BUILDING AN ECOSYSTEM FOR CULTIVATED MEAT IN INDIA

DECEMBER 2021

JOINT REPORT BY

CIIE BUILT AT IIMA × gfi India

ABOUT CIIE.CO

CIIE.CO is The Innovation Continuum. This continuum spreads across incubation, acceleration, seed and growth funding, and research. Founded at IIM Ahmedabad in 2002 as an academic centre, CIIE.CO has grown and pivoted to include acceleration, incubation, investment, research, and publication. Overall, we have aimed at filling the multiple, ever-evolving gaps in the Indian innovation-driven entrepreneurship space in many ways. Among various initiatives, CIIE.CO has conceptualized and hosted India's first accelerator, created India's first and so far the only cleantech-focused fund, accelerated over 1,000 entrepreneurs, funded over 200 startups, and inspired over 700,000 with our publication - Stay Hungry Stay Foolish. All the initiatives on The Innovation Continuum aim at supporting fearless, innovation-driven entrepreneurs. Working with like-minded partners, including corporates, government agencies, investors, and academia helps us push harder towards co-creating exponential change.

ABOUT THE GOOD FOOD INSTITUTE INDIA

The Good Food Institute India (GFI India) is a non-profit organization which serves as the central expert body, thought leader, and convener in the space of plant-based, cultivated, and fermentation-derived meat, eggs, and dairy - collectively known as the 'alternative protein' or 'smart protein' sector. GFI India is part of an international network of nonprofits with partners in Brazil, Israel, U.S., Europe, and Asia Pacific, on a mission to build a more secure, sustainable, and just global food system. With unique insight across the scientific, policy, industry, and investment landscapes, we use the power of food innovation and markets to accelerate the transition of the world's food system toward smart protein. In building the sector from the ground up in India, we aim to establish a model for its growth all across the developing world.

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How About That

FOREWORD

Over the last few years we have seen very encouraging growth in India's Biotechnology Sector, owing to significant ecosystem building work that has contributed to a strong foundation for research and education, translation and product development across the country. India's Bioeconomy has grown to US $70 Bn in 2020 at 12.3% CAGR & is expected to achieve US $150 Bn by 2025.

The Covid-19 pandemic has clearly indicated the need for India to emerge as a global front runner for the development and deployment of new and emerging technologies. There has never been a greater need for all stakeholders - governments, corporates, startups, innovators, local bodies, regulators, and others - to work closely towards building innovative, affordable, and accessible products for domestic and global markets.

The area of 'smart protein' presents an opportunity to create exponential impact through next-generation solutions for contributing to food security, clean environment, conserving natural resources, and more. We need an affordable, resilient supply chain of protein to supplement nutrition, poultry, dairy, and meat. The blueprint for this already exists, as we have seen from the early-2000s with India becoming a manufacturing hub for recombinant insulin, a product that historically came from the pancreases of cows and pigs. Cutting edge technological advancements has led to insulin now being 'synthesized' in biotech factories, sparing the need to extract it from animals.

This report lays out the global state of the alternative protein industry, the economic, sustainability, and public health benefits of the sector and the value Indian science, business, and investment can offer with the vision to position India as a strong bio-manufacturing hub for innovative, affordable, and accessible products for domestic and global

markets.

BIRAC acts as a key facilitation agency for nurturing the growth of the biotechnology sector in India, by building a pipeline of bio-entrepreneurs and startups, building capacity through the establishment of a pan-India bio-incubation network, and connecting academia to industry. Organizations like the Good Food Institute India are playing a pivotal role, both globally and in India, to advance the case of the smart protein sector. Biotech incubators can play a critical role to bring such novel innovations and technologies to the forefront through the startup ecosystem.

There is a need to build on the existing momentum to the technology development & technology deployment by bringing together all stakeholders from academia, industry, investors and enablers to support entrepreneurs and startups working in this emerging area of cultivated proteins to push forward and demonstrate a model for biotech industrial growth in this niche area.

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Biotechnology Industry Research Assistance Council (BIRAC)

PREFACE

Smart protein (alternative protein) is a fast-growing global industry leveraging food science and biotechnology to offer safe, nutritious, and sustainable solutions to animal-sourced protein - a critical endeavour for human and planetary health. Across all three production modalities: plant-based, fermentation-derived, and cultivated proteins, smart protein offers tremendous promise to address climate change, food insecurity, land and water scarcity, environmental pollution, and public health risks such as zoonotic disease and future pandemics.

Governments such as Israel, Singapore, and Canada are already supporting the sector through significant investment and regulatory advancement, seeing it as a major piece of their economic and food security story over the next decade.

While the global sector is going from strength to strength with cultivated meat investments surpassing $1 billion, the success of the industry in producing sustainable protein sources will rely heavily on scientific advancements borne by industry and academia alike. Bringing down costs and developing robust, scalable bioprocesses remain high priorities to advance towards a more secure, sustainable future - and India, with its robust biopharmaceutical industry, agricultural biodiversity, and world-class talent pool, offers immense value to the international smart protein sector in this regard. Currently, India has two startups and three academic research groups innovating in cultivated meat and seafood. Opportunities abound for collaboration and strategic partnerships between existing life science and food companies, and producers of smart protein foods.

CIIE.CO, in partnership with GFI India, undertook this research study to conduct a first-of-its-kind landscape study of the cultivated meat sector in India with a focus on ecosystem building. The research combines

insights from secondary data as well as in-depth interviews with multiple industry stakeholders including academicians and researchers, startups and entrepreneurs, input providers, policy-makers, support institutions, and investors. The report details our stakeholder analysis - the hurdles they face, the opportunities they envision for the future, and the support they require to make this a reality.

The report also presents a theoretical 'maturity model' to evaluate cultivated meat startups, adapted from BIRAC's Technological Readiness Level guidelines for industrial biotechnology startups. We hope to provide readers with a reference outline to benchmark key product and process developments while leveraging the requisite ecosystem support.

Herein lies a set of path-breaking interventions* for building an enabling ecosystem for the cultivated meat in India. Through this, we hope to encourage more entrepreneurs, scientists, students, and industry to enter this promising new field of deep technology.

**The cultivated meat industry is developing at breathtaking speed and we are seeing new developments emerging every week. At the time of reading this report there may be significant further developments in the sector that haven't been accounted for. However, the interventions we are proposing for building a domestic industry for cultivated meat in India remain valid and critical to a sustainable, secure, and just food system.*

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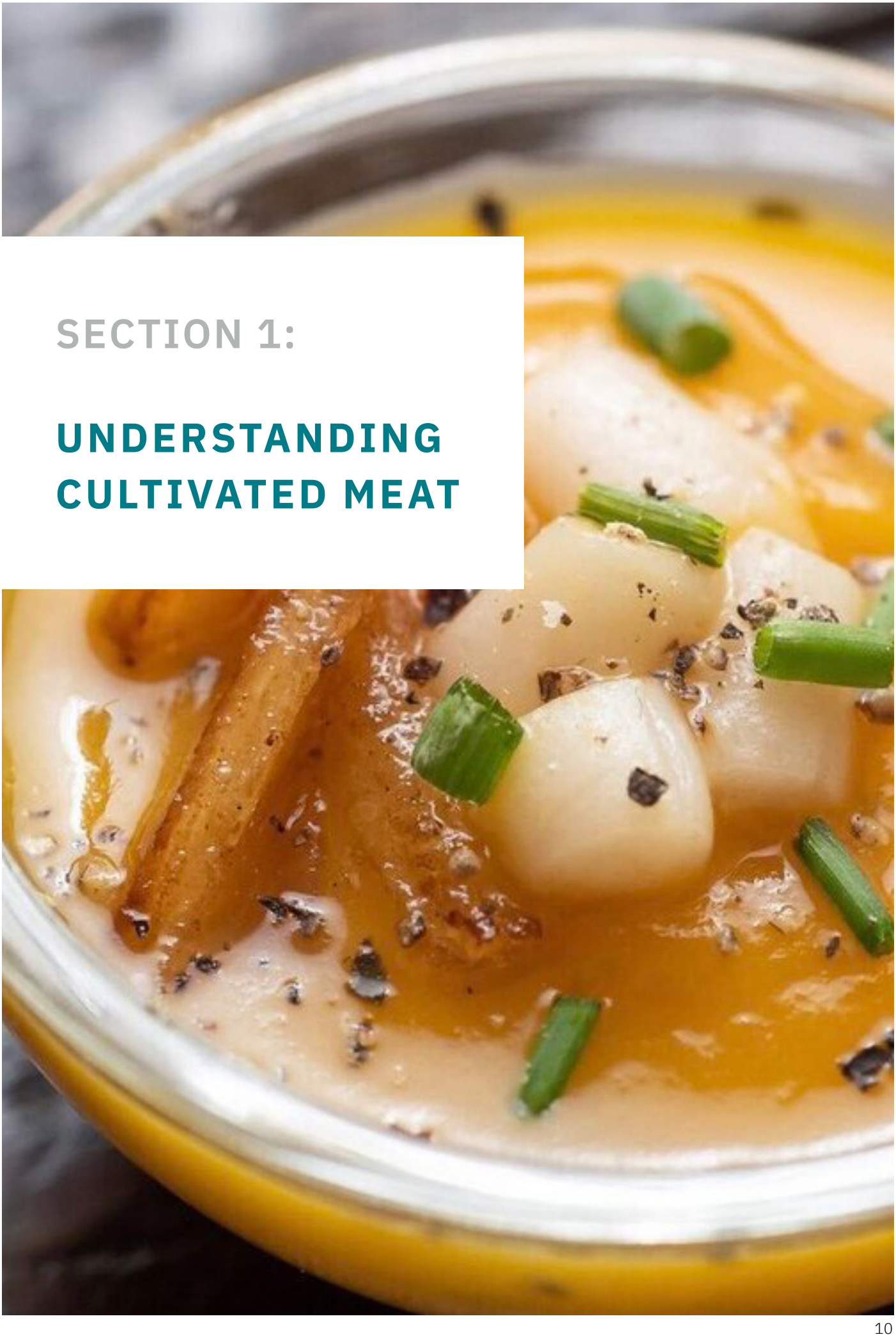

SECTION 1:

UNDERSTANDING CULTIVATED MEAT

1.1 Why Smart Protein?

Our existing protein supply chain, involving the rearing and slaughter of livestock, presents a number of pressing challenges to human and planetary health. As populations and incomes rise globally over the next decades and the demand for aspirational animal-derived proteins increases correspondingly, the consequences are projected to be serious - particularly across the developing world.

Large-scale animal agriculture is a leading driver of ecosystem loss and environmental degradation worldwide. As much as 80% of the Amazon rainforests have already been destroyed and are now mostly occupied by pastures and feed crops for livestock. A recent report in the journal Science identifies a much larger potential for GHG emissions reduction through dietary changes towards consuming less animal-derived food and has advocated that changes in food systems are imminent.[1]

Additionally, in the wake of the Covid-19 pandemic, public health concerns about antibiotic resistance and zoonotic disease are also real and imminent. The Centre for Disease Dynamics, Economics and Policy (CDDEP), in mapping resistance trends in food animals across low and middle-income countries, found the highest levels of antimicrobial resistance in farm animals in China and India.

[1] Global food system emissions could preclude achieving the 1.5° and 2° climate change targets (2020, November). Science. https://science.sciencemag.org/content/370/6517/705?fbclid=IwAR2iNLv55K5YvFChegLyeF_xDmFvR2kL4yoRixWR4Qu566o0IdN6QL1h-8k

Air Pollution

- Animal agriculture produces significantly more greenhouse gases than all of the traffic in the world combined.
- Factory farming is responsible for 18% of CO_2 greenhouse emissions and 64% of ammonia which creates acid rain.
- Herds of cows and sheep account for 37% of the total methane generated. Methane is 25 to 100 times more damaging than CO_2.
- To meet a 1.5˚C reduction in global warming requires imperative changes to how food is produced even if fossil fuel emissions are prohibited.[2]

Water Pollution

- In the US, 55% of water is consumed for animal agriculture, while only 5% is used by households.
- It takes 683 gallons of H_2O to make 1 gallon of milk.
- 2,400 gallons of water makes 1 lb of beef.
- 477 gallons are needed to produce 1 lb of eggs.
- 900 gallons are utilized to produce cheese.

Land usage

- Animal agriculture takes up over 40% of the planet.
- 56 million acres of land feed factory-farmed animals, while only 4 million acres produce plants for human consumption.
- 70% of the grain grown in the U.S. is used to feed farmed animals.
- It takes 10 lbs of grain to produce 1 lb of meat.

Source: World Animal Foundation

[2] Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets https://science.sciencemag.org/content/370/6517/705?fbclid=IwAR2iNLv55K5YvFChegLyeF_xDmFvR2kL4yoRixWR4Qu566o0IdN6QL1h-8k

Overuse of antibiotics within animal agriculture threatens our ability to treat infectious and non-infectious diseases as levels of antimicrobial drug resistance grow. This leaves humans exposed to serious and previously curable bacterial diseases. It is estimated that by 2050, antimicrobial resistance will be responsible for more deaths than cancer and will cost US $2.9 trillion annually to OECD countries.[3] These threats are particularly dire in low- and-middle-income countries, which already make up 75% of global foodborne illness deaths despite only having 41% of the world's population.[4]

Despite the catastrophic impact, the consumption of animal-sourced foods is at an all-time high. With a transition to higher-protein diets in developing countries, the production and demand for meat is expected to rise by more than 50% by 2050.[5] This surge in demand will be a result of population growth, rising incomes, and urbanization. With the global population forecasted to reach almost 10 billion by 2050[6] (almost one-sixth of whom will be in India), there is an urgent need to reimagine food systems today.

With an increased spotlight on these myriad challenges, there has been an uptick in global conversations around the threats from animal-derived foods on human and planetary health.

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[3] No Time To Wait: Securing The Future From Drug-Resistant Infections (2019, April). Interagency Coordination Group on Antimicrobial Resistance. https://www.who.int/docs/default-source/documents/no-time-to-wait-securing-the-future-from-drug-resistant-infections-en.pdfsfvrsn=5b424d7_6

[4] Improving food safety: an emerging imperative in low-income countries (2020, June). The Global Alliance for Improved Nutrition. https://www.gainhealth.org/media/news/improving-food-safety-emerging-imperative-low-income-countries

[5] United Nations, Food and Agriculture Organization. (2018). The future of food and agriculture: Alternative pathways to 2050. Retrieved from http://www.fao.org/3/CA1564EN/CA1564EN.pdf

[6] United Nations, Department of Economic and Social Affairs, Population Division. (2017). World population prospects: The 2017 revision, key findings and advance tables. (Working Paper No. ESA/P/WP/248). Retrieved from https://population.un.org/wpp/Publications/Files/WPP2017_KeyFindings.pdf

The European Union (EU), for example, as part of the European Green Deal has pledged €100 billion from 2021-2027 for making the EU's economy sustainable, which includes a Farm to Fork strategy for investing in plant-based and other alternative proteins.[7]

Among consumers, increased awareness of the effects of diet on health and concerns about meat production on the environment and animal welfare are leading to a trend of meat reduction rather than complete meat restriction. According to global surveys conducted by Euromonitor International in 2015-2017, meat reduction is becoming more prevalent with respondents aiming to cut down their individual meat intake. Research from the Good Food Institute India reveals similar drivers among Indians, with a high willingness to try meat substitutes as long as they replicate the taste of the culturally entrenched meat-based dishes we know and love - making the need for innovation in alternative sources of protein and its products imperative, so that consumers can satisfy their needs with a simple switch rather than a sacrifice. The smart protein sector represents a hugely promising opportunity to provide that switch.

Smart protein foods are food products which can reliably and predictably substitute the consumption of animal-derived meat, eggs, and dairy, while vastly lowering impacts on planetary and public health. Smart protein products can be made using one or a combination of the following three modalities, from a product, cost, and infrastructure perspective - cultivated meat, plant-based protein, fermentation-derived protein.

[7] Smith K. (n.d.). EU Pledges €10 Billion for Plant-Based and Alternative Proteins. LIVEKINDLY. https://www.livekindly.co/eu-pledges-plant-based-alternative-proteins/

Cultivated meat

Cultivated meat is a novel method to produce meat from cell cultures. It is identical to animal meat at the cellular level, and thus, can provide the same sensory and nutritional profile of conventionally produced meat, while providing a more safe, repeatable, and sustainable production system. It isn't imitation or synthetic meat; it's actual animal meat grown outside an animal.

A note on nomenclature: The industry is converging on using the term cultivated meat but other accepted terms include cultured meat and cell-based meat. More on this issue here[8] and here.[9]

Plant-based protein

Plant-based smart protein products are direct replacements for animal-based products such as meat, seafood, eggs, and dairy. These products use the biomimicry approach to replicate the taste and texture of meat.

Fermentation-derived protein

Fermentation-derived protein refers to utilizing microbial organisms to produce a foodstuff, either using the organism itself as a primary source of protein or deriving specialized ingredients, such as flavorings, enzymes, and fats, for incorporation into plant-based products or cultivated meat.[10]

[8] https://www.gfi.org/cultivatemeat
[9] https://www.gfi.org/cultivatedmeat
[10] GFI's 2019 State of Industry Report: Cultivated Meat

Further, the value chain of the smart protein industry can be understood as follows: [11]

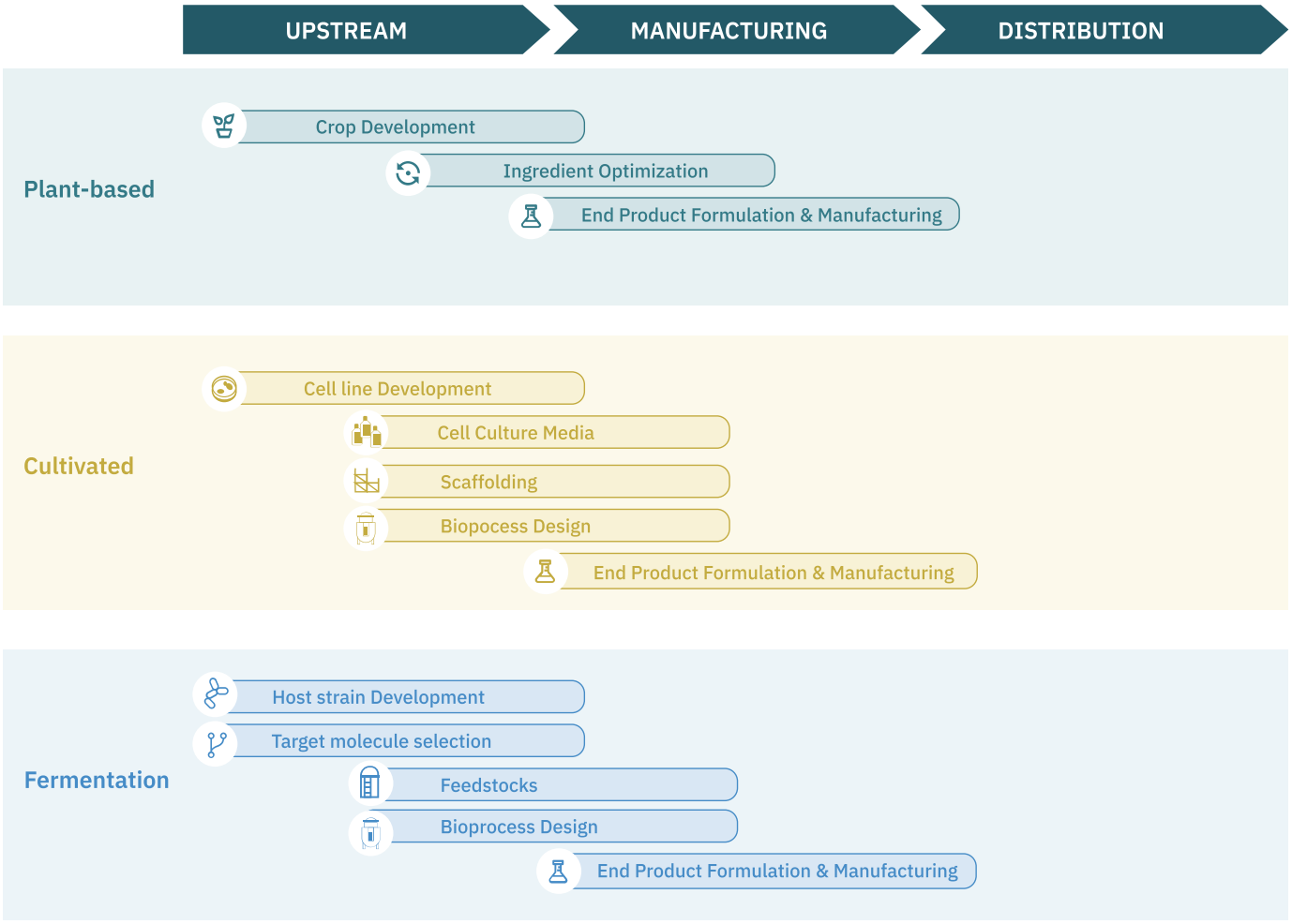


Image Credit: GFI Analysis, Morgan Zaidel (GFI Fellow)

[11] Weston Z. (2020, July 14). Zak Weston: Growing meat — a market-based approach to building an ethical food system. EAForum https://eaforum.issarice.com/posts/ZxH5dRZDhk3GmNwiD/zak-weston-growing-meat-a-market-based-approach-to-building

1.2 The Technology behind Cultivated Meat

Cultivated meat comprises four key technology components that are critical to driving innovation from bench to industrial scale:

Cell Lines

A cell line is a **population of cells** that are immortalized and stable. At a lab scale, the process of producing cultivated meat begins by isolating starter cells from the animal tissue biopsy. These cells are then subjected to serial passaging and immortalization procedures to create the most viable cell line. A variety of cell lines thus formed are then stored at **cell banks**.

Cell Culture Medium Optimization

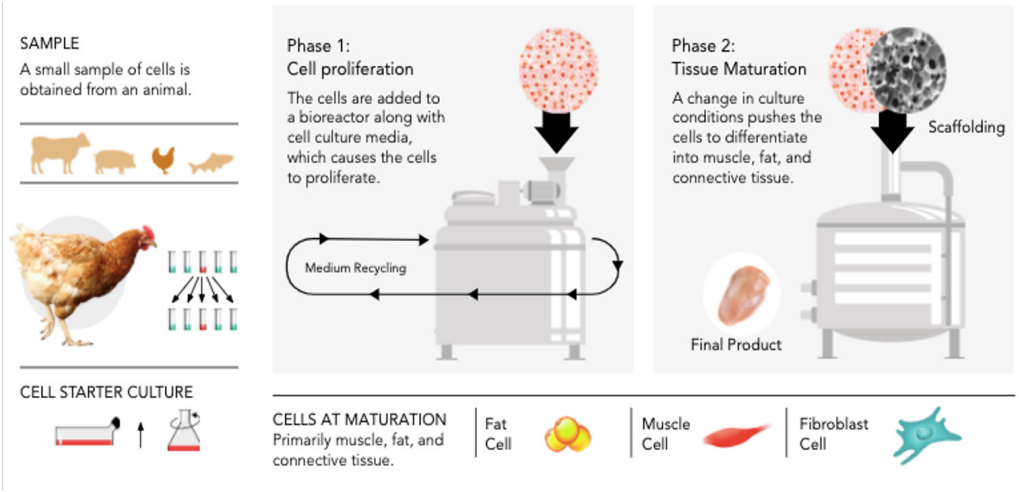
Optimization of cell culture media components which contain **building blocks** of cellular structures - pH buffers, proteins, fats, growth factors (ingredients which signal the cells to form muscles, blood, fat, etc.). Culture media is essential for supporting the proliferation and differentiation of cells and is the biggest cost-driver in the cultivated meat value chain. Culture media for cultivated meat needs to be non-animal derived (Fetal Bovine Serum free), efficient, and cost-effective.

Scaffolding

A porous, edible, or biodegradable **support structure** for cellular adherence, meant to support and direct the growth of cells and derive muscle tissue structures identical to animal-derived meat.

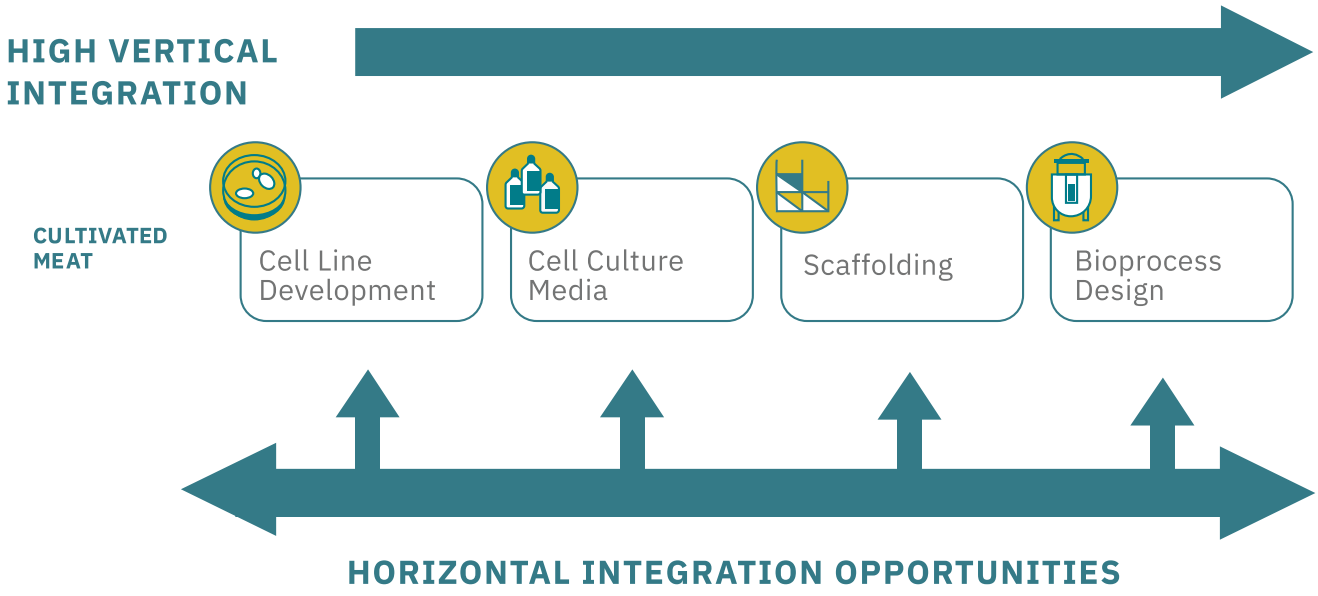
Bioreactors

Engineering novel bioreactor systems to aid cells to replicate at astronomical scales within a conducive environment. Cultivated meat bioreactors (or cultivators) are designed to support controlled cell proliferation, sustenance, and terminal differentiation to harvest animal tissue constructs (as cultivated meat) at a commercial scale.



Source: GFI Analysis

The cultivated meat sector is rife with a multitude of challenges across the four **value chain** entry points thereby offering ample opportunity for researchers, startups, and corporates to innovate.



Tracing the value chain from cell line development all the way upto bioprocess design presents several **integration opportunities**. Some of the current opportunities (not comprehensive), are listed below.

UPSTREAM TECHNOLOGY AND PRODUCTION	OPPORTUNITIES
Cell Line Development	• Cell line isolation and characterization • Cell immortalization and differentiation • Cell banks and repositories • Footprint free methodologies (zero genomic integration
Cell Culture Media	• Serum-free media formulations • Growth factor engineering • Computational discovery of growth and differentiation drivers • Convergence cultivated meat and fermentation research for high-value ingredients and industrial scale-up
Scaffolding	• Biodegradable and edible scaffolds • 3D bioprinting of scaffolds
Bioreactors	• Novel designs for mammalian cultures • Pilot-scale designs • Media recycling and continuous flow automation
DOWNSTREAM PRODUCTION	**OPPORTUNITIES**
Production	• Plant-based hybrids • Culture media/component manufacturing • Large scale bioreactor and facility design, construction
Supply chain	• Global sourcing, quality assurance, packaging (shelf life)

Source: Adapted from GFI's 2019 State of the Industry Report: Cultivated Meat

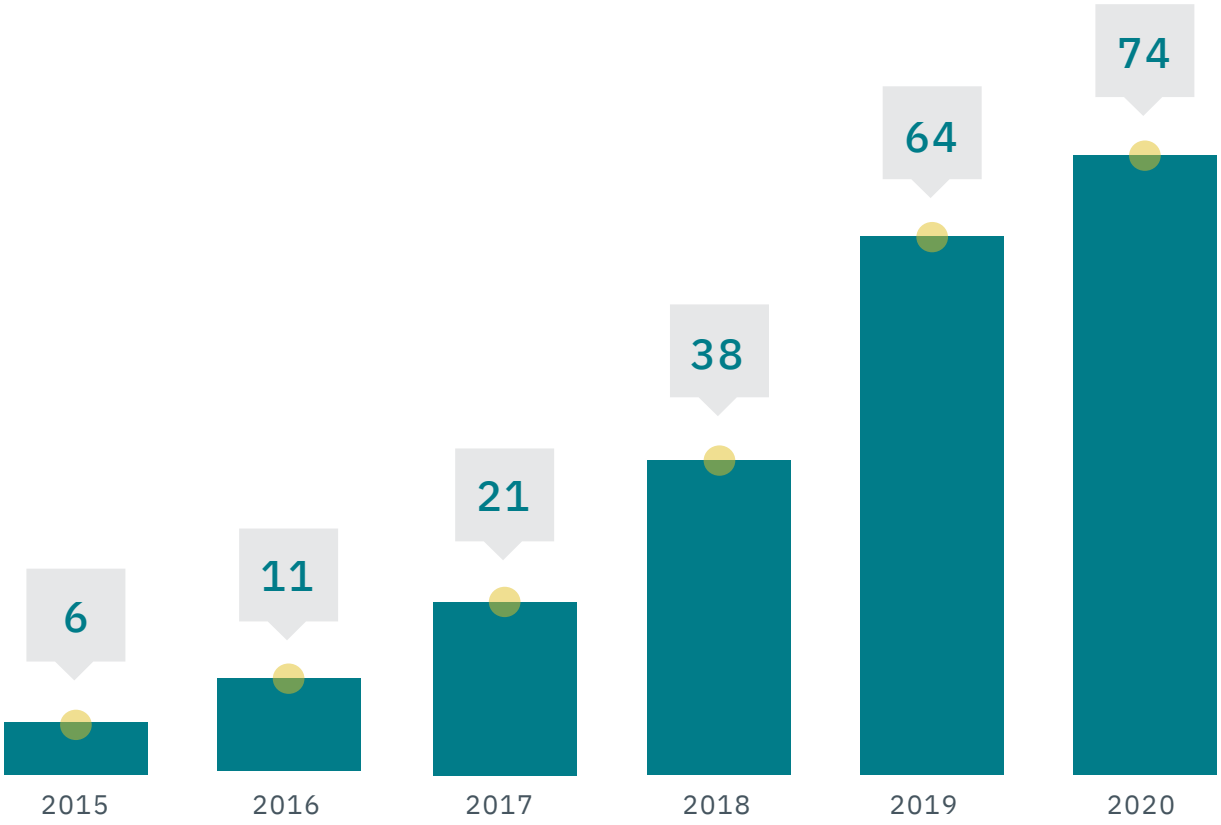
1.3 Global Overview[12]

Cultivated meat first caught public attention back in 2013 when Mark Post created the world's first cultivated hamburger.[13] However, for the next couple of years, the advancements were still perceived as academic. The first major inflection point for cultivated meat as an emerging industry came in 2016 when Memphis Meats **(now Upside Foods)** became the first-ever cultivated meat company to raise a seed investment round; Upside Foods has since raised multiple funding rounds based on the critical technology milestones achieved.

The initial success of Upside Foods with a gradual increase in investor appetite led to over 70 cultivated meat and seafood industry startups in 19+ countries across five continents by the end of 2020. Nearly 60% of startups have raised external funding, some strikingly with corporate partnerships with conventional meat companies such as Tyson, Cargill, Merck, and PHW-Gruppe. In addition, globally 40+ life science companies have announced their involvement in various integration opportunities across the sector.

Almost one-third of cultivated meat companies are based in the United States. The remaining two-thirds exist in the EU-UK region, Canada, Israel, and Asia Pacific with first-of-its-kind companies emerging in Russia, Switzerland, Argentina, France, and Chile. At least 20 new cultivated meat ventures have been incorporated in 2020 alone.

[12] Adapted from GFI's State of the Industry Report Cultivated Meat 2019
[13] Jha A. (2013, Aug 6). First lab-grown hamburger gets full marks for 'mouth feel'. The Guardian. https://www.theguardian.com/science/2013/aug/05/world-first-synthetic-hamburger-mouth-feel

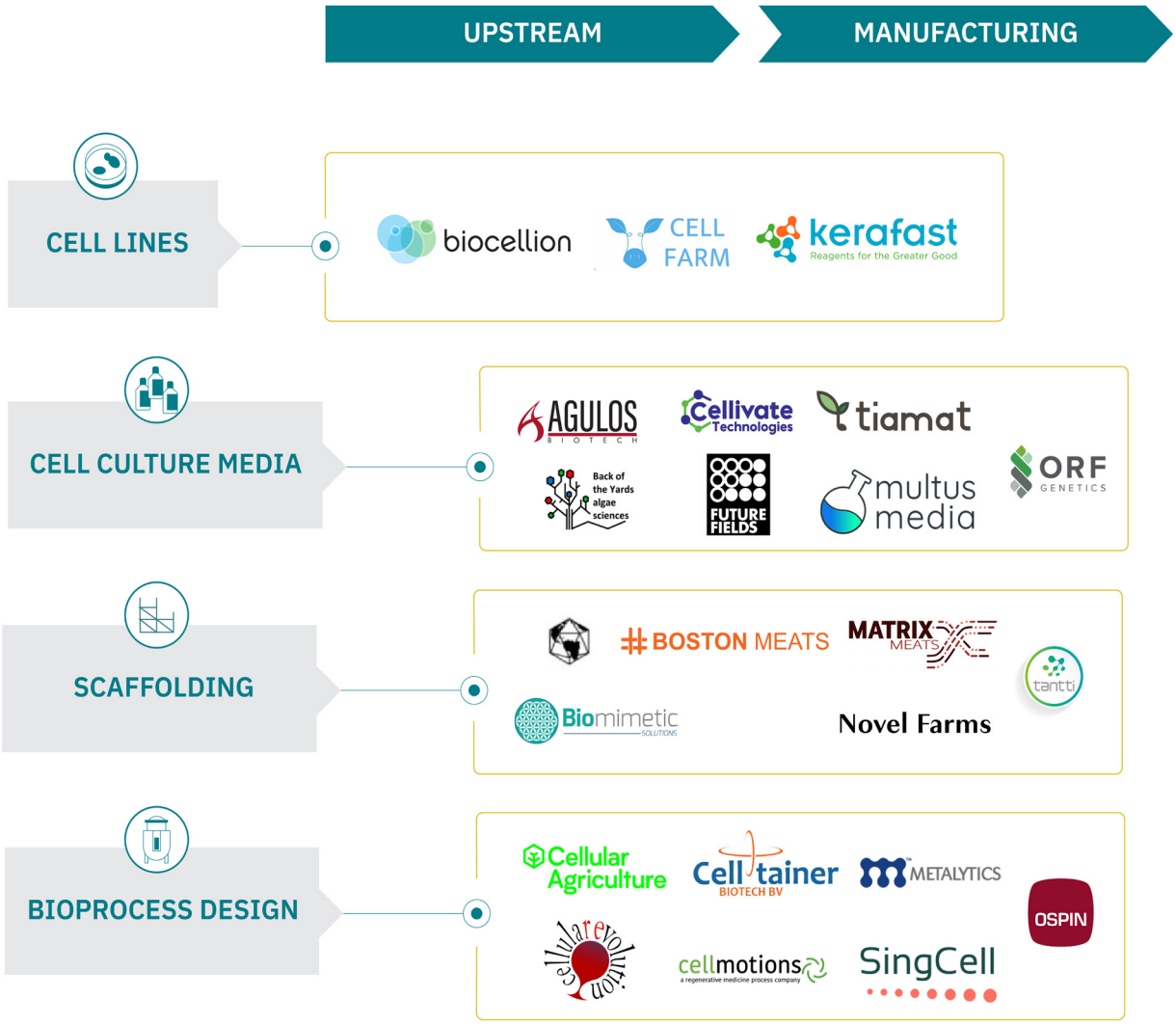


Total number of companies either working on manufacturing cultivated protein products or supplying key technologies in the sector from 2015-2020 (Note: companies formed before 2015 (5) - have been excluded from the comparison above). Source: GFI's company database[14]

Products and Innovation

Startups are now producing more than 15 different types of cultivated meat and seafood from multiple livestock species. The main cultivated meat product types include beef, chicken, pork, and sheep. The cultivated seafood producers are working on vertically integrated systems for producing shrimp, tuna, salmon, crustaceans, fish maw, and sturgeon. On the other hand, sector enabling startups are innovating on cell culture media, cell lines, scaffolding, and bioreactors to support core industrial players.

[14] GFI Alternative Protein Company Database



An indicative list of startups working on upstream technologies (cell lines, cell culture media, scaffolding and bioprocess design) and downstream manufacturing technologies.

Sharp rise in funding

Thus far, companies have raised a total of US $1.3 billion in venture capital funding in the field globally until Q3 2021.[15] Cultivated meat boasts 125 unique investors spanning 21 countries, with nearly half of these in the United States. The vast majority are venture capital groups, corporate venture arms, angel investors, and startup accelerators. Many investors also belong to the GlassWall Syndicate - a network of investors with a common mission to accelerate the growth of animal-free industries, including smart proteins.

[15] GFI analysis of PitchBook Data, Inc.

Strikingly, the first three quarters of 2021 witnessed cultivated meat companies raising upwards of $763 million - more than the combined total of US $415 million invested in the industry in 2020. Upside Foods' landmark US $161 million (Series B) led the charts, followed by Aleph Farms' (US $105 million, Series B), Mosa Meats (US $55 million, Series B), and Shiok Meats (US $12.6 million, Series A).

Some of the recent advancements in the sector globally have been:

1. Focus on key technological inputs (B2B):

Until 2019, startups in the sector had mostly been **vertically integrated**, attempting to address multiple technical challenges, such as **cell line optimization, cost reduction, and scale-up**. However, the industry seems to be gradually shifting toward horizontal expansion with several enabler-startups cropping up to solve upstream and downstream challenges.

2. Regulatory developments:

In 2018, U.S. Department of Agriculture (USDA) and the U.S. Food and Drug Administration (FDA) agreed to a joint regulatory framework. Later in 2019, a formal agreement provided cultivated meat with a clearer path to market in the United States. In December 2020, the Singapore Food Agency (SFA) granted the world's first regulatory approval for cultivated meat to Eat JUST, Inc., to sell its cultivated chicken nuggets. Eat JUST, through its cultivated meat division GOOD Meat, has initially launched its product with a restaurant partner, 1880. In April 2021, the company partnered with Foodpanda, Asia's leading food and grocery delivery platform, to launch the world's first home delivery of cultivated chicken. In July 2021, a Singapore-based contract development and manufacturing organization (CDMO), Esco Aster, received the first-ever commercial, regulatory approval for a cultivated meat manufacturing platform.

3. Stage of product development:

In 2019, boosted by the outstanding Series A investments in the sector, more startups came out with lab-scale proofs of concept, and many switched to focusing on scaling up production, implying a gradual shift in maturity of the sector. In 2020 several cultivated meat startups such as Singapore's Shiok Meats and Israel's SuperMeat unveiled products for consumer tastings.

4. Investments in industrial-scale manufacturing facilities:

In 2021, Upside Foods created history with a brand new cultivated meat production facility. The 53,000 sq.ft plant, known as Engineering, Production, and Innovation Center (EPIC), features custom-made, patented cultivators, is the world's most advanced cultivated meat production facility designed to bring products "out of the lab" into industrial scale. Additionally, GOOD Meat partnered with state-backed Doha Venture Capital and Qatar Free Zones Authority to develop a large-scale cell-based meat plant in the country, which will be larger than GOOD Meat's facility in Singapore. In November 2021, Shiok Meats, producing cultivated crustacean products, unveiled a "mini production plant" at its headquarters in Singapore.

5. Strategic investors and partner:

In 2020-21, we saw an increasing number of industry incumbents get involved in the cultivated meat industry, either through investments or forming partnerships with cultivated meat companies. As a recent example, JBS, the largest global protein company, announced the acquisition of Spanish company BioTech Foods and along with setting up Brazil's first cultivated protein research & development (R&D) center through an investment of US $100 million. The deal enables both companies to pool their strengths and accelerate the development of the cultivated protein market.

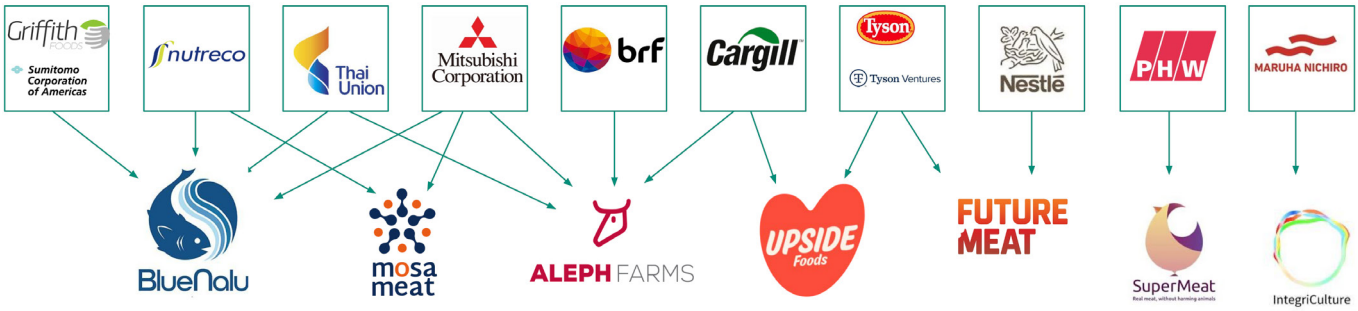


Fig: Strategic investors and partnerships in the cultivated meat industry

1.4 Theoretical Maturity Model for Cultivated Meat Startups[16]

TRL 1

IDEATION

Literature survey. Problem identified. Hypothesis defined and formulated.

Cultivated Meat Startups need:

- Core team capabilities: Scientific
- Inhouse R&D capability

TRL 2

PROOF OF PRINCIPLE

Lab-scale analytical experiments initiated. Basic principles observed from bench-scale studies. Parameters yet to be optimized.

Cultivated Meat Startups need:

- Tie-up with bio-incubator lab for infra support

TRL 3

PROOF OF CONCEPT DEMONSTRATED

Concept proven at bench-scale level. (Optimization of parameters at bench-scale.)

Cultivated Meat Startups need:

- Tie-up with bio-incubator lab for infra support

TRL 4

PROOF OF CONCEPT ESTABLISHED

Concept proven from bench-scale to bioreactor level experiments under optimised conditions at less than 100L. Necessary approvals to be obtained for using GMOs (RCGM/GEAC).

Cultivated Meat Startups need:

- Business Development + Legal/ Compliance
- In-house R&D capability (for core technological components)
- Key strategic collaborations (for non-core technological components)

[16] Definitions adapted from BIRAC's Technological Readiness Level guidelines for industrial biotechnology startups https://www.birac.nic.in/webcontent/birac_trl_doc7_industrial_biotechnology_12_09_2018.pdf; modified to incorporate volumes (scales) specific to cultivated meat sector

TRL 5

EARLY STAGE VALIDATION

Process development (including downstream processing) for isolation/ enhancement/ extraction of the product at bioreactor level at less than 100L.

Cultivated Meat Startups need:

- Independent pilot scale facility (Contract Manufacturing)

TRL 6

EARLY STAGE VALIDATION

Stability of the product and repeatability of the process to obtain a consistent product. Complete technology package developed. Obtaining all the regulatory clearances for Industrial scale-up with respect to standard guidelines, if applicable.

Cultivated Meat Startups need:

- Independent pilot scale facility (Contract Manufacturing)

TRL 7

LATE STAGE VALIDATION

Pilot scale demonstration of the technology (1,000 L or 1,000 Kg Scale). Technology demonstration in actual environment.

Cultivated Meat Startups need:

- Independent pilot scale facility (Contract Manufacturing)

TRL 8

PRE-COMMERCIALIZATION

Late stage technology development (Scale up to 10,000L or 10,000kg demonstration scale).

Cultivated Meat Startups need:

- Core team capabilities: Marketing/ Sales
- Industrial scale manufacturing facilities (Contract Manufacturing/ Tech licensing)

TRL 9

COMMERCIALIZATION AND POST MARKET STUDIES

Obtained all the regulatory clearances for market entry and ready for commercialization.

Cultivated Meat Startups need:

- Core team capabilities: Marketing/ Sales
- Industrial scale manufacturing facilities (Contract Manufacturing/ Tech licensing)

[17] The maturity model has been laid out for the vertically integrated cultivated meat startups producing end products only.

SECTION 2:

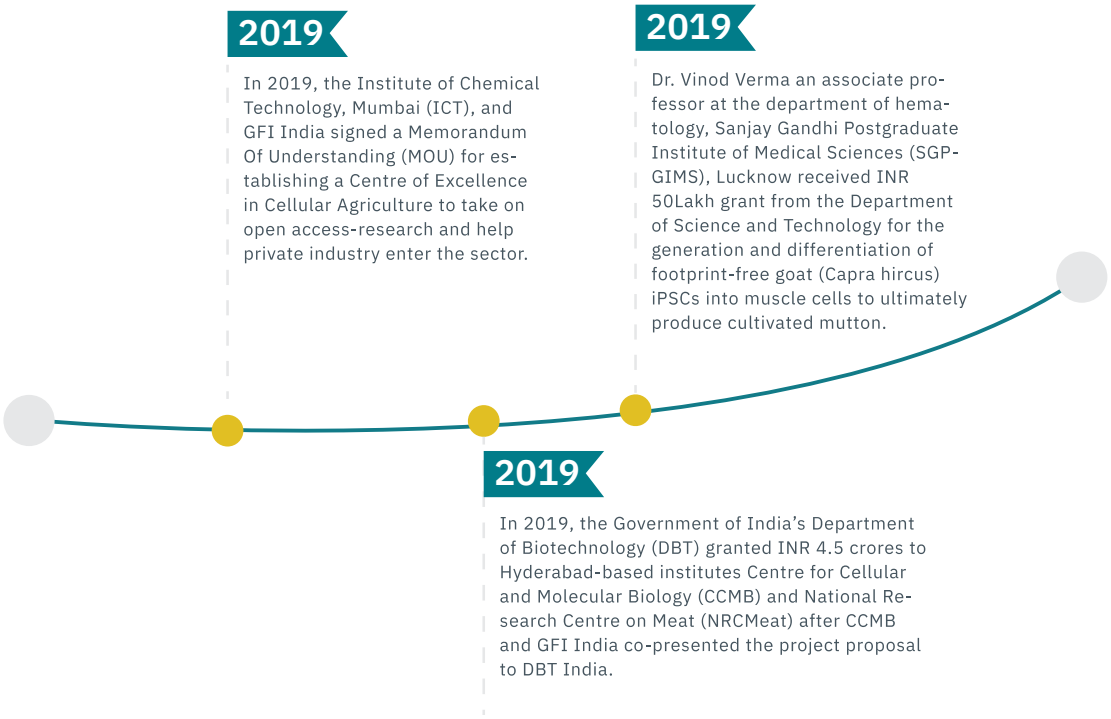
STAKEHOLDER ANALYSIS

2. Stakeholder Analysis

The broader cultivated meat ecosystem in India is steadily gaining momentum with good inroads in research and development. Prominent research institutions, startups, and corporates are providing a lucrative opportunity for multiple stakeholders to join and co-create an ecosystem that could result in several enterprises in the coming decade.

2.1 Academicians & Researchers

Even though cultivated meat research in India is nascent, it is gaining significant momentum due to the increased participation of scientists, researchers, and government funding agencies. India could emerge as a smart protein research and development powerhouse by leveraging its world-class institutes with quality talent, technical expertise, and ultra-modern research infrastructure.



GFI India has been at the forefront of cultivating relationships and collaborations with research organizations and subject matter experts across the country to create a thriving smart protein ecosystem.

Below is a snapshot of the top tier research institutes GFI India is currently engaging with to advance open access research and innovation. GFI India aims to increase its outreach to more such organizations in the coming years.

Fig: GFI India's Cultivated Meat Map of India

Institutes with inter-disciplinary and infrastructural strength are crucial for advancing cultivated meat research and development. For example, the Bangalore Life Sciences Cluster **(BLiSC)** at National Centre for Biological Sciences **(NCBS), inStem,** and Centre for Cellular and Molecular Platforms **(C-CAMP)** provide cutting-edge technology infrastructure for researchers and startups.

Bio-incubators such as Indian Institute of Technology Madras bioincubator **(IITM Bioincubator)** and Atal Incubation Centre, Centre for Cellular and Molecular Biology **(AIC-CCMB)** have been actively involved with cultivated meat research and infrastructure creation. Another nation-wide case in point is the **Bio-NEST network** (Bio-incubators Nurturing Entrepreneurship for Scaling Technologies), an initiative of **BIRAC** (Biotechnology Industry Research Assistance Council). The Bio-NEST network supports **50 bio-incubators** in India to provide incubation space and technical and business mentorship to promising biotech entrepreneurs.

WHAT NEEDS TO BE SOLVED

1. Creating an ecosystem for the cultivated meat sector in India

The research infrastructure in relevant areas of cell biology and food technology through bio-incubators has been made available for the talent pool in the country. GFI India has compiled a list of existing accelerator and incubator programs aligned with the smart protein sector.

2. Push for generating IP

Even though the number of research articles relevant to cultivated meat has picked up significantly, IP is yet to witness an uptick due to a lack of enterprising researchers in this sector. A fresh proactive approach from academia to generate new IP is required.

3. Empowering Technology Transfer Offices (TTOs) about the value of cultivated meat research

TTOs at key research institutions need to be informed and guided on the commercial viability of cultivated meat technologies and be encouraged to conduct an impact assessment of associated products being developed at the lab scale. This will ensure that IP is patented and subsequently valued appropriately to get licensed at optimal rates.

WHAT LIES IN THE FUTURE

1. India as a CRO[18] for the cultivated meat industry

India's existing capabilities in biopharmaceutical manufacturing and fermentation lend themselves well to the cultivated meat industry. In addition, the cost of innovation in India is relatively low compared to other highly-skilled markets. The Global Innovation Index indicates India has consistently outperformed other economies in its income group, with India's ranking going up from 81 (2015) to 46 (2021).

2. Cell Banks and research tools for cultivated meat R&D

India has the infrastructure and capacity to become a manufacturing hub for cell lines and provide manufacturing avenues for antibodies, constructs, synthetic biology tool kits, pathway analysis globally. A large talent pool in cross-disciplinary research and readily available infrastructure of bio-incubators ensure that the same can be achieved at much lower costs than Western counterparts.

3. Synergies for upcoming Indian startups

The potential development of an ecosystem including cell banks, lab scale facilities, and specialized co-manufacturers are expected to hugely boost startups in India in the next 3-5 years. As the integration

[18] Contract Research Organization

of allied research areas with cultivated meat gradually increases, more entrepreneurs will start accessing resources and mentorship from biotechnology and engineering institutes.

WHAT SUPPORT THEY NEED

1. More funding for research

While the policies are being drafted, there is a pressing requirement for larger grants and funding for researchers, labs, and incubators. For example, The National Science Foundation (NSF), an independent federal agency of the U.S. government, awarded the University of California Davis a US $3.5 million five-year grant for cultivated meat research. The grant emerged through the UC Davis Cultivated Meat Consortium, formed in 2019 with the support of Good Food Institute and cultivated meat companies in California. The consortium functions as a hub for cultivated meat research projects, student training, and knowledge creation and dissemination. In Israel, a cultivated meat consortium has been approved by the Israel Innovation Authority (IIA). It will be receiving up to US $19 million in government investment. The consortium consists of 12 companies and nine academic labs.

2. Increasing infrastructural capacity

In 2021, the U.S. Department of Agriculture (USDA) announced an investment of US $10 million to create a center for excellence in cellular agriculture at Tufts University. More such centers will be required globally to support entrepreneurs and innovators to create opportunities for the best teams and ideas. By mapping cultivated meat research infrastructure across several institutes in India, GFI India identifies existing infrastructural capacities and deficits to accelerate R&D.

3. Cultivated meat coursework and curriculum building

The science behind cultivated meat is quintessentially multidisciplinary. Therefore, it is essential to develop educational

> We have been able to provide required mentoring to startups because of strong scientific capabilities, connections and support infrastructure essential to handhold these ventures at an early stage.
>
> **Dr. Taslimarif Saiyed**
> *CEO and Director*
> *C-CAMP*

programs that can cover the depth and complexity of knowledge and skills needed across multiple subject domains at academic institutions. However, currently, only a few foreign universities offer smart protein majors or dedicated subject matter coursework. GFI has launched the smart protein coursework at universities around the globe, including a new undergraduate course at Nanyang Technological University, Singapore (NTU Singapore) on alternative proteins and cultivated meat. GFI India aims to bring these learning opportunities to its country by early 2022 to develop a strong interdisciplinary talent pipeline.

> When we reach production mode, we will need a lot of backend support from research institutes and universities - especially in sourcing cell lines to handle market demand.
>
> **Siddharth Manvati (Ph.D.)**
> *Co-Founder*
> *Clear Meat*

2.2 Startups & Entrepreneurs

Roughly two dozen cultivated meat startups globally at the end of 2018 have now grown to over a hundred companies focused on bringing cultivated meat solutions to the market.This has primarily been driven by the increasing confidence from corporate behemoths and large investors, recognizing this technology's massive social and economic impact potential. Some of the major recent investments in cultivated meat across the globe are as follows:

STARTUP NAMES	STAGE OF PRODUCT DEVELOPMENT	INVESTMENT RAISED TILL DATE (JAN 2021)
Future Meat Technologies (Israel)	Built a 500 kg/day production facility in Israel; currently building a larger facility in the US with an eye to 2022 regulatory approval and launch	**US $387.80 million** *Including a mammoth $347 million Series B round, the largest in history
GOOD Meat (United States)	Received regulatory approval and sale of cultivated chicken in Singapore, and gearing towards production and launch in Qatar and other markets	**US $267.00 million** *This does not include other funding raised by GOOD Meat's parent company Eat JUST Inc for their other (plant-based) business lines
Upside Foods, formerly - Memphis Meats (United States)	Limited scale commercialization expected in 2021 (at a premium price)	**US $208.40 million**

STARTUP NAMES	STAGE OF PRODUCT DEVELOPMENT	INVESTMENT RAISED TILL DATE (JAN 2021)
Mosa Meat (Netherlands)	First pilot production plant to commence operation in 2021; first industrial production line will start in 2022 - leading to launch of first products in test markets at a small scale	**US $92.30 million**
Blue Nalu (United States)	Currently in the initial phase of development - producing whole seafood medallions and fillets at pilot-scale; planning to introduce products into a test market during the second-half of 2021[19], and anticipates that in the next five years, its first factory will be producing 10 million pounds of cultivated seafood annually[20].	**US $29.60 million**
Shiok Meats (Singapore)	The launch of a commercial pilot plant for its minced shrimp product is expected in 2022.	**US $20.30 million**
Aleph Farms (Israel)	Unveiled the industry's first prototype of a cultivated beef steak in Jan 2021 and launched a visitor center in 2020	**US $131.40 million**

[19] Company statement, 18/7/2020
[20] Pitchbook 22/9/2020

Examples of Plant Based Meat startups in India[22]

Imagine Meats, GoodDot, MisterVeg, ProMeat, Greenest, Blue Tribe Foods, Shaka Harry

Over half of India's smart protein startups have been incorporated or have become market-ready within the last 18-24 months[21], with entrepreneurs already venturing into cultivated meat.

Before the commercialization stage, cultivated meat entrepreneurs have three major milestones to achieve - (i) Narrowing down on customer base and their food preferences, (ii) Product development and, (iii) Capacity building to ensure market opportunity and optimize taste, texture, and replaceability. The complexity at each stage creates both challenges and opportunities.

Cultivated meat startups in India

Clear Meat, India's first homegrown cultivated meat startup, has developed and tasted its first cultivated chicken mince product in early 2020, and is planning to launch their first market ready product by 2023.

MyoWorks, an early-stage startup, is looking to manufacture a range of ingredients and scaffolds for the cultivated-meat industry globally. MyoWorks received The Government of India's DBT's Biotechnology Ignition Grant (BIG) worth INR 50 lakh to demonstrate preliminary proof-of-concept and qualified as semifinalists for the US $15 million Feed the Next Billion competition - Xprize.

[21] https://nutritioninvestor.com/13-indian-innovators-at-smart-protein-summit-2020

[22] GFI India Entrepreneur Database. (n.d.). Retrieved (December 31, 2020), from https://airtable.com/shrXIIOlPp3metAuB/tblk3g6IkFWrBShLa

WHAT NEEDS TO BE SOLVED

TECHNICAL BOTTLENECKS:

1. Cost reduction in cell culture media

- The biggest challenge for startups is to lower significant costs stemming mainly from culture media. Cell culture media constitutes more than 90% of the overall product development costs in cultivated meat. Albumin (a transport protein) and proteins such as insulin and growth factors form the bulk of the cost of culture media.
- GFI recently surveyed several cell culture media suppliers or suppliers of recombinant proteins and growth factors and received responses from 19 cultivated meat manufacturers and 21 cell culture media or growth factors suppliers. Most suppliers indicated that the culture medium production costs per liter could drop below $5, and a few participant companies stated the cost to fall below $1 over the next five years. Scale-up facilities and efficient ingredient sourcing also indicated that culture media prices could also fall below $1/L.
- Some ways by which startups, along with input providers, can work to reduce their media costs include:
    1. Developing cost-effective serum-free formulations and recombinant albumin at scale.
    2. Developing more affordable replacements for expensive growth factors.
    3. Identifying and modulating cell signalling pathways and exploiting conditioned media from animal cell culture to remove the need of growth factors altogether.

2. Achieving scale

Facilities for research and prototyping are available. Still, the large-scale infrastructure for production will need more innovation and investment, which is scarce in India and will need to be nurtured.

COMMERCIALIZATION BOTTLENECKS:

1. Identifying the right customer and product-market fit

Entrepreneurs must have clarity when deciding their target customer, meat category, end product, and supply chain, given the cultural complexity behind meat consumption in India. Leveraging technological capability and infrastructure alongside customer awareness campaigns will enable startups to find more clear paths into markets. Startups would benefit from answering the following questions:

- **Customer segmentation** - Demographic, geographic, psychographic or behavioural?
- **Problems being solved for the customer** - Health, cultural or environmental?
- **Meat category** - Chicken, seafood, mutton, beef or pork?
- **Food products** - Minced, whole or chopped meat?
- **Supply Chain** - HoReCa[23], organized retail or local street shops?

2. Demand estimation

A recent consumer survey has found significantly higher acceptance of cultivated meat in India than in the United States. Indian entrepreneurs, like their international counterparts, would need to test the waters by extensive customer validation and launching their products at a limited scale before scaling up the production process. Indian customers are widely perceived as price-sensitive, which is another challenge for entrepreneurs to solve to achieve product-market fit.

3. Regulatory approval for the sale of cultivated meat

Singapore is the first country in the world to grant regulatory permission for the sale of cultivated meat. We expect the USA, Japan, Israel, China, and other governments to follow suit. Still, in the meantime, the policy for market entry remains ambiguous in the world's largest markets,

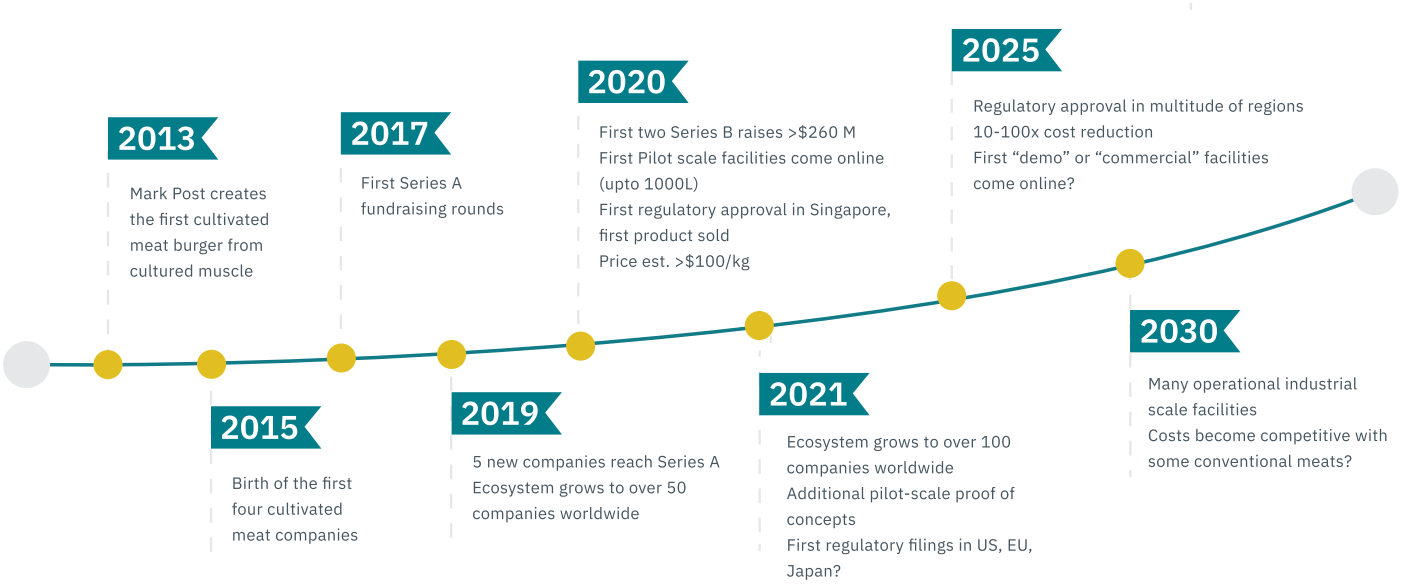
[23] Hotels, Restaurants, Cafes

such as India.

WHAT LIES IN THE FUTURE

1. Timeline for cultivated meat products to hit the shelves globally

There is no strong consensus on when consumers will be able to purchase affordable and sustainable cultivated meat products; several factors such as technology and scale-up bottlenecks, sustained investments, and regulatory roadblocks will critically influence the commercial availability of cultivated meat. Recently, GFI and CE Delft published a life cycle assessment (LCA) and techno-economic assessment (TEA) which dissects a hypothetical commercial scale cultivated meat production facility operational in 2030. This study concludes that a consumer shift towards cultivated meat not only reduces the broader carbon footprint and overall environmental impact but also will achieve significant cost-parity with conventional meat. It is expected that cultivated/plant-based hybrids could be the first products to hit the shelves, followed by 'processed cultivated meat' products such as nuggets, keema, etc., with price parity. Whole tissue meats will require significant technical optimization and capacity building before achieving parity on taste, texture, and pricing. Below is a global snapshot of the past, present, and near future of this growing sector. India is expected to follow suit once these global milestones are achieved.



2. Expanding the deep-tech startup ecosystem

An increase in the number of startups within this domain is anticipated only when key infrastructural bottlenecks are addressed within the deep-tech startup ecosystem through government-sponsored initiatives, with cultivated meat research inclusivity, such as:

- The Department of Biotechnology's University Research Joint Industries Translational **(URJIT)** mission to facilitate academia-industry linkages
- The Department of Science & Technology's Sophisticated Analytical & Technical Help Institute **(SATHI)** infrastructure program for setting up of shared, professionally managed science and technology infrastructure facility which will be made accessible to academia, startups, manufacturing units, industries, and R&D labs.

3. Synergies in bio services and cold chain

There is a potential opportunity for startups to partner with manufacturers designing and supplying bioreactors and fermentation tanks for the pharmaceutical industry, which has an established regulatory and quality compliance system in place. There is huge scope in building unique solutions in the cold chain, such as in cell transport and storage, mobile manufacturing, etc.

4. Alternate business models

With more than 70 startups already advancing in product development globally, there is merit in considering an alternate approach - accelerating the path to market for international startups instead of duplicating the entire technology development for Indian markets. This creates a massive opportunity for startups and input providers to partner with global companies in what will be a multi-billion dollar industry. To address the demand for cultivated meat in India, startups might consider decentralized manufacturing models for local markets.

WHAT SUPPORT THEY NEED

1. Policy interventions

Entrepreneurs will be looking towards the Food Safety and Standard Authority of India **(FSSAI)** and other stakeholders' for India's first regulatory policy draft on cultivated meat. Regulatory go-to-market strategy will be crucial when startups scale-up products to enter the market after 2022.

2. Scale-up support

Startups can make new product development in-house and partner with life sciences companies to produce recombinant proteins and ingredients at scale since it requires significant resources to manufacture. Partnerships with ingredient manufacturers to manufacture inputs will

> The bio-services segment constitutes nearly 14% of the biotech sector in India, with thousands of manufacturers doing contract manufacturing for the global pharma industry. There is a huge opportunity to leverage this existing expertise to accelerate technology transfer for manufacturing in the smart protein sector.
>
> **Nicole Rocque**
> *Innovation Specialist*
> *GFI India*
> *(formerly biotech sector team at Invest India)*

3. Catalytic and patient capital

For startups to take their products to commercialization, they will be dependent primarily on grant money and patient capital during the early stages. Their funding requirements can be broadly classified into:

- **R&D stage** - Ignition grants and institutional support.
- **PoC stage**[24] - Angel funding and seed-stage investment to demonstrate product or process feasibility.
- **MVP stage**[25] - Mid- to late-stage venture capital funding will be required as infrastructure requirements will significantly increase. Startups at this stage will need large grants and equity funding in the following 2-5 years.

[24] PoC - Proof of Concept
[25] MVP - Minimum Viable Product

2.3 Input Providers

As the cultivated meat industry continues to grow, we see the emergence of a number of 'tools' or 'picks and shovels' companies providing great technology in cell culture media, scaffolds, cultivator or fermenter design, and even the cell lines itself.

India, with its excellent track record in biopharmaceutical manufacturing and food processing, can do a great deal to drive down the cost of smart proteins. For example, input providers like Laurus Bio (formerly Richcore Lifesciences) and MyoWorks are producing cost-effective recombinant proteins, fats, and edible scaffolds respectively for the cultivated meat industry globally cost effectively.

WHAT NEEDS TO BE SOLVED

1. Preparing for future demand

To cater to the food industry, the biggest challenge for input providers will be to develop huge manufacturing capacities to address future demand. They are already preparing to increase manufacturing capacity for recombinant proteins. While the companies are anticipating volume-based cost reduction, there are challenges such as yield optimization, which will require innovation. For example, scaling-up and giving consumers an experience identical to animal-derived proteins together will require extremely consistent and food-grade inputs and fail-proof manufacturing systems in place.

2. Species-specific inputs

Satisfying diverse food preferences through cultivated meat production from various animal species will require specific inputs such as optimized cell lines, scaffolds, cell culture media components, and bioprocessing protocols. For instance, cultivating mammalian cells to produce meats like pork may require different bioprocesses than do avian meats like chicken and duck, or aquatic meats like shrimp and tuna.

Startups may choose to optimize these inputs in-house or work with strategic partners to create proprietary inputs for their own products. These partners could be contract R&D and manufacturing organizations, research institutes, etc.consumers an experience identical to animal-derived meat/ proteins together will require extremely consistent and food-grade inputs and fail-proof manufacturing systems in place

WHAT LIES IN THE FUTURE

1. Relatively easier quality standards for the food industry compared to pharma

Having followed stringent manufacturing compliances for the pharmaceutical industry, life sciences companies will find it easier to meet verification standards for the cultivated meat industry.

2. Manufacturing hub for global markets

Indian input companies are getting ready to host enough capacity to supply growth factors, recombinant proteins and even scaffolds to international startups. They hold great competitive and cost advantage due to readily available talent and excellent incubator infrastructure resulting in lower operational costs.

3. Scaffolding

We will witness the development of edible scaffolds which are free from animal-derived components. Researchers are now working on creating compatible scaffolds for muscle tissue growth by employing non-mammalian biomaterials such as chitin from fungi, alginate from seaweed, decellularized plant leaves, and recombinant proteins like gelatin and collagen produced in microorganisms.

WHAT SUPPORT THEY NEED

1. Demand projections

To create additional capacity to address future demand, input providers will depend on better demand forecasting from startups

> It is very much possible to reduce cell culture media costs from hundreds of dollars per liter to $1 or less per liter if the purification standards are altered to food-grade from those in pharma, and if the production is done at enzyme scale.
>
> **Elliot Swartz (Ph.D.)**
> *Senior Scientist*
> *GFI USA*

and future regulatory status from global regulatory agencies.

2. Innovation support from research institutes

As input providers shift towards creating specialized components and solutions across the value chain, they will need to collaborate with the existing network of research institutes to accelerate the process.

3. Strategic partnerships within the global value chain

India, with its robust biopharmaceutical industry and talent pool offers specific value to the international alternative protein sector. Opportunities abound for collaboration and strategic partnerships between existing life science and input providers, and global producers of cultivated meat to enable manufacturing at scale. As an example, Laurus Bio a biomanufacturing organization develops food-grade growth factors and recombinant proteins to cater to the cell-culture requirements for cultivated meat companies globally, focusing on meeting both the cost and industrial-scale manufacturing requirements of the industry.

> The critical challenge for global cultured meat startups is to formulate a cost-effective culture media. Biotech companies can enable these startups by innovating and optimising their manufacturing processes and by building scale to achieve a many-fold reduction in the cost of these media ingredients.

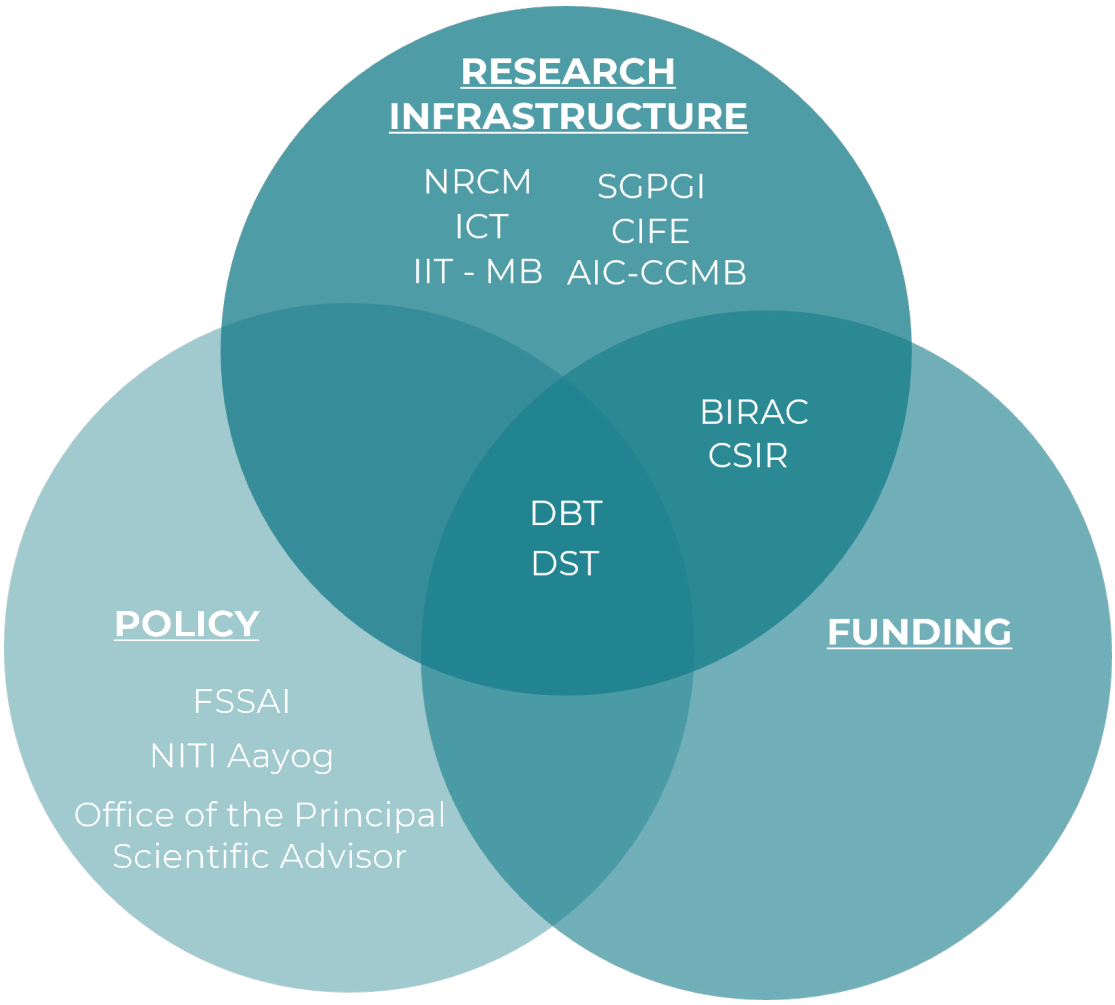
Rajesh Krishnamurthy
Chief Business Officer
Laurus Bio

> There will be a ‘second wave’ of startups across the world which will directly procure ready-made scaffolds off the shelf, instead of building them in-house. This will be a turning point for input providers.

Shubhankar Takle
Co-founder
MyoWorks

2.4 Policy-makers, Support Institutions

The ecosystem support for cultivated meat in India hinges around 3 pillars - **Funding, Research Infrastructure, and Policy**. Stakeholders co-create research infrastructure and funding opportunities for researchers and startups along with advocacy for policy. A recent push from government institutes to increase funding for innovation and infrastructure is attracting investor interest from India and abroad. The Venn diagram (not comprehensive) below highlights some major support institutions with significant interdependencies currently building a robust ecosystem in the sector.



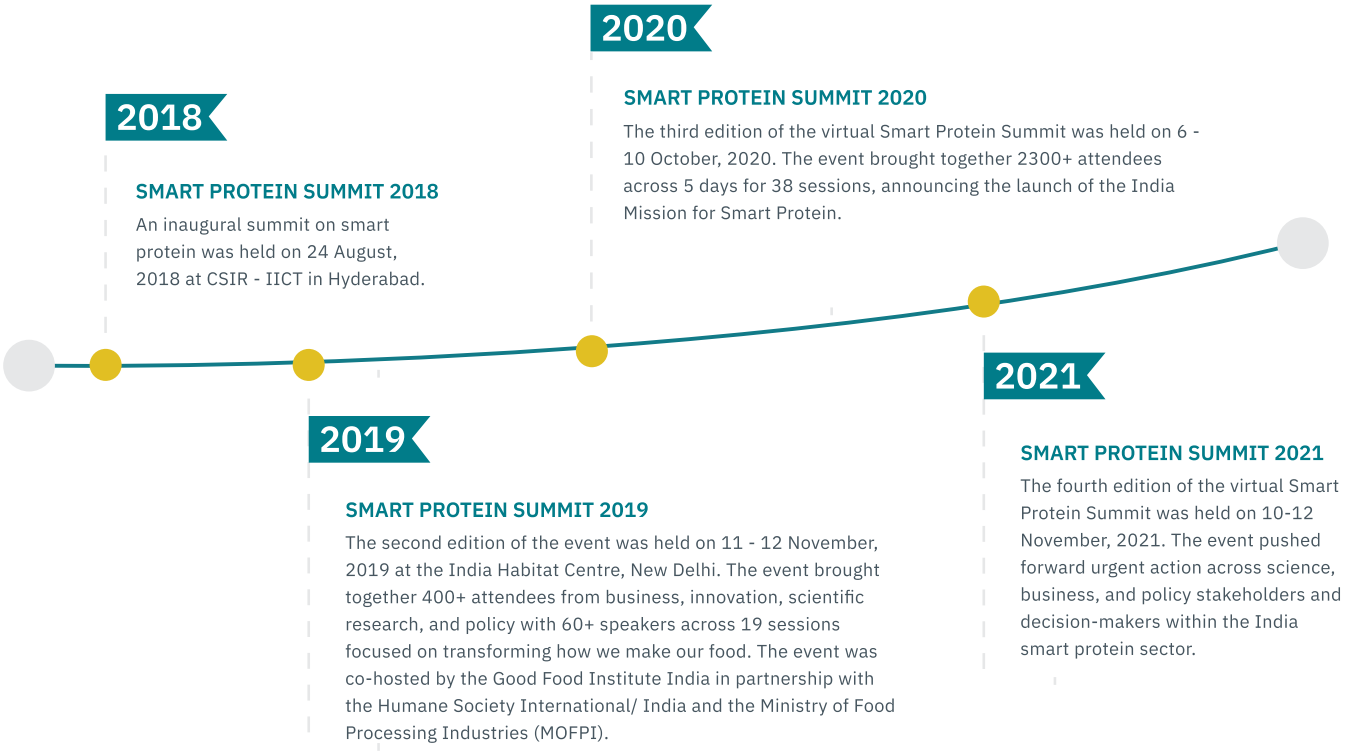


Fig: Major Summits and Conferences in India

WHAT NEEDS TO BE SOLVED

1. GMO (Genetically Modified Organisms) or non-GMO

Cultivated meat does not require the use of Genetically Modified Organisms, and leading global startups like Mosa Meats, Blue Nalu, Aleph Farms, and Shiok Meats have made public statements that they do not utilize GMO. Since GMO foods are banned in India, non-GMO methods of product development will be the preferred manufacturing routes for startups.

2. More institutional support for early-stage research

Researchers, students, and entrepreneurs need more institutional support in the form of new and customized courses on cultivated meat, access to high-risk capital and dedicated infrastructure facilities to kickstart their careers in the sector. Such reforms will attract more entrepreneurs and scientists to the sector.

3. Industry-Academia Linkages

DST and DBT were the two major players contributing 63% and 14%, respectively, of the total extramural R&D support in the country during 2016-17. To promote research in cultivated meat opportunities, industry

participation in the form of collaborative or commissioned research with academia will be essential. For greater participation by academia and the success thereof, the incentive structures for commercialization need to be put into place.

WHAT LIES IN THE FUTURE

1. India's first policy draft on cultivated meat

GFI India has offered input to the Food Safety & Standards Authority of India (FSSAI) on cultivated meat since 2018, following which a Working Group was formed to keep track of advancements in regulation in other regulatory jurisdictions. As momentum continues to build with developments such as Singapore's approval of cultivated meat for sale, a regulatory path to market in India may evolve in the next 2 years.

2. Active involvement of incubators and accelerators

To handhold early-stage startups, institutions that provide funding and non-funding support could play a substantial role in promoting success in the sector. Since the sector involves multiple value chain players, sensitisation at each point is critical. Organizations like CIIE.CO and other government-funded academic incubators could provide thought leadership, mentorship about viable business models, and design acceleration and open innovation programs with corporate partners.

WHAT SUPPORT THEY NEED

1. Policy inputs

Greater involvement and engagement from all stakeholders, across industry and academia, is needed to provide critical inputs to policy-makers. In addition, endorsement from policy leadership can play a major role in building consumer trust, and accelerating the government's dedicated support towards the sector. As an example, Israel's President Isaaz Herzog, and then-Prime Minister Benjamin Netanyahu became the

The Good Food Institute has awarded over US $13 million since 2019 towards open-access research addressing key research challenges in the smart protein industry. However, it is noteworthy too that virtually none of this — public or private funding — has gone into solutions specific to emerging markets. You can read more about GFI Research Funding Opportunities here.

world's first Heads of State & Government respectively in partnership with the Good Food Institute Israel, ahead of announcing a national plan to support alternative protein as a key piece of the country's lauded technology development and economic growth goals.

2. Funding open-access research in smart protein

Countries like Singapore and Israel are presently leading the way in the development of cultivated meat research and innovation, with both countries receiving government support for innovation and open-access R&D. Bilateral funding mechanisms for smart protein research, similar to early funding initiatives focused on renewable energy research, will work towards incentivizing private sector innovation.

> Nearly all biotech startups are dependent on BIRAC grants for the first 18-24 months of R&D. Grants are essential for researchers to validate whether their technology can be commercialized or not.

Nitish Sathyanarayanan
Co-founder and Science Officer
Impres Health

> We need to have incentives in the education system to create entrepreneurs. In the coming few years, a combination of successful biotech entrepreneurs along with food experts would be needed to set up cultivated meat startups.

Varun Deshpande
Managing Director
GFI Asia

2.5 Investors

With the emergence of the plant-based protein category as a viable alternative, and institutional funding already in place, both Indian and international investors are now eager to understand advancements in product development and policy concerning cultivated meat. As we see a growing number of plant-based meat startups in India, investors are now showing greater confidence in the larger smart protein sector as well, and are now eager to understand advancements in product development and policy concerning cultivated meat also.

Big Idea Ventures and Ashika Group have announced the launch of an accelerator program for smart protein in India with support from GFI India. The accelerator program will provide entrepreneurs access to capital mentorship, and a network of stakeholders across the value chain.

Ahimsa VC launched India's first investment fund focused on smart protein providing pre-seed and seed funding to startups with a focus on the food and materials sectors, with GFI India support. The fund is looking to make investments across plant-based, fermentation-derived and cultivated protein.

Magnetic has announced a platform for world-class food-tech entrepreneurship in collaboration with GFI India. The firm is already advising several companies in the plant-based foods domain, across meat, dairy, and manufacturing.

WHAT NEEDS TO BE SOLVED

1. Involvement of strategic investors

Early involvement of strategic investors from traditional meat companies or fermentation and biopharmaceutical-based companies providing access to capital, infrastructure, and knowledge can give invaluable support to startups to scale their proprietary technology, bioprocessing techniques, and access to a network of supply chain partners. Startups, in turn, can provide stability to the internal value chain for the investment partners.

2. Investor appetite for deep-tech investments

Deep-tech investors in the Indian ecosystem are still conservative on betting their money on cultivated meat startups due to extremely high R&D and infrastructure costs, along with a long gestation period and delayed timeline to market commercialzation. However, instances of startups like Mosa Meats bringing down the cost of their first cultivated patty from €2.5 lakh to €9 suggest that these parameters are likely to improve in the next decade.

WHAT LIES IN THE FUTURE

1. Catalytic capital at POC stage

Startups will seek patient capital and strategic support from angel investors and micro-VCs at the proof of concept stage, to elevate themselves to the next stage to build minimum viable products. The risk of long gestation periods is likely to be balanced by the fact that startups' infrastructure requirements at this stage are already supported by bio-incubators and institutional grants to a large extent.

2. Choosing the right business model

Startups will need to demonstrate scalable technology solutions and

business models in order to attract Series A funding and beyond. Key for them will be to (i) prove the MVP and hit the market quickly, and (ii) significantly cut costs through either in-house development of key inputs, or through partnerships with input providers. It will also be interesting to see whether investors prefer B2B or B2C models - B2B models might not be perceived as scalable while B2C models will account for huge customer acquisition costs.

WHAT SUPPORT THEY NEED

1. Clarity on policy timeline

A clear policy timeline and incentives for entrepreneurs from supporting institutions will enable investors to develop their thesis for this sector early-on.

> There has been an advent of new food technologies coupled with awareness about food security & environment in general. As a result, innovation around food tech has picked up in the last few years.
>
> **Chintan Antani**
> *AVP - Seed Investing*
> *CIIE.CO*

> There is a need for impact funds and VC funds to enter the space. While plant-based meat startups will commercialize faster, cultivated meat startups will take a few more years to see traction.
>
> **Mark Kahn**
> *Managing Partner*
> *Omnivore*

2. Better understanding of scaling up timelines of startups

Better understanding of product development timelines, and market entry and launch strategy from startups will increase investor confidence and contribute to greater funding.

> There is good involvement of support institutions in generating a buzz around the sector, and as a result, the interest from investors has increased a lot recently.
>
> **Siddharth Manvati (Ph.D.)**
> *Co-Founder*
> *Clear Meat*

CONCLUSION

Conclusion

2020 and 2021 was a period of firsts for cultivated meat, with the first regulatory approval for the commercial sale of a cultivated meat product, the world's first Heads of State & Government trying a cultivated meat product, significant growth in global investment momentum, and the first significant funding from a leading government agency towards a cultivated meat research consortium. All this has built tremendous momentum in the global cultivated meat landscape.

Cultivated meat companies have raised through Q3 2021 a total of US $763 million outpacing the rate of growth in 2020 which saw US $415 million invested in a year that had doubled the total amount raised by the industry prior. A lot of the growth we are seeing is being driven by advancements in the underlying technology as more startups come closer to pilot-scale proofs of concept, facilities come online, and governments around the world look to create a path to market for cultivated meat products.

However progress in the sector is not inevitable. Significant challenges remain on cost-reduction and scale-up before we will see widespread commercialization of the sector. The existing infrastructure that is technologically suitable for cultivated meat production has been designed for biopharma, a price-insensitive application at a much smaller scale than what will be needed to produce millions of metric tons of meat. Justifying investment in production facilities is difficult without prior regulatory approvals. Startups, suppliers, and investors all have questions about demand forecasts, timelines, margins, and overall strategy.

Thus far, private sector investment in alternative protein research has driven significant progress toward commercializing innovation in the sector - but current investment levels pale in comparison to the size of the challenges the sector is taking on and the opportunities it

can create. Government funding for open-access research, innovation and technology transfer, and infrastructure development will create opportunities for skill development, major job creation, and exports - all while enabling India to adhere to our promises under the Sustainable Development Goals and to nourish our growing population.

Through this report and the concluding stakeholder mapping below, we have attempted to draw up a roadmap for promoting biomanufacturing and the cultivated meat industry in India and globally.

Stakeholder Mapping

Role and Contribution at Each Stage for the Commercialization of Cultivated Meat.

	SCALE-UP STAGES			
STAKEHOLDERS	**LAB**	**PILOT**	**DEMO**	**MANUFACTURING**
Academicians, Researchers	Exploratory and investigative research, technology review papers	Develop bench-scale POC (Proof Of Concept)	Prove technology scalability with various cell lines	Collaborate with industry to demonstrate scale-up and bioprocess viability
Input providers (cell lines, scaffolds, bioreactors, growth media)	Samples sourced for non-core components	Commercial tie-ups at limited scale	Commercial tie-ups at moderate scale	Commercial tie-ups at large scale
Policy-makers, Support Institutions	Exploratory research grants Mentorship and incubation support Equipment and lab infrastructure	Large grants to establish POC. Seed round funding support Mentorship and incubation support Regulatory approvals and clearances	Scale-up grants for funding. Series A funding rounds Regulatory approvals and clearances	Subsidized debt funding Series B and further Advanced approvals and clearances for large-scale commercialization
Investors	University grants Philanthropic support Friends & Family Angel Investors	Early-stage Venture Capital Impact Investors	Early-stage Venture Capital Impact Investors Corporate VCs	Late-stage Venture Capital Strategic Investors Impact Investors Corporate VCs

ACKNOWLEDGEMENTS

We thank the following entrepreneurs, investors, enablers, stakeholders, and subject matter experts who have shared their insights and data for this study.

Blake Byrne, GFI US

Deepak Raghothaman, Ferrero

Elliot Swartz, GFI US

Himanshu Gadgil, Enzene Biosciences

Mark Kahn, Omnivore

Nitish Sathyanarayanan, NCBS - INSTEM

Rajesh Krishnamurthy, Laurus Bio (formerly Richcore Lifesciences)

Satish Kumar Singh, Ceres Food Labs

Saurabh Gurnurkar, UQUIFA

Shubhankar Takle, MyoWorks

Siddharth Manvati, Clear Meat

Taslimarif Saiyed, C-CAMP

Tom Ben Arye, GFI Israel

Vinod Kumar, String Bio

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