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Biomanufacturing 2.0: India's Opportunity to Lead Through Frugal Innovation and BioE3-Driven Scale

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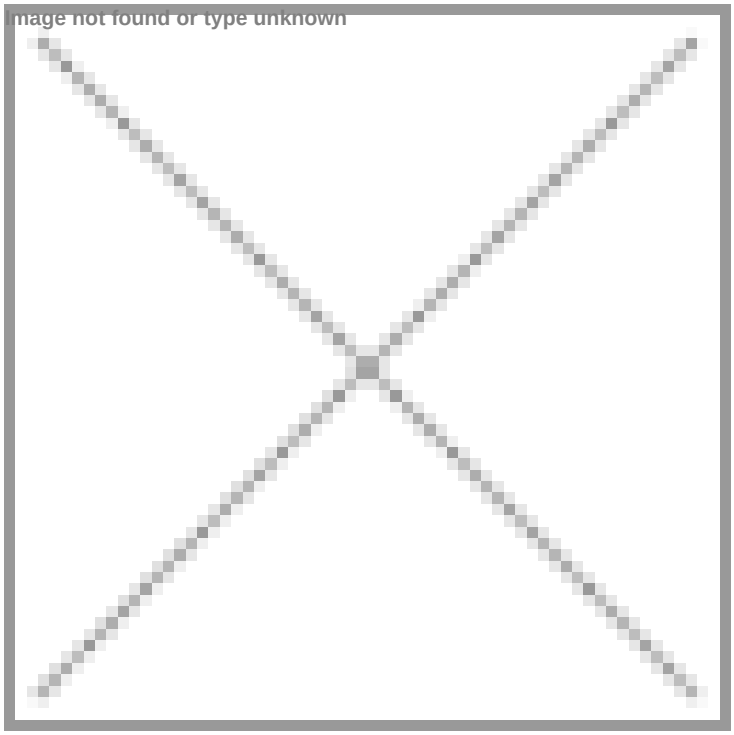
The next decade of global biomanufacturing will be defined by a single question: Can the world do more with less?



Biomanufacturing has moved from a background capability to a global strategic priority. The COVID-19 pandemic made that unambiguously clear. The race for vaccines and raw materials exposed how fragile even the strongest supply chains were. It also showed that local biomanufacturing strength can alter global outcomes. Few countries have internalised this lesson as quickly or as decisively as India.

India's leap into the global bioeconomy

India today supplies nearly 60 percent of the world's vaccines by volume. The country also exports biopharmaceuticals, enzymes, and fermentation products ranking India among top global producers. India's bioeconomy has expanded from roughly $10 billion in 2014 to an estimated $165–170 billion in 2024, growing at approximately 18 percent in the last 4 years and now contributing over 4 percent to national GDP.

This transformation not only reflects a conducive policy environment, but also a rapidly maturing innovation ecosystem. And the economic effects are tangible: stronger supply chains, import substitution for critical intermediates and raw materials, and billions saved annually.

Much of this momentum in efficiency and scale can be attributed to the last decade. What has changed?

The shift: Biomanufacturing 1.0 versus 2.0

Traditional biomanufacturing was built around large, fixed installations. These plants required enormous capital investment, took years to construct, and relied predominantly on microbial fermentation or mammalian cell systems housed in heavy stainless-steel infrastructure. While this model worked, it was slow, capital-intensive, and inflexible. Water consumption, power requirements, and waste generation ran high and the ability to pivot quickly during crises was limited.

Biomanufacturing 2.0 is different in almost every dimension. It's built around faster design cycles, modular bioreactors, distributed facilities, and digital tools that eliminate months of trial-and-error. AI modeling, automation, and real-time monitoring make it possible to adjust processes dynamically without lengthy validation cycles. The entire system becomes lighter, faster, and substantially less environmentally burdensome.

This is exactly the kind of shift where India has natural advantages. The country's cost structure, engineering culture, and demonstrated ability to innovate under constraint align perfectly with this new paradigm. India's long-standing ability to "do more with less" is being re-expressed in this next generation of biomanufacturing.

When markets and governments push in the same direction

Frugal innovation has been part of India’s DNA. Whether it’s space tech like Chandrayaan-3 or digital infrastructure like UPI, when industry and government efforts align, we can achieve much efficiency at scale.

For Biomanufacturing 2.0, the BioE3 policy is a major catalyst. Launched in 2023, BioE3 has the ambitious aim of making India achieve a US $300 billion bioeconomy by 2030, with focus on advanced fermentation, distributed manufacturing, and precision bioprocessing. The BioE3 advanced biomanufacturing hubs are providing startups and mid-size innovators access to equipment and facilities they normally cannot afford, from omics tools to digital systems, from analytics labs to pilot-reactor spaces. For large businesses, BioE3 means an environment where practices and expectations can get aligned earlier in the development cycle, especially around quality, data, and regulatory requirements.

Thanks to this push from the Centre, companies are building modular bioreactors with reduced capex, deploying continuous fermentation systems that cut energy consumption and operating pilot lines with that shorten scale-up timelines by several months. India is also developing strain-design platforms, AI-driven process-control systems, and micro-biomanufacturing networks for food, feed and materials. These are the early signals of a system that is learning to innovate at scale.

The strategic imperative ahead

The coming decade will show how well India converts this momentum into long-term leadership. Between 2025 and 2027, the focus must be on fully activating the BioE3 hubs, improving supply chains for raw materials, intermediates and equipment, ultimately reducing our dependence on imports. As we move into the following years, the integration of AI-driven optimisation, automated control systems, and the blending of biomanufacturing will define the country’s competitiveness. After 2030, as more countries tie trade access to sustainability metrics and environmental performance, India will have the chance to export not only products but entire manufacturing services that are designed for frugal, compliant, and environmentally mindful production.

Natural advantage + competitive advantage = global leadership:

In addition to policy, India’s biodiversity, climate, and broad base of natural flora and fauna are a huge advantage for research and for developing new biological processes. These are strengths that many countries are now trying to rebuild or compensate for. Power, labour, land, all of these are far cheaper than in Western markets. A large-scale fermentation facility costs 25–30 percent less to operate in India than in North America or Europe. This difference lets teams experiment without burning money at the same speed as their global competitors.

An unintended effect of the pandemic is also the transformation in investor’s mindset. Those who previously avoided manufacturing now actively look for opportunities in bioprocessing, deep tech, and advanced production. They understand that biology-based solutions are not just another industry; they are the base for healthcare resilience, food security, and sustainable materials. Today, investors are backing companies from seed stage all the way up to growth rounds, something that was rare even five years ago.

The next decade of global biomanufacturing will be defined by a single question: Can the world do more with less? Fewer

resources, lower costs, smaller environmental footprints, faster development cycles, greater resilience. If there is one country that has repeatedly shown this is possible, it's India.

The foundational elements are in place: a growing bioeconomy, supportive policy frameworks, proven cost advantages, and a track record of frugal innovation. The infrastructure is being built. The talent pipeline is expanding. Investment momentum is real and accelerating.

What remains is strategic clarity. What kind of biomanufacturing system does India need to build to stay competitive in a world moving at digital speed? The answer to that question will determine whether India becomes not just a supplier, but the global center of gravity for next-generation biomanufacturing. Environmental necessity, proven operational advantages, and rising global demand have converged to create an opportunity that India is uniquely positioned to seize.

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