

**INNOVATION
CENTRE
DENMARK**



THE FUTURE OF FOODS

**ALTERNATIVE PROTEINS
INNOVATION CLUSTERS IN THE US**

INNOVATION CENTRE DENMARK BOSTON

2023

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EXECUTIVE SUMMARY

The rising global demand for protein-rich food, coupled with growing concerns regarding the environment and health, has led to the emergence of alternative proteins as a promising biosolution to address the world's protein demand and simultaneously reduce the CO₂ footprint from the food sector.

Alternative proteins encompass, among others, cultivated meat, plant-based proteins, and fermentation-based proteins, offering benefits in terms of environmental sustainability, public health improvement, and animal welfare advancement.

The Danish government has pledged to reduce Denmark's CO₂ footprint by 70 pct. by 2030, and the food and agricultural technology sector is one out of four specific areas (called missions) mentioned in the Danish Green Research Strategy where we can develop new solutions and processes to reach our overall reduction goal.

With this goal in mind, Innovation Centre Denmark in Boston has dedicated 2023 to make a deeper innovative dive into alternative protein space in the US to identify trends, stakeholders and the leading innovation hubs regarding alternative proteins.

It is crucial to underscore that the alternative protein industry is in its infancy. Because of the sector's novelty, this report is mainly based on the results of more than 50 qualitative interviews with key opinion leaders from Industry, Academia, Investors, startups and government. While certain technologies have existed for an extended period, most scientific breakthroughs enabling the production of these innovative food products have emerged in recent years. The novelty is also the reason for the lack of long and consistent data series in some report areas.

Meat consumption has reached an all-time high worldwide. The global consumption of meat proteins is projected to increase by 14% by 2030 as compared to the average base period of 2018-2020. Projections by the United Nations (UN) indicate that global meat production will double by 2050. By transitioning from conventional meat and dairy products

to alternative protein sources, the environmental impact of proteogenic food on the climate crisis is reduced. Elevating the worldwide market share of alternative proteins from the present 2% to 8% by 2030 has the potential to reduce emissions comparable to decarbonising 95% of the aviation sector. (BCG, 2022) Increased concerns regarding sustainability, food security, and the ecological and public health consequences of industrial animal agriculture have stimulated a pressing need to develop protein alternatives that are attractive to the public instead of being restricted to niche markets. As a result, there has been a remarkable increase in innovation in the alternative protein space in the last decade.

In Chapter 1, the report starts by providing an introduction to alternative proteins and the three sub-sectors. This is followed by chapter 2, with a brief overview of the global hotspots beyond the US. Chapter 3 provides an analysis of the main Innovation ecosystem for alternative proteins in the US. The analysis is based on five perspectives from Government, Universities, Investors, Startups and Corporates. Lastly, in chapter 4, we are looking into the future of alternative proteins.

According to the Good Food Institute (GFI), Denmark has the potential to become a leader in the alternative protein revolution. In 2021, the Danish authorities allocated a substantial amount of 1.25 billion Danish kroner (\$177 million) to excel in the advancement of plant-based food production, establishing an unprecedented climate agreement specifically targeting the food and agricultural sectors. This financial commitment represents the most substantial investment made by any member state of the European Union thus far, emphasising the nation's dedication to research and development in plant-based initiatives.





ALTERNATIVE PROTEINS – WHAT IS THE FUZZ ABOUT?

Meat consumption has reached an all-time high worldwide. The global consumption of meat proteins is projected to increase by 14% by 2030 as compared to the average base period of 2018-2020. Projections by the United Nations (UN) indicate that global meat production will double by 2050.

The increasing demand for meat poses a major challenge to both Danish and global ambitions of reducing greenhouse gas emissions. Denmark has committed to 70 per cent reductions by 2030 compared to 1990 levels and to achieving carbon neutrality by 2050. While Denmark has developed promising solutions to address greenhouse gas emissions across various sectors within the food production sector, we have yet to see the changes and innovations that will allow it to meet the 2030 goals.

Transitioning from conventional meat and dairy products to alternative protein sources represents a promising strategy for addressing the impact of proteogenic food on the environment. For example, if the global market share of alternative proteins increased from the current 2% to 8% by 2030, it could reduce emissions by an amount comparable to decarbonising 95% of the aviation sector. (BCG, 2022).

In addition to the climate change related advantages, other concerns about our reliance on industrial animal production – ranging from concerns about food security to animal welfare – are also driving demand for the development of protein alternatives that are attractive to mainstream consumers. While the industry is arguably still in its infancy, it has, in the last decade, experienced a remarkable increase in successful innovation, with whole new categories of products making it into the supermarkets and onto the plates of consumers.

Arguably, innovation within the alternative proteins can be seen as an important part of a biosolutions trend – the emergence of a range of bio-related technologies and products, e.g. within the food, energy, and materials sectors, that seek to mitigate the environmental impacts of our consumption and industrial production by leveraging biological processes or products.

1. INTRODUCTION TO ALTERNATIVE PROTEINS

This report provides an introduction to alternative proteins and the innovation ecosystem in the US that is currently leading the development and commercialisation of alternative protein products.

It is our hope that the document can serve as a short guide providing Danish and other European policy makers, entrepreneurs, companies, and research institutions a starting point for thinking about the key stakeholders and opportunities to consider within the alternative protein space.

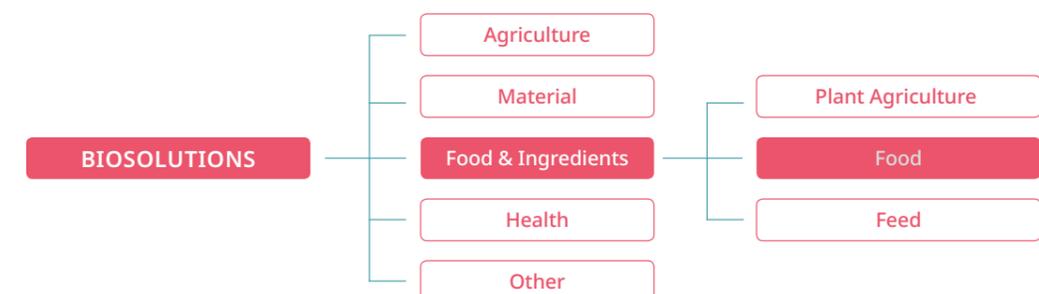
In the introduction, we provide an overview of what alternative proteins are and a high level of motivation for why they should be considered an important part of the toolbox needed to address the growing demand for proteins without compromising climate ambitions.

With a focus on the US, the second chapter presents an analysis of the alternative protein innovation ecosystem. In the analysis of the ecosystem, we lean on the MIT Stakeholder framework, taking a look at the role and readiness of universities, governments, risk capital providers, entrepreneurs, and corporates, respectively.

The insights presented are based on desk research as well as interviews carried out with more than 50 key innovation stakeholders across the identified biosolutions clusters in the US.

“Biosolutions are the products of the discovery, development, upscaling, and commercialisation of biological products on an industrial scale. It involves utilising biological systems to convert raw materials, create value, and develop new or adapt value chains while prioritising sustainable production. Using science and technology, biosolutions work towards reducing or mitigating adverse effects on climate and the environment.”

FIGURE 1: BREAK-DOWN OF BIOSOLUTIONS



ALTERNATIVE PROTEINS – WHAT ARE THEY?

The category of alternative proteins encompasses, among other products, cultivated meat, plant-based proteins, and fermentation-based proteins.

CULTIVATED MEAT

Cultured meat is a new way of producing meat using tissue engineering techniques to grow edible animal tissues. It involves arranging the same types of cells found in animals into structures that resemble their natural counterparts. This allows cultivated meat to closely mimic traditional meat's taste, texture, and nutritional qualities. In June 2023, the FDA approved Upside Foods and GOOD Meat to sell cultivated chicken, making the US the second country, after Singapore, to authorise the sale of lab-grown poultry.

FERMENTATION

For thousands of years, microbial cultures have been employed in food production, with ancient societies using cultures to preserve food, produce alcoholic beverages, and improve the nutritional value and bioavailability of foods like kimchi and tempeh. In recent times, fermentation has expanded beyond its historical applications. It has become an important tool in a wide range of fields, including industrial chemistry, biomaterials, therapeutics, fuels, and advanced food ingredients. Within the alternative protein industry, fermentation is applied in three primary ways:



TRADITIONAL FERMENTATION

enzymatic conversions of major and minor food components (Marco et al., 2017).



BIOMASS FERMENTATION

capitalises on the rapid propagation and elevated protein yield of numerous microorganisms to produce substantial protein quantities cost-effectively



PRECISION FERMENTATION

utilises engineered microbial strains to synthesise targeted functional ingredients. (GFI, 2023)

PLANT-BASED

Unlike animal-based proteins, which are derived from animal sources such as meat, dairy, and eggs, plant-based proteins are obtained from plant sources such as legumes (e.g., beans, lentils, chickpeas), grains (e.g., wheat, rice, oats), nuts and seeds (e.g., almonds, cashews, pistachio), and vegetables (e.g., spinach, broccoli, peas). (Langyan, et al., 2022)

“Increased utilisation of plant-based products, cultivated meat, and fermentation can potentially revolutionise the food production industry in a way that significantly reduces the environmental impact of our food system.”

Quote from anonymous food industry leader



2. ECOSYSTEM ANALYSIS – INNOVATION HOT SPOTS IN THE US

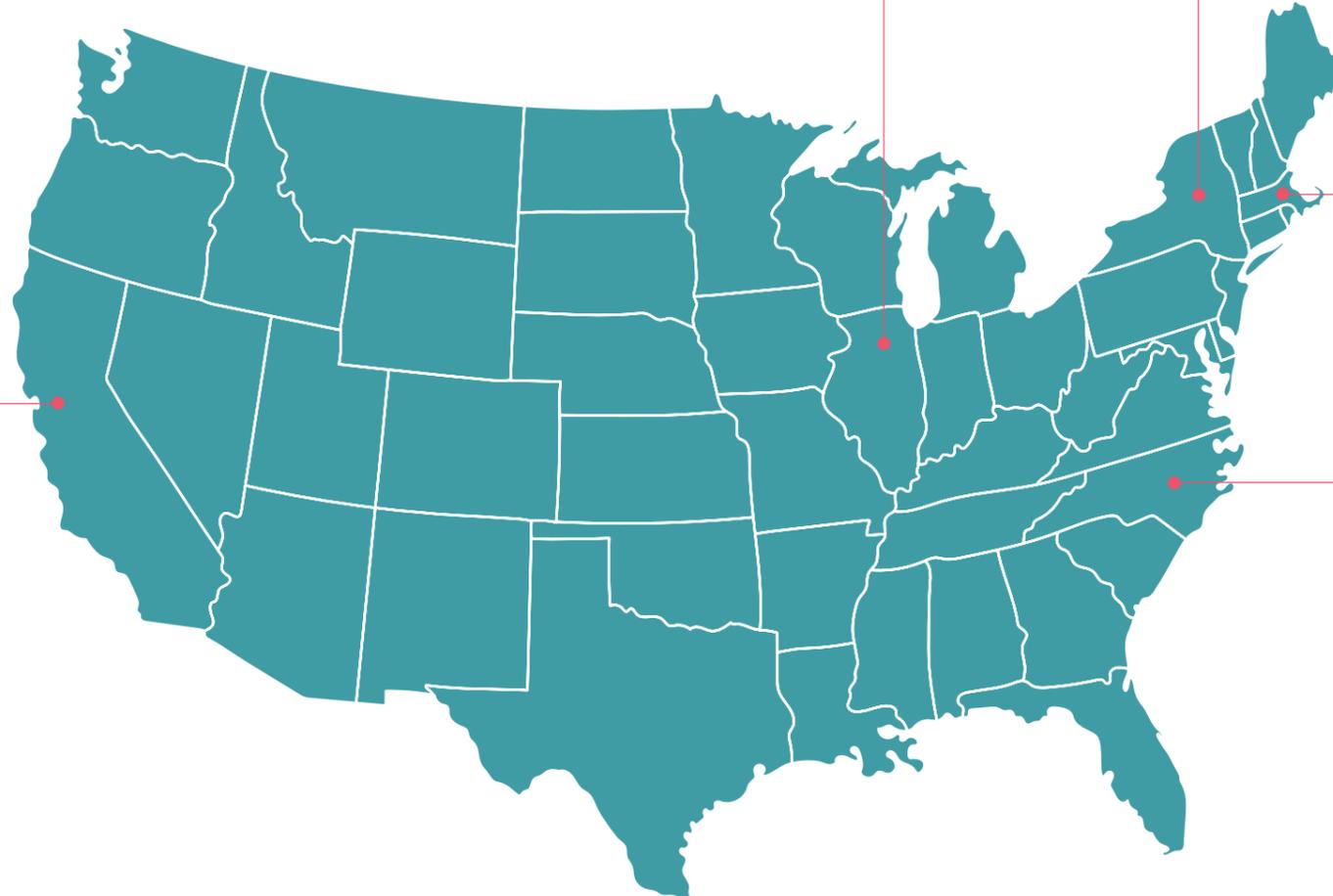
This report gathered insights from key innovation stakeholders in the alternative protein industry regarding thriving alternative protein hotspots in the US. According to their feedback, Boston, the Bay Area, North Carolina, Chicago, and New York were consistently highlighted as the most important innovation hotspots in the alternative protein space.

Chicago

- Home to **S2G Ventures**, one of the most active investors in the alternative protein space
- Chicago is the traditional **centre of the US food and beverage manufacturing** generating \$9.4 billion annually in output and employing over 65K people. (Chicago Business Bulletin, 2022)

Bay Area

- Home to **UC Davis**, a world-leading research institute in alternative proteins and **Berkley's Alternative Meats (Alt: Meat) X-Lab**
- Leader in the US in terms of invested capital **\$927.94 million**
- Birthplace of pioneering startups such as **Upside Foods, Good Meat, Impossible Foods**



New York

- SOSV, the world's most active investor in life sciences, launched their new accelerator sight, **IndieBio New York**, in 2020
- Host of the annual **Future Food Tech (FFT)** summit on alternative proteins, where more than 800 players of the alternative protein industry meet

Boston

- Home to **Tufts University**, a world-leading research institute in cultivated meat. Tufts is leading the US centre of excellence on cellular agriculture. Additional partners are MIT, UMASS, Virginia Tech, Virginia State and University of California
- **\$360.26 Million** total invested risk capital in the alternative protein space in the US to date
- **World-leading life science cluster** and home to specialised companies and talent such as Ginkgo Bioworks

North Carolina Research Triangle

- Home to the **North Carolina (NC) Food Innovation Lab**, which received \$4.4 million in public funding for plant-based research
- Home to the **research triangle** with three tier one research universities—Duke University, North Carolina State University and University of North Carolina Chapel Hill

In addition to the qualitative investigation of the hotspots, a bibliometric analysis was conducted, focusing on precision fermentation, cultivated meat, and plant-based proteins to understand the research hotspots in the field. In addition to the identified hotspots in the US, the Copenhagen area was also included as a comparative point of particular interest in our context. The analysis revealed regional variations within each cluster and technology.

When examining plant-based products, Boston, New York, the Bay Area, and Copenhagen demonstrated significant research productivity based on scholarly output. Boston, New York, and Copenhagen also stood out for their strong inclination towards collaborative frameworks in academic research related to plant-based products, indicating a commitment to international collaboration.

FIGURE 2: ALTERNATIVE PROTEIN CLUSTERS IN THE US

HOT SPOTS BEYOND THE US

While US is the frontrunner in many aspects of the alternative protein industry, it is worth briefly looking at the global picture before turning to an in-depth analysis of the innovation ecosystem in the US.

Based on investments, innovation, and scholarly output, Denmark, Singapore, Israel, Canada, the Netherlands, Qatar, and China all stand out as emerging leaders in the field. Some of the key achievements of these research and investment hotspots are outlined below.

DENMARK

According to the Good Food Institute (GFI), Denmark has the potential to become a leader in the alternative protein revolution. In 2021, The Danish Ministry for Food, Agriculture, and Fisheries revealed plans to invest \$100 million in establishing a recently formed Grant called Plantefonden (the plant-based grant). The fund will remain operational until 2030 and exclusively allocate funds to plant-based food initiatives. This announcement follows closely on the heels of the government's investment of \$177 million over nine years in plant-based research and production in 2021. This financial commitment represents the most substantial investment made by any member state of the European Union thus far, emphasising the nation's commitment to research and development in plant-based initiatives.



TALENT

Large talent pool and unique academic landscape with world-leading universities like the Technological University Denmark (DTU) and Aarhus University



SUSTAINABILITY LEADER

World leader in sustainable solutions: Denmark ranks first in *Environmental Performance Index 2022*



PUBLIC FUNDING

The recent investment of 177\$ Million into a plant-based fund exemplifies only one of the many commitments the Danish government has made to more sustainable protein sources



COMPETITION

Its biosolutions industry is globally competitive, with 4-5 times as many biotech patents per capita as the average of the ten leading research nations (Copenhagen Economics, 2022)

FIGURE 3: GLOBAL HOTSPOTS



SINGAPORE

Attracting numerous startups aiming to create and introduce meat-free substitutes for traditional meat products, Singapore stands out as a global pioneer. According to the Good Food Institute, there are currently at least 36 alternative protein enterprises situated in the city-state, collectively securing over US \$213 million in funding. Singapore serves as a noteworthy model for governments that actively promote the advancement of this industry, providing strong advocacy for alternative proteins. The reason for this is partly due to its geographical location. With less than 1% of its land used for farming, Singapore heavily relies on imports, with more than 90% of its food supply being imported, making it vulnerable to potential supply chain disruptions. Notably, Singapore was also the first country to approve the selling of lab-grown meat by Eat Just. (The Guardian, 2022)

ISRAEL

Israel has established itself as a frontrunner in providing national backing for alternative proteins, particularly cultivated meat. With \$637 million invested from 2020-2022, Israel accounts for 24 per cent of global investment in the cultivated meat sector. The government leadership consistently demonstrates explicit and frequent support for alternative proteins. (GFI, 2023)

CANADA

In 2022, Canada emerged as a global leader in public funding for plant-based foods in North America. Protein Industries Canada, a cluster of excellence, supported 45 plant-based protein R&D projects, including a Regulatory Centre of Excellence and an online resource for easier navigation of policies and funding. They also provided funding to enhance the production capacity of Canadian-grown chickpea tofu and develop new products for the plant-based cheese market. (Protein Industries Canada, 2022)

QATAR

Leading plant-based egg and cultivated meat company Eat Just secured a \$200 million investment round, with Qatar's sovereign wealth fund, the Qatar Investment Authority, as the lead investor. Additionally, Doha Venture Capital, a state-supported investment fund, and the Qatar Free Zones Authority, an autonomous body responsible for overseeing and regulating free zones in the country, unveiled intentions to construct a cultivated meat production facility in Doha, with a total investment of \$200 million.

CHINA

During the "Two Sessions" in March 2022, China's pivotal yearly political conference, President Xi Jinping explicitly advocated for diversifying protein sources, including those derived from plants and microorganisms. China's "Greater Food Approach," a recurring term in significant speeches and documents, highlights the goals of enhancing self-sufficiency, quality, and diversity of food sources. Developing the plant-based industry aligns with China's food security blueprint and its focus on achieving these objectives. This development is also reflected in China's significant output of research publications in the field of alternative proteins. (GFI, 2023)

THE NETHERLANDS

The Netherlands stands as a pivotal force in food technology, investing heavily in alternative proteins. With a robust commitment to sustainability, the Dutch contribute substantially to the global shift towards alternative protein sources. Recent data reveals a surge in plant-based and lab-grown innovations, showcasing the country's prowess in research and development. As of 2022, the Netherlands has witnessed a 25% increase in investments in alternative protein ventures, solidifying its role in shaping the future of sustainable and scalable food solutions on a global scale.



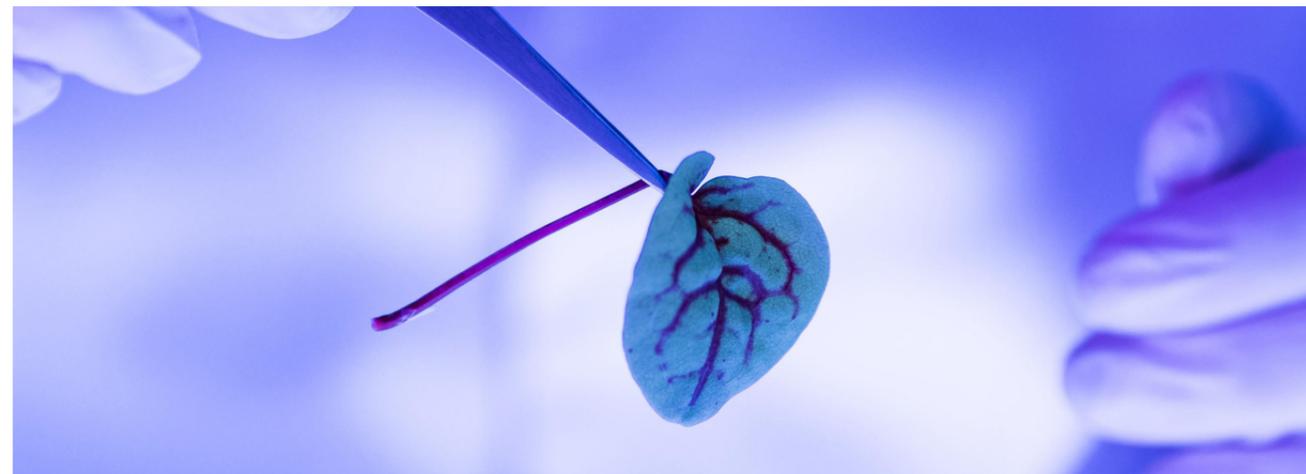
US INNOVATION ECOSYSTEM

This chapter is mapping out the key players and forces. Our hope is that this stakeholder map of the US will help entrepreneurs, corporates, academia, policy makers, and other decision-makers in Denmark, Europe, and beyond learn from and more effectively engage with innovation in the US. The findings are based on reports, interviews with industry experts, and relevant articles.

US GOVERNMENT – A LEADER IN TRANSFORMING THE INDUSTRY

Government stakeholders in the US, both at the state and federal levels, have a significant impact on the growth and development of the emerging alternative protein industry. Government stakeholders can play a crucial role in supporting the innovation ecosystem by providing public funding for R&D, fostering international collaboration, and shaping policies that are conducive to innovation and successful commercialisation. Policies such as the executive order on biomanufacturing by the Biden administration show a growing recognition of the potential impact of the biosolutions industry on the food sector.

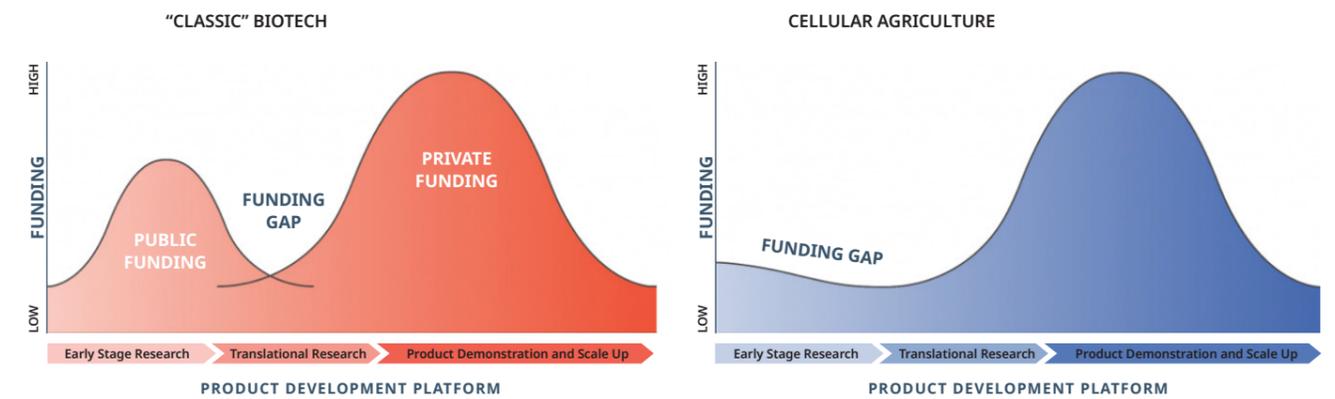
The Covid-19 pandemic and other crises exposing geopolitical uncertainties have made governments acknowledge the importance of nurturing domestic food sources as a strategic response to the vulnerabilities inherent in a globalised food system. As the alternative protein industry expands its scope in terms of crop utilisation, infrastructure development, and export opportunities, governments are increasingly recognising its potential and are committing to fostering the necessary knowledge, facilitating scalability, and providing support to an industry that has the capacity to generate millions of jobs and trillions of dollars in economic value on a global scale. (GFI, 2023)



PUBLIC FUNDING

It has been argued that there still exists a major funding gap in the cellular agriculture space.

FIGURE 4: THE FUNDING GAP



Generally, the path of biotechnology innovation commences with publicly funded fundamental research, which often involves high costs and exploratory investigations beyond the capacity of individual companies. The advancement of cellular agriculture is constrained by insufficient funding for pre-competitive and early-stage research, impeding scientific breakthroughs in the field.

As the initial research progresses and demonstrates promise, companies then transition the discoveries from the laboratory setting to tangible products that have the potential to revolutionise various industries. (New Harvest, 2023).

However, in the United States, it seems that both at the federal and state levels, steps are being taken to address the funding gap and to promote plant-based proteins. Key developments include:

FEDERAL FUNDING:

In 2022, the US Department of Agriculture's National Institute of Food and Agriculture (USDA-NIFA) initiated three new projects at the University of Massachusetts Amherst, Virginia State University, and Washington State University. (USDA, 2022) In late 2022, Congress passed the FY23 Omnibus Appropriations Package, directing an additional \$1 million towards alternative protein research, raising the total funding to \$6 million.

STATE INITIATIVES:

California allocated \$5 million from its 2023 budget specifically for alternative protein research, focusing on plant-based proteins. Additionally, they set aside \$100 million to expand the availability of plant-based and sustainable lunches in public schools. New York City implemented two significant initiatives in support of plant-based food. First, a Chefs Council was established with the objective of creating delicious, nutritious, and culturally relevant plant-based meals for public schools in NYC. Second, the New York City Health + Hospital policy mandated plant-based meals as the default option for hospital lunches.

FIGURE 5: THE MAJOR PROVIDERS OF PUBLIC FUNDS INCLUDE

 ANIMAL CHARITY EVALUATORS Animal Charity Evaluators	 NIST National Institute of Standards and Technology U.S. Department of Commerce NIST	 WSDA Washington State Department of Agriculture Washington State Department of Agriculture	 FFAR FFAR (Foundation for Food and Agriculture Research)
 arpa-e CHANGING WHAT'S POSSIBLE DoE ARPA-E	 NEW HARVEST New Harvest	 BioMADE BioMADE	 SBIR America's Seed Fund SBIR
 NSF	 California State Government	 NIFA	 USDA
 Bill & Melinda Gates Foundation	 USDA ARS USDA ARS	 Noble Family Innovation Fund	Crowdfunding



The alternative protein industry has witnessed a surge in public grants and investments, particularly on the East Coast. These investments show the growing interest in and support for alternative protein R&D.

Institution	Year	Funding	Purpose
UC Davis	2020	\$3.5 million over 5 years	Cultivated meat research, including cost-effective media development, tissue structure creation, and life cycle analysis
Tufts University and partner institutions	2021	\$10 million over 5 years	Establishment of a prominent cultivated protein research centre as part of the USDA's Sustainable Agricultural Systems program, aiming to drive growth in cellular agriculture
North Carolina Food Innovation Lab	2018	\$4.4 million	Product research, manufacturing, and services within the plant-based foods sector
USDA-NIFA	2022	\$6 million	Plant-derived protein investigations at multiple universities, including \$1 million from the FY23 Omnibus Appropriations Package

Source: GFI

In 2022, the US administration announced to strengthen the biotechnology field in the US, through an executive order - the National Biotechnology and Biomanufacturing Initiative. The administration's policy aims to facilitate a collaborative effort among various agencies to promote the progress of biotechnology and biomanufacturing as a means of addressing diverse challenges in sectors such as food security, agriculture, and supply chain resilience within the US economy.

From the Executive Order:

"For biotechnology and biomanufacturing to help us achieve our societal goals, the United States needs to invest in foundational scientific capabilities. We need to develop genetic engineering technologies and techniques to be able to write circuitry for cells and predictably program biology in the same way in which we write software and program computers; unlock the power of biological data, including through computing tools and artificial intelligence; and advance the science of scale-up production while reducing the obstacles for commercialisation so that innovative technologies and products can reach markets faster."

To realise these objectives, the Administration’s National Biotechnology and Biomanufacturing Initiative policy seeks to:

- Bolster and coordinate federal investment in key research and development areas of biotechnology and biomanufacturing
- Improve and expand domestic biomanufacturing production capacity and processes while also increasing piloting and prototyping efforts in biotechnology and biomanufacturing to accelerate the translation of basic research results into practice
- Boost sustainable biomass production and create climate-smart incentives for US agricultural producers
- Expand market opportunities for bioenergy and biobased products and services.

FIGURE 6: THEME 2 FROM THE USDA SECTION IN THE BOLD GOALS FOR BIOMANUFACTURING

Theme 2: Improving Food Nutrition, Quality, and Consumer Choice		
Goal 2.1	Develop New Food and Feed Sources	Develop new food and feed sources, including production of novel or enhanced protein and fat sources at scale, to support the United Nations Sustainable Development Goal to eliminate Global Hunger by 2030.
Goal 2.2	Enhance Nutrient Density in Foods	Within the next 20 years, enhance nutrient density in agricultural plants and animals, develop underutilised plants and animals that have enhanced nutrient density, are build on traditional ecological knowledge to better utilise and conserve culturally important and nutritionally relevant plants and animals.
Goal 2.3	Reduce Foodborne Illness	Reduce incidence of foodborne illness, including with new and improved screening tools, toward meeting goals set in Healthy People 2030, such as a 25% reduction in Salmonella illness.

In line with the Executive order, it was announced that the Department of Defense (DoD) will allocate \$1 billion over the upcoming five years to enhance the domestic bioindustrial manufacturing infrastructure. The objective is to stimulate the creation of a domestic bioindustrial manufacturing base accessible to US innovators. While it is unclear how much of this investment will directly benefit solutions in the fermentation, plant-based and cultivated proteins spaces, the investments do indicate a growing willingness to finance R&D that likely will benefit the alternative protein industry in the long run.

POLICY DEVELOPMENT

The Food and Drug Administration (FDA) and the United States Department of Agriculture (USDA) play critical roles in ensuring the safety, labelling and quality of alternative protein products to build consumer confidence and maintain industry integrity. Unlike in the EU, where entrepreneurs are often left on their own to navigate the demanding application process for Novel Foods with the European Food Safety Authority (EFSA), interviews with the FDA revealed that they are actively trying to support startups and entrepreneurs, align regulatory frameworks with industry needs and foster an environment conducive to innovation and market expansion. In the US, there is no specific definition of or regulation for novel foods; instead, they are governed under normal food regulations, regardless of their origin in terms of technology, time, or location. If a new substance is not categorised as a food, it would be regulated as either a direct food additive or a food contact substance, depending on its intended use. The FDA evaluates any new food ingredient as either a food additive, requiring pre-market approval, or as Generally Recognised as Safe (GRAS) for specific uses, determined independently by a panel of experts separate from the FDA. A milestone worth noting is that in June 2023, the FDA approved Upside Foods’ and Good Meats’ cultivated chicken – a significant breakthrough for the industry.

INTERNATIONAL COLLABORATION AND PROMOTION

Effective collaboration among governmental entities, national and international public sector stakeholders, and the private sector is key to driving fundamental scientific competencies, fostering innovation, and successfully growing the bioeconomy of the US. The Bold Goals for US Biotechnology and Biomanufacturing include strategies to accelerate the advancement of alternative proteins and related fields, and the strategic framework underscores the critical role of fostering robust public-private partnerships that serve as catalysts for innovation and ensure effective coordination with both domestic and international collaborators.

By cultivating collaborative networks and strengthening cooperation, the US solidifies its commitment to driving progress and innovation in the alternative protein sector, establishing itself as a prominent leader in the industry (The White House Office of Science and Technology Policy, 2023).

TRENDS & OBSERVATIONS – GOVERNMENT

Taking a step back, we observe three related trends in the US Government to alternative proteins and biomanufacturing:

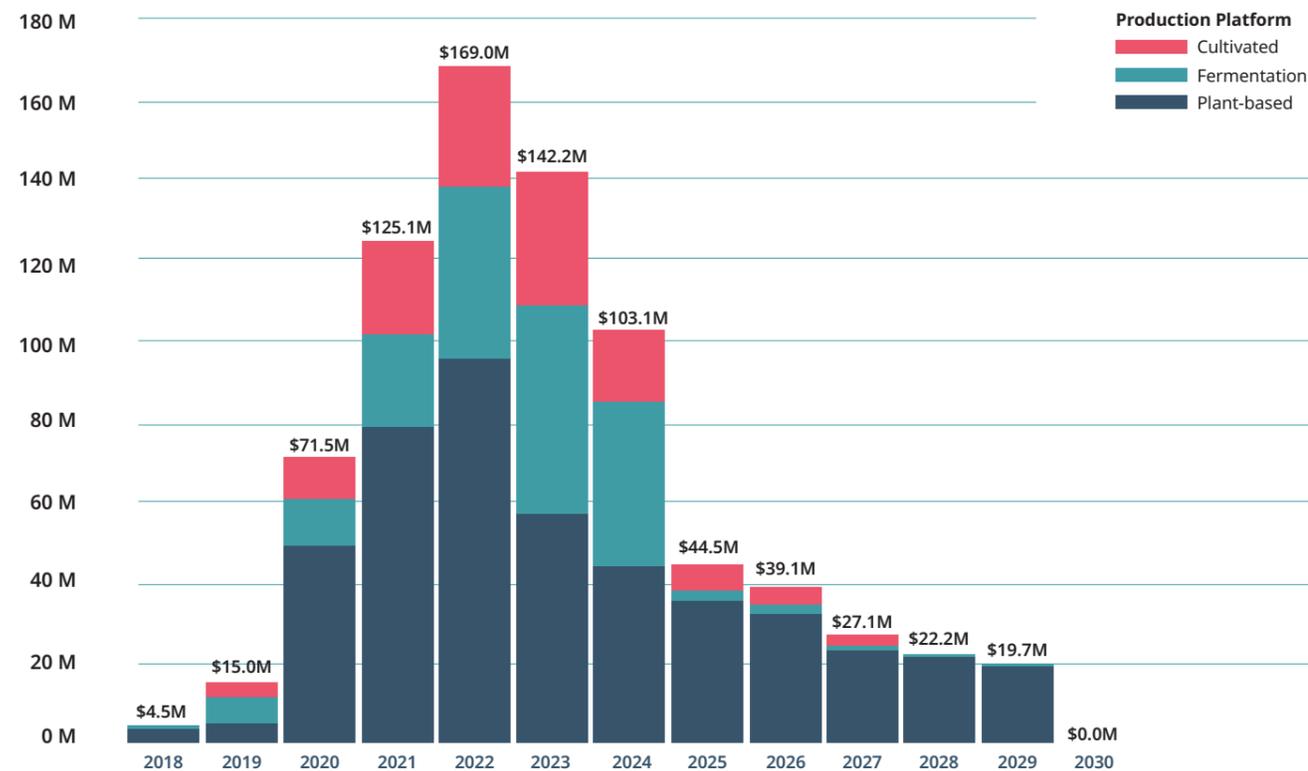
1. Public funding increases
2. Recent policy developments aim to lower the barrier for new products to enter the market
3. Shifts in the political landscape suggest the strategic focus on the bio-economy will remain

PUBLIC FUNDING INCREASES

While the private sector invests significantly more in the US than in other countries, public funding will be necessary to accelerate the industry. Especially in the early stages of the technologies' development, the focus should be on establishing enabling environments that foster increased private sector investment by de-risking the industry (ClimateWorks Foundation, 2021). While other regions like the EU have historically made larger public financial commitments, the allocation of \$1.2 billion by the Department of Defense (DoD) shows that the US government is increasingly willing to commit significant public funding to R&D in the bio-economy. A part of the funding is expected to be allocated to research alternative proteins, though it is unclear how much. Investments like these have the potential to stimulate the establishment of a strong domestic bio-industrial manufacturing base accessible to US innovators (US Department of Defense, 2022).

FIGURE 7: GOOD FOOD INSTITUTE 2023. 2018-2022 CLEAR INCREASE IN PUBLIC INVESTMENTS FROM GOVERNMENTS

EXPENDITURES AND COMMITMENTS BY YEAR



https://public.tableau.com/app/profile/goodfood/viz/ExternalFundingDashboard1_0_16837527939270/ExternalFundingDashboard1_0

RECENT POLICY DEVELOPMENTS AIM TO LOWER THE BARRIER FOR NEW PRODUCTS TO ENTER THE MARKET

Recent FDA approvals have cleared the path for the first „cell-cultivated chicken“. UPSIDE Foods has made significant progress towards commercialisation in the US, receiving a positive assessment from the United States Department of Agriculture (USDA) on June 12, 2023. This accomplishment comes after securing FDA clearance seven months earlier. Similarly, GOOD Meat, which obtained FDA endorsement three months ago, has also obtained USDA authorisation for its cultivated chicken labels in the US, receiving the necessary approvals on June 8, 2023. These commercial launches are crucial for paving the way for future product introductions and driving wider industry growth.

In addition, industry experts anticipate an influx of European startups entering the US market. Due to the challenging regulatory environment in the EU, particularly for cultured meat, the US (as well as other non-EU markets) has become an attractive launch pad for European entrepreneurs in the space.

“I think the European approach to regulation is dramatically different from the United States and some parts of Asia. Europe has adopted a precautionary principle, which means that regulatory decisions are made slowly while evidence amasses the safety of things. My understanding is there is even more resistance to biotechnology in Europe than there is in the United States. And it’s fairly significant here. “

Source: Alternative protein non profit leader

“Even if your product is non-GM, especially when it’s cultured meat, the regulatory path in Europe is still a bit of a question mark. I mean, there are no approvals, and I think Mosa Meat will at some point get an approval, but it’s still a bit of a question mark how and when and what does that look like.”

- Lauri Reuter, Nordic Foodtech VC, 2023

POLITICAL SHIFTS

The US has the potential to expand the “*bioeconomy*”. Biden’s commitment to the Investing in America agenda, as demonstrated through initiatives like the American Rescue Plan, the Bipartisan Infrastructure Law, the CHIPS and Science Act, and the Inflation Reduction Act, contributes to the US maintaining a global frontrunner position.

During the Biden-Harris Administration, private companies have announced substantial investments of \$470 billion in manufacturing and clean energy, including significant investments in biomanufacturing.

However, to remain competitive, new strategies are set to be implemented as other countries position themselves to become global leaders in biotechnology solutions and bio-based products. Consequently, the Executive Order (EO 14081) was signed in September 2022, establishing the National Biotechnology and Biomanufacturing Initiative. This initiative aims to ensure that advanced biotechnology products invented in the US are manufactured within the country, creating domestic employment opportunities, strengthening supply chains, and reducing costs for American families.

The ambitious objectives and current global trends indicate that the US is poised to enhance its biomanufacturing capabilities and reduce dependence on international imports. In June 2023, the Biden administration expressed its commitment to developing a skilled workforce to achieve this objective, and progress in this direction is already underway. (The White House, 2023). These advancements collectively contribute to creating conducive conditions for innovation and growth in the biomanufacturing sector, ultimately creating a favourable ecosystem for the alternative protein industry.

CASE STUDY TUFTS UNIVERSITY



The Centers of Excellence program, overseen by USDA’s National Institute for Food and Agriculture (NIFA), facilitates the establishment of academic and professional networks focused on specific research domains, fostering the growth of a skilled workforce. Through this program, Centers of Excellence gain preferential consideration for competitive grants from NIFA. Moreover, these Centers offer valuable opportunities for students to actively participate in promising research areas and acquire recognised qualifications in the respective field.

Tufts University is heading the consortium, which was launched in 2021. By leveraging the expertise of Tufts University in engineering, nutrition, biology, and public policy, the Center aims to advance public understanding of cultivated meat and precision fermentation. Alongside conducting scientific research, developing innovative technologies, and investigating the impacts of cellular agriculture, the Center actively contributes to the development of the alternative protein workforce through its groundbreaking offering, the world’s first Certificate in Cellular Agriculture, fostering both academic and industry careers. Additionally, the Center has established official partnerships with major players in the food industry.

US UNIVERSITIES – CREATING KNOWLEDGE AND NURTURING THE NEXT GENERATION OF TALENT

The US is home to some of the world’s top universities that play a pivotal role in fostering innovation ecosystems and driving forward advancements in biotech. These institutions provide a fertile ground for groundbreaking research, collaboration, and nurturing the talent needed to grow new industries.

With their cutting-edge facilities, renowned faculty, and diverse academic programs, US universities such as UC Davis, the Massachusetts Institute of Technology, and Tufts contribute significantly to the growth and development of the innovation ecosystems, fueling progress and shaping the future of the alternative protein industry. Our analysis shows a tendency towards an increased volume of publications in the field of alternative proteins globally.

Taking a closer look at the US and the respective subfields within alternative proteins, we can identify a set of universities that are hot spots for impactful research.

Within cultivated meat, for example, Tufts and UC Davis, both recipients of the USD 10 Million grant, collaborate on developing solutions within cellular agriculture by approaching key challenges in the field from multiple angles. Their efforts are reflected in their scholarly output.

FIGURE 8: SCIENTIFIC ARTICLES FROM SELECTED UNIVERSITIES

University	Location	Scholarly Output	Views Count	Field-Weighted Citation Impact	Citation Count
Tufts University	Boston, Massachusetts	11	499	3.93	151
University of California at Davis	Davis, California	11	428	2.04	88
Harvard University	Cambridge, Massachusetts	5	437	2.34	97
Massachusetts Institute of Technology (MIT)	Cambridge, Massachusetts	5	275	6.23	52
Pennsylvania State University	University Park, Pennsylvania	5	379	2.86	70
Texas A&M University	College Station, Texas	5	513	2.78	54

Through interviews with diverse stakeholders across potential clusters, the substantial role played by universities in fostering the next generation of entrepreneurs was highlighted. For leading universities, this role extends beyond the facilitation of spin-offs through Technology Transfer Offices (TTO) to proactively provide opportunities for students to gain hands-on experience in highly relevant research domains. Examples of university-led initiatives aimed at supporting early-stage entrepreneurs in the field are included in the table below.



In Boston, the MIT Innovation Headquarters (iHQ) serves as a dedicated platform designed to stimulate innovation and entrepreneurship among MIT students (MIT InnovationHQ, 2023). Boston is also home to a notable student initiative known as the Cultivate Tomorrow Hackathon, which promotes entrepreneurship within the alternative protein space. This annual competition engages student teams in addressing pressing challenges in the field of cellular agriculture. Through the hackathon, student participants are offered an industry mentor, facilitating knowledge exchange and guidance throughout the problem-solving process. The Cultivate Tomorrow Hackathon is organised by the non-profit organisation Nucleate Cultivate (Protein Report, 2023) (Nucleate Cultivate, 2023).



In the Bay Area, Berkeley is home to the Alternative Meats (Alt: Meat) X-Lab at the Sutardja Center for Entrepreneurship & Technology at UC Berkeley's College of Engineering. The lab aims to catalyse entrepreneurship in the field (Alt: Meat Lab, 2023).



The Food Innovation Lab at the Robert Mondavi Institute for Wine and Food Science at the University of California Davis is a notable facility equipped with pilot plants and other research infrastructure. This specialised setting holds the potential for fostering innovative initiatives and research endeavours in the realm of food and beverages, including within the alternative protein space (University of California Davis, 2023).



In North Carolina, the NC Food Innovation Lab serves as a hub for innovation in the alternative protein space (About the NC Food Innovation Lab, 2023).

UNIVERSITIES ARE SHIFTING THEIR FOCUS

As a part of the interview series undertaken to inform this report, we spoke to Professor Julian McClements and Professor David Kaplan, two experts in the field of alternative proteins, about the current state of the academic research landscape.

Professor McClements pointed out that he sees it as a bit of a trend that renowned professors from different parts of biology and the food sciences shift their research focus to alternative proteins. He, in some ways, exemplifies this trend, having himself redirected his research to this rapidly expanding domain. Similarly, another important factor that will be critical for the continued growth of alternative protein research in the US is the significant interest shown by students and young researchers.

Professor McClements

Dr. David Julian McClements is a renowned Food Science professor at the University of Massachusetts Amherst. Renowned for his innovative research in structured food-based delivery systems for bioactive components, he brings to bear an impressive academic record, highlighted by over 1200 peer-reviewed publications and several award-winning books.

"I believe that over the past two to five years, many academics have transitioned to this field [alternative proteins]. Personally, I completely shifted my research focus to this area. I used to work on health and wellness, utilising nanotechnology to enhance the bioavailability of nutraceuticals and vitamins. However, I recognised the immense importance of the alternative protein field and redirected all my research efforts towards it. Now, we are working on plant-based meats, cheese and egg alternatives, and seafood substitutes, taking a structural design approach. Many other professors have made similar changes because they understand the significance of transforming our food supply system."

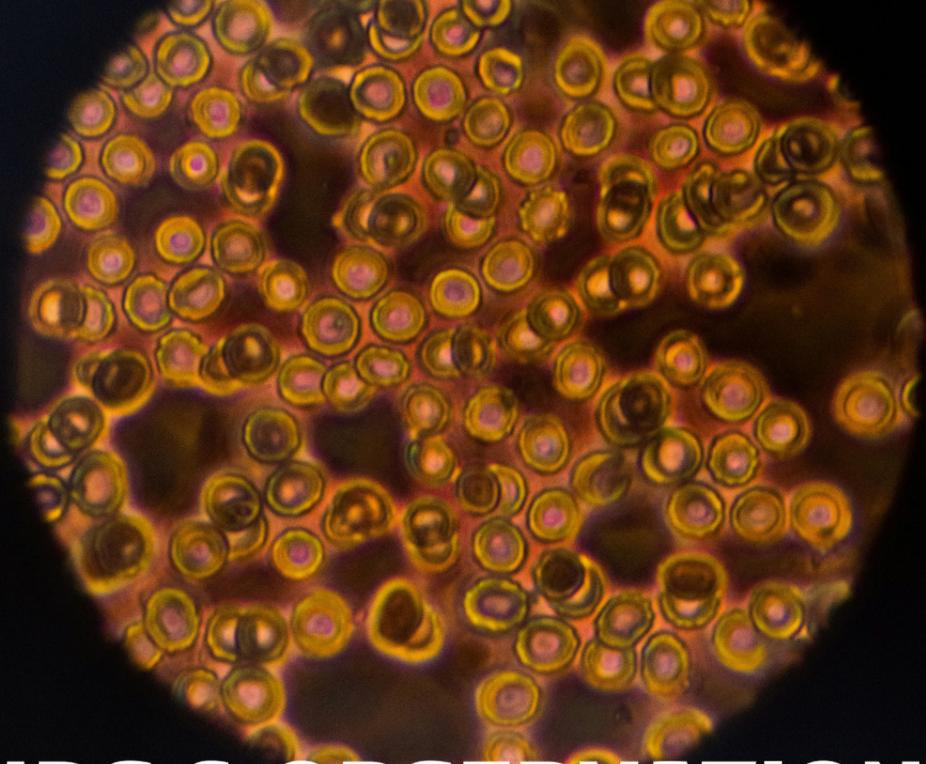
David Kaplan

Dr. David Kaplan is the Stern Family Endowed Professor of Engineering at Tufts University, a Distinguished University Professor, and Professor and Chair of the Department of Biomedical Engineering. Kaplan is the principal investigator of the Kaplan lab, one of the world's leading research labs for cell agriculture.

In an interview with the Tufts Daily, Kaplan noted that

"There's been so much investment in startups to produce these foods, that there's a gap between what academic fundamental science has demonstrated versus what companies are promising. We're trying to fill that gap."

Kaplan and his team hope to develop the solid science that the field of cultivated meat needs to cut through the hype. To accomplish this goal, Tufts will collaborate with Virginia Tech, Virginia State University, the University of California, Davis, MIT and the University of Massachusetts Boston in their research funded by the \$10 million USDA grant — each approaching the problem from a different angle.



TRENDS & OBSERVATIONS – ACADEMIA AND RESEARCH

UNIVERSITIES ARE SHIFTING THEIR FOCUS TO ALTERNATIVE PROTEINS.

The relevance of the alternative protein space is increasing – especially on the West- and East Coast of the US. This trend is leading to a growing number of researchers redirecting their focus to the field. This trend is further bolstered by the rising interest and ambition of students who aspire to work in the alternative protein industry.

FOCUS ON EMPOWERING THE NEXT GENERATION OF TALENT

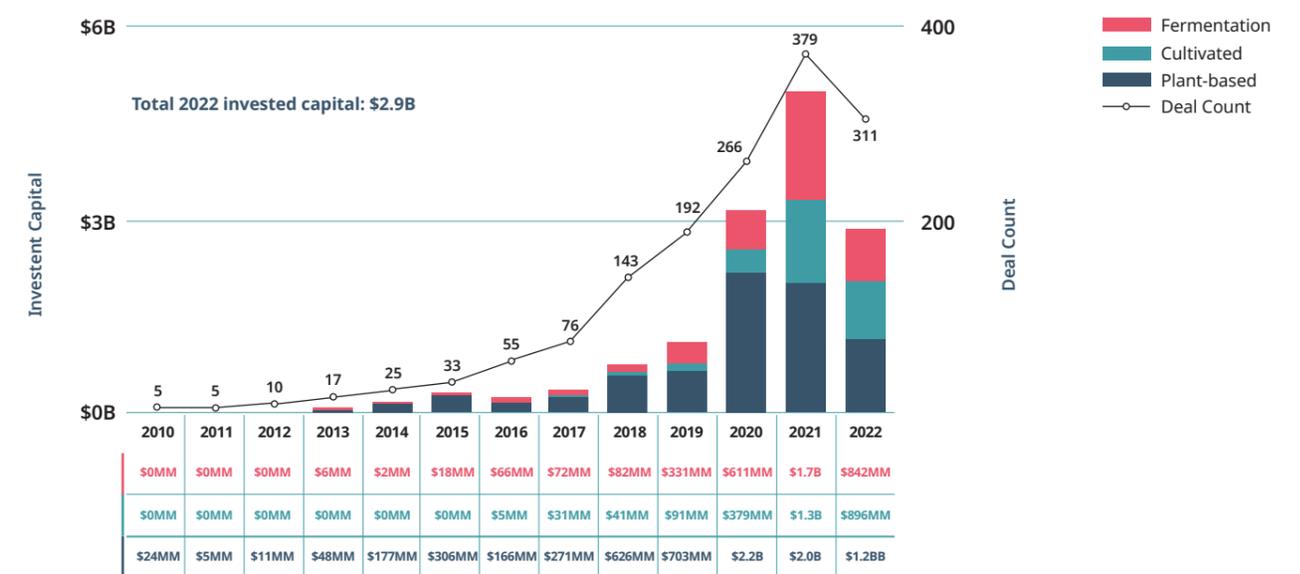
Universities are actively nurturing the next generation of talent by supporting initiatives, innovation spaces, and hackathons dedicated to alternative protein solutions. These efforts help cultivate entrepreneurial talent needed in the alternative protein sector, encouraging innovation and driving progress in the field. US universities are actively engaged in fostering entrepreneurship among their students and scientific staff. Our interviews revealed that North Carolina, Boston and the Bay Area have established specialised units or initiatives aimed at enhancing and facilitating entrepreneurship within the food and alternative proteins sector. These dedicated units provide valuable support, resources, and guidance to aspiring entrepreneurs and contribute to the overall ecosystem for fostering innovation and business development in these regions.

US RISK CAPITAL PROVIDERS – DRIVING INVESTMENTS IN THE FOODS OF TOMORROW

Investors play an indispensable role in driving development in the alternative protein space. While investors provide essential financial support needed to drive growth in companies involved in cultivated meat, fermentation, and plant-based proteins, their involvement is not limited to monetary resources.

Smart investors can also bring strategic guidance, industry expertise, and extensive networks to the table. These contributions can enable companies to better navigate challenges and seize emerging opportunities within the dynamic alternative protein market. Through their active engagement, smart investors actively drive innovation, facilitate the scaling up of production capabilities, and facilitate the expansion of market reach. Ultimately, their efforts contribute to the continuous advancement and commercial viability of alternative protein technologies and products.

FIGURE 9: ANNUAL GLOBAL ALTERNATIVE PROTEIN INVESTMENT TREND (2010-2022)



Source: Good Food Institute

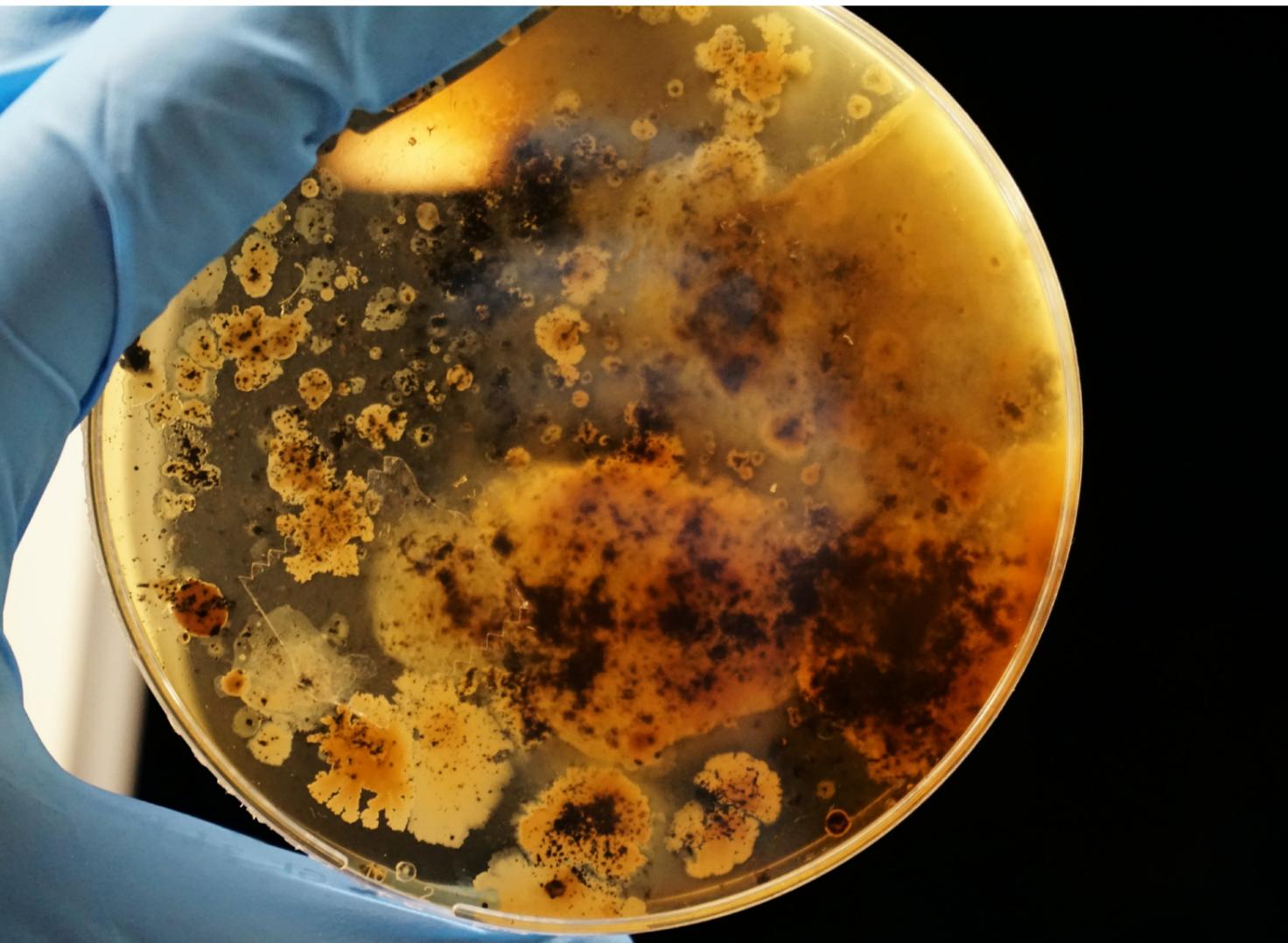
The overall development is that US VC Investment is much higher than Europe. Several experts explain this development due to the regulatory environment in the EU, which makes it more attractive to scale up in the US.

Based on the information and analysis of VC investment in the alternative protein sector, most investments have been concentrated in the Bay Area. However, significant investments have also been observed in Boston and the Research Triangle Park in North Carolina.

FIGURE 10: TOTAL FUNDING IN THE US HOTSPOTS

Potential Cluster region	Total Funding
Boston	\$360.26 Million
Bay Area	\$927.94 Million
Research Triangle Park (NC)	\$48.31 Million

In the context of alternative protein investments, our analysis reveals that Boston attracted 48 investments, North Carolina received 44 investments, and the Bay Area witnessed a total of 508 investments. Our analysis shows that over 90% of the investments in the Boston cluster were made in one startup (Motif).

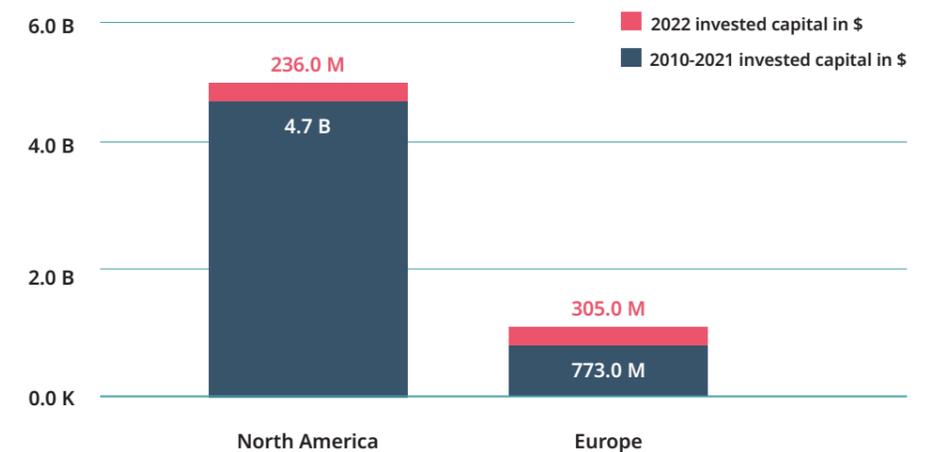


INVESTMENTS IN PLANT-BASED VENTURES

In 2022, plant-based meat, seafood, eggs, and dairy companies collectively secured a funding of \$1.2 billion, contributing to a cumulative investment total of \$7.8 billion. This figure indicates a deceleration of 41% compared to the previous year, slightly underperforming the overall global decline of 35% in venture funding.

Notably, specific regions experienced contrasting patterns, with accelerated funding growth observed in Europe by 15%. In 2022, 47 deals were registered in Europe and 46 deals in the United States. Moreover, it is noteworthy that the plant-based sector witnessed a unique trend where Europe surpassed the United States in funding in 2022. This sub-sector stood out as the only industry in which Europe received more investment compared to its American counterpart during that year. (GFI, 2022b)

FIGURE 11: INVESTMENTS IN PLANT-BASED COMPANIES (2010-2022)



Source: Modified from Good Food Institute

In its latest state of the industry reports on cultivated meat, fermentation, and plant-based food, the Good Food Institute (GFI) has gathered useful data on the most active investors in the alternative protein space. Based on data from the GFI, the most active investors in the US are Big Idea Ventures, Indiebio, and Unovis Asset Management.



INVESTMENTS IN CULTIVATED MEAT VENTURES

Table Most active investors in the plant-based space in clusters in the United States in 2022. The table summarises data from organisations that publicly disclosed three or more investments in plant-based companies during the year 2022 (GFI, 2022b)

FIGURE 12: MOST ACTIVE INVESTORS IN THE PLANT-BASED SPACE IN CLUSTERS IN THE UNITED STATES IN 2022

Investor	Investor type	Headquarters	2022 deal count	Total deal count
Big Idea Ventures	VC	New York, USA	15	52
SOSV (Indiebio)	VC	Princeton, USA	8	34
Unovis Asset Management	VC	New York, USA	5	41
Plug and Play Tech Center	Accelerator/ Incubator	Sunnyville, USA	5	7
Sustainable food Ventures	VC	Raleigh, USA	4	10
Lever VC	VC	Brooklyn, USA	3	10
S2G Ventures	VC	Chicago, USA	3	10
Siddhi Capital	VC	Cherry Hill, USA	3	6

Source: Modified from Good Food Institute

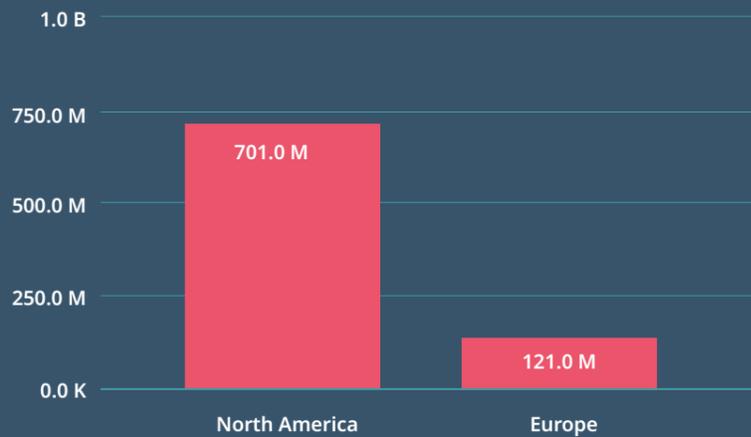
In 2022, cultivated meat and seafood companies attracted significant funding amounting to \$896 million, representing a deceleration of 33% compared to the previous year. This performance, although lower than the previous year, outperformed the overall decline in global venture funding, which stood at 35% year-over-year. Notably, the cultivated meat and seafood sector fared better than select sectors favoured by venture capital funds, such as fintech, which experienced a larger decline of 46%.

The challenging macroeconomic and market conditions of 2022, including declines in public equity markets, rising interest rates due to heightened inflation, the ongoing impact of the pandemic, severe climate events, and geopolitical tensions arising from the invasion of Ukraine, contributed to a decrease in investment activities across various industries. Despite these difficulties, the cultivated meat and seafood sector achieved notable milestones in terms of investment deals.

The novelty of this industry means that obtaining consistent data for the same time periods has been difficult, which is why there is a deviation in time periods across the three sub-sectors. Two particularly noteworthy transactions occurred during this period, as UPSIDE Foods secured an impressive \$400 million in a Series C funding round, and Wildtype raised a substantial \$100 million in a Series B funding round. These funding rounds represent the largest investment amounts to date in the cultivated meat and seafood industry. The significant investments in these companies underscore the continued confidence and support from investors, highlighting the promising potential of the cultivated meat and seafood market, even in the face of challenging economic conditions. (GFI, 2022c)

During the period from 2016 to 2022, the United States witnessed a total of 25 deals in the cultivated meat sector, while Europe recorded 18 deals.

FIGURE 13: INVESTMENTS IN CULTIVATED MEAT AND SEAFOOD COMPANIES FROM 2016-2022 (GFI, 2022C)



Based on data from the Good Food Institute (GFI), the most active investors in the US are Big Idea Ventures, Indiebio, and AgFunder.

INVESTMENTS IN FERMENTATION VENTURES

FIGURE 14: MOST ACTIVE INVESTORS IN THE CULTIVATED FOOD SPACE IN CLUSTERS IN THE UNITED STATES IN 2022

Investor	Investor type	Headquarters	2022 deal count	Total deal count
Big Idea Ventures	VC	New York, USA	14	36
SOSV (Indiebio)	VC	Princeton, USA	9	35
AgFunder	VC	San Francisco, USA	4	5
Sustainable Food Ventures	VC	Raleigh, USA	4	10
Cargill	CVC	Minneapolis, USA	3	7

Source: Modified from Good Food Institute

In 2022, fermentation companies globally secured a total funding of \$842 million, indicating a significant deceleration of 50 % compared to the previous year's record-breaking investments. Nevertheless, this funding accounted for approximately a quarter of the total funding ever raised in the category, underscoring its significance. Regional trends revealed an acceleration of funding in Europe by 37 %. Although the fermentation sector underperformed the overall decline in global venture funding of 35 % year-over-year, it is important to approach this comparison with caution.

This is because the fermentation market constitutes a relatively small segment, characterised by a limited number of substantial fundraising deals that heavily influence the investment figures. Notably, in 2021, two deals alone accounted for 41 % of the total invested capital for the year, while four deals represented 65%. These figures were driven by well-established companies in the emerging fermentation market, which currently feature few mature players.

Consequently, fewer companies required large funding rounds in 2022, although Meati and Remilk, two other maturing companies, successfully raised rounds exceeding \$100 million each. In 2022, Europe experienced a higher number of deal counts compared to the United States in a specific sector, with 34 deals recorded in Europe and 28 deals in the United States. (GFI, 2022a)

FIGURE 15: INVESTMENTS IN FERMENTATION COMPANIES DURING 2013-2022



Based on data from the Good Food Institute (GFI), the most active investors in the US are Indiebio, Big Idea Ventures, and Plug and Play Tech Center.

A LACK OF BUSINESS ANGELS?

An issue that has received limited attention thus far but did come up in our interviews with experts in the field is the lack of business angels in the alternative protein industry. Many entrepreneurs in the industry actively seek experience and expertise from business angels with experience in the field but face difficulties in finding suitable candidates. (Atomico, 2021).

The underlying reasons for this issue remain unclear, although industry experts have suggested that it may at least in part simply be attributed to the industry's novelty. In addition, some experts we spoke to noted that the complexity and long timelines involved with commercialising products in this space may deter successful entrepreneurs from starting and supporting new ventures.

FIGURE 16: MOST ACTIVE INVESTORS IN THE FERMENTATION SPACE IN CLUSTERS IN THE UNITED STATES IN 2022

Investor	Investor type	Headquarters	2022 deal count	Total deal count
SOSV (Indiebio)	VC	Princeton, USA	12	40
Big Idea Ventures	VC	New York, USA	10	23
Plug and Play Tech Center	Accelerator/ Incubator	Sunnyville, USA	5	7
Sustainable food Ventures	VC	Raleigh, USA	4	10
Lever VC	VC	Brooklyn, USA	3	10
S2G Ventures	VC	Chicago, USA	3	10
Siddhi Capital	VC	Cherry Hill, USA	3	6

Source: Modified from Good Food Institute

"We've seen a number of people, such as the original founder of Beyond Meat, go on to launch new food companies, which is commendable as they are the ones driving this industry. [...] However, I believe that some of the entrepreneurs we're currently working with, regardless of whether they succeed or fail, might not want to return to the food industry for a while. I think many of them venture into the food industry, thinking it's going to be easy. They imagine selling at a farmer's market, but when they start encountering the regulations, year-to-year crop variability, and the multitude of challenges associated with producing new food products, they often rethink their decision."

- Bill Aimutis, Executive Director at NC Food Innovation Lab



CASE STUDY

CLEAR CURRENT CAPITAL



In response to recent market trends and growing consumer demand, the alternative protein industry has benefited from a rise in risk capital providers focusing on sustainable foods. An example of such a provider is Clear Current Capital, a venture capital fund focusing on impact investing in early-stage companies involved in plant-based food and cell-cultured meat. They aim to foster a humane, sustainable, and nutritious food system by supporting innovative early-stage alternative protein companies.

In 2021, they announced the launch of their new impact fund, Fund II, which focuses on early-stage investments in US-based companies operating in the plant-based food, cell-cultured meat, and fermented food sectors, along with other enterprises aligned with their mission. Fund II expands Clear Current Capital's commitment to environmental sustainability, animal welfare, and addressing issues related to large-scale industrial food production while addressing climate change and health and promoting transparency in the food industry.

THE US IS OUT-INVESTING EUROPE

While Europe may be head-to-head with the US regarding the number of deals in the alternative protein space, the US is far ahead regarding the total volume of private capital deployed in the space.

ALTERNATIVE PROTEIN CLUSTERS IN THE US ARE AT DIFFERENT STAGES

When examining the average age of startups, investment volume, and number of investors per company in different clusters, it is apparent that these clusters are at different stages of development. The startups in the Bay Area, which are generally older, have likely made more progress in technological advancements and market readiness. As a result, they have secured larger investments, which have been crucial for their growth. Except for the outlier in terms of investment volume in Boston, companies in Research Triangle Park are slightly older than those in Boston. However, the fact that Research Triangle Park has not attracted as much investment on average as Boston could be attributed to the more favourable investor landscape in Boston, with roots in its thriving biopharmaceutical cluster.

TRENDS & OBSERVATIONS – RISK CAPITAL

When taking a step back to look at the alternative protein investment landscape across the US, we see that:

1. The US is out-investing Europe
2. The alternative protein clusters in the US are at different stages and have companies that are at very different stages
3. Investments in alternative protein ventures are here to stay
4. While early-stage investments are increasing, late-stage scale-ups, especially those in large-scale manufacturing, struggle to attract investors due to perceived low return

INVESTMENT TRENDS SUGGEST THAT ALTERNATIVE PROTEINS ARE HERE TO STAY

Interviewed industry experts believe that despite the ongoing challenges in the market, the alternative protein industry holds potential upside for both investors and the industry itself. The current downturn has reduced deal valuations, making startups more willing to make concessions on the terms of deals, which works in favour of investors.

The space may also benefit from more general trends towards sustainable investing. In the Pitchbook Analyst notes for impact investing in Q4 of 2022, it is noted that there is sustained interest in environmental, social, and governance (ESG) factors, with private impact funds holding a significant amount of funds ready to be invested, amounting to \$113 billion in funds that have not been invested yet. This creates a favourable environment for alternative proteins, as the industry is increasingly seen as well-aligned with ESG principles.

While the alternative protein industry is still in many ways in its infancy, plant-based companies are actively innovating and filling gaps in the market, such as whole-cut meat and seafood. As these companies scale up production and improve the taste and affordability of their products, sales are expected to accelerate, attracting further investment when macroeconomic and market conditions stabilise.

The involvement of major food companies and food service providers like Kraft Heinz, PepsiCo, Nestlé, ADM, Kroger, and Pinduoduo through launches and partnerships also helps de-risk the sector and, in turn, attract the attention of new investors. In fact, the number of unique investors in plant-based companies increased by 17 per cent in 2022, surpassing 1,500 investors.

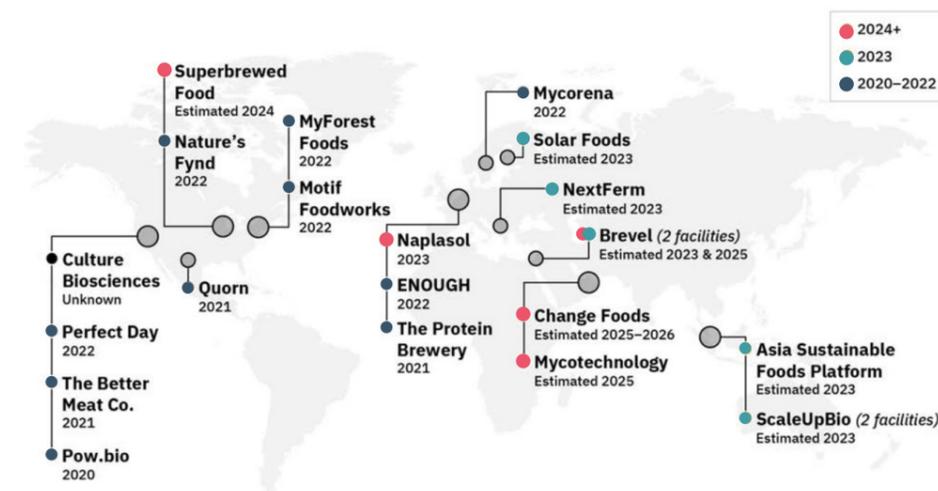


US ENTREPRENEURS

Entrepreneurs do not operate in a vacuum. Innovation-Driven Enterprises (IDEs) thrive in innovation ecosystems like Greater Boston, Silicon Valley, Israel, London, and Shenzhen, where entrepreneurs can benefit greatly from the networks and resources available in these ecosystems that are crucial for their success and growth. In the following sections, we look at some of the specific companies currently redefining the food industry and how their products are making their way from labs in the innovation clusters and onto the plates of consumers.

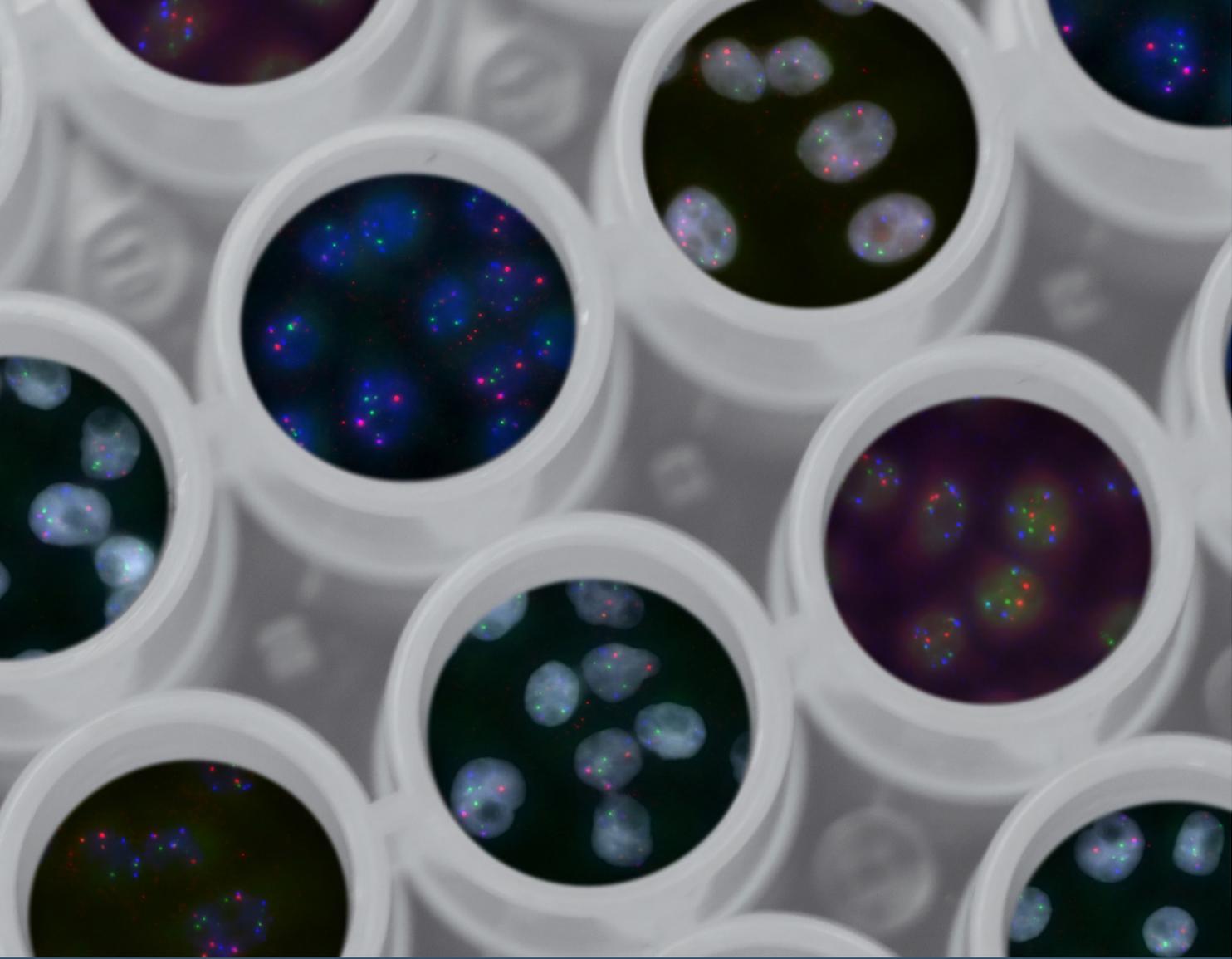
FERMENTATION VENTURES

FIGURE 17: CURRENT AND FUTURE FERMENTATION FACILITIES. FIGURE FROM THE GFI REPORT ON FERMENTATION



As of the beginning of 2023, there are 136 firms primarily dedicated to fermentation for alternative proteins, 42 of which are based in the US, with an additional 100+ companies entering the industry through partnerships or business-to-business (B2B) offerings.

In the past year, several interesting B2B enterprises have emerged that tackle critical challenges in fermentation that, in turn, potentially will make it easier for the next generation of fermentation-based entrepreneurs. For instance, Ginkgo Bioworks, established in 2008, focus on expanding production capacity, which is currently a major bottleneck in precision fermentation. While a significant portion of fermentation companies currently specialise in end-product formulation and manufacturing, as the industry matures, it is expected that more firms will specialise in specific stages of the technology stack. (GFI, 2022a)



BOSTON: THE PRECISION FERMENTATION HOTSPOT?



MOTIF FOOD

A prominent example of such a precision fermentation start-up is Motif Foodworks. They develop plant-based food products using genetic engineering and precision fermentation techniques. By leveraging these innovative approaches, they enable Consumer Goods Companies to create plant-based alternatives that closely mimic the taste, appearance, and texture of traditional meat products. Motif Foodworks offers a range of services, including bioprocessing, finished products, and food services.

As a spinout of Gingko Bioworks, Motif Foodworks is an interesting example illustrating the power of local innovation ecosystems. In partnership with Gingko, they utilise commercially developed yeast strains and processes, capitalising on the resources and expertise available within their local ecosystem. This strategic collaboration further enhances their ability to drive innovation and deliver cutting-edge solutions in the alternative protein industry.

PLANT-BASED VENTURES

Globally, the market for plant-based products continues to see frequent launches and increased distribution through various channels such as retail, food service, and e-commerce. While the below is by no means an exhaustive compilation of all the product introductions in 2022, the following examples do illustrate the diverse, expanding, and innovative nature of this sector.

RETAIL

In 2022, a noteworthy retail trend emerged as prominent food corporations introduced plant-based versions of well-established, beloved branded products. This development brings excitement to consumers seeking more sustainable alternatives to their favourite foods. It also signifies a strategic move by more established food companies to endorse plant-based alternatives by leveraging the trusted household brand names for these plant-based offerings.

New product launches from 2022:

- Kraft Heinz: Dairy-free cream cheese
- Kellogg's: Plant-based eggo waffle
- Bel Group: Plant-based Babybel
- Nestlé: Plant-based Kitkat
- Trader Joe's: Liquid plant-based egg
- Beyond meat: Plant-based steak
- Thai Union: Plant-based shrimp dumplings

New product launches from 2023:

- Ben & Jerry's: Vegan Ice cream
- Violife: Sour Cream

FOOD SERVICE

Following an unprecedented decline in 2020, the food service sector has made a remarkable comeback as a compelling go-to-market strategy for plant-based companies. By entering the food service industry, companies gain increased control over the preparation of their products while also playing a vital role in enhancing accessibility and familiarity with plant-based options among consumers worldwide. In 2022, plant-based products made their way into various segments of the food service industry, ranging from fast food chains and upscale restaurants to novel settings like airlines and schools.

Fast Food and chains:

- Starbucks: Sandwiches with plant-based proteins from JUST Egg and Daring Chicken.
- KFC: launched plant-based chicken
- Burger King: Impossible Burgers

High-end restaurants:

- Coletta in NYC: Whole cuts from Chunk Foods
- Umarm Bacon: served in NYC, CA and Nashville

E-COMMERCE

E-commerce serves as a favoured distribution channel for plant-based companies, attracting a demographic of younger consumers who show greater interest in alternative proteins. This channel grants manufacturers greater control over their product launch timelines than is the case when companies launch through retailers or food service partners.

Noteworthy e-commerce advancements in 2022 encompass:

- Current Foods: Plant-based fish
- Juicy Marbles: Plant-based steak

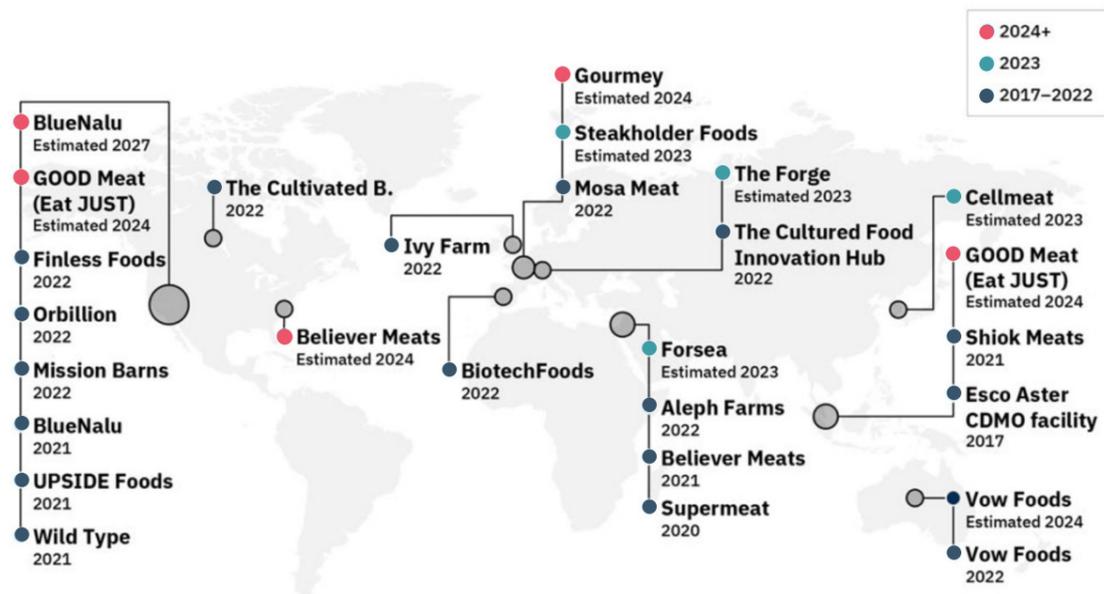
The limited manufacturing capacity remains a major obstacle in attaining price parity for plant-based proteins. Plant-based companies often rely on contract manufacturers or establish their own production facilities (or a combination of both). Still, there is a pressing requirement for investment to construct dedicated facilities optimised for plant-based food production. This urgency arises from expanding manufacturing capabilities and meeting the growing demand for plant-based products. (GFI, 2022b)

CULTIVATED MEAT VENTURES

Over 150 companies are exclusively dedicated to cultivated meat or seafood, with an additional 70 companies involved with the industry through partnerships or by offering products/services within the cultivated meat technology sphere.

These companies primarily operate in the food and beverage or life sciences sectors, aiming to provide essential resources, infrastructure, and expertise to cultivated meat startups. An example is the Boston-based B2B company Ark Biotech, which supplies the cultivated meat industry with industrial-scale bioreactors, operating systems, and services. (GFI, 2022c)

FIGURE 18: CULTIVATED MEAT PRODUCTION FACILITIES



Source: Good Food Institute



THE BAY AREA: LIFTING THE INDUSTRY TO THE NEXT LEVEL



UPSIDE FOODS GETS APPROVAL

By obtaining FDA approval to sell cultivated chicken, UPSIDE (and Good Meat) made the United States the second country, after Singapore, to authorize the sale of lab-grown poultry. In a significant milestone for the food industry, UPSIDE Foods has made history by introducing its cultivated chicken at the renowned Michelin-starred Bar Crenn in San Francisco, California, in July 2023. This breakthrough marked the first-ever availability of cultivated meat to consumers in the United States.

In an interview with MIT Technology Review, Eric Schulze, Upside Foods VP, says,

"It's an incredible, historic moment; the next giant hurdle is scaling up. Frankly, that's what matters."

CASE STUDY

NORTH CAROLINA FOOD INNOVATION LAB – DRIVING PLANT-BASED FOOD INNOVATION FROM CONCEPT TO COMMERCIALISATION.

The Food Lab in North Carolina has been highlighted as a model that fosters entrepreneurs in the plant-based space. In an interview with Bill Aimutis, the Executive Director of the NC Food Innovation Lab, he explained that the Lab was established with the specific aim of promoting food innovation and generating new food manufacturing jobs. The Lab provides funding for a range of resources and services, including product development labs, a pilot facility for scaling up operations, and assistance with ideation, pitch decks,

and connections to venture capital for entrepreneurs, multinational food companies, and contract manufacturers. The lab plays a pivotal role in facilitating collaboration and innovation within the alternative protein industry in North Carolina. Furthermore, an intriguing aspect is the international appeal of the North Carolina Food Innovation Lab, which has successfully attracted startups from abroad that now have established their ventures within its premises.

WHO ARE THE FOUNDERS?

Maybe surprisingly, in the interview, Aimutis observed that many of the people who start food startups at the lab do not necessarily have a background in food science but may come from marketing or other seemingly unrelated disciplines. This underscores the need for inclusive entrepreneurship initiatives that do not exclude individuals without a background in food science, and it emphasises the necessity of dedicated spaces such as a Food Innovation Lab to provide opportunities for non-food scientists to embark on their food startup ventures. These initiatives promote innovation and progress in the food industry by empowering and assisting entrepreneurs from a diverse range of fields and backgrounds.

“Mostly, we work with people who have been in various professions, and their only relationship with food is as consumers. They have an idea they want to pursue and wish to work for themselves instead of someone else. It’s fascinating. Among all the entrepreneurs we collaborate with - and there are at least 50 right now - most of them have no food industry background. We see many individuals from finance, marketing, and engineering. In the past six months, however, we’ve started noticing an influx of people with a food background. I believe this trend has evolved due to large food companies downsizing their workforce. These are people who have decided they don’t want to return to working for a large corporation. They have a food product idea and have decided to start their own food company. We’re beginning to see a rise in this kind of customer.”

Aimutis 2023, Executive Director NC Food Innovation Lab

TRENDS & OBSERVATIONS – ENTREPRENEURS

Looking across the diverse set of companies operating in the alternative protein space, we, in particular, find two noteworthy trends:

1. Developers and manufacturers are successfully using a number of different channels to bring their products to market.
2. Emergence of companies with a focus on specific stages of the technology stack.

THERE ARE MANY WAYS TO MAKE PLANT BASED PRODUCTS

Developers and manufacturers are successfully using a number of different channels to bring new products and product categories to market. This includes working with retailers, established food corporations, fast-food chains, as well as e-commerce targeted directly at the consumer.

EMERGENCE OF COMPANIES WITH A FOCUS ON SPECIFIC STAGES OF THE TECHNOLOGY STACK

At present, a considerable number of fermentation companies primarily specialise in end-product formulation and manufacturing. However, as the industry continues to mature, we expect and, to some extent, already see the emergence of companies focusing on specific parts of the technology stack.



US CORPORATES

In our interviews with industry experts, it seems clear that many of the major corporations in the food space consider the alternative protein industry as an industry in its infancy. Nevertheless, as a likely disruptor of much of their existing business, the emerging alternative protein industry is clearly an area of large interest to the established food companies.

Traditional food companies are making strategic investments through venture arms to monitor, build relationships, and potentially make acquisitions in the future.

Every single company of the top five meat companies and the top five consumer packaged goods (CPG) food companies in the US have some level of engagement with alternative proteins. As of 2022, the second-ranking CPG food company and the top three meat companies (in terms of revenue) actively participate in the cultivated meat sector.

FIGURE 19: CONVENTIONAL COMPANIES WITH INVOLVEMENT IN ALTERNATIVE PROTEINS

	PEPSICO	NESTLÉ	Kraft/Heinz	ABInBev	General Mills	Tyson	JBS	Cargill	Smithfield	Hormel
	CPG Companies					Meat Companies				
Investment	✓	✓	✓		✓	✓	✓	✓		
Acquisition		✓	✓				✓			
Partnership	✓	✓	✓	✓				✓		✓
Manufacturing and R&D		✓	✓	✓	✓	✓	✓	✓	✓	✓

✓ Fermentation
✓ Cultivated
✓ Plant-based

Source: Good Food Institute

PROJECT SPOTLIGHT: MERCK'S WORK ON OPTIMISING CELL CULTURE MEDIA

In recent years, Merck has focused on optimising cell culture media for cultivated meat. One of the main cost drivers in cultured meat is the cell culture media, which currently accounts for a significant portion of the product's marginal costs, ranging from 55% to over 95%. To enable large-scale production of cultured meat, developing more cost-effective media that support the efficient growth and differentiation of specific cell types without using animal-derived materials like fetal bovine serum is crucial. Merck is actively addressing these challenges by working towards designing and commercialising animal-origin-free media formu-

lations that facilitate the efficient production of cultured seafood and cultured meat from avian and mammalian species. Additionally, Merck has engaged in collaborations with universities to further advance their research. In 2021, Merck, Tufts University, and the Technological University of Darmstadt entered into a three-year collaborative agreement to explore bioreactor design. The growing interest of companies like Merck in the alternative protein industry exemplifies how corporations are leveraging their expertise to address specific challenges within the technology stack.

CORPORATIONS AND INNOVATION HOT SPOTS

To better understand how and where corporations engage with the innovation taking place in the various innovation clusters, we investigated the concentration of relevant corporate entities across the US.

In Boston, four corporate entities engage in ingredient or equipment production for alternative protein manufacturing, while the Bay Area hosts nine companies involved in various aspects of alternative proteins, including food ingredients, equipment, and manufacturing.

The presence of notable corporates, both established and emerging, contributes to the prominence of these regions in the alternative protein domain. Other regions, such as North Carolina, show a higher prevalence of entities with diversified focuses rather than exclusive engagement in alternative proteins.

The Bay Area and Boston stand out as regions housing prominent corporate entities actively involved in all subcategories of the alternative protein sector. Their diverse corporate landscape, including established and emerging companies, solidifies their position in the alternative protein domain.

CONSUMERS DRIVE CORPORATIONS' INTEREST IN ALTERNATIVE PROTEINS

Corporates are showing an increasing interest in the alternative protein space and this can be attributed to two key trends. Firstly, there is an anticipated gap between protein demand and the capacity of the current supply chain, making alternative protein production methods increasingly appealing. Secondly, consumers are showing greater interest in alternative proteins, driven by the rise of flexitarian diets and the demand for sustainable and healthy nutrition.

According to EY Parthenon, the market for alternative proteins experienced significant growth, reaching a value of USD 14.1 billion in 2021. Projections suggest that this market is expected to expand further and reach USD 17.4 billion by 2027, exhibiting a compound annual growth rate (CAGR) of 3.7% during the period 2022-2027. Notably, this growth is driven by transformations observed in the dairy and meat industries, indicating a shifting landscape within these sectors. (EY, 2023)

The plant-based alternative market in Europe has been experiencing rapid growth for several years. This is primarily due to the increasing popularity of these products beyond the limited group of vegans and vegetarians. In Europe, this trend arises from the increasing importance consumers place on healthy diets, reducing environmental impact, and prioritising animal welfare. (Faber, Henn, Brugarolas, & Perez-Cueto, 2021)

Based on the BCG report "Taking Alternative Proteins Mainstream", published in spring 2023, the various subcategories within alternative proteins demonstrate divergent developmental trajectories. Notably, the largest category, alternative dairy, experienced a growth rate of 12% in US retail during 2022. In contrast, the subcategory of alternative meat (plant-based) exhibited a decline or negative growth of 0.4%. These contrasting trends may be attributed to underlying technological disparities, suggesting that product innovation efforts could potentially address this disparity and contribute to the growth of the alternative meat segment (BCG, 2023).

While corporates may be more risk-averse than startups, when consumers show their taste for alternative food products through the purchases they make, the corporates will follow and invest in the innovation that allows them to deliver products to changing consumer demands.



In this final chapter, we embark on a succinct exploration of the key lessons and conclusions derived from our analysis of innovation hotspots in the US alternative protein landscape. Additionally, we endeavour to provide a glimpse into the potential trajectory of the future alternative protein industry. The report offers a valuable array of noteworthy findings, contributing significantly to our understanding of this evolving field vis-à-vis:

- Universities, startups, and large companies displayed clear and focused areas of interest within subcategories of alternative proteins
- In contrast, analysing the focus of risk capital and government stakeholders posed significant challenges due to the multifaceted nature of their involvement in the alternative protein sector
- Despite the presence of multiple clusters across the United States, the diversification observed continually transforms the landscape of the alternative protein sector, introducing dynamic variations and evolving its nature
- Most identified clusters exhibit alignment with their corresponding stakeholder groups, signifying concerted and cooperative efforts yet leaving ample opportunities for enhanced collaboration

3. A TASTE OF TOMORROW: LESSONS FROM THE US ECOSYSTEM AND THE FUTURE OF ALTERNATIVE PROTEINS

With the rapid advancement of alternative proteins, we are increasingly finding ourselves in a new era where we can choose from a growing pool of diverse and sustainable food products. Plant-based proteins have rapidly gained ground in the past decade, expanding choices for consumers remarkably.

Moreover, proteins derived from modern food manufacturing practices like cultivated meat, precision fermentation, and the exploration of insects as protein sources show great promise for feeding a growing global population.

THE ROLE OF INNOVATION CLUSTERS

The realisation of alternative proteins' full potential hinges upon successfully addressing both technical and non-technical challenges. As we speak, startups, academic research labs, and corporate innovators within the development-intensive clusters explored in this report are making headway with the technical challenges. However, the innovation clusters, with their potential to foster cross-sectoral collaboration and coordination, also seem like a promising starting point for addressing many of the non-technical challenges faced by the alternative protein industry. In addition to the core stakeholders in the innovation ecosystems explored in the previous chapter, it is also worth noting the important role that industry-supporting organisations like the Good Food Institute and New Harvest have played in paving the way for the technical and commercial breakthroughs highlighted in this report.

The acceleration of adoption rates for alternative proteins and their transition into mainstream choices is intricately intertwined with political actions and legislation. Governments play a pivotal role in shaping this transformation. Take, for instance, Denmark's imposition of a tax on agricultural emissions, which stands as a prime illustration of how regulations can sway the balance in favour of plant-based proteins. Such measures can significantly expedite the shift from animal-based to plant-based alternatives, emphasising the far-reaching impact of political decisions on the future of our food systems.

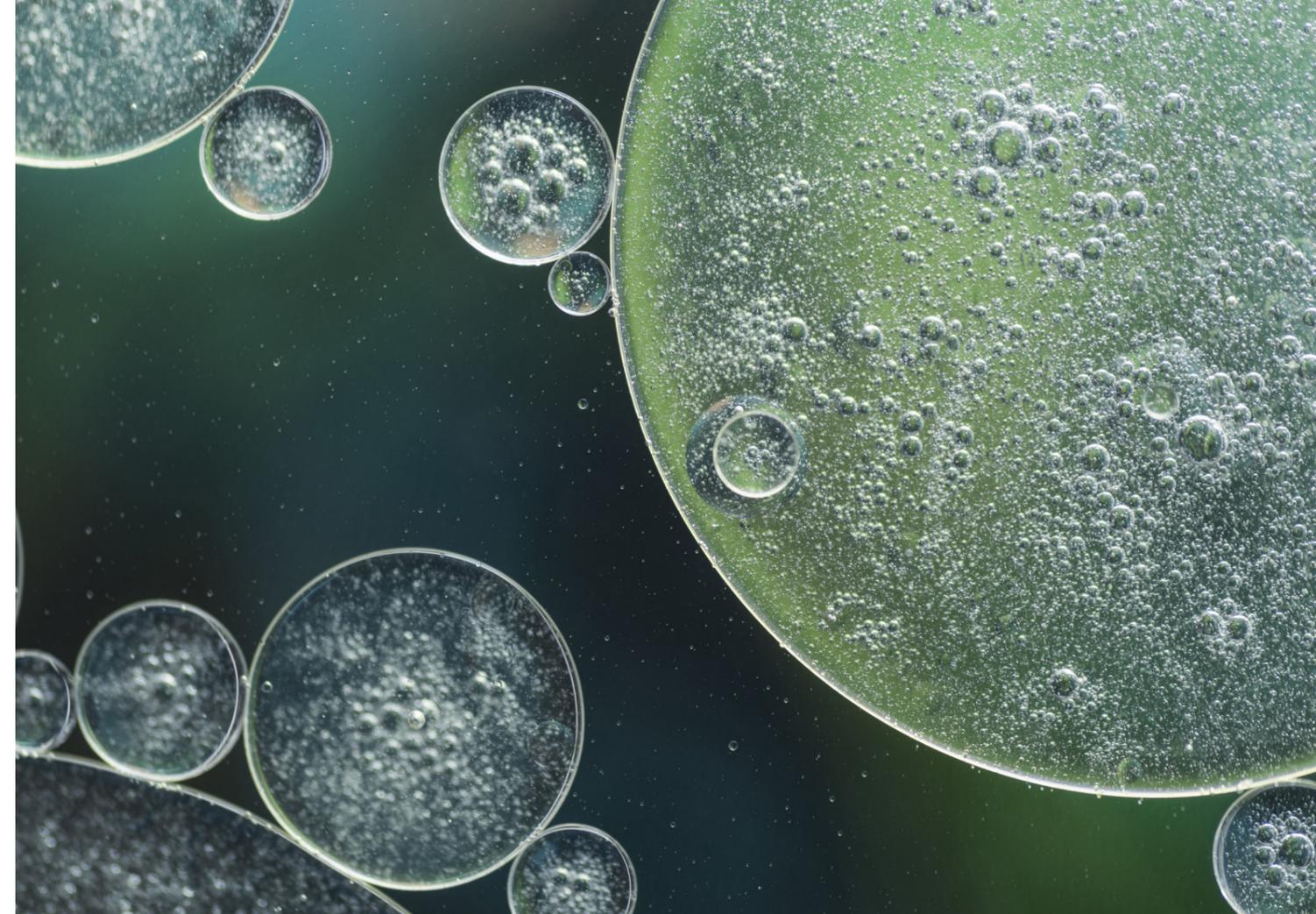
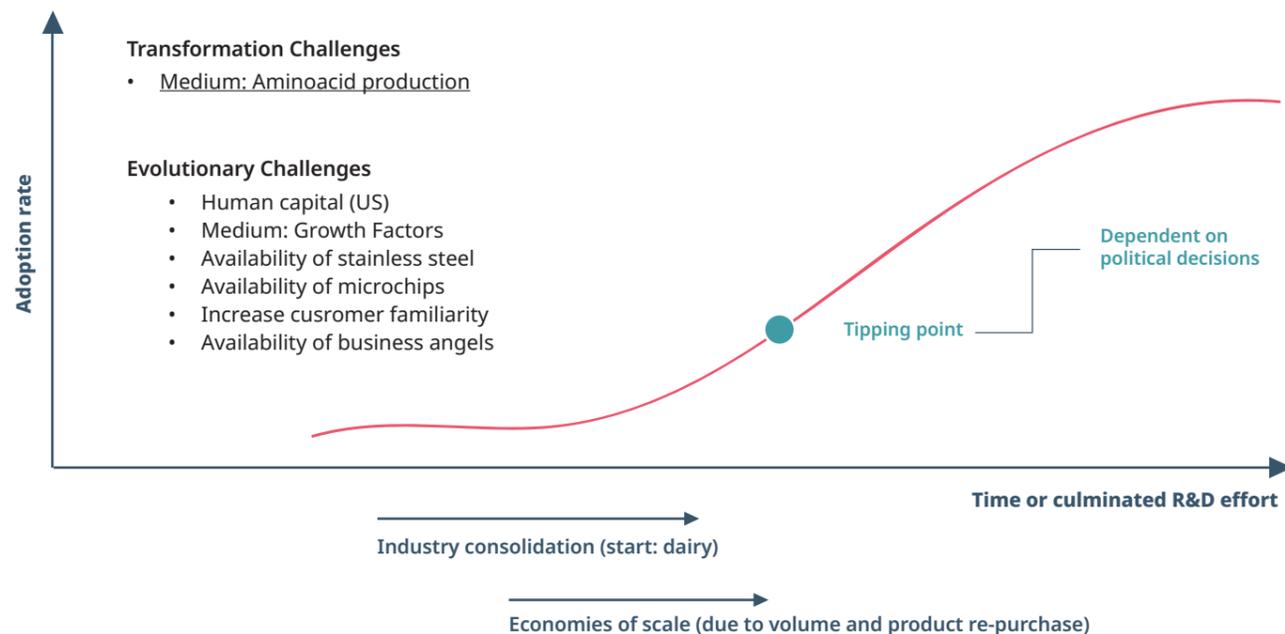
THE CHALLENGES TO BE ADDRESSED

The expansion of alternative protein products to the mainstream food market globally hinges upon two key factors:

1. The attainment of large-scale, cost-effective production capabilities for alternative proteins
2. The emergence of mainstream consumer demand that facilitates the financial viability of scaling production.

Among the technical challenges specific to subcategories of alternative proteins, cost-effective production of amino acids and growth factors in cultivated meat emerges as a prominent concern. Location-dependent non-technical challenges include a scarcity of skilled workers (human capital), limited availability of stainless steel and microchips, and a lack of accessible business angel support. An overarching challenge that cuts across alternative protein categories pertains to aligning consumer needs and familiarity with the products to drive repurchase decisions. Challenges can be classified into those with uncertain scientific solutions, such as inexpensive amino acid production, and those amenable to incremental progress, exemplified by growth factor production.

FIGURE 20: ADOPTION RATE AND R&D EFFORT



When it comes to consumer acceptance within the alternative protein industry, it is crucial to be aware that the range of products encompassed by this field is very diverse, including plant-based and cultured meat alternatives. A comprehensive review of existing literature conducted by Siddiqui et al. has revealed that acceptance levels vary significantly across different product categories. Additionally, it is important to recognise that consumers are not a homogeneous group but exhibit varying motives for their food consumption behaviours, such as health considerations, aversions, adherence to social norms, and food neophobia (Siddiqui, et al., 2022). Several potential interventions have been identified to foster consumers' greater acceptance of alternative proteins.

These interventions encompass educational strategies aimed at providing consumers with relevant information, training initiatives that equip individuals with the skills to cook with alternative proteins, and persuasive approaches that emphasise the potential health benefits of consuming these products. By implementing these interventions, it is anticipated that consumer acceptance of alternative proteins can be positively influenced. (Onwezen, 2021).

This report aspires not only to enhance comprehension of the opportunities and challenges within these alternative proteins but also to serve as a vital roadmap to identify and engage with key stakeholders in the innovation ecosystem. Such engagement is essential to fulfil the vast potential of this growing industry and ensure that it can truly deliver on its promising prospects.

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