
Multimodal AI Reshapes Biotechnology and Digital Medicine



Artificial intelligence is accelerating progress across biotechnology and digital medicine by linking genomic, clinical and imaging data to generate more comprehensive insights than any single source alone. Multimodal approaches are now informing target identification, molecule design, clinical trial optimisation and imaging-based diagnosis, with reported gains in speed, cost and precision. The shift is economic as well as technical. The global AI market was valued at \$233.46 billion in 2024 (€215.69 billion) and is projected to reach \$1771.62 billion (€1,636.75 billion) by 2032 at a 29.2% compound annual growth rate. Within pharma and biotech, AI was valued at \$1.8 billion (€1.66 billion) in 2023 and is projected to reach \$13.1 billion (€12.10 billion) by 2034 at 18.8% growth, reflecting adoption across discovery, development and manufacturing.

Multimodal Applications Advance Discovery and Care

Machine learning systems analyse large-scale datasets to surface patterns in genetic sequences, protein structures and patient records, supporting hypothesis generation and candidate screening. Multimodal AI integrates genomic sequences, clinical records, molecular structures and imaging to elevate predictive power and context. Reported applications span four areas of discovery efficiency: accessing new biological targets through structure prediction and literature mining; improving or creating compounds via generative models such as variational autoencoders and generative adversarial networks, increasing success rates by predicting efficacy, safety and responsive subpopulations and accelerating and reducing costs through virtual screening, synthesis route optimisation and early toxicity prediction.

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In clinical domains, more than 500 AI or ML medical algorithms have been cleared for market use, with the majority related to diagnostic imaging. Convolutional neural networks support classification and detection, U-Net architectures enable segmentation, and transformer-based models capture long-range dependencies in complex anatomy. These techniques are being applied to earlier detection, longitudinal monitoring and workflow standardisation. Beyond pixel analysis, multimodal pipelines combine imaging with omics to discover biomarkers linked to disease subtypes or treatment response, informing personalised therapies. Wearables and sensors extend these capabilities to real-time monitoring and timely intervention.

Industry activity mirrors these technical shifts. Major firms are investing heavily to boost research productivity. Organisations report dedicated AI and ML roles, with efforts focused on streamlining target identification, informatics and clinical development.

Market Shift and Investment Trends

Economic signals align with technical advances. The broader AI sector saw venture commitments rise from \$3 billion (€2.33 billion) in 2012 to more than \$130 billion (€109.92 billion) in 2021. In biotech, funding for AI-focused startups rose by approximately 23% compared to 2019, reaching nearly \$1.9 billion (€1.65 billion), while AI-related biotech and healthcare startups secured \$12.5 billion (€10.86 billion) in a record year. Across the United States and Europe, biotech raised nearly \$19 billion (€16.50 billion) in venture capital, with a substantial share directed to AI-driven initiatives. Funding rebounded to \$6.7 billion (€5.82 billion) through early December in a subsequent year and large rounds in early 2024 for companies building AI-enabled platforms in drug discovery, gene therapy and precision medicine underscored continued investor interest.

Macroeconomic conditions tempered deal volumes in 2022 and 2023 as inflation, interest rates, market volatility and geopolitical factors weighed on risk appetite. Investor expectations have shifted from platform potential to demonstrable outcomes such as drug approvals or clinically validated impact. The largest financings over the past decade tended to favour companies combining proprietary innovation, scalability and clear market demand, while acknowledging that many valuations remain forward-looking.

Public markets reflect a similar cadence. After a surge linked to pandemic-era innovation, biotech IPO activity slowed markedly in 2022 and 2023. In 2024, listings were on track to roughly match the prior two years, with notable entries such as Tempus AI in June 2024 and subsequent strategic capital partnerships. With IPO windows narrower, partnerships and private mergers and acquisitions have gained prominence as routes to scale and liquidity. Patent cliffs and the need for pipeline renewal are reinforcing incentives for collaborations between large pharma and early-stage AI biotech firms, as illustrated by arrangements initiated when companies were still at Series A stage and later expanded with significant private capital and public filings.

Regulation, Transparency and Equity

Rapid adoption raises regulatory and ethical considerations. Biomedical datasets underpinning AI models can be limited, noisy or biased, which affects reliability and generalisability. Deep learning systems may function as opaque black boxes, complicating validation in complex biological systems. Regulatory frameworks are evolving to address data protection, transparency and accountability under instruments such as the GDPR in Europe and the HIPAA in the United States. Agencies are proposing approaches for AI-based software as a medical device that emphasise interpretability, continuous validation and real-world performance monitoring. Examples include outputs designed to be interpretable and the use of saliency maps to highlight image regions relevant to decisions.

Equity risks persist where training data underrepresent specific populations, with consequences for dermatology, cardiology and other fields. Initiatives that deploy AI-supported diagnostics in underserved regions and open-source electronic medical record systems across multiple countries illustrate steps to reduce imbalances, though infrastructural and integration barriers remain. Fairness-aware tools, bias mitigation strategies and explainable methods are identified as priorities, alongside adaptive regulation and continuous ethical oversight. Publication and patent trends indicate sustained growth across drug discovery, precision medicine and genomics, while the authors note potential publication bias favouring positive outcomes and recommend broadening evidence to include grey literature, expert input and failure analyses.

Multimodal AI is reshaping biopharmaceutical research and healthcare delivery by unifying diverse datasets to accelerate discovery, personalise treatment and streamline clinical workflows. Market valuations, venture activity and regulatory engagement track the same trajectory, linking technical progress to economic value and operational change. Real-world deployment depends on data quality, interpretability, fairness and robust validation, supported by adaptive regulation and collaborative ethics. The near-term opportunity lies in pairing targeted investments and partnerships with governance that sustains trust, so efficiency gains translate into durable clinical benefit and equitable access.

Source: [npj digital medicine](#)

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