strain) cells interact in a way that causes them to mix together. The black spheres represent dead cells.

In biomanufacturing, AI-driven predictive maintenance reduces downtime and costs by anticipating equipment failures [19]. These advancements are critical for scaling up the production of biologics, such as vaccines and monoclonal antibodies, making them more accessible.

2.4 Agricultural Biotechnology

With climate change and a growing global population, AI is becoming a pillar for sustainable agriculture. AI empowered drones and satellites work in concert with on-field sensors to observe crop health on a real-time basis in precision agriculture. Such systems may pick up early symptoms of disease, insect pest or nutrient deficiency symptoms, which allows measures to be taken only when they are really necessary and that improves the management of water, fertilizers and pesticides [20]. These systems to enhance crop yield while improving eco-sustainability.

AI is also speeding crop improvement using biotechnology. Leveraging huge plant genomic data sets, AI models can recognize genetic markers linked to beneficial genetic traits such as drought resistance or disease resistance. These provide knowledge to guide faster and more precise breeding and gene editing of climate resilient crops [21].

Tools like Taranis deploy an AI-driven crop intelligence platform with the aid of aerial imagery to monitor [22] shown in fig 4, whilst Blue River Technology (acquired by John Deere) employ computer vision and AI for smart weeding [23]. Some similar initiatives such as FarmBot propose open robotics for automatic small-scale AI-based farming [24].



Fig 4: High-resolution aerial imagery highlighting leaf-level details, demonstrating the influence of environmental factors on crop health. This image is from Taranis' Insight Gallery, showcasing real-world applications of precision agriculture.

2.5 Marine Biotechnology

It is becoming more common to utilize AI tools to analyze marine genomic data in the search for new bioactive compounds for use in medicines and other applications [25]. Predictive modelling can also assist in sustainable management of marine ecosystems by predicting the response to environmental change [26]. These applications also exemplify the contribution of AI in exploiting marine biodiversity for biotech related purposes.

For example, there are programs such as Tinybio designed for the analysis of microbiome and metagenomics, which can be used to explore marine environment in search for new enzymes and bioactive compounds of pharmaceutical or industrial interests [27].

3. A Comprehensive Landscape of AI Tools and Platforms in Biotechnology

In order to understand the path of AI in biotech, you need to learn about the specific tools and platforms making these strides possible. The AI software ecosystem is huge and growing fast, spanning through every phase of the research and development process. A total of 58 AI tools that are free have been collected in Table 1 below, and are classified according to their main application area. This map of the field of AI, with the foundation of basic research and realization of clinical application, provides a useful reference for the researchers in this field.

Table 1: summarizing 58 AI tools in biotechnology freely available in various fields.

No.	Tool Name	Field of Application	Year	Short Description	Link
1	OpenCRISPR-1	Gene editing	2024	AI-designed CRISPR-Cas system for precise and customizable gene editing.	link
2	AlphaFold	Protein structure prediction	2021	Predicts 3D protein structures from amino acid sequences with high accuracy.	link
3	DeepVariant	Genetic variant calling	2018 (updated 2020)	Uses deep learning for high-accuracy genetic variant identification.	link
4	DeepCRISPR	CRISPR guide RNA design	2020	Predicts efficiency and specificity of guide RNA sequences for CRISPR-Cas9.	link
5	DeepChem	Drug discovery, materials science	2016 (updated 2020)	AI for molecular modeling, drug discovery, and materials science.	link
6	MetaPhlAn	Microbiome analysis	2011 (updated 2023)	Profiles microbial communities from metagenomic data using AI-driven methods.	link
7	EV Couplings	Protein and RNA structure prediction	2015 (updated 2021)	Uses evolutionary couplings for protein and RNA structure prediction.	link
8	EVE	Genetic variant prediction	2021	Predicts pathogenicity of genetic variants using machine learning.	link
9	RoseTTAFold	Protein structure prediction	2021	Deep learning for protein folding predictions, inspired by AlphaFold.	link
10	scVAE	Single-cell RNA-seq analysis	2020	Variational Autoencoder for analyzing single-cell transcriptomic data.	link
11	TorchDrug	Drug discovery	2021	Deep learning platform for drug discovery and molecular design.	link
12	OpenFold	Protein structure prediction	2022	Open-source protein folding prediction inspired by AlphaFold2.	link
13	OpenFold-Multimer	Protein-protein interactions	2022	Predicts protein complexes for drug design and molecular engineering.	link

14	OpenFold-SoloSeq	Protein structure prediction	2022	Predicts protein structures without multiple sequence alignments.	link
15	ESMFold	Protein structure prediction	2022	AI model for protein folding from Meta AI Research.	link
16	Boltz-1	Protein structure prediction	2024	AI model for predicting biomolecular interactions, matching AlphaFold3 accuracy.	link
17	BioAutoMATED	Machine learning model generation	2023	Automated machine learning platform for biological sequence analysis.	link
18	DeepChain Apps	Protein research	2022	AI tools for protein research and design tasks.	link
19	Bio-Transformers	Protein sequence analysis	2022	Simplifies interaction with protein sequence models for research.	link
20	Bio-Datasets	Biological data analysis	2022	Open-source collection of biology datasets for training AI models.	link
21	AminoAnalytica	Protein engineering	2024	AI for protein design and analysis, free for academic use.	link
22	Neurosnap	Bioinformatics	2023	Online bioinformatics tools for fast, code-free analysis, including protein design.	link
23	RDKit	Cheminformatics	2006 (updated 2020)	Open-source library for cheminformatics, supports AI-driven molecular modeling.	link
24	Open Drug Discovery Toolkit (ODDT)	Drug discovery	2015 (updated 2020)	Open-source tool for computer-aided drug discovery with machine learning functions.	link
25	Bioconductor (AI packages)	Genomic data analysis	2002 (updated 2023)	R-based packages with AI components for genomic data analysis.	link
26	CellProfiler (with AI plugins)	Image analysis	2005 (updated 2025)	Open-source image analysis software with AI plugins like Cellpose for cell segmentation.	link
27	DeepMetabolism	Metabolomics	2020	Uses deep learning for metabolomics data analysis.	link
28	BioTuring	Single-cell RNA-seq analysis	2020	AI solutions for single-cell RNA-seq data analysis.	link
29	Genialis	Genomics data interpretation	2020	AI-driven platform for genomics data interpretation.	link
30	Tinybio	Metagenomics, microbiome analysis	2020	Secure decentralized biometric authentication functionality.	link
31	SPARROW	Drug discovery	2024	AI algorithm for identifying optimal molecules for drug testing.	link
32	DeepLearningBio	Bioinformatics	2020	Deep learning framework for various bioinformatics tasks.	link
33	AI4Bio	Multi-omics analysis	2021	AI tool for integrating multi-omics data for biological insights.	link
34	BioNet	Network biology	2020	AI-driven platform for network biology and omics data analysis.	link

35	DeepSeq	Sequence analysis	2020	Deep learning for sequence analysis in genomics.	link
36	BioML	Machine learning in biology	2020	Machine learning platform for biological data analysis.	link
37	AIPath	Pathology	2020	AI-assisted pathology for cancer diagnosis using image analysis.	link
38	Benchling	Plasmid, crispr-cas	2019	Platform for design of plasmids, primers, crispr with AI.	link
39	BioAI	General bioinformatics	2020	AI tools for various bioinformatics applications.	link
40	Evo 2	Genomic sequence analysis	2025	Generative AI for predicting protein functions across all domains of life.	link
41	EVEscape	Viral mutation prediction	2023	Predicts viral mutations and variants using evolutionary and biological data.	link
42	DeepFold	Protein folding	2020	Deep learning for protein folding and structure prediction.	link
43	BioSeqAI	Sequence analysis	2020	AI for biological sequence analysis and annotation.	link
44	AI4Genomics	Genomics	2020	AI tools for genomic data analysis and interpretation.	link
45	DeepPath	Pathology	2020	Deep learning for pathology image analysis and diagnosis.	link
46	BioImageAI	Image analysis	2020	AI for biological image analysis and processing.	link
47	Alphaproteo	Proteomics	2020	AI tools for proteomic data analysis and protein identification. (paid)	link
48	DeepMicro	Microbiome analysis	2020	Deep learning for microbiome data analysis and profiling.	link
49	BioNLP	Natural language processing	2020	AI for processing and analyzing biological literature.	link
50	TXGNN	Drug discovery	2024	AI platform for drug discovery and repurposing.	link
51	DiffDock	Molecular Docking	2022	AI-augmented molecular docking for structure-based drug discovery	link
52	DeepAntigen	Vaccine Design	2021	Deep learning for prediction of T-cell epitopes	link
53	iBioGen	Synthetic Biology Design	2021	AI-driven platform for designing synthetic genetic circuits	link
54	mGénie	Metagenomic Analysis	2021	AI-powered tool for rapid metagenomic classification	link
55	AiCE	Protein Engineering	2022	AI-guided strategy for protein engineering combining structural and evolutionary data	link
56	DeepFRI	Protein Function Prediction	2020	Deep learning for protein function prediction from sequence and structure	link
57	OncoScan-AI	Cancer Genomics	2020	AI system for analyzing cancer genomic profiles	link
58	BioKlustering	Biological Data Clustering	2019	Machine learning tool for clustering and analyzing biological data	link

4. Future Trends in AI for Biotechnology

The future of AI in biotechnology holds significant potentials, with emerging technologies poised to drive further innovation. Below are key trends identified in recent literature.

4.1 Generative AI and Synthetic Biology

Generative AI is a branch of AI capable of producing new content, now has the potential to transform biotechnology with respect to de novo design. De novo design is a capability of generative AI that makes it possible to create completely new biological molecules -proteins, enzymes, and even genetic sequences- with desired properties. This potential holds particular promise in synthetic biology, where AI can drive the de novo design of biological components, as it may contribute to the development of new biofuels, bioplastics, and antibiotics [28]. In fact, generative AI has the ability to solve some of the world's most pressing issues, such as antimicrobial resistance and sustainable production.

Generative AI is not just limited to the design of molecules; researchers are exploring the use of generative AI to design entire biological systems or pathways, providing opportunities to bioengineer bio-systems like never before. iBioSim is true to its name, thinking about ways AI methods might be applied to design synthetic genetic circuits with predictable behavior [29].

4.2 Explainable AI (XAI)

Since AI approaches will find increasing use in biotechnology in the future, the role of explainable AI (XAI) for providing transparent decision-making, and ultimately regulatory approval of AI-based products is crucial [30]. One of the greatest challenges to scaling AI in biopharma, especially in clinical environments, is the "black box" problem with many deep learning models. Even though these systems can come up with extremely accurate predictions, many operate in an opaque way, making it hard for scientists and doctors to understand why a particular conclusion was drawn.

This opaqueness is a major hurdle for regulatory agencies such as U.S. Food and Drug Administration (FDA) and the European Medicines Agency (EMA), that need validation and interpretability to prove that medical products are working as expected. The goal of XAI methods is to render black-box AI models explainable and interpretable, offering understandable to human reasoning for predictions [31]. This is critically important to establish the credibility of AI for all stakeholders—regulatory agencies, clinicians, and patients—and to turn what Beradelli called a “black box” into a reliable, auditable, and trustworthy scientific method.

4.3 AI in Gene Editing

AI will improve the precision and safety of gene-editing tools, such as CRISPR in minimizing off-target effects and enhancing therapeutic efficacy [32]. The combination of AI and gene editing carries especially exciting potential for genetic diseases. For example, the AI-designed gene editors are a huge milestone [33].

However, ethical issues, like the risk of externalities and unethical applications, require strong regulation [34]. The powerful AI tools that can be applied to crafting life-saving therapeutics also pose a “dual-use” risk. One major biosecurity concern is the potential misuse, intentional or otherwise, of AI models for protein design, which would be able to design new proteins, and could thus lead to the creation of more virulent infectious agents or novel bioweapons.

4.4 Challenges and Limitations

Despite its potential, AI in biotechnology faces several challenges, including data privacy and security concerns, particularly in genomics [35]. The use of vast amounts of sensitive biological and health data raises critical concerns about privacy and security. Robust frameworks and technologies are needed to protect this data from breaches and misuse, especially in genomic and clinical applications.

Additionally, biases in AI models, often due to non-diverse training datasets, could lead to inequitable outcomes [36]. For instance, many large-scale genomic datasets are predominantly of European ancestry. Models trained on this data may perform less accurately for individuals from other ethnic backgrounds, leading to inequitable health outcomes and exacerbating health disparities.

Another significant challenge is the regulatory landscape for AI-driven biotechnology, which is complex and still evolving. Agencies like the FDA and EMA are developing frameworks for AI-enabled medical devices and drugs, but they face the unique challenge of validating systems that can learn and adapt over time [37]. Establishing clear guidelines for model validation, performance monitoring, and accountability is essential for ensuring patient safety and fostering innovation.

Addressing these challenges is critical for ensuring the responsible development of AI in biotechnology, transforming them into new frontiers for scientific and technological advancement.

5. AI in Biotechnology for Global Health Equity

AI has the potential to significantly impact global health equity by enabling low-income countries (LICs) to leapfrog traditional development paths. However, it also poses risks of widening the gap between rich and poor nations if not implemented inclusively and ethically.

5.1 Opportunities for Low-Income Countries

AI allows LICs to adopt advanced technologies without needing extensive traditional infrastructure. This can lead to accelerated development in various sectors. For instance, in healthcare delivery, Rwanda uses drones for healthcare delivery, with 75% of its blood supply delivered by Zipline drones, significantly improving access to critical medical supplies in remote areas [38].

AI-powered diagnostic tools and telemedicine platforms can bridge geographic divides, bringing specialist expertise to rural communities where doctors are scarce [39]. In education, AI-powered educational tools like RoboTutor can provide personalized learning to millions of children, addressing educational disparities that are a root cause of inequality [40].

Initiatives like BharatGen in India are developing AI models tailored to local languages, genetic diversity, and specific health needs, ensuring relevance and accessibility of AI-driven solutions [41]. This approach allows for culturally and contextually appropriate interventions.

AI is enabling laboratories in low-resource settings to develop cost-effective protocols and affordable alternatives to conventional biotechnological materials, and enhance existing protocols to create an eco-friendly DNA staining techniques. [42]

5.2 Risks of Widening the Gap

Despite these opportunities, there are significant risks that AI could exacerbate existing inequalities. AI-driven technologies may attract more investment to high-income countries (HICs), potentially diverting resources and talent away from LICs and widening the technological and economic gap [43].

As AI automates labor-intensive tasks, LICs specializing in such sectors may face reduced demand for their goods and services, leading to economic challenges and job displacement if not managed with proactive reskilling and economic diversification strategies [44].

Without adequate access to infrastructure, data, and expertise, LICs risk being left behind in the AI revolution. This could deepen the digital divide and further entrench health disparities, as advanced AI-driven diagnostics and treatments become inaccessible to those who need them most

[45].

The reliance on large datasets for AI training raises concerns about data ownership, privacy, and potential exploitation, particularly when data from LICs is used to develop solutions primarily benefiting HICs [46]. This phenomenon, sometimes termed "data colonialism," can lead to the deployment of biased, Western-centric models that fail to serve, or even harm, the very communities they are intended to help.

5.3 Strategies for Inclusive Development

To ensure that AI in biotechnology advances global health equity, a concerted and multi-faceted approach is required. LICs must invest in education and training to build AI literacy, data science skills, and biotechnological expertise. This includes fostering local research and development ecosystems [47].

Collaborations between governments, private sector companies, academic institutions, and non-governmental organizations are essential to facilitate AI adoption and technology transfer. Examples include efforts to establish AI research centers in South Africa [48].

Developing comprehensive national AI strategies, including research funding, regulatory frameworks, and ethical guidelines, is crucial for guiding responsible development and ensuring alignment with national development goals. The African Union's AI strategy is a notable example [49].

Promoting open science principles and equitable data sharing mechanisms can democratize access to AI tools and datasets, fostering collaborative innovation and reducing disparities [50]. Furthermore, prioritizing the development of AI solutions that are specifically designed to address the unique challenges and contexts of LICs, rather than simply importing solutions from HICs, is vital for ensuring relevance and impact [51].

These strategies align with theories of leapfrogging and absorptive capacity, suggesting that LICs can strategically adopt advanced technologies by learning from HICs and adapting them to their specific needs, thereby accelerating their development trajectories.

6. Conclusion

The integration of artificial intelligence into biotechnology marks a transformative epoch in science and medicine. From accelerating the discovery of novel drugs and decoding the complexities of the human genome to engineering life's fundamental building blocks and

cultivating a more sustainable agricultural future, AI's impact is both profound and pervasive. It is reshaping research paradigms, breaking down long-standing barriers, and opening up possibilities that were once the domain of science fiction.

This paper has provided a comprehensive overview of AI's current applications in biotechnology, presented a detailed survey of 58 freely available AI tools and platforms that are driving innovation in the field, examined future trends and challenges, and critically analyzed the implications for global health equity. The findings highlight the immense potential of AI to accelerate biotechnological innovation while addressing global challenges, such as disease treatment, food security, and environmental sustainability.

However, the full realization of AI's potential is contingent upon addressing significant challenges. Data privacy and security, algorithmic bias, and the need for robust regulatory frameworks are paramount concerns. The "black box" nature of some AI models necessitates the development of Explainable AI (XAI) to foster trust and enable critical validation, especially in clinical applications. These challenges are not merely technical; they are deeply intertwined with ethical and societal considerations that demand proactive and thoughtful governance.

Crucially, this paper has emphasized the dual potential of AI in shaping global health equity. While AI offers a unique opportunity for low- and middle-income countries (LMICs) to leapfrog traditional developmental stages and address pressing health and agricultural challenges, there is a significant risk of exacerbating existing inequalities. The digital divide, potential for investment diversion, and the risk of economic disruption in labor-intensive sectors underscore the need for inclusive strategies.

To ensure that AI-driven biotechnology serves as a force for global good, a concerted and collaborative effort is required. This includes investing in capacity building and education within LMICs, fostering public-private partnerships, and developing national AI strategies that prioritize equitable access and benefit. Promoting open science and locally tailored solutions will be vital in democratizing access to these powerful technologies and ensuring their relevance to diverse contexts.

The path forward for AI in biotechnology must be guided by a steadfast commitment to ethical governance, inclusivity, and global collaboration. By proactively addressing the challenges and strategically leveraging the opportunities, AI can help create a fairer, healthier, and more sustainable world for all.

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