

BioManufacturing

The revolution is upon us

Key Highlights	A Snapshot of Biomanufacturing	Research and Development	Market challenges	Increasing R&I Investment . Digitalisation
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Introduction Statement

The biomanufacturing revolution is upon us. Since the year 2000, biomanufacturing has risen to become a significant industry, with the ability to engineer biology along with the deployment of automation, data-analytics and AI in production processes, advancing significantly.

As of 2022, biomanufacturing could even be considered a mature market- the economies of scale found in the industry enable significant cost reductions in central unit operations. At Oak Universe, we are characterised by our ethos of supporting Europe's Fourth Industrial Revolution- and that also includes the Biomanufacturing revolution.

The biotech industry could perhaps be characterised as one of the most innovative industries and is rapidly driving revolutionary change in our ways of living at a rapid pace. Commonly associated with healthcare and pharmaceutical outputs, this industry was one of the main drivers of the development, and subsequent mass production of various brands of Covid vaccination jab. But contrary to the common association, biomanufacturing is also involved in creating food, agriculture, materials and energy production, with innovations in these fields set to take off rapidly in the next 10-20 years.

In this short paper, we present a brief industry outlook of the biomanufacturing industry, capturing the key trends in the market.

A Snapshot of Biomanufacturing

Once considered a natural phenomenon, biology may now be viewed as a fundamentally programmable technology through DNA, otherwise known as genetic code. Within the bioengineering sector, the cost of cell programming has declined by 50% year-on-year, with this technology driving the genetic engineering evolution towards the field of synthetic biology- that is, the design and build of new biological parts, systems and processes for a set purpose¹. As a whole, the European biotechnology market collected total revenues of \$78.7 billion in 2019, which represents a compound annual growth rate of 7.2% between 2015 and 2019. Since the Covid-19 pandemic, these figures have skyrocketed. Take Covid-19 vaccine developer BioNTech, whose market cap skyrocketed by almost 160% in a year, going from a market cap of around €22.5 billion in December 2020, to €61.5 billion in December 2021. Indeed, 15 biotech companies in Europe had a market cap in the billions as of December 2021.

Of course, healthcare is only one aspect of the biomanufacturing market. Along with interdisciplinary fields such as applied immunology, genomics and the development of diagnostic tests and pharmaceutical therapies, food production, agriculture and medicine are the most important applications of biotechnology in Europe. Over the next 10 to 20 years, more than half of the direct impact by new biotech applications will be felt in the consumer products and services sectors, materials sector, energy production sector, agriculture sector and food sector. The importance of this sector is demonstrated by the rapid growth in investment. In 2020, global venture capital funding and deals were worth \$36.6 billion, and biotech IPOs doubled in terms of capital raised in comparison to 2019. Moreover, McKinsey predict that the economic benefits of biomanufacturing could be worth up to \$4 trillion a year across the next 10-20 years, as a result of the combined innovation attached to the industry and an ongoing fall in costs.

Case Example: Bioreactors

Within the biomanufacturing industry, one of the biggest market opportunities in the next 10 years is the increasing development and commercialisation of bioreactors. Growth for the European bioreactors market was valued at over \$1.7 billion in 2019 and is expected to witness a compound annual growth rate of over 13.7% from 2020 to 2026. Increasing funding and investment from the governments of various countries across the EU will favour the growth of the bioreactors market. While this growth and funding is mainly driven by the Covid-19 vaccine initiative, which the EU allocated significant funding towards, a growing number of new market biotechnology firms in Europe will further boost the production and adoption of bioreactors. Single-use bioreactors particularly, are expected to progress at a compound annual growth rate of 16.7%, with the adoption of single-use bioreactors in biomanufacturing facilities credited with multiple benefits, including reductions in cross-contamination, flexibility in the use of floor space to manufacture different types of low-volume products and the ability to manufacture multiple products.

Leading European Biotechnology Firms by Venture Financing (2020)

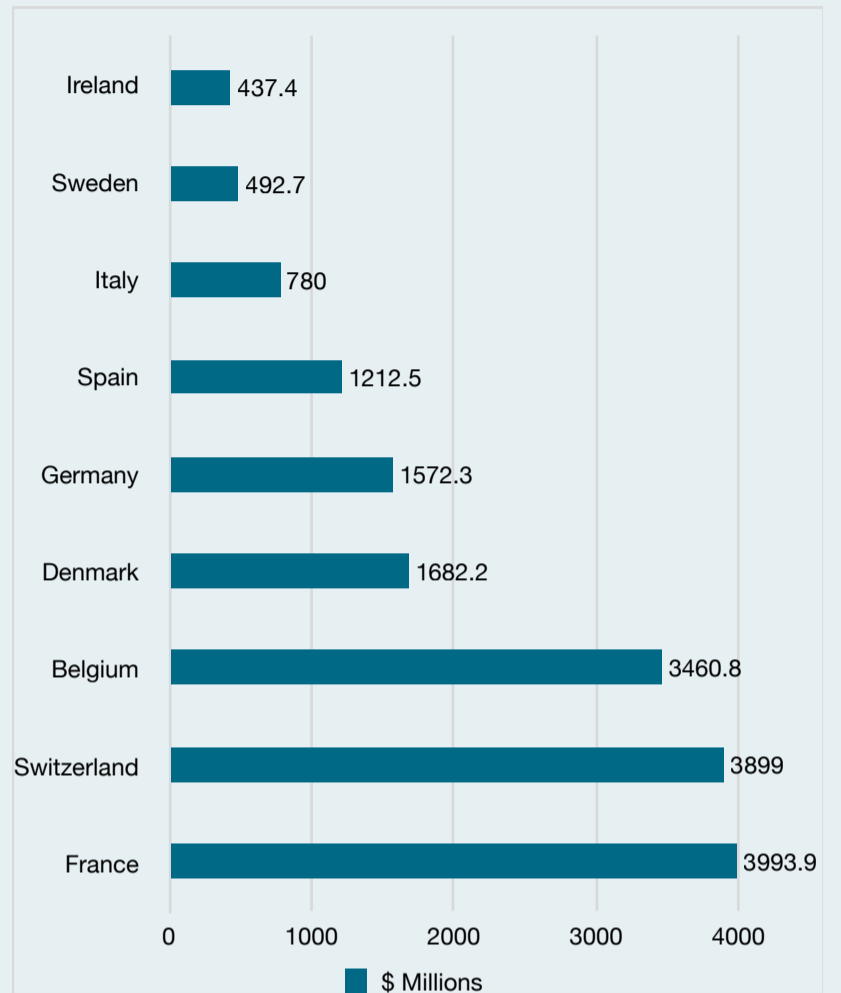
Company (Country)	Venture Capital in \$ million
CureVac (Germany)	300
Legend Biotech (Ireland)	132
Immunocore (UK)	114
iTeos Therapeutics (Belgium)	109.6
Freeline Therapeutics (UK)	105.2
Oxford Nanopore Technologies (UK)	93
ALX Oncology (Ireland)	92.1
Alvotech (Ireland)	87.7
ATAI Life Sciences (Germany)	81.6
Lava Therapeutics (Netherlands)	72.8

Research and Development of Biomanufacturing

Moreover, research and development spending in the biotechnology business sector continues to grow, with France, Switzerland, Belgium and Denmark demonstrating the most expenditure.

At present, several drivers are fuelling the growth of the biomanufacturing industry. Perhaps one of the main drivers is the increasing trend for biomanufacturing vendors to integrate automation technologies. While in the early stages of implementation within the industry, and mainly adopted by larger market actors, the integration of automation technologies in biomanufacturing vendors is facilitating a boost in the bioproduction workflow, whilst at the same time reducing time, cost, labour and errors. An increasing number of pipeline products is further driving biomanufacturing. For example, the global plant based biomanufacturing market is predicted to expand rapidly within the next five years due to a significant number of pipeline products, across a wide number of firms. Sustainable, innovative and scalable biomanufacturing solutions across value chains are driving the performance, economic and environmental advantages of this form of manufacturing. But is the biomanufacturing revolution sustainable, and from an investment perspective, will it continue on an upwards curve? We look at some of the challenges and opportunities for the industry to answer these questions.

**Business Sector Biotechnology R&D
(Selected European Countries, 2019)**

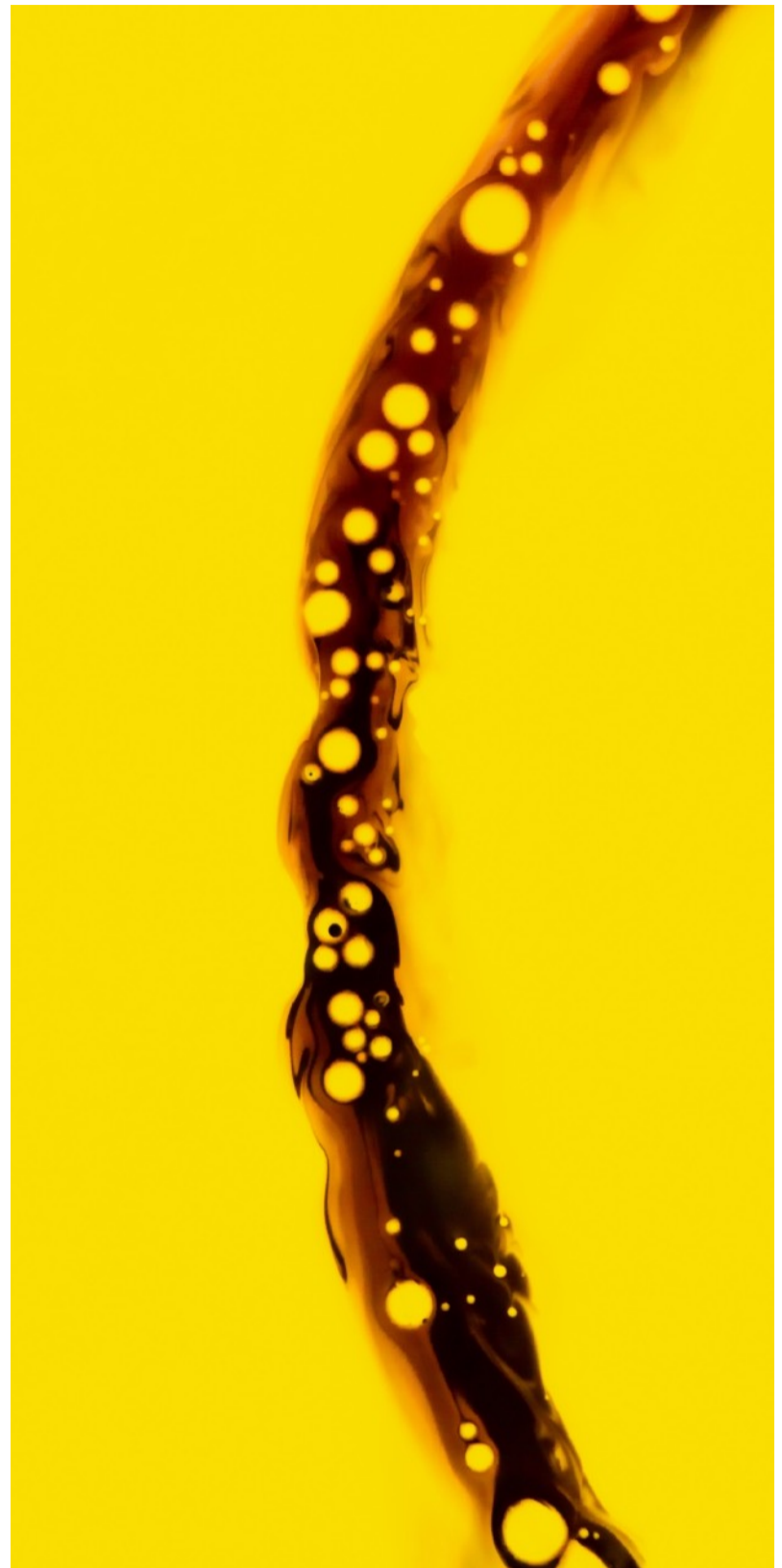


Market Challenges for Biomanufacturing

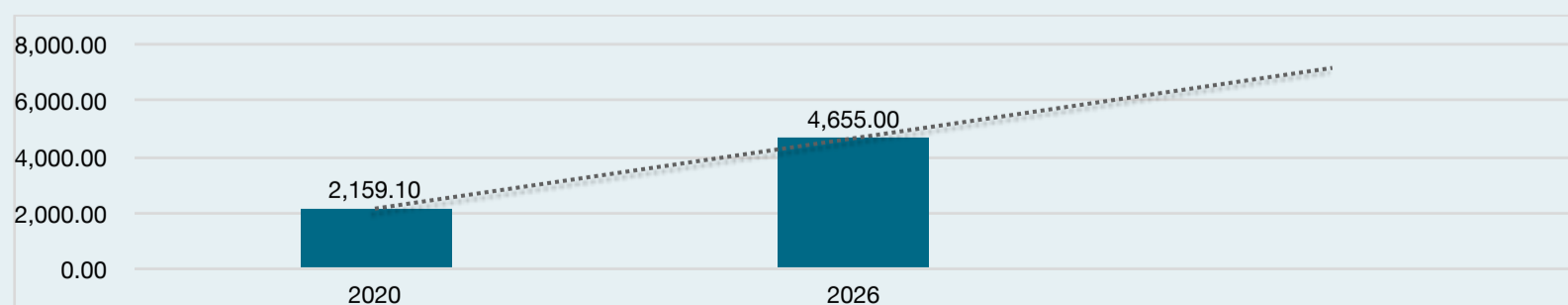
Although the biomanufacturing industry continues to expand and grow, there are some challenges within the sector, which may be particularly challenging for smaller, medium-sized firms. The industry is associated with unpredictable costs, and high levels of capital expenditure. Moreover, high operational complexity and compatibility challenges further add to costs and can result in delays to the manufacturing process.

Manufacturers require increasing access to scale in both the development and deployment of biomanufacturing solutions, to accelerate and support the growth of the bioeconomy. The World Economic Forum recommends that this is done through the formation of strategic partnerships across large platform developers, mature-consumer facing companies and application-specific technologies, leveraging of the increasing data sets generated by automation, AI, and platform developers, and building a network of manufacturing partners and technologies (i.e., joint investments in pre-competitive facilities, public-private sector partnerships)¹.

The lack of skilled professionals within this industry presents a further challenge to biomanufacturing. To realise the full potential of the bioeconomy, and facilitate distributed and local modes of manufacturing, then the workforce needs to be significantly expanded. Ultimately, this a challenge that ultimately must be countered at the level of educational policy (i.e., via greater investment in early STEM education). However, given the general shift towards digitalization and automation in the manufacturing industry as a whole, there exists a common skillset across the traditional technologies in manufacturing, which can be translated and applied to the biomanufacturing workforce with the right guidance and support. Finally, we identify policy as being a potential challenge for the industry in the coming years. The biomanufacturing industry is fuelled by innovation, and it is imperative that policy aligns with the pace of this level of innovation, in order to allow for novel solutions while simultaneously managing risks.



Europe Bioreactors Market, Compound Annual Growth 2020-2026 (\$ million)



Market Opportunities for Biomanufacturing

Despite challenges, the biomanufacturing industry will continue to grow due to the obvious performance, environmental and economic advantages. We identify two key market opportunities that will shape biomanufacturing in the next decade.



Solving Global Crises

Biomanufacturing presents the opportunity to develop technologies that can help to counter major global crises, including preparedness for and prevention of pandemics, and microplastic pollution. According to the World Economic Forum, the next two decades will reveal major advances in three areas that will help to solve these global problems.

In the first instance, biomanufacturing will advance bioremediation, with the continued development of enzymes and microbes to metabolize contaminants of wastewater and transform them into useful bioproducts. In the second instance, advances in biosecurity will result from the generation of localised biomanufacturing capabilities across both developed and developing nations.

This will enable for both fast and effective responses to emergent pandemics. In the third instance, advances in bioinnovation will allow for the development of both novel and existing materials and ingredients, enhancing value chains and providing alternative materials to petrochemicals.

Increasing R&D Investment, Digital Transformation



With the increasing adoption of Industry 4.0 technologies in biomanufacturing, comes increased benefits to the production process. Real-time monitoring is one area that AI could present a significant impact, given that accurate predictive controllers can enable for process robustness improvements, anticipate failures, minimise waste, and thus ensure product quality. Supply chain timelines can also be optimised due to the continuous monitoring and predictive control associated with this type of technology. Centralized systems of analytics can provide optimised production schedules and resources, allowing for factors such as weather, raw material availability, global demand and sustainability to be considered.

Certain value chains will be particularly benefited by the increasing implementation of Industry 4.0 technologies in biomanufacturing. For example, in the biopharma industry, analytics platforms will allow biomanufacturers to provide more accurate demand forecasts, reduce the level of input and effort required to investigate process

deviations, improve cycle times, reduce discards and improve yields. In a similar vein, “digital twins” (that is, the creation of a computer model of a complex manufacturing environment) provides benefits to the biopharma industry in that the implementation of such models allows collaboration to be rewarded, and benefits from the work achieved already in other industries.

Summary

An increasing number of industries are turning to innovative solutions for manufacturing interactions. Increasingly, machines are equipped with decision-making capabilities, and biomanufacturing is no different. This growing, revolutionary industry, can capitalise on the benefits of data-driven manufacturing, to propel the already exponential growth of the industry, helping to fashion novel solutions, to real world problems, and providing both social and environmental benefits. With the industry boasting an already impressive track record for venture capital investment, we posit that future investments towards the scaling-up of the biomanufacturing industry will signify more than just profitable

The Snapshot

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The industry is associated with unpredictable costs, and high levels of capital expenditure



The lack of skilled professionals within this industry presents a further challenge to biomanufacturing.



Biomanufacturing presents the opportunity to develop technologies that can help to counter major global crises, including preparedness for and prevention of pandemics, and microplastic pollution.



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