

CONVERGENCE BETWEEN BIOECONOMY AND ARTIFICIAL INTELLIGENCE: A BENCHMARKING BETWEEN EU AND US UNDER 2026 PROSPECTS

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Abstract

This paper aims to analyze the current evolution of the global biotechnology sector, with a focus on green biotechnology and biopharma in the context of the multiple disruptive elements identified at international level and the increasing share of the influence of artificial intelligence on the sector. In the current context, the article aims to analyze how innovations, artificial intelligence and the BioTech industries have redefined their strategies and some of the world's best-placed players. The analysis highlights that while biotechnology remains a resilient engine of economic growth, new challenges related to AI ethics, data sovereignty and R&D costs are forcing a re-evaluation of traditional business models.

Keywords: Global Biotechnology, Artificial Intelligence, Green Biotech, Biopharma, Disruptive Innovation.

JEL classification: L65 O31 O33.

Introduction

The convergence between the bioeconomy and artificial intelligence has emerged as one of the most significant technological and economic developments of the current decade. Biotechnology is increasingly evolving into a data-driven sector in which artificial intelligence accelerates research and development, supports the discovery of new therapies, and enhances the sustainability and efficiency of agricultural and industrial bioprocesses.

Against this background, the present paper examines how artificial intelligence influences the competitiveness and strategic positioning of the biotechnology sectors in the European Union and the United States. These two regions represent distinct but highly relevant innovation models: the United States benefits from a highly integrated ecosystem supported by strong private investment and advanced research infrastructure, while the European Union combines substantial public funding with a regulatory framework strongly oriented toward sustainability, responsible innovation and strategic autonomy.

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The paper provides a comparative analysis of the European and American biotechnology ecosystems, with particular attention to green biotechnology, biopharma and agricultural biotechnology. It also explores the disruptive role of artificial intelligence in reshaping research processes, business models and regulatory approaches, and discusses the main technological and strategic trends expected to influence the sector during the 2026–2030 period.

By integrating economic, technological and policy perspectives, the article offers a structured interpretation of the emerging relationship between biotechnology and artificial intelligence and highlights its implications for global competitiveness and the future development of the bioeconomy.

Research methodology

This study employs a comparative qualitative research design aimed at examining the convergence between biotechnology and artificial intelligence in the European Union and the United States. The analysis is based on secondary data collected from institutional reports, market studies, scientific publications and official documents issued by international organizations, public authorities and major companies operating in the biotechnology sector.

The methodological approach combines three complementary perspectives. First, a comparative analysis is used to identify the main structural differences and similarities between the European and American biotechnology ecosystems in terms of financing, regulatory frameworks, innovation capacity and market dynamics. Second, a strategic analysis is conducted to assess the role of artificial intelligence as a disruptive factor influencing research and development processes, business models and competitive positioning. Third, a prospective approach is applied to explore the technological and economic trends likely to shape the biotechnology sector during the 2026–2030 period.

The study focuses on three major biotechnology domains: biopharmaceuticals, agricultural biotechnology and green biotechnology. The selection of these domains reflects their significant contribution to global economic growth, public health, food security and environmental sustainability. The analysis does not aim to provide econometric testing, but rather to develop an integrated interpretative framework that links technological innovation, policy developments and market evolution.

By combining recent statistical evidence with strategic and comparative analysis, the paper offers a structured perspective on how artificial intelligence is reshaping the global bioeconomy and influencing the relative competitive advantages of the European Union and the United States.

Chapter I: European Green Biotechnology – defining elements

The year 2021 was a historic moment in terms of attracting funds for research and development in the field of biotechnologies. Recent reports have

narrated a significant increase in the BioTech industry, especially since 2020, a phenomenon that can be explained by the new economic and social realities generated, among other things, by the COVID-19 pandemic. In fact, the pandemic year of 2020 was the catalyst that demonstrated to the relevant industries that investment volumes can evolve quickly even in a rather turbulent business environment. Many companies also experienced serious failures during the same period, an example of this being cancer studies that were in many cases suspended to allow all available resources to be channeled towards the development of effective vaccines in the shortest possible time.

In 2021, the **European Investment Bank Group** encouraged a major budget allocation for new funding for renewables and green efficiency, emphasizing Europe's pledge to improve access to green resources⁴.

The period 2021-2025 was a good time for the **European Investment Bank Group** to strengthen its role as the 'EU climate bank'⁵, while reaching historic funding thresholds.

Initially, the EIB set a target of more than 50% of annual financing going to climate action by 2025. This goal was achieved in advance. Thus, according to official reports, the year 2022 meant reaching a share of financing on the "green" component of approximately 58%, and in 2025 the same share rose to over 60% (the equivalent of approximately 50.3 billion EUR).⁶ The total amount allocated to "green" investments between 2021 and 2025 amounted to over 560 billion at the end of 2024. EUR.⁷

For the period 2026-2030, the EIB Group will also introduce a new financing target of €30 billion, practically doubling the volumes assumed from the years 2021-2025. These efforts will focus on increasing *energy competitiveness and security (reducing energy prices* and further promoting clean technologies), doubling the volume of financing for adaptation projects that will primarily target the agricultural and water resources sectors, as well as promoting resilient infrastructure.

The year 2026 will represent for many of these milestones the year of maturity of these programmed investments. For the financial year 2025, the

⁴ https://www.eib.org/files/publications/sustainability_report_2021_en.pdf accessed on 02.04.2026

⁵ <https://www.eib.org/en/press/all/2025-353-eib-group-to-accelerate-and-simplify-green-investment-boosting-european-competitiveness-energy-security-and-tech-leadership?lang=ro>, accessed on 02.04.2026

⁶ <https://www.eib.org/en/publications/online/all/eib-group-activity-report-2025> accessed on 02.04.2026

⁷ <https://www.eib.org/en/publications/20230176-eib-group-climate-bank-roadmap-mid-term-review> accessed on 02.04.2026

EIB has disclosed a record allocation of €20 billion, dedicated specifically to projects within the sectors of sustainable energy and applied biotechnology⁸.

The recent energy crisis has transformed the objectives of the European Investment Bank (EIB) Group from a purely green strategy into a pillar of national security and strategic autonomy for the whole of Europe. Instead of slowing down the green transition, the recent crisis, which does not seem to be easily solved and without long-term effects, will act as a catalyst, forcing the acceleration of investments to reduce dependence on fossil fuel imports.

The likely impact of the authors will be reflected in the following directions:

- *budget extension through REPowerEU+⁹*
- *prioritizing investments in the Biotechnology and clean technologies sector – "cleantech"*
- *the modification of some aspects of the energy strategy at European level, namely the fact that climate objectives, which were often seen as a cost, in the current context, are classified as strategic objectives at continental level.*

The level of transactions in the biotechnology segment, especially agricultural in the European Union, is estimated at around €14.70 billion in 2026, with a projection to grow to around €33.17 billion by 2034¹⁰. The "biostimulants" sector makes Europe a global market leader with a market share of over 38%, estimated at over €1.5 billion in 2026.¹¹

Europe maintains its leading status through the Dutch Belgian "innovation corridor" and technology clusters located in Switzerland. Companies such as **Novo Nordisk, AstraZeneca, Novartis, Roche and Sanofi** dominate the market capitalization chart, with a combined value exceeding the €1.1 trillion in 2026.¹²

An important competitive advantage of the European Union lies in its capacity to combine biotechnology development with broader policy objectives related to sustainability, digitalization and data governance. Unlike other major economic regions, the European model integrates research funding, climate policies and regulatory instruments into a coherent framework that supports both technological innovation and societal objectives. This integrated approach creates favorable conditions for the convergence between biotechnology and

⁸ <https://www.caleaeuropeana.ro/raport-bei-anul-2025-a-marc-at-un-moment-de-referinta-pentru-grupul-bei-care-a-atins-un-nivel-istoric-de-100-miliarde-de-euro-in-finantari-noi/#:~:text=Raport%20BEI:%20Anul%202025%20a%20marcat%20un,100%20miliarde%20de%20euro%20%C3%AEn%20finan%C8%9B%C4%83ri%20noi.> accessed on 05.05.2026

⁹ https://commission.europa.eu/topics/energy/repowereu_de accessed on 02.05.2026

¹⁰ [https://www.mordorintelligence.com/industry-reports/europe-biostimulants-market#:~:text=Europe%20Biostimulants%20Market%20Analysis%20by%20Mordor%20Intelligence.,\(CE\)%20marked%20products%20that%20streamline%20cross%2Dborder%20sales.](https://www.mordorintelligence.com/industry-reports/europe-biostimulants-market#:~:text=Europe%20Biostimulants%20Market%20Analysis%20by%20Mordor%20Intelligence.,(CE)%20marked%20products%20that%20streamline%20cross%2Dborder%20sales.) accessed on 02.05.2026

¹¹ Ditto 6

¹² <https://www.alpha-sense.com/largest-pharmaceutical-companies-by-market-cap/> accessed on 02.05.2026

artificial intelligence, particularly in areas such as precision agriculture, biopharmaceutical research and circular bio-based industries. As a result, Europe is increasingly positioning itself not only as a major biotechnology market, but also as a regulatory and strategic leader in the development of responsible and sustainable BioTech ecosystems.

Chapter II: The Biotechnology Sector in the United States of America – Innovation and Resilience

The biotechnology sector has grown a consistently positive dynamic in the US as well, especially after 2004, providing answers and solutions to national economic challenges, especially during the 2020 pandemic, generating well-paid jobs and a significant economic impact, generally helping the entire US economy, almost blocked by the restrictions imposed during that period.

Biotechnology industries have experienced constant growth rates, especially in the last 5 years, supporting the national economy and generating a substantial impact on the US economy.

There are a few areas that can be mentioned as spearheads of the **BioTech** field when we talk about the American economy. The U.S. is undoubtedly the world leader in the **BioPharma** industry. The U.S. economy is home to the world's largest innovation ecosystem (industrial clusters located in the Boston and San Francisco regions) and holds more than 40% of the global biologics market¹³. Although the US is certainly also a leader in agricultural biotechnology, the "spearhead" of this sector is not organic or organic farming, but conventional agriculture based on modern biotechnologies (GMOs). The US is massively focused on gene editing (CRISPR), genetically modified seeds (corn, soybeans, cotton) and precision technologies, with more than 90% of America's main crops being modified by biotechnology.

The United States maintains a preeminent position in biopharmaceutical research and development (R&D) through strategic allocation of substantial resources toward the discovery and advancement of some fresh therapeutic protocols. This innovative ecosystem is characterized by synergistic collaborations between private pharmaceutical enterprises, academic institutions, and research organizations. Furthermore, federal support is committed to further cultivate this culture of scientific advancement.

US is also known for its rigorous regulatory framework, primarily governed by the **Food and Drug Administration (FDA)**. These standards ensure clinical efficacy and safety for providers and patients. Moreover, the nation's robust intellectual property protection rules provide the necessary legal security to incentivize continued long-term investment in high-risk pharmaceutical R&D.

¹³ <https://pharmaboardroom.com/country-reports/healthcare-life-sciences-review-usa-2026/>
accessed on 02.05.2026

Based on internationally available data, the most active and expanding **BioTech companies** in the U.S. are *Moderna, Takeda, AbbVie, Amgen, Regeneron, BioMarin, FUJIFILM Dozent Technologies and Frederick National Laboratory for Cancer Research*.

Companies such as *Moderna, AbbVie and Amgen* have expanded their manufacturing facilities at an accelerated pace over the past 5 years, benefiting from a robust regulatory framework. The U.S. remains a leader in personalized medicine and precision genomics, turning previously incurable conditions into manageable conditions.

The U.S. share for 2024 accounted for 38% of the global agricultural biotechnology market, and it is estimated that by the end of this year the U.S. will hold a market share of about 40%.¹⁴

According to **USDA ERS**¹⁵ data, between 2024 and 2025, the adoption of genetically engineered (GE) seed varieties within the United States reached unprecedented levels.

The gene editing segment (CRISPR-Cas9) seems to be the main catalyst for innovations for 2026, being preferred for its precision in the development of crops resistant to climate stress generated by climate changes manifested in recent years and the emergence of new categories of pests, resistant to classic treatments.

Although plant genetic modification remains the dominant segment in the market, a new trend should be mentioned in this context, namely microbe-based biotechnology, which is growing rapidly, offering alternatives to the now classic genetically modified seed crops.

The latest estimates for the American market in the BioTech area (including the Pharma industry) mention that the total reported value for last year, of over USD 690 billion, projects a massive growth for the current year as well¹⁶.

An additional structural advantage of the United States stems from its ability to rapidly transform scientific discoveries into commercially viable products and scalable industrial solutions. This capacity is supported by a highly integrated innovation ecosystem that combines world-leading universities, specialized research institutes, venture capital, and large pharmaceutical and biotechnology corporations. In contrast to the more policy-driven European model, the U.S. approach is characterized by strong entrepreneurial dynamics, faster access to private financing, and a regulatory environment that, while rigorous, often enables quicker market deployment of

¹⁴ <https://www.coherentmarketinsights.com/industry-reports/agricultural-biotechnology-market> accessed on 07.05.2026

¹⁵ <https://www.ers.usda.gov/data-products/adoption-of-genetically-engineered-crops-in-the-united-states/recent-trends-in-ge-adoption> accessed on 07.05.2026

¹⁶ <https://www.precedenceresearch.com/biologics-market> accessed on 07.05.2026

innovative therapies and technologies. The increasing integration of artificial intelligence further strengthens this ecosystem by accelerating drug discovery, optimizing clinical trials, and enhancing the development of precision agriculture and genomics-based applications. As a result, the United States continues to maintain a leading position in the global biotechnology industry and sets many of the technological and commercial trends that shape the future evolution of the bioeconomy.

Chapter III Competitive Analysis of Global Leaders and the Disruptive Impact of Artificial Intelligence

In the **BioTech** industry of 2026, the dividing line between what we call a traditional company and what represents a company that exists and grows thanks to innovation and technological research processes has become almost invisible. Of the companies mentioned in this article, at least the six major international competitors – **Novo Nordisk, Roche, Novartis, AstraZeneca, Sanofi and Pfizer** – have integrated what we now call Artificial **Intelligence** (AI) not only as a support tool in the research area, but also as the core of their entrepreneurial efficiency. This transition to a business oriented towards the inclusion and use of AI in as many company-wide processes as possible has inevitably generated systemic challenges that put pressure on the very profitability models established at the beginning of this decade.

Some companies, especially those operating in the pharma area, are already making extensive use of artificial intelligence to analyze and simulate the behavior of new innovative molecules that are in the testing procedure through the various clinical trials.

Although particularly useful, the help provided by AI can prove to be extremely expensive in the medium and long term, if the learning algorithms fail to generate a quasi-efficient and efficient "Deep Learning" process. Any result generated today with the help of AI and subsequently invalidated, for various reasons, by clinical trials will generate huge losses for these companies, either through the inefficiency of these new molecules, or through the additional costs, incurred after the research and testing phase to remedy the deficiencies.

Another challenge that did not exist a few decades ago is the so-called **Genetic Data Sovereignty** or, more clearly, protecting patients' data and preventing them from accessing computer systems from outside the country. In 2026, AI oncology analysis platforms, for example, are processing exabytes of data available and stored in both the US and the EU. The integration of AI into research processes makes it necessary to access these global databases. However, new data protection regulations in the EU and the US already severely limit AI's ability to "learn" cross-border. **Roche**, for example, is currently forced to invest heavily in Federated Learning (shared learning

without raw data transfer), a method that protects patient privacy but increases the complexity and costs of research infrastructure by more than 30%.¹⁷

Recently, another well-known company, **Novartis**, was forced to develop "Explainable AI" departments to logically translate machine decision-making processes into understandable clinical language, because regulatory authorities, such as the EMA, increasingly refuse and reject approval files for new pharma molecules, if the molecule's mechanism of action is determined exclusively by algorithmic inference. without the interaction of the human factor¹⁸.

Another and final challenge that I will mention in this chapter with reference to the pharma industry based largely or exclusively on the involvement of AI refers to the non-uniformity of historical data and time series that are practically part of the "menu" of any AI algorithm currently trained. Specifically, **Sanofi** recently admitted that a so-called "digital cleansing" is needed for clinical data collected in previous decades to be standardized and usable by AI algorithms¹⁹. This "digital cleaning" will undoubtedly require massive investment. AI trained on inconsistent data produces erroneous results, which can lead to the underrepresentation of certain variables in simulated clinical trials, risking the exclusion of products from international markets. Moreover, as in the case of commercial AI models, there is a tendency for the AI model to provide erroneous data, a trend that can be catastrophic for a business model in such sensitive industries.

Another sector synergistic to the BioTech industry that is particularly influenced by AI is that of agricultural biotechnology. The integration of artificial intelligence in the agricultural sector is not only a natural stage of technological evolution but is already a disruptive factor that will redefine the way we produce food, in which we optimize the resources of the present while managing the resilience of ecosystems in the face of future climate change.

Perhaps the most visible technological evolution is already taking place at this time in the processes of crop improvement. Traditionally, the development of a new hybrid took years, in some cases even over a decade. Today, advanced algorithms can analyze massive genomic databases to analyze the likely interactions of certain mutant or non-mutant genes under different environmental conditions. This enormous analysis and simulation capacity allows the total time required for genomic editing (such as CRISPR) to be reduced, allowing the creation of cultures with specific traits in record time.

In addition to the above, crop monitoring systems, mounted on drones, tractors or other machinery, can identify changes in crop health or nutrient

¹⁷ <https://cordis.europa.eu/project/id/831472> accessed on 07.05.2026

¹⁸ https://www.novartis.com/sites/novartis_com/files/novartis-responsible-use-of-ai-systems.pdf accessed on 08.05.2026

¹⁹ <https://fortune.com/2024/02/19/sanofi-ceo-ai-promises-great-era-drug-discovery-fundamentally-change-medicine/> accessed on 08.05.2026

deficiencies, before they are widely visible and begin to cause permanent damage. This targeted biotechnology, implemented with the help of artificial intelligence, allows the application of treatments only to the affected plots, reducing the consumption of pesticides and fertilizers, compared to the classic approach, according to which the treatments were applied in the necessary dose, to the entire crop, whether affected or not.

The integration of artificial intelligence into biotechnology is transforming not only the speed of scientific discovery, but also the economic logic and organizational structures of leading companies. AI has evolved from a supporting analytical tool into a strategic capability that influences the entire innovation cycle, from target identification and molecular design to clinical development, manufacturing optimization and post-market monitoring. At the same time, this transformation introduces new challenges related to data quality, model transparency, cybersecurity and regulatory compliance. The effective use of artificial intelligence therefore depends not only on access to advanced algorithms, but also on the ability of organizations to develop robust data governance frameworks and interdisciplinary expertise. In this context, competitive advantage increasingly derives from the capacity to combine biological knowledge, computational infrastructure and regulatory readiness into integrated innovation systems capable of delivering faster, more reliable and more sustainable outcomes.

Chapter IV: Prospective Trajectories and Evolutionary Technologies in the Biotech Sector

For 2026–2030 predictions are characterizing these following years like a profound transformation momentum across the biotechnology landscape, with particularly significant advancements anticipated within the medical and agricultural sectors.

Although the current period is found to be particularly complicated at the socio-economic and political level, the resettlement of the world economy and the global polarization of the economies of most of the states of the month will not be able to stop the evolutionary processes of the BioTech fields. If recent years have been dominated by the response of economies to multiple global crises, the next time horizon will most likely be defined by the convergence between generative artificial intelligence, precision genetic engineering and sustainable bioprocessing.

By 2030, the process of developing innovative new molecules will be radically transformed. New predictive technologies, based on artificial intelligence, for example "**AlphaFold**",²⁰ will enable the design of innovative

²⁰ Jumper, J. et al. (Nature, 2021/2024 updates): Highly accurate protein structure prediction with AlphaFold. accessed on 02.05.2026

proteins from scratch, shortening research times from a few years to just a few months. The algorithms will be able to predict not only the structure of proteins, but also complex interactions within human biological systems, reducing the failure rate in clinical trials and allowing the creation of "personalized" therapies, depending on the patient and condition.

If the first generations of artificial intelligence-based R&D iterations, the so-called CRISP therapies, focused on editing cells outside the patient's body, the 2026-2030 horizon will probably mark the emergence and maturation of new technological versions, which will advance in the direction of operating these genomic edits right at the level of the patient's body. Technologies such as "**Prime Editing**"²¹ will become standard, offering surgical precision at the molecular level, capable of correcting point mutations directly in the patient's body. This dynamic will turn chronic genetic diseases into curable or partially curable conditions.

The BioTech revolution will not only redefine the medical industries, but also other industrial branches such as those of the various materials necessary for the medical act.

For the agricultural sector, the 2026-2030 horizon will likely mean the shift from traditional agriculture to innovative and sustainable agriculture, also known in the literature as Agriculture 4.0²², where biotechnology and digitalization will work together to ensure global food security, under likely climate stress.

The period 2026–2030 is expected to mark a new stage in the evolution of biotechnology, characterized by the accelerated convergence of artificial intelligence, advanced genomic engineering and sustainable industrial processes. The most competitive ecosystems will be those capable of integrating scientific excellence, digital infrastructure, access to capital and adaptive regulatory frameworks into coherent innovation strategies. In the medical field, technologies such as AlphaFold and Prime Editing are likely to significantly reduce research timelines and improve the precision of therapeutic development, while in agriculture the expansion of Agriculture 4.0 will support the creation of more resilient and resource-efficient production systems. At the same time, the growing strategic importance of biotechnology and artificial intelligence will intensify global competition for talent, data and technological sovereignty. Under these conditions, the ability to align innovation with sustainability, public trust and responsible governance will become a decisive factor in shaping the future hierarchy of the global bioeconomy.

²¹ Anzalone, A. V. et al. (Nature, 2019/2023): Search-and-replace genome editing without double-strand breaks or donor DNA. accessed on 02.05.2026

²² https://www.researchgate.net/publication/398616382_AGRICULTURE_40_-_INNOVATION_S_FOR_SUSTAINABLE_DEVELOPMENT accessed on 02.05.2026

Conclusions

The **BioTech** industries in the European space have experienced a process of accentuated development in recent years, the European Union consolidating its top position in the world R&D hierarchy, through a robust institutional ecosystem and a business environment focused on the need to adopt innovative technologies.

In the **Biopharma** sector, the European Union operates in a framework marked by the heterogeneity of national health systems and reimbursement policies. This regulatory fragmentation unfortunately constitutes a significant barrier to the cross-border roll-out of innovative therapies.

Simultaneously, at the agricultural level, along with the implementation of innovative technologies, the bloc has intensified efforts to restore ecosystems by reducing human intervention and the reintroduction of regional native species, integrating precision agriculture and agroecology to ensure the long-term viability of sustainable food systems.

In contrast, the **U.S. BioTech** industry has long held global hegemony in the commercialization of disruptive therapies, benefiting from effective synergy between academia, the private sector, and government authorities. This model facilitates the harmonization of regulations and the acceleration of clinical trials.

At a global level, the demand for innovative biotechnological solutions is fueled by the urgent need to address some of the challenges of the current century, namely the identification of innovative therapies to combat the major diseases and conditions that have affected humanity for centuries, and at the economic and social level, climate change with all its possible implications and the scarcity of resources. From an economic perspective, BioTech industries will generate new competitive advantages in multiple fields. However, regional disparities remain evident: while the US dominates in terms of innovation capacity, Europe, through the voice of states such as Germany, France and Spain, must adopt much more incisive strategies to maintain the pace imposed by international competitors and to reduce a possible competitiveness gap.

From this perspective, the future of the bioeconomy will be shaped by those regions and organizations capable of transforming the convergence between artificial intelligence and biotechnology into a strategic instrument for improving public health, strengthening food security, advancing climate objectives and generating long-term economic value.

Future Research Directions

Future research could extend the present analysis by developing quantitative models to measure the relationship between artificial intelligence adoption and biotechnology competitiveness across different regions and industrial segments. Additional studies may also investigate the impact of regulatory frameworks, data governance and ethical standards on the pace of

innovation and market diffusion. Another promising direction concerns the analysis of emerging economies and their capacity to integrate biotechnology and artificial intelligence into sustainable development strategies. Finally, further research may explore the skills and institutional capabilities required to support this convergence, particularly in the context of growing demand for interdisciplinary expertise at the intersection of life sciences, digital technologies and public policy.

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