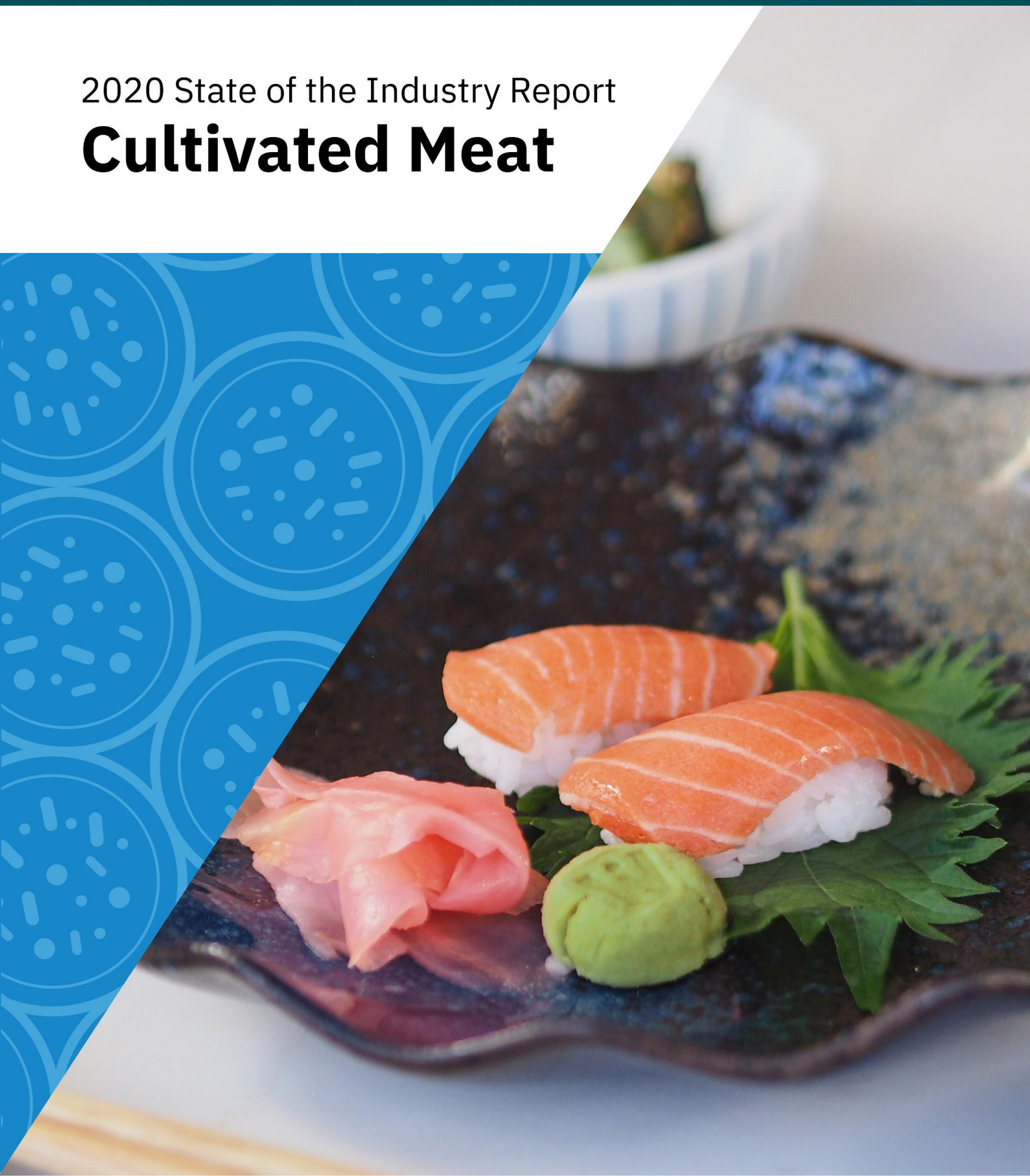
Good Food Institute

2020 State of the Industry Report

Cultivated Meat



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The Good Food Institute is a 501(c)3 nonprofit organization developing the roadmap for a sustainable, secure, and just protein supply. We identify the most effective solutions, mobilize resources and talent, and empower partners across the food system to make alternative proteins accessible, affordable, and delicious.

This report, as well as all of GFI's research, data, and insights, is made possible by gifts and grants from our global family of donors.

Executive summary

Image credit: New Age Meats

Executive summary

2020 was a year of firsts for the cultivated meat industry—capped off with a head of government consuming cultivated meat in Israel and the first commercial sale of cultivated meat in Singapore. The regulatory approval of a cultivated chicken product in Singapore is a good sign for regulatory green lights in other countries.

The industry's commercial landscape now comprises more than 70 startups focused on developing cultivated meat inputs, services, or end products. Another 40+ primarily life science companies have publicly announced a formal initiative or business line to supply cultivated meat startups with critical inputs and meet manufacturing and infrastructure needs. Companies at the leading edge of the industry are now manufacturing cultivated meat at pilot scale, a crucial early step to assess the viability of industrial-scale production.

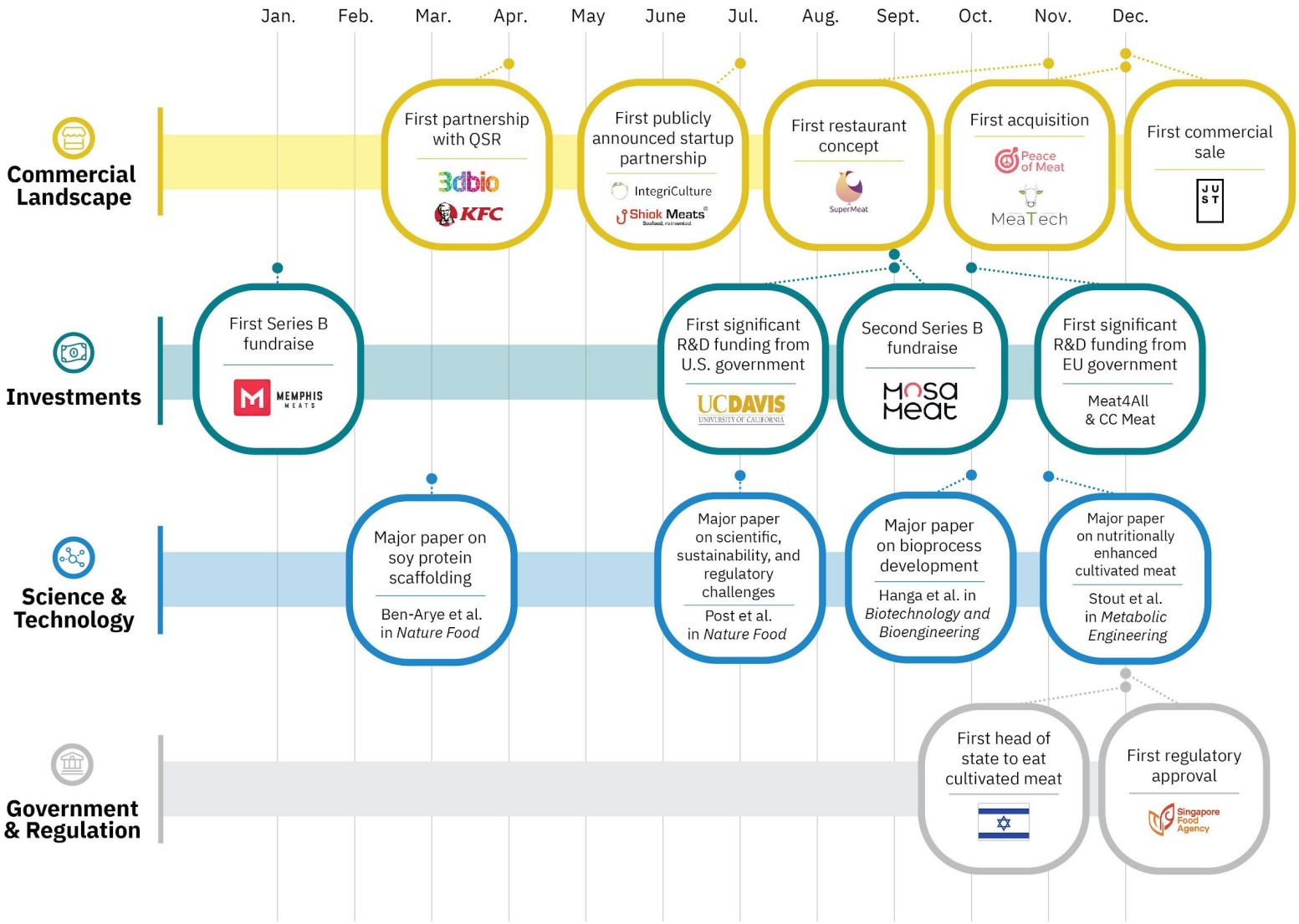
Investment in the nascent field topped $350 million in 2020, nearly double the previous cumulative investment in the industry. 2020 saw the industry's first Series B funding rounds as well as the first substantial public-sector R&D funding in both the United States and the European Union. Within the alternative protein sector (which includes plant-based and fermentation segments), cultivated meat accounted for 14 percent of overall annual private-sector investments.

Cultivated meat is increasingly recognized as a valuable research topic by the international scientific community. The public sector is beginning to fund cultivated meat research centers, and important research findings are being published in prestigious scientific journals. These efforts to develop an academic ecosystem of cultivated meat research are also inspiring a veritable wave of students to pursue research that will speed up commercialization.

While the literature suggests that fundamental technological breakthroughs are not necessary to eventually achieve economically viable, scaled production of cultivated meat, significant chemical, biological, and mechanical engineering challenges remain in order to reduce costs and increase yields.

Developments throughout 2020 suggest that while the industry is in the early stages, it may be on a trajectory that will lead to price competitiveness with conventionally produced meat. Only then will cultivated meat fulfill its long-term promise of providing real, craveable meat without the external costs of conventional meat.

Figure 1: 2020 cultivated meat year at a glance



Introduction

Image credit: Avant Meats

Section 1: Introduction

The Good Food Institute exists to advance the technology and markets for alternative proteins. While plant-based and fermentation-derived alternatives are fundamentally and rapidly shifting how consumers think about meat, whether there is a ceiling on consumer adoption of these analogue products remains to be seen. In light of this, the promise of cultivated meat—genuine animal meat produced by culturing animal cells directly without the external costs that come with raising live animals—captivates industry, academia, and consumers alike.

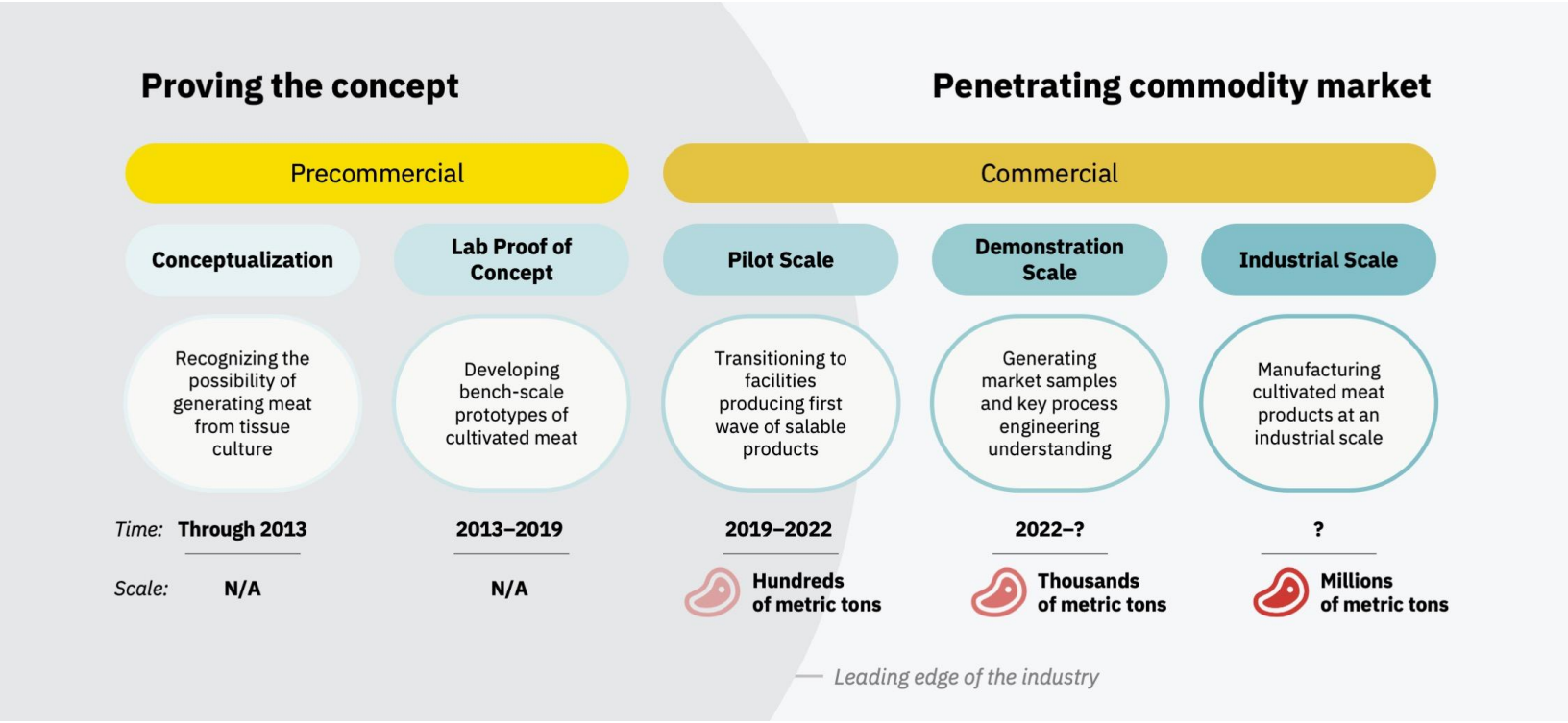
Meat, traditionally sourced from slaughtered animals, has for thousands of years been a staple in societies around the world. 2020 marked a **milestone** in its history as cultivated meat made its debut on a restaurant menu. While **Eat Just's** regulatory approval and sale of cultivated chicken in Singapore is a significant event in this potentially transformative industry, it is but one of many developments in 2020 for cultivated meat.

GFI is pleased to offer its third annual state of the industry report as a snapshot of the global cultivated meat industry in 2020.

"In 2013, Prof. Mark Post served up a cultivated meat hamburger in front of a studio audience in London, the event paid for by Google founder Sergey Brin. Two years later, a small handful of scientific entrepreneurs, including Post and Minnesota cardiologist Uma Valeti, formed cultivated meat companies. These moves were driven by the promise of cultivated meat—real meat with a fraction of the adverse climate impact and with no contribution to antibiotic resistance or pandemic risk—but no one knew whether the world was ready. Now we know."

—Bruce Friedrich, executive director at The Good Food Institute

Figure 2: Leading edge of cultivated meat production



The project of cultivated meat is designed, at its core, to develop a drop-in replacement for commodity meat at industrial scale. The industry's leading edge currently operates at pilot scale; numerous startups are working toward growing more and more cells in increasingly large bioreactors. Figure 2 is GFI's best encapsulation of the industry's leading edge with respect to scaled production of cultivated meat.

Commercial landscape

Image credit: Memphis Meats

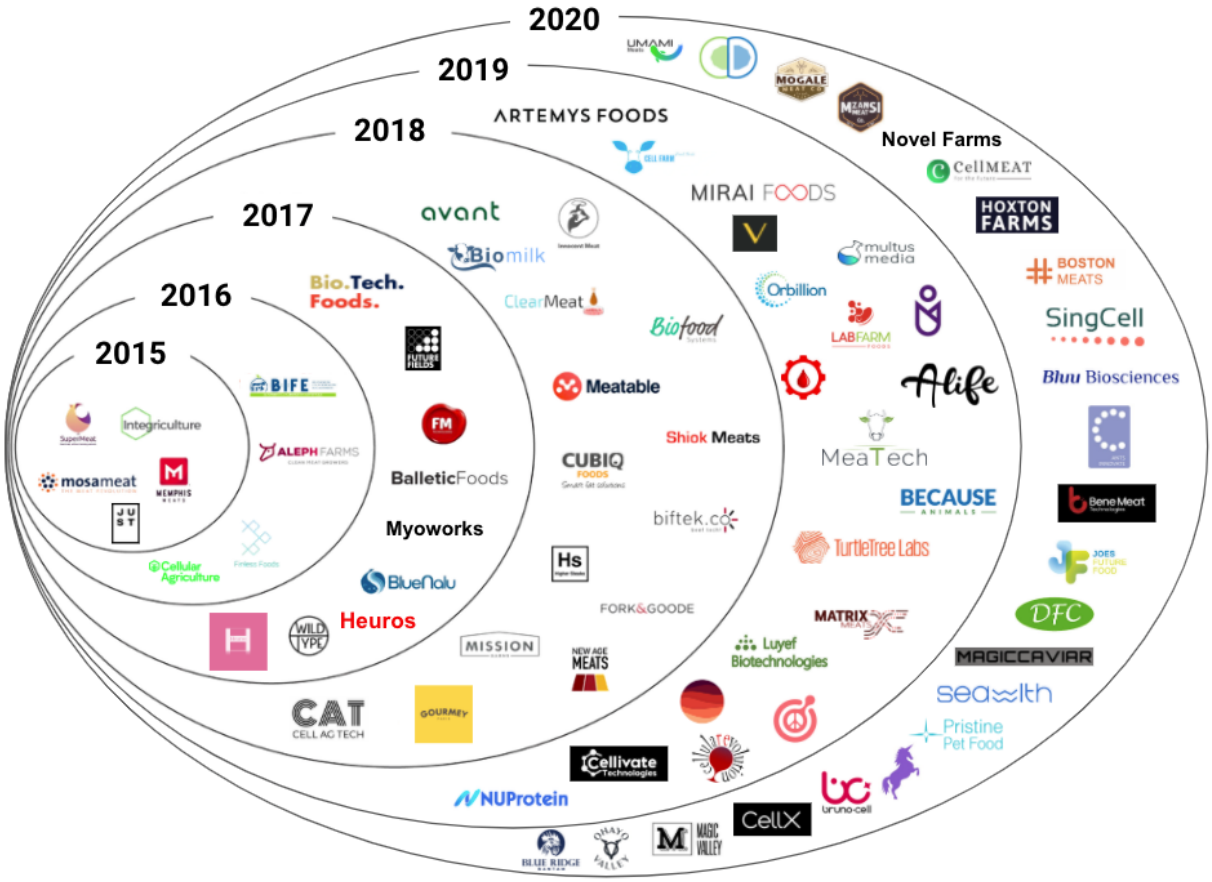
Section 2: Commercial landscape

Overview

Entrepreneurial investment in cultivated meat continued at a swift pace in 2020:

- At least **20** new cultivated meat ventures emerged.
- The number of startups focused exclusively on developing cultivated meat inputs or end products rose to more than **70**.
- The number of companies, largely in the life sciences, that have publicly announced a business line in cultivated meat increased to **40**.

Figure 3: Commercial landscape expansion



Source: GFI company database, Crunchbase, manufacturer websites.
Note: Companies within the 2015 circle were founded before year-end 2015.

A note on Covid-19

"Among other things, the tragedies and difficulties of 2020 shed light on the importance of worldwide food security and sustainability. This has galvanized our industry and brought us a greater sense of urgency than ever before. Despite these challenges, there were many exciting developments in 2020. Perhaps one of the more notable events was Singapore approving the sale of a cultivated meat product."

—Pallevi Srivastva, head of cell culture media and process development at Wildtype

It is impossible to tell the full story of cultivated meat in 2020 without accounting for the effects of Covid-19:

- The pandemic, particularly in its early days, affected the ability of scientists to conduct bench research by limiting both lab time and sourcing of important reagents.
- Timelines for scientific milestones were extended.
- Some **companies temporarily pivoted** to manufacturing goods—like hand sanitizer—that were in short supply.

Despite these constraints, companies continued to meaningfully advance both R&D and commercialization efforts.

Early in 2020, industry insiders expressed concern that the pandemic would tighten funding opportunities for cultivated meat startups. However, the industry's impressive 2020 funding totals signal growth and opportunity. As the full story of Covid-19's impact on the nascent industry continues to unfold, the world is recognizing that modernizing meat production with alternative proteins is an important step toward **avoiding future pandemics**.

Receipt from the first consumer sale of cultivated meat. Singapore restaurant 1880 added Eat Just's *GOOD* cultivated chicken bites to the menu in December 2020. | Image credit: Eat Just

Major developments

First commercial launch

The cultivated meat industry cleared a critical milestone in December 2020 when Eat Just received regulatory approval to **sell its cultivated chicken product** in Singapore. Eat Just made the first commercial sale to **1880**, its restaurant partner in the country. 1880 sold Eat Just's cultivated chicken bites to consumers for the very first time via a series of invitation-only dinners in December before adding the product to the menu for all diners in early 2021.

Tasting events

The pace of tastings and sampling events accelerated in 2020, and companies are offering more substantial quantities of cultivated meat to tasters than ever before:

- **GFI Israel** and **Aleph Farms** **hosted Israeli prime minister Benjamin Netanyahu** for a tasting of Aleph Farms' cultivated steak. Also, while not a tasting event, Aleph Farms' recent **launch of a visitor center** is a substantial step forward in transparency and trust-building with consumers.
- **The Chicken**, from **SuperMeat**, is a **hybrid restaurant concept and pilot plant**. Essentially a test kitchen, The Chicken is an innovative concept that brings the consumer closer to both the manufacture and the organoleptic experience of cultivated meat.
- **Lab Farm Foods**, based in Manhattan, unveiled its **chicken nuggets and pork pâté** in a demonstration in October.

- **Avant Meats**, Hong Kong's sole cultivated meat company, unveiled its **fish fillet** in a cooking demonstration with a renowned local chef.
- Additional seafood tastings included new **sushi-grade salmon** from **Wildtype** and the **first-ever tasting of cultivated lobster** from **Shiok Meats**.
- **Higher Steaks** and **Mission Barns** hosted tasting events for their **cultivated bacon** and **pork belly**.

SuperMeat's **The Chicken**, a hybrid restaurant concept and pilot plant. | Image credit: SuperMeat.

New entrants

A variety of new organizations staked their claim in the industry in 2020, including these notables:

- **Thermo Fisher** and **3M**, among many others, publicly announced a focus on cultivated meat. The participation of large food and life science companies will be critical to creating the necessary conditions for economically viable, scaled production of cultivated meat.
- **Diverse Farm**, based in Japan, became the first cultivated meat manufacturer to emerge from a joint venture between a restaurant and regenerative medicine institute.
- Geographically, the web of cultivated meat startup activity extended into Africa, with the launch of **Mzansi Meat Co.** and **Mogale Meat Co.**

For the full list of known entrants, see **Figure 4**, **Table 1**, and **Table 2**.

Box 1: Pilot-scale facilities represent the first major scale-up progress

The scaleup of a bioprocess, whether for production of biofuels, therapeutic antibodies, or cultivated meat, generally occurs in four phases: **lab scale**, **pilot scale**, **demonstration scale**, and **commercial (industrial) scale**. Pilot scale, in particular, is an essential proof of concept that enables companies and investors to assess raw-material and production costs as well as bioproduct yield.

Pilot-scale cultivated meat facilities will produce hundreds or thousands of kilograms of biomass annually. This means that companies are likely to have capacity to supply a limited number of high-end restaurants in the coming one to three years.

Several leading cultivated meat companies are now transitioning to pilot-scale facilities. **BlueNalu**, for instance, **recently announced** the lease of a good manufacturing practice (GMP) pilot-scale food production facility that will be used for commercial production of the company's seafood. And in November 2020, Israel's **SuperMeat** parlayed its pilot plant into a new restaurant concept called **The Chicken**. Diners can now sign up to be served cultivated chicken produced in an adjacent pilot plant visible through a nearby glass window. **Mosa Meat** announced that **it would also open a pilot plant, in Maastricht, in addition to achieving significant reductions in the cost** of its growth medium.

This industry milestone represents a significant step toward achieving commercial-scale production of cultivated meat. We expect a small wave of cultivated meat companies to announce construction and operation of pilot facilities in the coming few years.

Table 1 is the complete list, as of December 2020, of publicly disclosed startups focused exclusively on developing cultivated meat inputs or end products. The list includes companies employing animal cell culture to create alternatives to other animal products, such as dairy, eggs, and gelatin.

Table 1: Cultivated meat ventures

Company	Location	Focus	Total disclosed funding ($M)	Founder(s)	Year founded
Aleph Farms	Ashdod, Israel	Full stack	$14.45	Strauss Group and Technion	2016
Alife Foods	Leipzig, Germany	Full stack	–	Steffen Sonnenberg, Dat Tran, Joe Natoli, Bernd Boeck	2019
Ants Innovate	Singapore	Full stack	–	Hanry Yu, Shujian Ong	2020
Artemys Foods	San Francisco, USA	Full stack	Undisclosed	Jessica Krieger, Joshua March	2019
ArtMeat	Kazan, Russia	Full stack	–	Askar Latyshev, Albert Rizvanov, Elena Zakirova	2019
Avant Meats	Hong Kong, SAR, China	Full stack	$3.10	Carrie Chan, Mario Chin	2018
B.I.F.E	Buenos Aires, Argentina	Full stack	Not profiled	Juan Craveri, Laura Correa	2016
Balletic Foods	San Francisco, USA	Full stack	Undisclosed	Anita Bröllochs	2017
Because Animals	Philadelphia, USA	Full stack	$2.50	Shannon Falconer, Joshua Errett	2019
Bene Meat	Prague, Czech Republic	Full stack	–	Roman Kříž	2020
Biftek	Gölbaşı, Turkey	Cell culture media	Undisclosed	Can Akcali, Erdem Erikci	2018
BioTech Foods	San Sebastián, Spain	Full stack	$2.74	Mercedes Vila Juárez	2017
BioBQ	Austin, USA	Full stack	Undisclosed	Katie Kam, Janet Zoldan	2018
BioMilk *DAIRY*	Rehovot, Israel	Full stack	Undisclosed	Nurit Argov-Argaman, Maggie Levy	2018
BIOMILQ *DAIRY*	Durham, USA	Full stack	$3.50	Michelle Egger, Leila Strickland	2019
BlueNalu	San Diego, USA	Full stack	$29.55	Lou Cooperhouse, Chris Somogyi, Chris Dammann	2017
Blue Ridge Bantam	Durham, USA	Full stack	Not profiled	Carson Bone, Khanh Nguyen	2020
Bluu Biosciences	Berlin, Germany	Full stack	Undisclosed	Sebastian Rakers, Ines Schiller	2020
Boston Meats	Boston, USA	Scaffolding	$1.50	Christophe Chantre	2020
Bruno Cell	Trento, Italy	Full stack	Undisclosed	Stefano Lattanzi	2020
Cell Ag Tech	Toronto, Canada	Full stack	–	Josh Pollack, Valentin Fulga	2018
Cell Farm Food Tech	Buenos Aires, Argentina	Cell lines	$0.20	Sofia Giampaoli, Carolina Bluguermann	2019
Cellivate Technologies	Singapore	Cell culture media	–	Viknish Krishnan-Kutty, Thirumalai Venkatesan	2019
CellMEAT	Gwangju, South Korea	Full stack	$0.85	Giljun Park	2019
Cellular Agriculture	Carmarthenshire, UK	Bioprocess design	–	Illtud Dunsford, Marianne Ellis	2016
CellulaREvolution	Newcastle, UK	Bioprocess design	$0.23	Leo Groenewegen, Martina Niotto, Che Cannon	2019

CellX	Shanghai, China	Full stack	$4.8	Ziliang Yang, Ran Liu, Binlu Huang	2020
ClearMeat	Delhi, India	Full stack	Undisclosed	Pawan K. Dhar, Siddharth Manvati	2018
Cubiq Foods	Barcelona, Spain	Full stack	$10.88	Andrés Montefeltro, Raquel Revilla	2018
Cultured Blood	Eindhoven, Netherlands	Cell culture media	–	Robert ten Hoor	2019
Cultured Decadence	Madison, USA	Full stack	$1.50	John Pattison, Ian Johnson	2020
Diverse Farm	Osaka, Japan	Full stack	–	Jiro Ohno, Masaharu Shimamura	2020
Finless Foods	San Francisco, USA	Full stack	$3.78	Mike Selden, Brian Wyrwas	2016
Fork & Goode	New York, USA	Full stack	$3.54	Niya Gupta, Andras Forgacs, Gabor Forgacs	2018
Future Fields	Edmonton, Canada	Cell culture media	$0.53	Matthew Anderson-Baron, Lejjy Gafour, Jalene Anderson-Baron	2017
Future Meat Technologies	Jerusalem, Israel	Full stack	$16.2	Yaakov Nahmias	2017
Gaia Foods	Singapore	Full stack	$0.13	Vinayaka Srinivas, Hung Nguyen	2019
Gourmey	Paris, France	Full stack	$0.20	Nicolas Morin-Forest, Antoine Davydoff, Victor Sayous	2019
Heuros	Brisbane, Australia	Cell culture media	$0.02	Nick Beaumont	2017
HigherSteaks	London, UK	Full stack	$2.62	Benjamina Bollag, Stephanie Wallis	2018
Hoxton Farms	London, UK	Full stack	–	Max Jamilly, Ed Steele	2020
Innocent Meat	Rostock, Germany	Full stack	$0.23	Patrick Nonnenmacher, Laura Gertenbach, Philipp Wolters	2018
IntegriCulture	Tokyo, Japan	Full stack	$10.20	Yuki Hanyu	2015
Jellatech *Gelatin*	Raleigh, USA	Full stack	Undisclosed	Kylie Hesp, Stephanie Michelson	2020
Joe's Future Food	Nanjing, China	Full stack	–	Zhou Guanghong, Ding Shijie	2020
Eat Just	San Francisco, USA	Full stack	$372.53*	Josh Tetrick, Josh Balk	2011
Lab Farm Foods	New York, USA	Full stack	$0.06	Dave Schnettler, Tiziano Barberi	2019
Luyef Biotechnologies	Santiago, Chile	Cell culture media	–	Kris Blanchard Tapia, Maria Soledad Gutiérrez, Randall Cossio, Andrea Villanueva	2019
MagicCaviar *Eggs*	Amsterdam, Netherlands	Full stack	–	Henri Kunz	2020
Magic Valley	Melbourne, Australia	Full stack	–	Paul Bevan	2020
Matrix Meats	Columbus, Ohio	Scaffolding	$3.00	Eric Jenkusky, Jed Johnson, Ross Kayuha, Flavio Lobato	2019
Meatable	Leiden, Netherlands	Full stack	$17.05	Krijn de Nood, Daan Luining	2018
MeaTech	Ness Ziona, Israel	Full stack	$13.99	Sharon Fima, Omri Schanin	2019
Memphis Meats	San Leandro, USA	Full stack	$208.31	Uma Valeti, Nicholas Genovese, Will Clem	2015

Mirai Foods AG	Zürich, Switzerland	Full stack	–	Christoph Mayr, Suman Kumar Das	2019
Mission Barns	San Francisco, USA	Full stack	$4.30	Eitan Fischer, David Bowman	2018
Mogale Meat Co	Pretoria, South Africa	Full stack	Undisclosed	Paul Bartels, Elize Venter	2020
Mosa Meat	Maastricht, Netherlands	Full stack	$92.3	Peter Verstrate, Mark Post	2015
Multus Media	London, UK	Cell culture media	Undisclosed	Kevin Pan	2019
Myoworks	Nashik, India	Scaffolding	Not profiled	Shubhankar Takle, Nihalsingh Sachdeva	2017
Mzansi Meat Co	Johannesburg, South Africa	Full stack	–	Jay Van Der Walt, Brett Thompson	2020
New Age Meats	San Francisco, USA	Full stack	$0.5	Brian Spears, Andra Necula	2018
Novel Farms	Berkeley, USA	Scaffolding	$0.13	Nieves Martinez Marshall	2020
Ohayo Valley	Kent, USA	Full stack	Not profiled	Jess Krieger	2020
Orbillion Bio	Berkeley, USA	Full stack	$0.94	Patricia Bubner and two undisclosed co-founders	2019
Peace of Meat	Flanders, Belgium	Full stack	$1.13	Dirk von Heinrichshorst, David Brandes, Eva Sommer	2019
Pristine Pet Food	Los Angeles, USA	Full stack	–	Diana Marmorstein	2020
Sea With	Daegu, South Korea	Full stack	Not profiled	Joonho Keum	2020
Shiok Meats	Singapore	Full stack	$20.30	Sandhya Sriram, Ka Yi Ling	2018
SingCell	Singapore	Bioprocess design	Undisclosed	Karolis Rosickas, Steve Oh, Colby Colasanto	2020
SuperMeat	Tel Aviv, Israel	Full stack	$6.23	Ido Savir, Koby Barak, Shir Friedman	2015
TurtleTree Labs *DAIRY*	Singapore	Full stack	$9.47	Fengru Lin, Mkulima Britt, Max Rye	2019
Umami Meats	Singapore	Cell lines, Cell culture media	–	Mihir Pershad	2020
Unicorn Biotechnologies	London, UK	Bioprocess design	–	Jack Reid, Adam Glen	2020
Vow	Sydney, Australia	Full stack	Undisclosed	George Peppou, Tim Noakesmith	2019
Wildtype	San Francisco, USA	Full stack	$16.00	Justin Kolbeck and Aryé Elfenbein	2017

 More information on these cultivated meat companies is available in GFI's **company database**.

Notes: The investment data in this section, sourced from GFI's PitchBook analysis—the methodology that we profile in the **investments** section—reflects industry developments through December 31, 2020. "Total disclosed funding ($M)" refers to invested capital. A dash under this column heading indicates that the company in the corresponding row is not associated with any disclosed funding rounds in PitchBook. "Undisclosed" means the company has raised an investment round, but the amount is undisclosed in PitchBook and thus not included in the funding totals. Finally, "Not profiled" means the company itself is not yet covered by PitchBook, and thus the company's financing activity is unknown.

*The capital raised by Eat Just is the company's total funding to date for both the plant-based and the cultivated business lines. Accordingly, GFI does not incorporate Eat Just's fundraising into the total industry investment calculation in the forthcoming investments section.

"Up until recently, nearly all cultivated meat startups have been based in the U.S. and Europe. But now other regions have picked up steam—especially Asia Pacific, as of 2020 home to at least 20 startups working on cultivated meat, seafood, milk, or supporting technologies like growth media and scaffolding. Many of them raised significant funding—total investment in the region exceeded $50 million and continues to grow fast."

—Michal Klar, APAC-based alternative protein investor; founder and editor of *Future Food Now*

Partnerships

Practitioners in any deep-tech industry understand the impossibility of "going it alone," and cultivated meat is no exception. Partnership will continue to be a cornerstone of scaling the production and distribution of cultivated products. In this regard, 2020 was an encouraging year. Below is a cross-section of 2020's publicly announced partnerships.

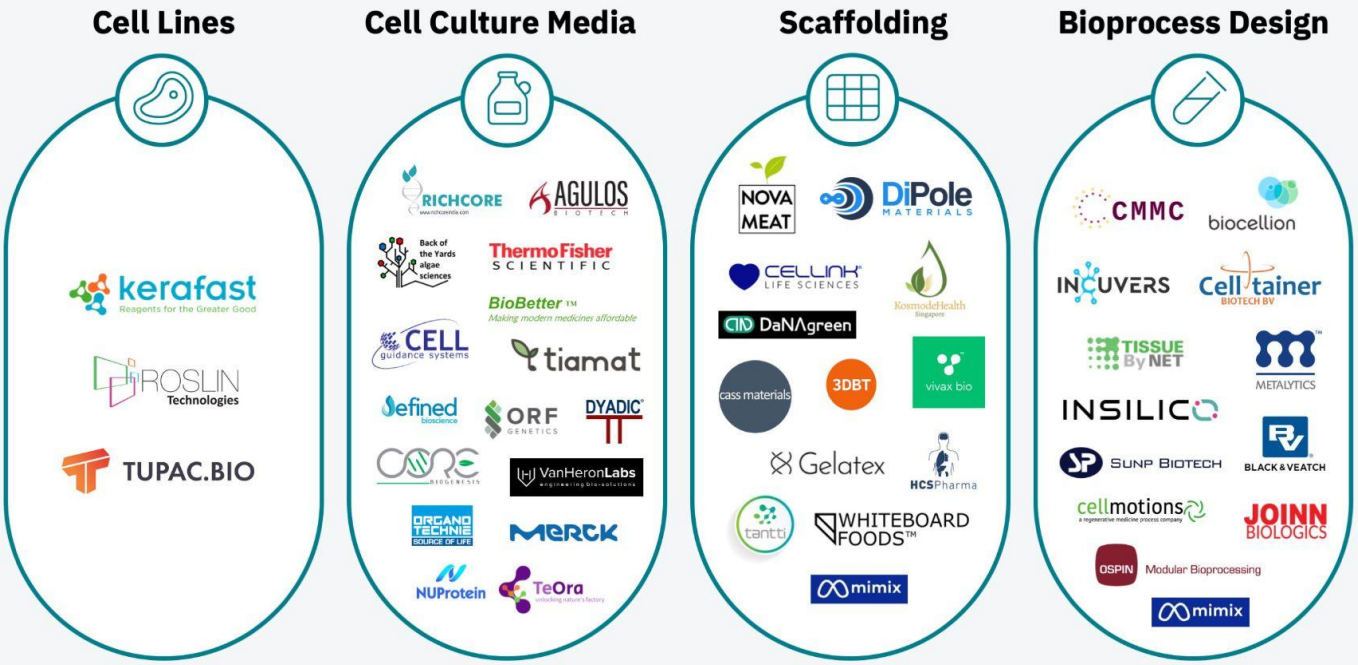
- In a potential harbinger of consolidation in the cultivated meat industry, the startup **MeaTech acquired Peace of Meat**, a cultivated fat developer.
- **Integriculture and Shiok Meats announced a collaboration** to scale up production of Shiok's cultivated shrimp meat. Integriculture is adapting its food-grade culture medium, as well as its scalable cell culture protocols (CulNet System), for shrimp cell culture. The partnership is among the first publicly announced collaborations between cultivated meat startups.
- The **Cultivated Meat Modeling Consortium**, whose partners include nonprofits, large corporations, startups, and investors, **revealed new bioreactor modeling technology** for the industry's use.
- **GFI announced a partnership with reagents company Kerafast** to facilitate access to high-quality cultivated meat cell lines.

  Deposit a cell line, or **sign up to receive updates** on new cell lines.
- Animal feed provider **Nutreco announced partnerships with both Mosa Meat and BlueNalu**.

- **BlueNalu also signed a memorandum of understanding with Pulmuone**, a leader in healthy and environmentally friendly food products, to bring cultivated meat to South Korea.
- Also in South Korea, **Noah Biotech signed an R&D and commercialization agreement with Eone Diagnomics Genome Center** to bring cultivated beef to market.
- **Aleph Farms announced a partnership with the multinational engineering firm Black & Veatch** to achieve scaled, sustainable production with a net-zero emissions supply chain.
- **3D Bioprinting Solutions announced a partnership with KFC Russia**, the world's first partnership between a cultivated meat company and a quick-service restaurant. They plan to trial and eventually commercialize 3D-printed cultivated nuggets.
- The United Kingdom's **3D Bio-Tissues announced a partnership with CPI** to improve cell culture media for the cultivated meat industry.
- Japan's **Nissin Food Holdings is partnering with the University of Tokyo** to develop **meat "cubes,"** potentially for its ubiquitous Cup Noodles brand.

Cultivated meatball from Mosa Meat. | Image credit: Mosa Meat

Figure 4: Companies with initiatives in cultivated meat (emergence of a commercial ecosystem)



Note: Figure 4 is not a comprehensive list of companies with projects or product/service offerings along the cultivated meat technology stack. It excludes companies with non-publicly announced initiatives in cultivated meat, as well as companies whose involvement in the industry is unknown to GFI.

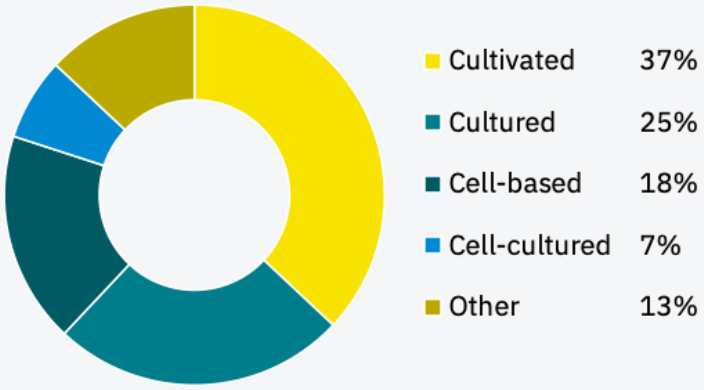
More than 40 additional companies have publicly announced formal projects or product/service offerings along the cultivated meat technology stack. Many of these companies are active in the life sciences industry and can provide critical inputs, infrastructure, and expertise to cultivated meat startups. This business-to-business (B2B) activity will be a valuable force multiplier for the industry, as these services and expertise will benefit multiple clients rather than stay siloed in a single company.

Are we missing your company? Did we get something wrong? We'd appreciate your feedback via **this form**.

Box 2: Nomenclature usage among startups

An analysis of current nomenclature usage among manufacturers suggests that 45 percent of industry players use the term *cultivated*, 24 percent use *cultured*, and 19 percent use *cell-based*. While *cultivated* is the plurality term globally, in the United States, industry trade group **AMPS Innovation** recommends either *cultured* or *cell-based* for its members.

Analysis of nomenclature use among startups

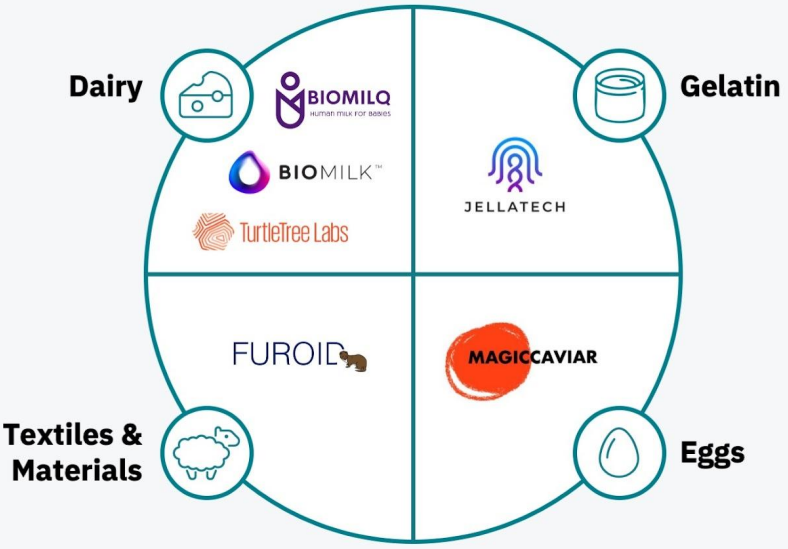


GFI analyzed the websites, LinkedIn profiles, and media statements of all known cultivated meat startups globally. For cases in which companies used more than one term, GFI made a determination of primary nomenclature based on prominence and frequency in public-facing materials.

Since the industry's inception, companies and the media have employed a wide range of terms to refer to genuine animal meat produced by cultivating animal cells directly, including *cell-based*, *cultured*, *clean*, and *slaughter-free*. Other terms, like *lab-grown*, are widely employed by the media but do not accurately describe the setting in which large-scale meat cultivation will take place.

Encouragingly, nomenclature use among manufacturers seems to be coalescing around a few terms that GFI believes more accurately reflect products derived from animal cell culture, including *cultivated*. A 2019 **consumer research report by GFI and Mattson** suggests that *cultivated meat* is the best available consumer-facing term today.

Figure 5: Emerging applications for animal cell culture technology



Note: Figure 5 represents animal cell culture companies with non-meat applications of which GFI is currently aware.

Although animal cell culture in food is applied primarily to cultivated meat production, a similar process can be used to produce milk, gelatin, egg, and other components or end products. Among these applications, dairy production is the most commercially advanced—three companies have publicly announced a focus in this domain, and in 2020 these companies raised a combined $13 million in venture capital financing. All three are focusing initially on human breast milk. The commercial production of gelatin, egg, wool, and other animal products using animal cell culture is in its relative infancy, as each subsector has only one publicly announced company.

Dairy, egg, and other end-product applications of animal cell culture are not the focus of this report. These subsectors are nascent, the technology not broadly validated, and the commercial players few. Nonetheless, these applications could significantly disrupt the market for conventional products in their respective categories, should the technology prove scalable and economically favorable. GFI will continue to evaluate the development of these potentially transformative subsectors and consider including them more substantively in state of the industry reports to come.

Are we missing something? Did we get something wrong? We'd appreciate your feedback via **this form**.

Investments

Image credit: HigherSteaks

Section 3: Investments

Overview

2020 was a breakout year for investments in cultivated meat. The past year not only saw invested capital increase nearly six times from 2019 but brought the segment's first Series B funding rounds.

In 2020, investment in cultivated meat companies accounted for 14 percent of overall funding in the alternative protein sector (which includes plant-based and fermentation segments), doubling from 7 percent in 2019. In fact, the (disclosed) $366 million raised in 2020 represents a full 72 percent of the total capital raised in cultivated meat from 2016 to 2020.

The cultivated segment further matured and diversified in 2020:

- Both **Memphis Meats** and **Mosa Meat** secured Series B funding rounds ($186 million and $75 million, respectively), the first such rounds in the segment's history.
- **MeaTech** acquired cultivated fat developer **Peace of Meat** for $18.2 million, one of only a few disclosed liquidity events among cultivated meat companies. We expect additional liquidity events over coming years as the segment continues to mature.
- **MeaTech** raised $7 million through a PIPE (private investment in public equity) deal, a less common fundraising approach among cultivated meat companies by which the stock or convertible debt of a public company is issued at a set price to investors. We categorized this deal as "other financing" in our investment analysis.
- Cultivated seafood began generating investor enthusiasm. Companies in the cultivated seafood subsector raised $45 million in 2020, up from $17 million in 2019.
- The animal cell culture dairy subsector experienced its first significant investments, with **TurtleTree Labs** securing $9.5 million of invested capital and **BIOMILQ** raising $3.5 million.

While investor interest has fueled growth and helped the cultivated segment mature in 2020, much more investment is needed to continue critical R&D, scale production, and bring down costs to better compete with conventionally produced animal protein. Companies serving other businesses (B2B) are important to achieving all these goals, yet B2B companies received just $5 million in funding in 2020. While this was a transformative increase from the prior (disclosed) $350,000 of total investments, this industry segment represents an important opportunity for investors moving forward.

While investment in the field continues to exhibit impressive year-over-year growth, cultivated meat accounts for but a small fraction of overall investment in **food tech**. Furthermore, the sum of investments in alternative proteins still pales in comparison to that of other fast-growing industries, such as **renewable energy** and **autonomous vehicles**.

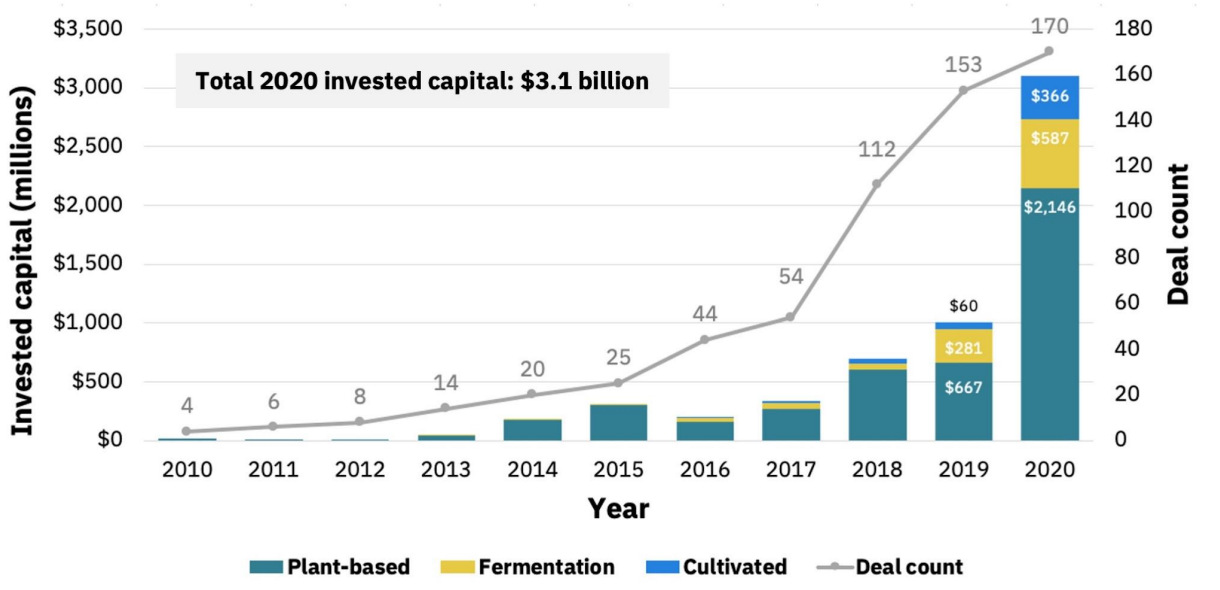
Table 2: 2020 investment overview

Total invested capital	Largest investment	Unique investors
$366 million in 2020 (72 percent of all-time investment, up 487 percent from 2019) **$505 million** (2016–2020)	**$186.25 million** (Memphis Meats)	**94** new in 2020 (62 percent growth from 2019) **245** total (2016–2020)
Invested capital deals	**Series B fundraising rounds**	**Series A fundraising rounds**
49 in 2020 **125** (2016–2020)	**2** in 2020 (the first for the cultivated meat industry)	**6** in 2020 **12** (2016–2020)

Source: GFI analysis of PitchBook data.
Note: Data has not been reviewed by PitchBook analysts. PitchBook's total invested capital includes deals with undisclosed dates and thus may not match the sum of annual invested capital figures in this report.

PitchBook

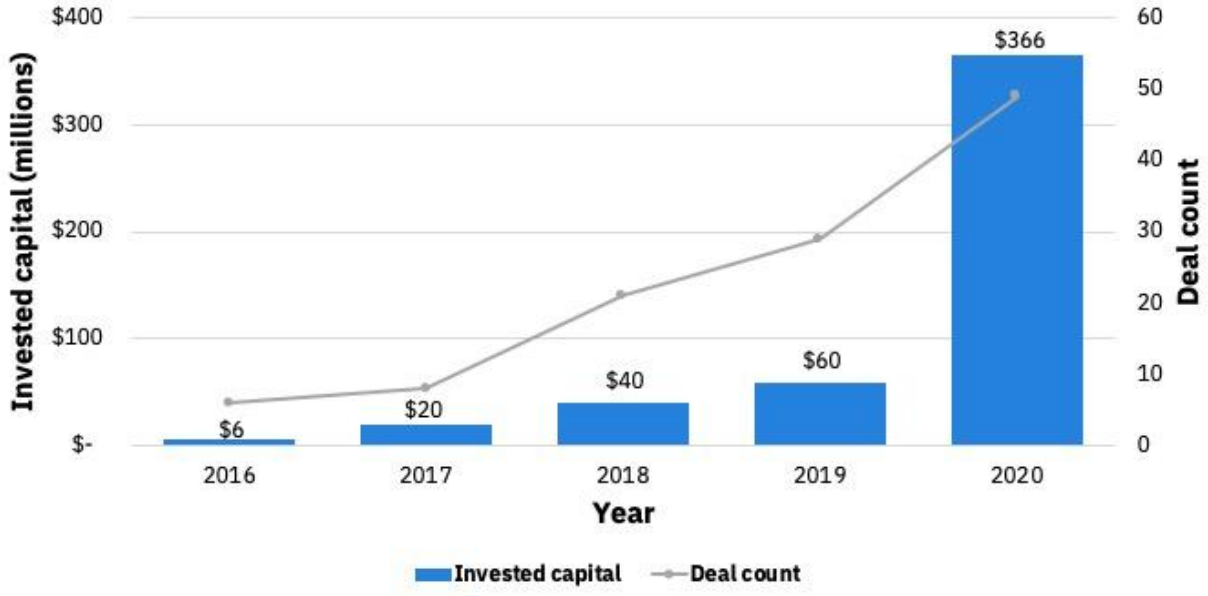
Figure 6: Annual alternative protein investment backdrop (2010–2020)



Source: GFI analysis of PitchBook data. *Note*: Data has not been reviewed by PitchBook analysts.

PitchBook

Figure 7: Annual investment in cultivated meat (2016–2020)



Source: GFI analysis of PitchBook data. *Note:* Data has not been reviewed by PitchBook analysts.

PitchBook

Box 3: Methodology of investment calculations

GFI conducted a global analysis of cultivated meat companies using data from PitchBook. Our analysis uses a list we custom built in PitchBook of companies that focus primarily on cultivating meat products or providing services to those who produce them. We excluded the many companies that are involved in meat cultivation but not as their core business (see **Figure 4**), such as **Eat Just** and **Richcore Lifesciences**, as the funding these companies devote to cultivated meat is undisclosed. PitchBook profiled 71 cultivated meat companies, 51 of which have disclosed deals. Of the 51 companies with disclosed deals, 38 companies have deals with publicly disclosed amounts. Because our aggregate calculations include only companies with deals and deal sizes disclosed to PitchBook, they are conservative estimates. For example, $505 million cumulative invested capital raised (2016–2020) excludes 46 deals (from a total of 120) with undisclosed or unavailable amounts. This means at least 38 percent of deals in this industry are not represented.

For the purposes of this report, *invested capital/investment* comprises accelerator and incubator funding, angel funding, seed funding, equity and product crowdfunding, early-stage venture capital, late-stage venture capital, private equity growth/expansion, capitalization, corporate venture, joint venture, convertible debt, and general debt completed deals. *Liquidity events* comprises mergers, acquisitions, reverse mergers, buyouts, leveraged buyouts, and IPOs, while *other financing* comprises subsequent public share offerings and private investment in public equity. We do not include capital raised through a SPAC IPO until the entity has merged with or acquired a target company. Please note that the figures published in this report may differ from prior figures published by GFI as we continually improve our dataset.

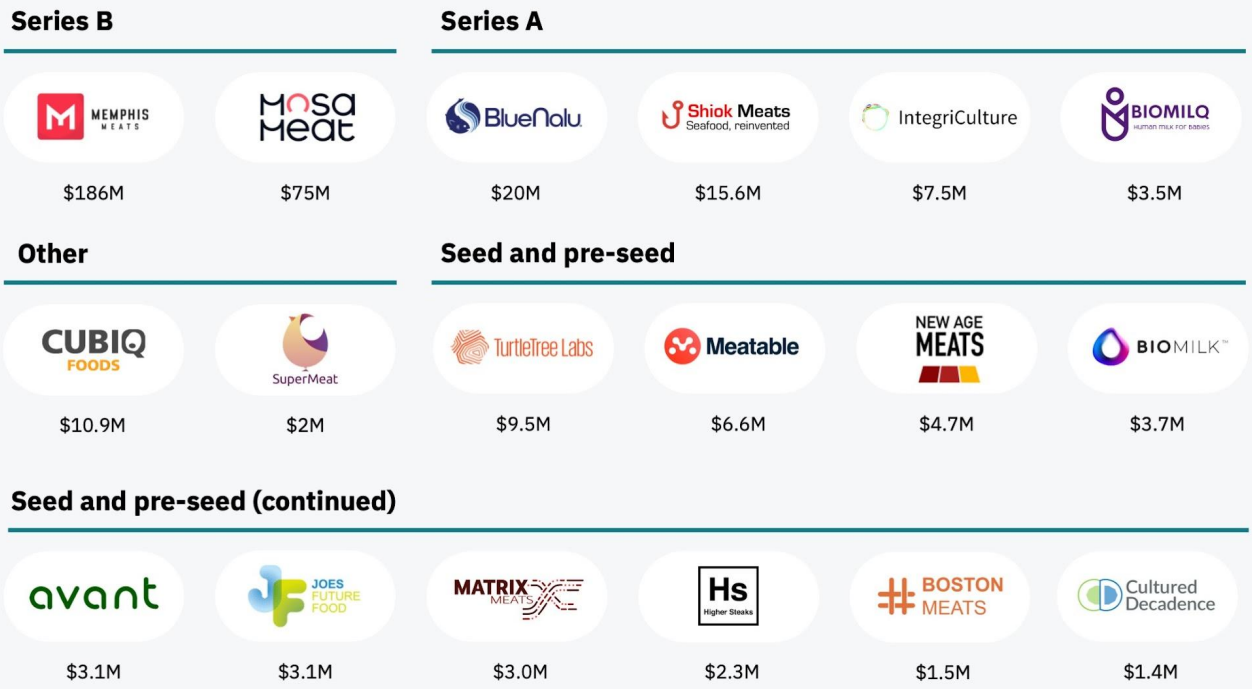
Table 3: Deal type summary statistics (2016–2020)

Deal type	Median	Minimum	Maximum	Count
Seed	$3M	–	$7M	40
Series A	$12M	$3M	$20M	12
Series B	$131M	$75M	$186M	2

Source: GFI analysis of PitchBook data.
Notes: Data has not been reviewed by PitchBook analysts. These figures represent summary statistics of invested capital rounds with disclosed deal amounts. Deal count includes rounds with undisclosed amounts. Due to their limited number and size, this table excludes angel, corporate, and Series 2 rounds. It also excludes uncategorized rounds.

PitchBook

Figure 8: 2020 key funding rounds



Note: We sourced some deal data in this figure from outside PitchBook; therefore, it may not be included in the calculated totals in other areas of the report.

Cultivated pork belly from HigherSteaks. | Image credit: HigherSteaks and Tailored Brands

Table 4: Most active investors in 2020

Investor	Logo	Investor type	Headquarters	2020 deal count	Portfolio companies (by number of investment rounds)
Agronomics		Venture capital	Douglas, United Kingdom	6	BlueNalu (3) Meatable (2) CellX (1) Mosa Meat (1) SuperMeat (1) Shiok Meats (1)
CPT Capital		Venture capital	London, United Kingdom	4	Aleph Farms (2) Avant Meats (1) BlueNalu (1) Matrix Meats (1) Memphis Meats (1) Mosa Meat (1) TurtleTree Labs (1)
Big Idea Ventures		Venture capital	New York, USA	4	Gaia Foods (1) Gourmey (1) Novel Farms (1) Orbillion (1) Peace of Meat (1) Shiok Meats (1)
SOSV / IndieBio		Venture capital	Princeton, USA / San Francisco, USA	4	Memphis Meats (4) New Age Meats (2) Because Animals (2) Finless Foods (2) Multus Media (2)
Artesian		Venture capital	Sydney, Australia	3	Avant Meats (2) TurtleTree Labs (2) Cell Farm (1) Orbillion (1)
Social Starts		Venture capital	San Francisco, USA	3	Gourmey (2) Finless Foods (1) Novel Farms (1) Peace of Meat (1)
Blue Horizon		Corporate venture capital	Zürich, Switzerland	3	Mosa Meat (2) BIOMILQ (1) Cubiq Foods (1) Finless Foods (1) SuperMeat (1)

Humboldt*		Venture capital	New York, USA	3	CellX (1) Meatable (1) Memphis Meats (1)
Unovis Asset Management		Venture capital	New York, USA	2	Aleph Farms (3) BlueNalu (2) Memphis Meats (2) Artemys Foods (1) Matrix Meats (1) Mosa Meat (1) SuperMeat (1)
VegInvest		Venture capital	New York, USA	2	Shiok Meats (2) BlueNalu (1) Mosa Meat (1) SuperMeat (1)
KBW Ventures		Venture capital	Dubai, United Arab Emirates	2	TurtleTree Labs (3) Memphis Meats (1)
Bell Food Group		Corporate venture capital	Basel, Switzerland	2	Mosa Meat (3)
EIT Food		Accelerator/ incubator	Leuven, Belgium	2	Aleph Farms (1) Mosa Meat (1) Peace of Meat (1)
Purple Orange Ventures		Venture capital	Berlin, Germany	2	CellX (1) BIOMILQ (1) Mission Barns (1)
Real Tech Fund		Venture capital	Tokyo, Japan	2	Integriculture (2) Shiok Meats (1)
Siddhi Capital		Venture capital	Cherry Hill, USA	2	Artemys Foods (1) BlueNalu (1) Matrix Meats (1)
208 Seed Ventures*		Angel group	Columbia, USA	2	Avant Meats (2)
Alumni Ventures Group*		Venture capital	Manchester, USA	2	Artemys Foods (1) Cultured Decadence (1)

Eat Beyond Global*	EAT BEYOND™	PE/buyout	Vancouver, Canada	2	TurtleTree Labs (1) SingCell (1)
Green Monday*	green monday	PE/ buyout	Hong Kong, SAR, China	2	TurtleTree Labs (2)
Lever VC / Lever VC China*	LEVER	Venture capital	Brooklyn, USA / China	2	Avant Meats (2) CellX (1) TurtleTree Labs (1)
VU Venture Partners*	VU VENTURE PARTNERS	Venture capital	San Francisco, USA	2	Finless Foods (1) Integriculture (1)

Source: GFI analysis of PitchBook data. *Notes:* Data has not been reviewed by PitchBook analysts. "Most active investors in 2020" includes any organization that made two or more publicly disclosed investments in a cultivated meat company during the calendar year 2020.

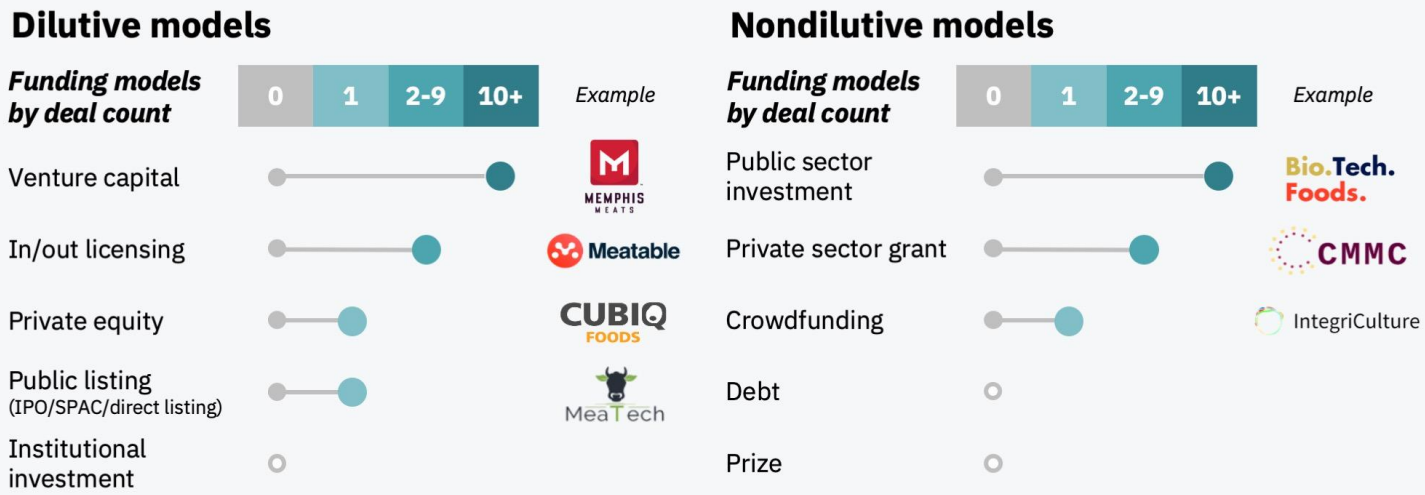
PitchBook

**Indicates companies that made disclosed investments in cultivated meat or dairy for the first time in 2020.*

Box 4: Publicly available investment vehicle

The vast majority of cultivated meat companies are private, making it difficult for the lay investor to access the segment. **Agronomics Limited (LSE: ANIC)** offers a solution: a **listed** vehicle on the Alternative Investment Market of the London Stock Exchange. The listing provides a wider range of investors access to this rapidly growing segment. Agronomics' cultivated meat **portfolio** includes **BlueNalu**, **CellX**, **Meatable**, **Mosa Meat**, **New Age Meats**, **Shiok Meats**, **and SuperMeat**.

Figure 9: Funding models by deal count



Note: Analysis inspired by Axial's "Funding models in life sciences" newsletter. We sourced some deal data in this figure from outside PitchBook.

As with the life sciences industry more broadly, shifting cultivated meat into commercial-scale production will require a rich and diverse set of financing strategies. In particular, the high technology risk and probable scarcity of early cash flows invite a range of capital acquisition strategies. Figure 9 highlights the menu of prevalent financing strategies and those most frequently deployed in the cultivated meat industry to date.

Public sector investment

To shorten the timeline for large-scale commercialization of cultivated meat, governments around the world should **prioritize cultivated meat research** and build out a supportive framework for developing this critical industry. Public funding for cultivated meat could prime the pump for dramatic improvements in our food system's productivity and our economy's growth. It is also an important lever for diversifying our food supply, ensuring both variety and security. The industry requires early-stage, high-risk R&D and increasingly necessitates significant infrastructure for production capacity—two areas where governments have historically played a significant role. Governments have been key in developing high-tech industries, such as semiconductors and solar power, and there is a tremendous opportunity to do the same for the cultivated meat sector.

We recommend two recent reports from leaders at **Breakthrough Energy Ventures** and the **Breakthrough Institute**. Both offer a thorough case for public sector financing in alternative proteins.

Broadly, the cultivated meat industry has seen a dearth of public funding, but 2020 brought the first encouraging signs that the public sector is beginning to recognize the importance of supporting cultivated meat research and commercialization:

- The U.S. government, via a grant from the National Science Foundation, **awarded a total of $3.55 million** for open-access cultivated meat research. This grant is to be dispersed over five years to a team of **researchers at University of California, Davis**. It is not only the U.S. government's largest investment in cultivated meat research to date but the first cultivated meat grant that the U.S. government has awarded to a university rather than a company.
- **BioTech Foods**, a Spanish cultivated meat startup and the leader of the Meat4All consortium, **received a $3.2 million grant** from the European Union's Horizon 2020 program.
- Iceland's **ORF Genetics** **secured a $3 million grant** from the European Commission's Grant Management Services to accelerate development and commercialization of its growth factors for cultivated meat.
- In Japan, **Integriculture** **acquired $2.2 million** from the Ministry of Economy, Trade, and Industry to help finance a small-scale facility for the company's CulNet System.
- In a first for the Australian cellular agriculture community, Western Australia's government **funded cultivated meat industry internships** for three PhD candidates.

"I was most excited to see the influx of funding from governments (e.g., NSF funding for UC Davis and EU funding for Meat4All) signaling federal commitment to cultured meat. This has fueled the rise of several new collaborative public-private research consortia concepts across the globe ... aiming to comprehensively address a wide array of topics from economics to consumer acceptance. Together these developments will propel fundamental research and accelerate market entry and adoption."

—Lavanya Anandan, head of external innovation and partnerships at Merck KGaA

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Science and technology

Image credit: BlueNalu

Section 4: Science and technology

Overview

Success in the cultivated meat industry will require developing **economically viable production systems at scale**. Fortunately, cultivated meat is preceded by decades of knowledge accumulation in cell culture, stem cell biology, tissue engineering, meat science, fermentation, and chemical and bioprocess engineering. Today, researchers and companies are innovating in every conceivable direction to advance the state of the art in this burgeoning field.

This section provides an inexhaustive audit of 2020's scientific and technological developments in the cultivated meat industry. Future publications will explore the application of cell culture technology to egg and dairy platforms.

For a comprehensive view of the current state of the science in cultivated meat, check out GFI's **science of cultivated meat** page.

Techno-economics

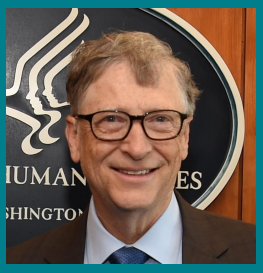
A techno-economic assessment (TEA) is the essential risk assessment step for understanding the technical and financial feasibility of scaling up cultivated meat production. Typically, the goal of a cultivated meat TEA is to elucidate the cost of producing cultivated meat in an industrial production setting.

Rigorous, open-access TEAs can help the industry align on the current state of the art in cultivated meat technology and identify areas for cost reduction and process intensification. The publicly available TEAs of cultivated meat production are linked here by the main institution affiliated with the research:

- **CE Delft / The Good Food Institute**
- **Open Philanthropy Foundation**
- **University of California, Davis**

These studies have all identified recombinant proteins and growth factors in cell culture medium as the dominant cost drivers of production. Additionally, the lack of data for cellular metabolism metrics has implications for process scaleup and selection of raw-material inputs. Studies also demonstrate that as raw-material costs decrease, capital expenditure for bioreactors and the facilities that house them will constitute the lion's share of production costs. While the literature suggests that fundamental technological breakthroughs are not necessary to eventually achieve economically viable, scaled production, significant chemical

and biological engineering challenges remain to further reduce costs and increase yields. For detailed recommendations on lowering production costs, developing new technologies, and drafting action-oriented policies to accelerate cultivated meat, see GFI's commentary for **technical audiences** and **policymakers** on CE Delft's TEA.



"Cultivated meat has all the same fat, muscles, and tendons as any animal. … All this can be done with little or no greenhouse gas emissions, aside from the electricity you need to power the labs where the process is done."

—Bill Gates, chair of the board at Breakthrough Energy, in *How to Avoid a Climate Disaster*

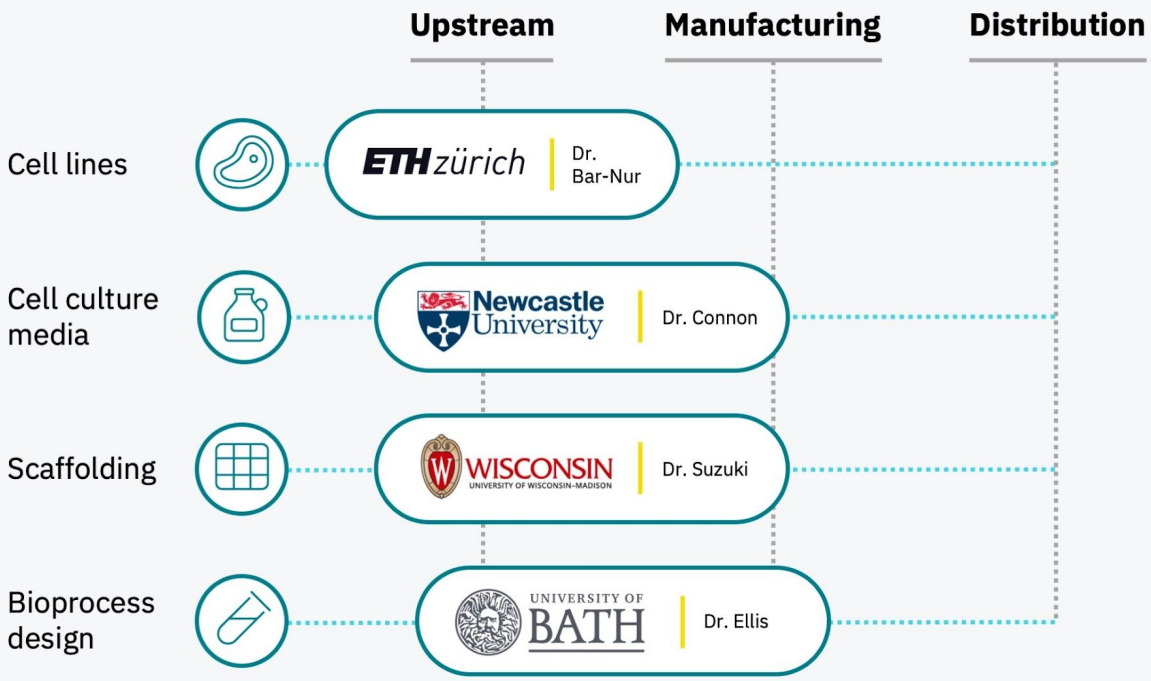
Ongoing research across the technology stack

Cultivated meat **research** is taking place in hundreds of **companies** and **academic laboratories** around the world, each racing to translate knowledge from chemistry, biology, physics, computer science, and engineering into a new paradigm for manufacturing commodity meat products at industrial scale.

Figure 10 highlights one research project along each point in the cultivated meat technology stack, which GFI classifies as cell lines, cell culture media, scaffolding, and bioprocess design.

For a comprehensive view of the state of the science in cultivated meat, including a deep dive into each component of the value chain, check out GFI's **science of cultivated meat** page.

Figure 10: Select GFI-research-grantee projects along the technology stack



Note: Each researcher featured in Figure 10 is a recipient of a GFI competitive research grant. This graphic does not reflect all research along the cultivated meat value chain.

Cell lines

Definition: Many different cell types can be used to produce cultivated meat. Further research is needed to make cell lines more accessible, study the potential of each cell type, and determine how the selection of cell type and properties influences downstream process considerations.

2020 research highlight: Dr. Ori Bar-Nur, an assistant professor at ETH Zürich, aims to (1) directly convert fibroblasts into induced myogenic progenitor cells as an alternative to conventional methods of growing muscle progenitors, and (2) assess the capacity of the induced myogenic progenitors to generate muscle fibers through serum withdrawal and exposure to small molecules. The project is devising new methods of producing animal muscle-cell lines and will reduce costs of cultivated meat production via long-term propagation of cell lines.

Cell culture media

Definition: Cell culture media contains the nutrients and growth factors that cells need to grow outside the body. Research on optimized formulations, food-grade and animal-free components, and recycling technologies is needed to make cell culture media significantly more affordable.

2020 research highlight: Dr. Che Connon, a professor at Newcastle University, plans to explore the potential of macromolecular crowding to promote myoblast and fat cell proliferation and enhance the production yield and quality of cultivated meat. Dr. Connon also aims to develop new serum-free media formulations for improved muscle cell proliferation and tissue formation and explore new platforms to assess disparate media formulations. The project is intended to increase cell density and product yield, as well as reduce media costs and growth factor needs in cultivated meat production.

Scaffolding

Definition: Scaffolds are 3D cell culture platforms that aim to recapitulate the natural 3D microenvironment of cells, which is important to facilitating more natural cell behavior and tissue formation. More research is needed to uncover the best materials and methods for optimizing meat traits.

2020 research highlight: Dr. Masatoshi Suzuki, an associate professor at the University of Wisconsin–Madison, seeks to develop 3D cultivated meat using bioengineered plant-based tissue scaffolds and characterize its texture, color, and composition. Prof. Suzuki's project, a collaboration with Prof. William Murphy of UW–Madison, also establishes large-scale production of musculoskeletal stem cells, such as muscle, fibro-adipogenic progenitor, and mesenchymal stem or stromal cells, using a sphere-based culture approach. The project's main aim is to reduce cost and improve sustainability of scaffolds compared with animal-based or synthetic scaffolds.

Bioprocess design

Definition: Bioprocess design holds the key to unlocking large-scale production of cultivated meat. Additional research is needed to determine the best-suited bioreactors for different cell types and products, as well as how future facilities will be operated.

2020 research highlight: Dr. Marianne Ellis, an associate professor at the University of Bath, plans to establish media consumption and waste production profiles for both expansion and differentiation in various bioreactors. Dr. Ellis's research will also produce correlations for the relationships among scaffold structure, fluid dynamics, and biological profiles in bioreactors. The project aims to improve understanding of cell behavior changes as culture size increases and develop a more compact, cost-effective bioreactor that enables cultivated meat production in novel scenarios.

Check out our **research grants** page to explore grant opportunities (at GFI and elsewhere!) and meet the scientists leading open-access cultivated meat research.

"Standouts in the academic field over the last year include the first large U.S. National Science Foundation grant for cultivated meat research, academic labs looking at increasingly more diverse ways of making meat from existing model organisms, such as *Drosophila* and zebrafish, and continued studies into **genetic modification to increase the nutritional content of cultivated meat**. … Academia has a large part to play in the future of cultivated meat. … Our work published in January on **reducing the cost of pluripotent stem cell media** (from more than $500 per liter to $10) gained as much interest from the cultivated meat field as from the stem cell field. … There is much work academic labs can contribute and openly share so that we can all benefit."

—Paul Burridge, Burridge Lab at Northwestern University

Box 5: Top journals cover cultivated meat research

Cultivated meat research is becoming high-profile, with publications recently featured in the prestigious journal *Nature Food*.

The first *Nature Food* paper, from GFI Israel's senior scientist Tom Ben-Arye, discusses bovine skeletal-muscle-tissue engineering. Bovine cells were co-cultured on an edible textured vegetable protein (TVP) scaffold, generating both muscle fibers and a complex extracellular matrix, with improved results by co-culture with bovine smooth muscle cells. Future work will include optimizing TVP structure and composition for cultivated meat, improving the bovine cell population, and developing a bioprocess in novel bioreactors.

Nature Food also published a **review paper** on cultivated meat. This piece is a first-of-its-kind collaboration between scientists at Mosa Meat, Aleph Farms, Memphis Meats, and additional cultivated meat leaders in academia. The paper discusses the scientific, sustainability, scalability, and regulatory challenges in cultivated meat.

The opportunity to publish papers in influential journals is one incentive for scientists to join the field of cultivated meat. Publications in high-profile, highly cited journals also provide powerful testimony that cultivated meat is a valued research topic in the scientific community.

Formation of a transdisciplinary research center

In September, the National Science Foundation **granted $3.55 million to support cultivated meat research** at UC Davis—the largest infusion of U.S. public research dollars into cellular agriculture yet and a signal of the field's scientific and intellectual merits. The grant grew out of the **Cultivated Meat Consortium**, an interdisciplinary assembly of students and researchers across UC Davis representing chemical, biological, and social sciences. The consortium acts as a force multiplier for research at the university and in the surrounding region by catalyzing knowledge exchange, idea generation, and training.

"2020 was a landmark year for cultivated meat in the academic sphere. University of California, Davis, received the first significant government grant for cultivated meat research, our team at Tufts University launched the first comprehensive undergraduate course on cellular agriculture, and alternative protein student groups have proliferated around the globe—in Berlin, Boulder, and Leuven, to name a few!"

—Natalie Rubio, PhD candidate at Tufts University and New Harvest fellow

Box 6: New tools in 2020

The availability of a broad swath of open-access resources is essential to the industry's success. New, free tools developed in 2020 benefit scientists, entrepreneurs, and investors:

- **Alternative protein curriculum repository.** GFI's curriculum repository hosts course materials to lower barriers for instructors everywhere who are interested in bringing the science of cellular agriculture to their students.
- **Bioreactor modeling.** The Cultivated Meat Modeling Consortium's model of a stirred-tank bioreactor hosting microcarriers and animal cells serves as a proof of concept for large-scale cultivation of meat.
- **Collaborative researcher directory.** GFI developed a database of researchers actively open to collaboration on alternative protein projects to ease the process of finding potential collaborators. For a comprehensive list of scientific laboratories involved in alternative protein research, see GFI's **scientific research database**.
- **PISCES** / **ATLAS.** GFI's Phylogenetic Index of Seafood CharactEriStics (PISCES) organizes data characterizing conventional seafood according to phylogenetic relationships. The Archetype Library for Alternative Seafood (ATLAS) focuses on culinarily relevant seafood archetypes.
- **Research tool directory.** GFI's crowdsourced directory of species-specific resources can save researchers time in finding the right tools or service providers for cultivated meat and dairy research.

Proliferation of cellular agriculture nonprofits

In mid-2020, several nonprofits joined forces to form the **International Cellular Agriculture Nonprofit Consortium**. The consortium comprises **Cellular Agriculture Australia**, **Cellular Agriculture Institute of the Commons** (Japan), **Cellular Agriculture UK**, **Cultivate**, **Cellular Agriculture France**, **Cellular Agriculture Canada**, **Cellular Agriculture Germany**, **Cellular Agriculture New Zealand**, **New Harvest**, and the multinational **Cellular Agriculture Society**. This coalition works to raise regional awareness of opportunities and challenges in cultivated meat and energize local decision-makers around prioritizing alternative protein development.

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Government and regulation

Image credit: Shiok Meats

Section 5: Government and regulation

Global leadership in the regulation of cultivated meat is likely to come first from countries committed to the growth of the sector. It is imperative that companies and governments—production and regulation—work in concert to successfully develop effective regulatory regimes. Singapore's groundbreaking approval of Eat Just's cultivated chicken product puts the Asia Pacific region at the leading edge as an architect of novel and progressive oversight of cultivated meat.

Below we profile regulatory progress in countries and regions that have announced material updates in 2020.

European Union

In May 2020, the European Commission published its **Farm to Fork Strategy**, identifying its ambition to move toward a more sustainable and healthy food system. Although the strategy does not explicitly mention cultivated meat, it endorses increased funding for research and innovation in the alternative protein sector.

Cultivated meat—when produced without genetic modification—is regulated under the **novel foods regulation of the European Union**. Companies must apply to the European Commission for premarket authorization of their products. The authorization procedure includes a safety evaluation by the European Food Safety Authority (EFSA). Premarket authorization is handled centrally, meaning that once the European Commission and representatives from the EU member states approve a product, the approval applies across all 27 member states.

New EU rules came into effect in March 2021 that allow for limited presubmission consultations between companies and EFSA. Additionally, companies seeking to apply for novel foods authorization are obliged to notify the regulator of any study commissioned in preparation of an application.

Israel

In December 2020, the industry took a monumental and symbolic leap forward when Israeli prime minister Benjamin Netanyahu became the **first head of government to sample a cultivated meat product**. At an event initiated by GFI Israel and hosted by Israel's **Aleph Farms**, GFI Israel presented Netanyahu with its national policy plan for establishing the Middle Eastern nation as a cultivated meat and alternative protein powerhouse.

GFI Israel managing director Nir Goldstein presenting Prime Minister Netanyahu with the organization's national policy plan. | Image credit: GPO Kobi Gideon

Netanyahu announced that he had directed Cabinet Secretary Tzahi Braverman to "**appoint a body to serve these industries in order to connect and oversee all the stakeholders operating in this field**." This is an encouraging step toward cultivated meat commercialization in one of the world's most tech-forward nations. At the same time, the **National Food Control Service** (FCS)—the nation's agency responsible for food regulation and standards—has dedicated a team of experts to further evaluate the required safety assessments for a cultivated meat regulatory framework. Some Israeli industry experts suggest that the FCS is

unlikely to develop an original framework and will instead follow the lead of U.S. or EU regulatory agencies.

Japan

There is some indication that, based on interpretation of Japanese law, it could be permissible at present to sell cultivated meat in Japan. As **GFI Asia Pacific's former managing director Elaine Siu and Integriculture's CEO Yuki Hanyu** explain, to comply with existing food regulations, cultivated meat products and production processes must not externally source growth factors or use immortalized cells. In any event, Japan must establish a clear regulatory framework and a safe and standardized research and commercialization oversight process.

While Japan did not report any definitive regulatory updates in 2020, **two events served as potential precursors to major regulatory developments**: the federal government's establishment of a foodtech research group and the formation of the Japan Association for Cellular Agriculture, an industry-academia-government initiative.

"While Shiok Meats, Ants Innovate, and other cultivated meat startups work to secure regulatory approval in Singapore, forward-thinking nations throughout Asia Pacific are racing to catch up. In Japan, a consortium of government, academia, and some of the country's largest food companies has begun meeting twice monthly to develop rules for cell-based food products—perhaps mindful that any successful climate strategy must include smarter ways of making meat."

—Mirte Gosker-Kneepkens, acting managing director at GFI Asia Pacific

Singapore

In November 2020, the Singapore Food Agency (SFA) became the first national regulator to **green-light the sale of a cultivated meat product**. The approval of Eat Just's cultivated chicken, for use as an ingredient in the company's chicken bites, was the culmination of a regulatory process developed over more than two years. The SFA's review was informed by a panel of outside experts who assessed the composition of the product, manufacturing process, integrity of the cell line, and potential for pathogenic contamination. More than 70 percent of Eat Just's **GOOD Meat cultured chicken** is composed of cultivated chicken cells, while the remainder is primarily mung bean protein (this meat-to-other-ingredients ratio is **on a par** with conventional chicken nuggets).

This regulatory approval is a monumental milestone. Importantly, it is not a blanket approval of cultivated meat products; it is specific to Eat Just's product and manufacturing process. Companies hoping to sell cultivated meat or seafood in Singapore must still submit regulatory filings for their specific formulations.

The SFA has not indicated whether this recent approval may eventually form the basis for a more encompassing regulatory framework. In November, the SFA updated a year-old **guidance document** on novel food safety assessments, which lists some informational requirements specific to cultivated meat products. However, the guidance provides few new details as to standards manufacturers will need to satisfy to obtain approval of their products. As it stands, the SFA strongly encourages companies interested in selling cultivated meat products in Singapore to contact the regulatory body early in the R&D and commercialization planning process.

United States

Federal regulation

Singapore's approval of Eat Just's cultivated chicken product invites the question, **will the United States be next?** 2020 saw considerable U.S. regulatory activity in this arena as federal oversight organizations worked to establish the beginnings of a cultivated meat regulatory regime:

- In April, the U.S. Government Accountability Office (GAO) **published a report** on the regulation of cultivated meat. The GAO's recommendations for interagency collaboration, including assigning key oversight roles and establishing milestones and metrics for tracking progress, could strengthen the collaborative work of the Food and Drug Administration (FDA) and the U.S. Department of Agriculture (USDA). The recommendations may also accelerate the development of a regulatory framework that will ensure consumer safety and well-crafted food policies.
- In July, the FDA and USDA Food Safety and Inspection Service released an on-demand **webinar** on their respective duties: *Roles and Responsibilities for Cultured Animal Cell Human and Animal Food Products*. The webinar covered the allocation of oversight responsibilities between the USDA and FDA as laid out in their March 2019 formal agreement: The FDA will oversee cell collection/banking and all cultivation inputs and processes up through the moment of biomass "harvest" from bioreactors. The USDA will regulate further processing and labeling for terrestrial meats, while the FDA will have jurisdiction over most seafood products through processing and labeling stages. The USDA also verified claims by staff that it plans to "develop regulatory requirements" for labels and solicit public comments for products subject to its labeling jurisdiction. The FDA said it does not plan to issue a rule proposal or new guidance on preharvest phases but views its existing guidance as sufficient.
- In October, the FDA published a **request for information** relating to cultivated seafood labeling. The agency will use information obtained through the comment process to determine what action, if any, it should take to ensure that cultivated fish and shellfish are labeled properly. For example, the FDA could pursue formal rulemaking or issue guidance not subject to administrative notice-and-comment requirements.

State litigation

A handful of states have enacted laws (collectively termed "label censorship laws") that restrict cultivated meat from being labeled "meat." In 2020, some of these laws were challenged in court on free speech and other grounds, which helps clear the way for accurate

labeling of cultivated meat. States with governing parties across the political spectrum, including **Kansas**, **Nebraska**, **Colorado**, **Washington**, and **Maryland**, rejected label censorship bills this year.

- A federal court in **Arkansas** temporarily enjoined the state's label censorship law, holding that it probably violates constitutional free-speech protections. The judge is now considering whether to make the injunction permanent or to strike down the law.
- In November, a federal appeals court heard a similar challenge to a label censorship law in **Missouri** from GFI and **Tofurky**. We are asking the court to hold that the law cannot be enforced while the lawsuit proceeds. A decision is expected in the first half of 2021.
- A lawsuit filed in October challenges a label censorship law in **Louisiana**, which would apply to both cultivated meat and some species of cultivated seafood. The state has agreed not to enforce the law while the suit is pending, and in 2021 a judge will consider whether to strike down the law.
- **Georgia** passed legislation in 2020 requiring cultivated meat companies to use terms such as *lab-grown*, *lab-created*, or *grown in a lab*. The law went into effect on December 31, 2020. GFI views this as a detrimental development, as these terms **do not accurately describe** the setting in which large-scale meat cultivation will take place.

Box 7: Cultivated meat image library

News articles about cultivated meat often feature the now-familiar image of a pile of ground beef in a petri dish, held by a blue-gloved hand. Although these images successfully get across the concepts of "science" and "meat," they're less effective at grounding the reader in an accurate vision of cultivated meat production. In 2020, GFI launched a **library of Creative Commons-licensed images of cultivated meat** to advance a more authentic representation of these products and better position them as familiar and delicious. This resource is available today thanks to the willingness of leaders in this industry to share their photos with the broader community.

If you have cultivated meat images you'd like to contribute, **share your photos with us**.

Are we missing something? Did we get something wrong? We'd appreciate your feedback via **this form**.

Conclusion and forecast

Image credit: SuperMeat

Section 6: Conclusion and forecast

Capturing even a fraction of the global meat demand is a colossal opportunity for cultivated meat companies. Doing so will require a remarkable deployment of scientific progress, infrastructure development, investment, and—crucially—a robust ecosystem to support the industry's growth. In light of this, 2020 was a hallmark year for the field of cultivated meat. The industry made considerable progress in scaling the technology, desiloing the industry via commercial partnerships, and carving out a key regulatory precedent. And 2020 is but a prelude to the ongoing developments of 2021 and beyond.

These are among the many developments in 2021 so far:

- **Aleph Farms** announced partnerships with two multinationals, **Mitsubishi Corp. in Japan** and **BRF S.A. in Brazil**, to commercialize cultivated meat in the coming years.
- **BlueNalu** secured **$60 million in convertible-note financing** to further fund development of a production facility and to initiate marketplace testing in the United States.
- **Future Meat Technologies** reported a **significant reduction in unit production costs** of its cultivated chicken.
- In partnership with GFI, Bill Gates's NGO, **Breakthrough Energy**, **released its federal policy priorities**, which recommend open-access R&D funding for cultivated meat and government incentives for private sector R&D and infrastructure development.

GFI will continue to investigate the potential of this burgeoning field to transform the meat industry into one where alternative proteins are no longer alternative.

Expert predictions

We asked industry experts for their predictions on what's next in cultivated meat.

For 2021, I see a large number of new investor groups making their first cultivated meat investments, which is great for the diversity of support needed in the field. I also predict more early M&A activities between complementary cultivated meat startups, which is also important to create faster breakthrough successes.
—Gary Lin, founder and managing director at Purple Orange Ventures

Looking to 2021 and beyond, I predict that cellular agriculture will evolve towards its own field of study. Cellular agriculture will be listed as a degree at prominent universities, with a separate and distinct curriculum, and our children will one day say, "I want to be a cellular agriculturist when I grow up!"
—Natalie Rubio, PhD candidate at Tufts University and New Harvest fellow

We will see rapid prototyping and development of scalable manufacturing processes in pilot production environments. We will also see the formation of creative partnerships to address the need to plunge culture media cost by several orders of magnitude. Finally, I believe we will see the emergence of novel combination approaches incorporating plant-based, fermentation, and cell-based inputs to deftly tune products to achieve superior taste, texture, and flavor.
—Lavanya Anandan, PhD, head of external innovation and partnerships at Merck KGaA

Among my predictions for 2021 is the construction of new and innovative pilot production facilities, which will be a crucial step toward the maturation of the cultivated meat industry.
—Pallevi Srivastva, PhD, head of cell culture media and process development at Wildtype

It is clear that the basic cultivated meat principle is easily achievable (such as Eat Just's chicken muscle cells), yet achieving a product that is comparable to traditional meat in physical properties and cost is going to require numerous scientific breakthroughs that will take time and come from diverse sources. 2021 is likely to be the year that major breakthroughs in the cultivated meat industry are made by academic labs, further changing the direction of the field. We expect to have our culture media under $1 per liter and are actively focusing on solving as many questions relating to using iPSC in cultivated meat as possible.
—Paul Burridge, PhD, Burridge Lab at Northwestern University

I expect to see at least one of the research projects currently underway on cultivated seafood bear fruit in 2021 in the form of publications and open-access research tools. It will become less and less true that researchers who want to work on cultivated seafood are forced to start almost from scratch, especially as the selection of off-the-shelf cell lines from food-relevant species grows.
—Claire Bomkamp, PhD, senior scientist—seafood specialization at The Good Food Institute

In 10 years, people will look back in disbelief at how low-quality meat alternatives were before the alternative protein revolution.
—Tom Ben-Arye, PhD, senior scientist at The Good Food Institute Israel

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Cover image courtesy of **Wildtype**.

About GFI

GFI is a 501(c)3 nonprofit organization developing the roadmap for a sustainable, secure, and just protein supply. We identify the most effective solutions, mobilize resources and talent, and empower partners across the food system to make alternative proteins accessible, affordable, and delicious.

Our vision:
A world where alternative proteins are no longer alternative.

Our programmatic priorities:

- **Science and technology:** Advancing foundational, open-access research in alternative proteins and creating a thriving research and training ecosystem around these game-changing fields.
- **Corporate engagement:** Partnering with companies and investors around the globe to drive investment, accelerate innovation, and scale the supply chain—all faster than market forces alone would allow.
- **Policy:** Advocating fair policy and public research funding for alternative proteins.

Alternative proteins are a global solution to global problems. In addition to the United States, GFI works in places where we can have the greatest possible impact on our global food system: Asia Pacific, Brazil, Europe, India, and Israel.

GFI is 100 percent powered by philanthropy. Our progress is possible thanks to gifts and grants from our global family of donors.

People around the world support our work because, together, we can transform our food system to mitigate climate change and environmental degradation, feed our planet's growing population, and secure a food supply that decreases the risk of zoonotic and antibiotic-resistant diseases.

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