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Rethinking Indiaâ??s Industrial Biotechnology Beyond Manufacturing and Startups

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Indiaâ??s bioeconomy has reached $195 billion by 2025, with industrial biotechnology leading at $90 billion. Growth is driven largely by contract manufacturing, with core technologies still imported. This article advocates for mission-driven strategies to enable technology origination, drive innovation, and strengthen translation. It also calls for building indigenous, biodiversity-based industrial biotechnology platforms and products.



India’s bioeconomy has grown from approximately $10 billion in 2014 to over $195 billion in 2025, contributing nearly 4.8 per cent to GDP. Industrial biotechnology now accounts for 46 per cent of the bioeconomy, followed by biopharma (33 per cent), bioservices (13 per cent) and bioagri (8 per cent).

There is a surge in biotechnology startups, rising from about 460 to more than 11,850 over the same period. Economic progress has been driven mainly by contract development and manufacturing, with core technologies and production platforms still largely imported. Indigenous, Research and Development (R&D)-led product innovation remains limited, and short-term capital-based startups often prioritise near-term returns over the long development cycles required for breakthrough innovation. India’s academic research ecosystem, meanwhile, remains strong in discovery but weak in translation. To evolve into a technology-originating industrial biotechnology ecosystem, India must adopt a mission-mode approach that translates its unique and rich biodiversity into commercially viable innovations.

Global Context of Innovation to Commercialisation

Industrial biotechnology refers to the use of living cells - primarily microorganisms, and to a lesser extent plants or animal cells - or their components to produce value-added products and processes. These include enzymes, fine and specialty chemicals, biomaterials, vitamins, nutraceuticals, animal nutrition ingredients, flavours, biosurfactants, and biofuels, bioremediation, crop-protection and soil fertility, as well as traditional fermentation products such as alcoholic beverages.

Innovation driven product development in this sector typically progresses through the Technology Readiness Level (TRL) framework. Early stages (TRL 1-3) of development establish biological feasibility and laboratory proof-of-concept. TRL 4-5 marks a critical transition stage at which techno-economic modelling must establish clear cost competitiveness. TRL 6-7 involves pilot and demonstration plants to validate scale-up and integrate full process flows. TRL 8-9 led to the commissioning of commercial facilities and the establishment of stable operations. The subsequent stage is of taking a product to customers.

However, the commercial success of industrial biotechnology products depends primarily on cost of goods, which is largely determined by the robustness of microbial production platforms, enzyme efficiency, and overall bioprocess performance.

Global leadership in industrial biotechnology has been driven largely by multinational corporations (MNCs) rather than startups. Companies such as Novozymes, DuPont, DSM-Firmenich, BASF, ADM, Ajinomoto, Evonik, Cargill, Clariant, and Corbion have invested decades to establish themselves as global leaders. Their success is rooted in sustained innovation and technological advancement across microbial production platforms, enzyme engineering, novel products, and large-scale bioprocessing.

Evolution of Industrial Biotechnology Ecosystem in India

India's industrial biotechnology sector began to take shape in the early 1990s with bulk microbial fermentation for enzymes, antibiotics, organic acids, vitamins, and amino acids - distinct from traditional alcoholic beverage production. A significant shift occurred in the mid-2000s, when several MNCs established advanced R&D centres in India.

Over the following decade, these centres attracted top-tier scientists and built specialised expertise in industrial biotechnology, creating a strong pool of domain talent. However, around the mid-2010s, most MNCs had wound down their R&D operations, even as this talent pool remained available to support the growth of domestic industrial biotechnology R&D.

In the 2010s, a few Indian companies invested in acquiring startups from advanced economies. These acquisitions were expected to seed domestic R&D capabilities and lead to commercially viable ventures. In practice, however, most projects struggled to progress beyond the mid-TRL stages due to techno-economic constraints and many of those efforts were eventually discontinued.

Consequently, the focus has shifted toward the Contract Development and Manufacturing Organization (CDMO) model, which offers more predictable, short-term returns. This segment is expanding rapidly and its strengths lie in cost-efficient, large-scale fermentation and process engineering.

Government initiatives- especially through the Department of Biotechnology (DBT) and Biotechnology Industry Research Assistance Council (BIRAC) - have successfully catalysed a vibrant startup ecosystem via schemes such as BIG/ETA, PACE/PCP, BioNEST and biotech parks. It is unclear how many of the 11,850+ startups are in the industrial biotechnology sector, how is their TRL progression, turnover, or level of success. Moreover, most startups struggle to progress beyond mid-TRL stages due to techno-economic hurdles and the necessary long-term investment.

In 2024, DBT-BIRAC, in collaboration with the Association of Biotechnology Led Enterprises (ABLE), proposed the Biotechnology for Economy, Environment and Employment (BioE3) strategy to foster high-performance biomanufacturing. Its impact on driving innovation will hopefully be evident in a few more years.

Pathways to Innovation-Driven Industrial Biotechnology

The central question is how to build an ecosystem for product development comparable to MNCs, given that they control proprietary technologies, engineered strains and enzymes - making it difficult for new entrants in India to compete and deliver equal or superior products in the short term.

Therefore, India should focus on its unique biodiversity to develop foundational strains, enzymes, and novel products. This effort can be structured in two phases. First, systematically explore indigenous biodiversity to identify novel strains, enzyme sources, and product opportunities, thereby reducing dependence on intellectual property controlled by MNCs. Second, translate these discoveries into commercially viable solutions by building deep domain expertise and innovation capability to cross the "valley of death" at mid-TRL stages.

Regulation complicates the landscape of easy access and usage of biodiversity. Stringencies of the Biological Diversity Act continue to impede indigenous product development through approval requirements and regulatory ambiguities. For companies considering high-risk, long-term investments with uncertain commercial outcomes, such regulatory liabilities can be a significant deterrent, leaving much of India's biodiversity underutilised. While biosafety-related approvals remain both necessary and appropriate, a more enabling and differentiated interpretation of these provisions could unlock substantial innovation potential.

India faces a shortage of industry-experienced skilled talent at all levels of industrial biotechnology. With the closure of many MNC R&D centres, opportunities for hands-on learning in innovation-driven product development have largely diminished. Therefore, India needs to offer competitive compensation and a strong professional work environment for innovation, to attract industry-trained talent from advanced economies, who may be looking for an opportunity to return to their home country.

A Mission-Mode Strategy

As India seeks to become an innovation-driven, technology-originating industrial bioeconomy, it must establish a mission-driven institutional framework with clear accountability, on the lines of the Indian Space Research Organisation, the Novo Nordisk Foundation, or the Joint BioEnergy Institute. Such a framework should support established industries in advancing indigenously developed innovations while reducing uncertainty at mid-TRL stages. India should attract experienced talent at multiple levels from MNCs abroad to help drive these initiatives.

Such an initiative should establish a professional R&D institution to systematically harness biodiversity; enable responsible but less stringent regulatory access to biodiversity; build indigenous microbial and plant cell industrial production platforms; foster innovations through a structured pathway to mid-TRL levels; generate novel product opportunities to enable industries to adopt, scale up, and commercialise.

Establishing such foundational capabilities will enable India to drive innovation and capture long-term value through ownership of technologies and products.

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