



2022 STATE OF THE INDUSTRY REPORT

Cultivated meat and seafood

Editors' note

Meat production is projected to nearly double by 2050 to meet growing global demand. But the way the world currently produces meat cannot meet this demand and still achieve global climate, food security, public health, and biodiversity goals. Making meat differently via alternative proteins can help feed a growing world safely and efficiently, and will be as essential to mitigating climate change as the global transition to renewable energy. When compared to conventional meat production, alternative protein production dramatically reduces emissions, requires far less land, eliminates the use of antibiotics in our food system, and feeds more people with fewer resources.

By reimagining protein, we can produce food that people love and usher in a more sustainable, secure, and just food future. Countries have committed to halve emissions and protect 30 percent of global land and ocean ecosystems by 2030. With just seven years to go, investing in alternative ways of making meat, seafood, eggs, and dairy is essential.

GFI's annual State of the Industry Reports equip food system stakeholders with a solid, in-depth understanding of the alternative protein market's challenges and opportunities. These reports also serve as a global call to action:

Alternative proteins are a scalable solution that, with proper levels of public and private support, can help address the biggest challenges of our time and transform our global food system for the better.

One powerful tool to tackle such challenges is cultivated meat. Meat grown directly from animal cells will offer consumers a way to consume genuine animal meat without adverse impacts on the environment, global health, and food security. Cultivated meat has the sensory and nutritional values meat consumers crave without the downsides of the conventional animal agriculture system. Cultivated meat and fat can also be used to enhance the sensory experience of plant-based products—an application we're particularly excited about.

This report details developments that moved cultivated meat and seafood forward in 2022. The sector still has miles to go, however, to reach its full potential. Funding and workforce constraints pose two of the biggest bottlenecks for scientific innovation and scaling. As companies continue to innovate, and as more talent, research funding, and investments flow into alternative proteins, the entire sector will accelerate, offering the world a fundamentally different and far more sustainable food future.

With gratitude and deep respect to all those on this journey, we invite you to dig deep into our 2022 State of the Industry Report, *Cultivated meat and seafood*.

Best,



Caroline Bushnell
VP of Corporate Engagement



Liz Specht, PhD
VP of Science and Technology



Jessica Almy
VP of Policy

About GFI's State of the Industry Report series

GFI's State of the Industry Report series serves as our annual alternative protein sector deep-dive. The series compiles business developments, key technologies, policy updates, and scientific breakthroughs from around the world that are advancing the entire field. This year's reports include:

- *Cultivated meat and seafood*
- *Fermentation: Meat, seafood, eggs, and dairy*
- *Plant-based meat, seafood, eggs, and dairy*
- *Global policy: Public support, regulation, and labeling*

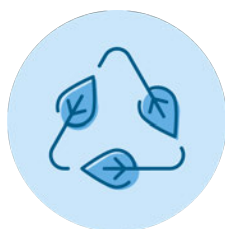
The *Cultivated meat and seafood* report synthesizes 2022 updates in the global cultivated meat industry—the industry dedicated to making real meat and seafood by growing animal cells. Animal cell culture technology has promising applications beyond meat production, including dairy, eggs, gelatin, drugs and supplements, and materials. This report focuses on cultivated meat and seafood. For a full primer on the process of creating cultivated meat, please visit GFI's [science of cultivated meat](#) page.

Symbols to look for

Throughout the 2022 State of the Industry Report series, look for symbols highlighting how developments in the past year advanced the alternative protein sector in the areas of health and nutrition, sustainability, and path-to-market progress. Dig deeper and opportunity icons are calls to action for researchers, investors, and others seeking to learn more and advance the field.



Health



Sustainability



Opportunity



Path-to-market



Dig deeper

Please note that The Good Food Institute is not a licensed investment or financial advisor, and nothing in this report is intended or should be construed as investment advice.

About the Good Food Institute

As a nonprofit think tank and international network of organizations powered by philanthropy, GFI works alongside scientists, businesses, and policymakers to make alternative proteins as delicious, affordable, and accessible as conventional meat. In Asia Pacific, Europe, Brazil, India, Israel, and the United States, our teams are mobilizing the international community to use markets and technology to replace harmful practices with ones that are better for the climate and biodiversity, food security, and global health.

We focus on three programmatic priorities:

Cultivating a strong scientific ecosystem

GFI's science and technology teams map out the most neglected areas that will allow alternative proteins to compete on taste and price. We develop open-access research and resources, educate and connect the next generation of scientists and entrepreneurs, and fund research that benefits alternative protein development across the sector.

Influencing policy and securing government investment

GFI's policy teams ensure that alternative proteins are a part of the policy discussion around climate change mitigation and global health. In every region where we have a presence, we advocate for government investment in alternative proteins and are paving the way for the approval of novel proteins such as cultivated meat.

Supporting industry to advance alternative proteins

GFI's corporate teams are replicating past market transformations and partnering with companies and investors across the globe to drive investment, accelerate innovation, and scale the supply chain—all faster than market forces alone would allow.

Stay connected

- **Newsletters** | GFI's suite of expertly curated newsletters puts timely news, insights, and opportunities right in your inbox. Check out gfi.org/newsletters to find the ones most suitable for your interests.
- **Monthly seminar series** | Each month, we host [online seminars](#) with leading experts from around the world: The *Business of Alt Protein* series is geared toward a commercially focused audience on topics related to starting and scaling a good food business. The *Science of Alt Protein* series addresses a technical audience and focuses on cutting-edge research developments that enable alternative protein innovation.

This State of the Industry Report series, as well as all of GFI's work, is made possible by gifts and grants from our global family of donors. If you are interested in learning more about giving to GFI, please visit [here](#) or contact philanthropy@gfi.org.

Table of contents

Editors' note	2
Symbols to look for	3
About the Good Food Institute	4
Executive summary	11
Section 1: Commercial landscape	17
Overview	17
Cultivated meat ventures	20
Involvement by conventional meat and food companies	24
Partnerships	25
Hybrids	28
Tastings	29
Facilities	30
Industry associations and alliances	32
Consumer insights	33
Nomenclature	36
More than meat: Promising applications for animal cell technology	37
Cultivated meat image library	38
Section 2: Investments	40
Overview	40
2022 investment overview	43
Methodology of investment calculations	45
Most active investors in 2022	50
Liquidity events	51
Other financing	52
Section 3: Science and technology	54
Overview	54
Research across the technology stack	54
Research on environmental and social impacts	60
Research on food safety, nutrition, and public health	62
Scientific ecosystem growth	66
Section 4: Government and regulation	72
Overview	72

Global public funding	72
Global regulation	74
Global coordination	81
Section 5: Forecast	84
Cultivated meat forecasts	84
A deeper dive into alternative protein market forecasts	86
Examining the structure of alternative protein market forecasts	88
Industry drivers	90
Industry roadblocks	91
Expert predictions	93
Conclusion	95
Acknowledgements	97

Executive summary

Executive summary

In 2022, cultivated meat and seafood moved closer to our plates than ever before.

Across the areas of science, innovation, talent, and public and private sector support, 2022 delivered major advances and grew momentum for this still early-stage industry—one on the cusp of transforming 12,000-year-old ways of making meat. New companies, production facilities, and partnerships were formed. A cultivated chicken product earned the go-ahead nod from the U.S. FDA. The world's largest dedicated food technology venture fund was launched. Fresh consumer insights and market analysis pointed to growing international interest in cultivated meat adoption. New partnerships and global alliances formed to advance the science and scaling of cultivated meat.

Cultivated meat and seafood, part of our 2022 State of the Industry Report series, takes a field-wide view of the progress made over the past year.

Commercial landscape

Major path-to-market milestones

- In the U.S., FDA completed its first premarket review for a cultivated meat product (**UPSIDE Foods'** cultivated chicken), with several other reviews pending. This brought cultivated meat one step closer to consumers' plates— a major de-risking signal for investors.
- In Singapore, **GOOD Meat's** cultivated chicken was served at a handful of iconic hawker stalls, further demonstrating cultivated meat's culinary versatility.

Private investment firsts

- The largest deals to date for both a cultivated meat and a cultivated seafood company occurred in 2022 (**UPSIDE Foods** and **Wildtype**).
- The number of unique investors in cultivated meat and seafood grew by 19 percent to 679 investors total. Median deal sizes by round were generally higher in 2022 vs. 2021, a year of record funding.

Large food companies lean in

- There are now more than 70 diversified companies with activity in the cultivated meat industry, up from 60 companies in 2021.
- The world's top three meat companies (by revenue) are all involved in the cultivated meat industry.

Innovation fuels competitiveness with conventional products

- Research on cell lines, cell culture media, and scaffolding is demonstrating the path to cost reduction and efficient scaling.
- Hybrid solutions permeated the alternative protein space, as food producers worked to blend plant-based, fermentation, and cultivated meat production in the pursuit of products that reach taste and price parity with conventional meat. For example, the world's first innovation center dedicated exclusively to hybrid cultivated and plant-based meat products opened in Singapore.

Power of partnerships

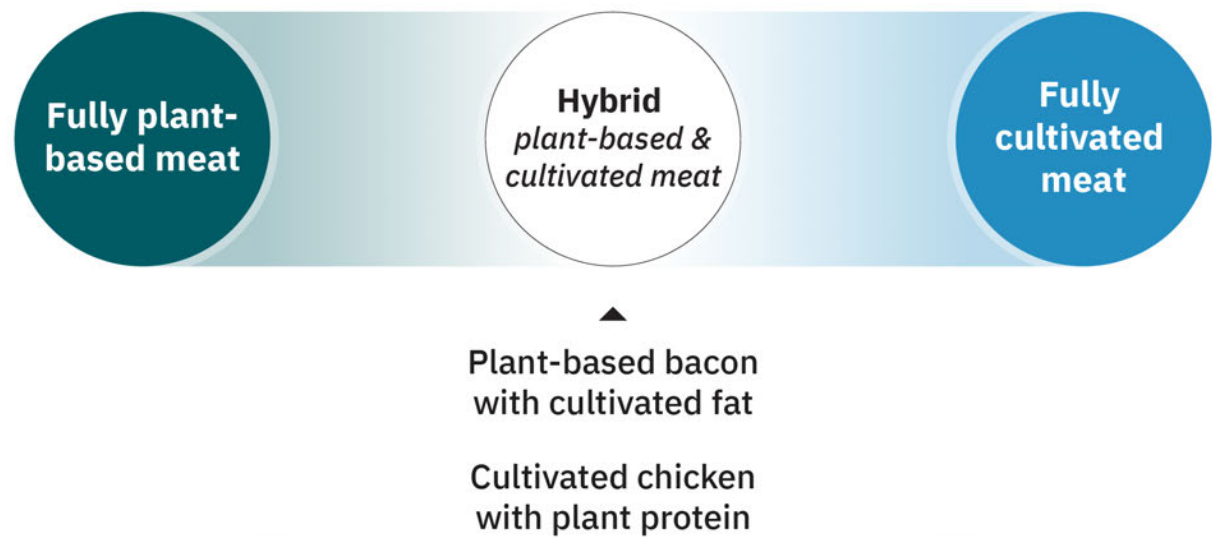
Notable partnerships formed in pursuit of scale. The U.S.-based Alliance for Meat, Poultry, and Seafood Innovation, the APAC Society for Cellular Agriculture, and Cellular Agriculture Europe teamed up to launch a new global alliance to collaborate on regulatory work, consumer research, and nomenclature.

“Cultivated” gains momentum

- New research showed consumer preferences for using “cultivated meat” over “cell-cultured meat.”
- A Memorandum of Understanding was signed by over 30 APAC companies and stakeholders agreeing to use “cultivated” as the common, shared term.

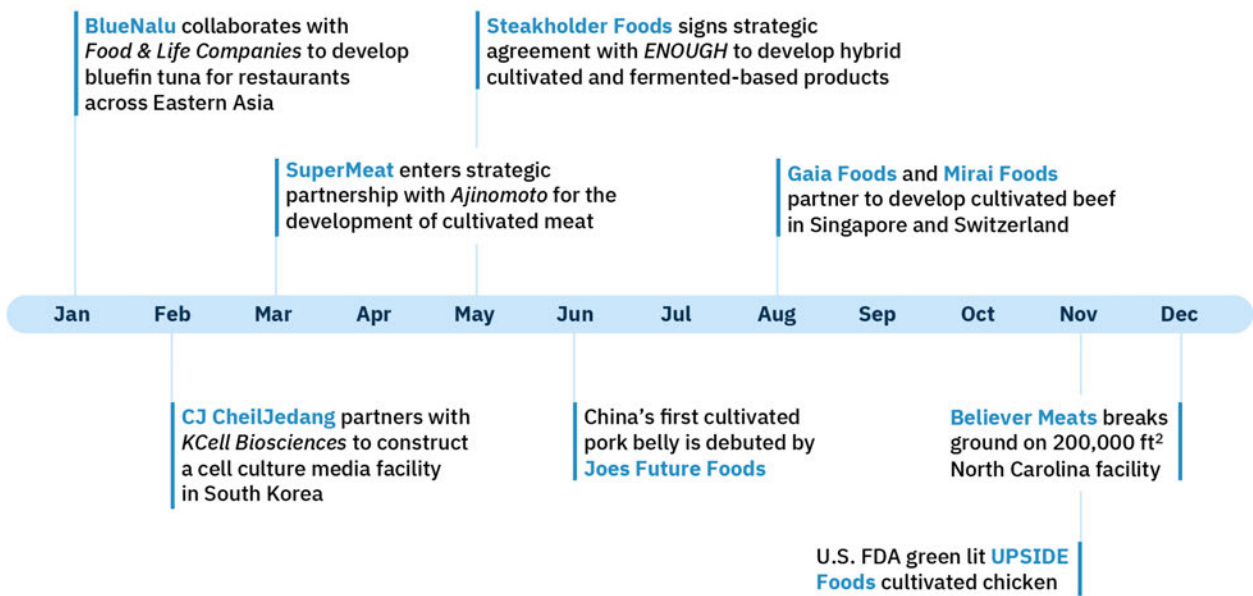


Figure 1: A spectrum of alternative protein products



Many companies working on cultivated meat will initially release hybrid plant protein/cultivated meat products.

Figure 2: Major highlights for cultivated meat in 2022



Investments

Cultivated meat and seafood companies raised \$896 million in 2022, bringing the total for the industry (since 2016) to \$2.78 billion. While the 2022 raises represent a deceleration of 33 percent year-over-year (YOY), this rate outperformed the overall global funding decline of 35 percent YOY and outpaced funding for select sectors popular with venture capital funds. Moreover, both APAC and Europe saw higher cultivated meat investments in 2022 than in the year prior. In APAC, cultivated meat companies raised more capital in 2022 than in all prior years combined. The largest deals to date for both a cultivated meat and a cultivated seafood company occurred in 2022, and the number of unique investors in cultivated meat and seafood grew by 19 percent to 679 total investors.

Table 1: Invested capital in cultivated meat

Category	2022	2021	All-time (since 2016)	2022 highlights,
Total invested capital	\$896MM	\$1.3B	\$2.8B	From 2016 to 2022, cultivated meat and seafood investments tripled on average annually.
Invested capital deal count	77	83	294	2022's largest investment was \$400MM (UPSIDE Foods).
Unique investors	110	263	679	The number of unique investors grew by 19% in 2022.
Growth stage deals (Series B and above)	3	7	12	These included Wildtype, UPSIDE Foods, and SciFi Foods.
Liquidity events	\$39MM	\$18MM	\$58MM	JBS acquired cultivated meat producer BioTech Foods.

Science and technology

New research advanced our understanding of cultivated meat and its impacts, while the research ecosystem grew at universities around the world:

- 13 multiyear research projects, including those focused on cell lines, serum-free cell culture media development, and scaffolding were published, many in open-access journals.
- New and updated life cycle assessments found that cultivating meat is a more efficient form of meat production compared to conventional meat, resulting in less land use and reduced air and water pollution.
- Awareness increased around cultivated meat's potential to eliminate antibiotics from meat production, the overuse of which threatens public health on a global scale.
- Universities worldwide launched seven new alternative protein courses and one certificate program.

Government and regulation

Governments around the world showed support for cultivated meat in notable ways, from an uptick in public policymaking and funding for R&D to FDA's greenlight of a cultivated chicken product in the U.S.

- In Europe, the Netherlands announced \$65 million in funding for cultivated meat and precision fermentation, the world's largest-ever public investment in the cellular agriculture field.
- Israel, China, and South Korea all increased policy support for cultivated meat development.
- The U.S. Congress directed nearly \$6 million in research funds to alternative protein R&D. California approved the first-ever state investment in cultivated meat research, directing \$5 million to R&D across three labs, two of which focus on cultivated meat.
- Israel launched the largest government-backed cultivated meat consortium to date, involving the country's top food producers and academic labs.

Section 1

Commercial landscape

Section 1: Commercial landscape

Overview

The past year marked the beginning of a phase-change in cultivated meat and seafood—from bright idea to delicious reality.

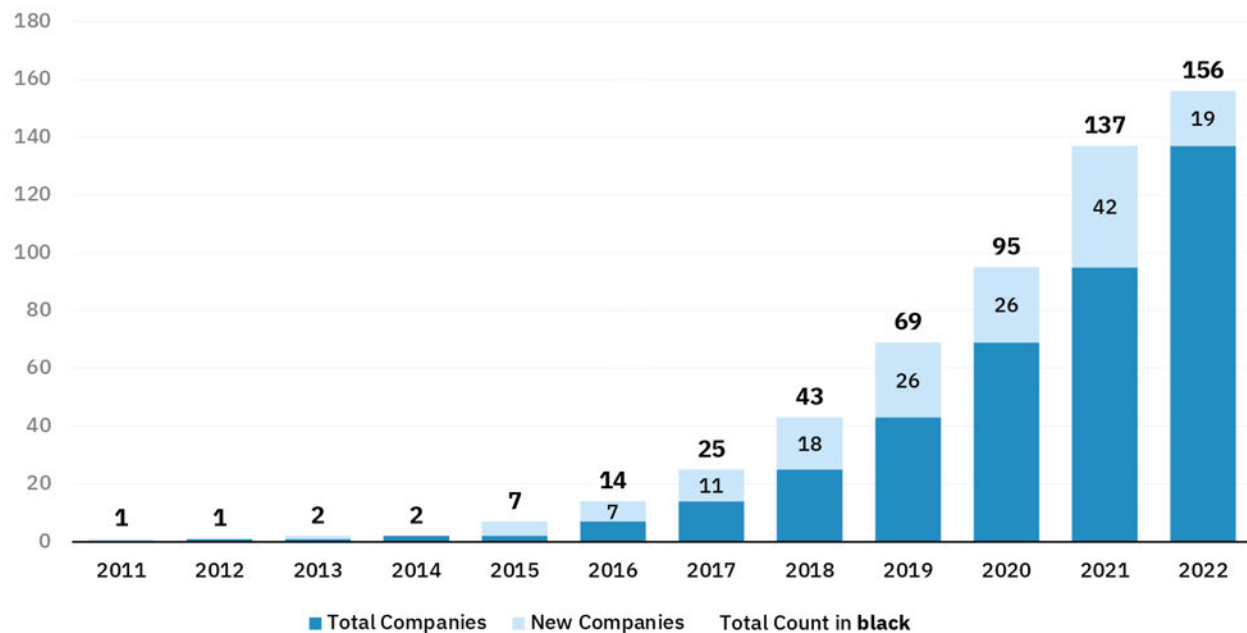
In 2022:

- FDA gave **UPSIDE Foods** a regulatory “green light” for their cultivated chicken—a major breakthrough for cultivated meat in the United States. With only a few regulatory steps remaining (a USDA grant of inspection and label pre-approval), cultivated meat has never been closer to the U.S. market than it is today.
- The total number of publicly announced cultivated meat companies rose to 156. Cultivated meat is officially a global industry. As of the end of 2022, there are companies headquartered in 26 different countries in every major world region.
- To date, there are 18 operational facilities worldwide dedicated to producing cultivated meat or seafood. Numerous cultivated meat companies broke ground on, opened, or announced facilities, bringing the total number of planned or operational pilot-scale (or larger) facilities to 27 (the first known pilot-scale facility opened in 2017).
- At least 11 new strategic partnerships were announced between cultivated meat companies and major food companies such as **ADM**, **Ajinomoto**, and **Tnuva**, bringing the total number of major partnerships to at least 35.
- The industry continued to align on “cultivated” as the go-to term: GFI APAC and the APAC Society for Cellular Agriculture announced a new Memorandum of Understanding stating that “cultivated” is the preferred English-language term with 36 signatories, including almost all producers based in APAC, invested multinationals, and other public and private industry players.
- New research commissioned by GFI further confirmed the finding that “cultivated meat” performs best with consumers for appeal and differentiation from conventional.



For everything you need to know and more, read [GFI's statement](#), [FDA's explanatory infographic](#), and press coverage from [The New York Times](#), [Wall Street Journal](#), and [TIME](#).

Figure 3: New and total publicly announced cultivated meat companies, by year founded



Sources: GFI company database, PitchBook, Crunchbase, manufacturer websites.

This graphic includes all publicly announced cultivated meat companies that GFI is aware of, but it may not include all cultivated meat companies founded in 2022 as many companies begin in stealth mode. For example, in our *2021 Cultivated meat and seafood* report, we reported that 21 new companies were founded in 2021, and that number has since increased to 40 as companies founded in 2021 launched out of stealth mode in 2022. We anticipate that the 18 companies founded and announced in 2022 are similarly an underestimate, and we expect more companies founded in 2022 to announce their work in 2023. Readers can refer to GFI's [company database](#) for an up-to-date count of announced cultivated meat companies.

Commercial firsts

As an industry, cultivated meat and seafood is still in its early days. Each new year brings new milestones and firsts, and 2022 was no exception:

Distribution firsts

Mar 2

GOOD Meat (the cultivated meat arm of alternative protein company Eat Just) partnered with chefs at Singaporean hawker stalls (food stands) to serve cultivated chicken, marking the first time hawker stalls have served cultivated meat.

Dec 8

GOOD Meat also announced the sale of their cultivated chicken at Singapore's Huber's Butchery, making Huber's the first butchery to serve cultivated meat.

Prototypes

Feb 10	Cultivated meat startup Space F <u>announced</u> South Korea's first prototypes of cultivated chicken fillets and nuggets as well as cultivated beef meatballs and a patty.
Mar 18	Germany-based Alife Foods <u>revealed</u> the first cultivated schnitzel (breaded cutlet) prototype.
Apr 1	Mogale Meat , a startup based in South Africa, <u>developed</u> Africa's first cultivated chicken breast made from cultivated and plant ingredients.
Apr 14	Mzansi Meat , also based in South Africa, <u>developed</u> Africa's first cultivated beef burger.
Aug 18	Brazil-based startup Cellva unveiled their first cultivated meat burger prototype. At the end of the year, they transitioned into developing cultivated pork fat.
Jun 10	China-based cultivated meat startup Joese Future Foods <u>debuted</u> China's first cultivated pork belly at the New Technology Conference.
Jul 26	Pearlita Foods <u>announced</u> a prototype of the first cultivated oyster meat.
Aug 8	Germany-based Bluu Seafood <u>announced</u> the development of cultivated fish sticks and fish balls made from a blend of cultivated fish and plant proteins.
Aug 27	Believer Meats (formerly Future Meat Technologies) <u>shared</u> their prototype of cultivated ground lamb meat.
Sep 4	Magic Valley , based in Australia, <u>unveiled</u> their cultivated lamb burger and taco prototypes.
Oct 4	Meatiply , based in Singapore, <u>debuted</u> three new product prototypes at an invitation-only tasting, including Asia's first cultivated smoked duck breast meat, made from a blend of cultivated and plant-based ingredients.
Nov 17	UK-based 3D Bio-Tissues <u>revealed</u> three cultivated meat fillet prototypes.
Dec 5	Brazilian-based Cellva launched its prototype of cultivated pork fat.
Dec 7	Singapore-based ImpacFat <u>unveiled</u> the world's first cultivated fish fat, rich in Omega-3 fatty acids.

Cultivated meat ventures

While more than 150 companies are purely focused on cultivated meat or seafood, 70 additional companies have joined the industry through partnerships or product/service offerings along the cultivated meat technology stack. Most of these companies are active in the food and beverage or life sciences industries and aim to 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.

- At least 156 dedicated cultivated meat companies have publicly announced themselves, up from 107 companies in 2021. This number is likely an underestimate of the true number of cultivated meat companies, as it is common for companies to begin in “stealth mode” and announce their formation upon hitting a first milestone, like successful fundraising or a product prototype.
- In addition, there are now more than 70 diversified companies with activity in the cultivated meat industry, up from 60 companies in 2021. Mature food and supply companies join the cultivated meat sector through investment, acquisition, or production of inputs for cultivated meat, including bioreactors, growth factors, cell culture media, cell lines, scaffolds, or ingredients for end-product formulation. Examples of major diversified companies with involvement in cultivated meat include Nestlé, Merck KGaA, Mitsubishi, JBS, Kerry, and CP Kelco.

Table 2: Distribution of companies by country and region

▼ Africa and Middle East				Count 20	
Israel	17	South Africa	3		
▼ Asia Pacific				Count 37	
Australia	4	Japan	3	Singapore	12
China	5	New Zealand	1	South Korea	7
India	4	Russia	1		
▼ Europe				Count 43	
Austria	1	Estonia	1	Spain	2
Belgium	1	France	3	Switzerland	1
Croatia	1	Germany	6	Turkey	1
Czech Republic	2	Italy	1	United Kingdom	17
Denmark	1	The Netherlands	5		
▼ Latin America				Count 4	
Brazil	1	Chile	2	Mexico	1
▼ North America				Count 52	
Canada	9	United States	43		

1–9 companies
10–19 companies
20+ companies

Sources: GFI company database, PitchBook, Crunchbase, manufacturer websites.

This graphic includes all publicly announced cultivated meat companies that GFI is aware of, but it may not include all cultivated meat companies founded in 2022 as many companies begin in stealth mode. We expect more companies founded in 2022 to announce their work in 2023. Readers can refer to GFI's [company database](#) for an up-to-date count of announced cultivated meat companies.



Please visit [this link](#) for a full list of all known cultivated meat companies.






















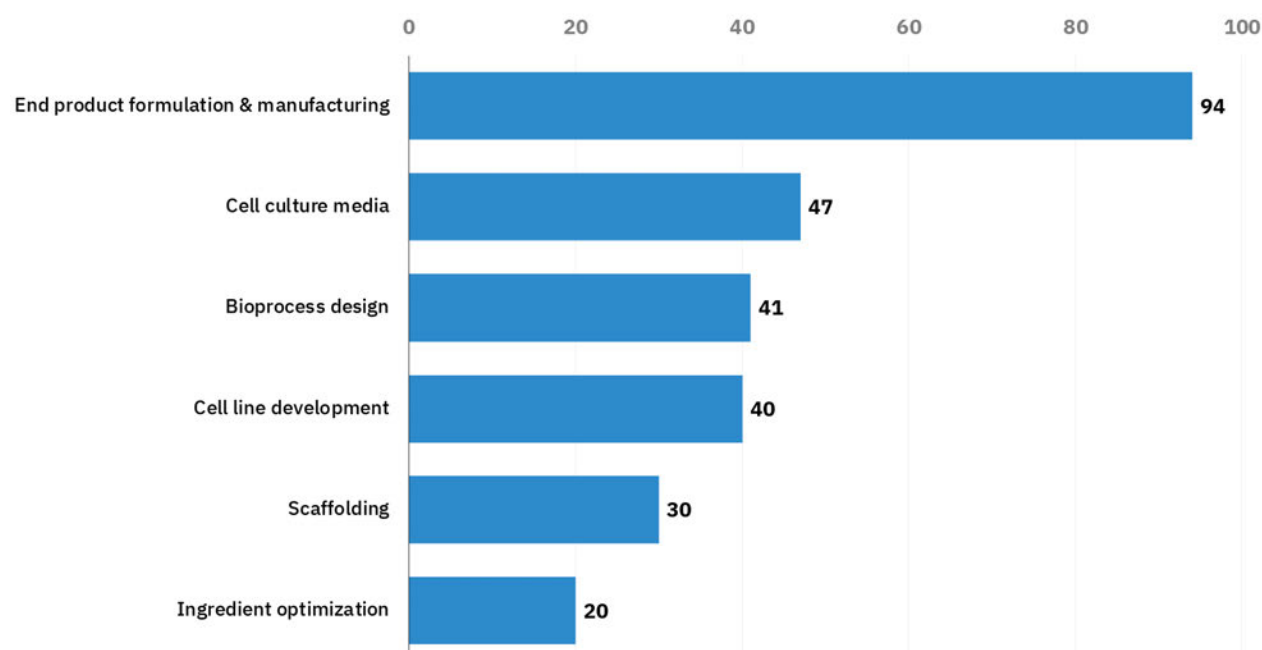
Company	Brief Description	Year Founded	Website	Logo	Protein Category	Company Focus	Technology Focus
3D Bio-Tissues Ltd.	U.K.-based research entity ...	2018	https://www.3dbiotissues.com/		Cultivated	Ingredients and inputs	Bioprocess design
108Labs	US-based company creatin...	2013	https://108labs.net/		Cultivated	Dairy	End product formulatio...
Agulos Biotech	U.S.-based startup developi...	2017	http://agulosbiotech.com/		Cultivated	Bioprocessing infrastru...	Cell culture media
Aleph Farms	Israel-based company prod...	2017	https://www.aleph-farms.com/		Cultivated	Meat	End product formulatio...
Alife Foods	Germany-based company p...	2019	http://alifefoods.de/		Cultivated	Meat	End product formulatio...
Alt Atlas Ltd.	AI-powered food ingredient...	2021	https://alt-atlas.com/		Cultivated	Meat	Ingredients and inp
Ambi Real Food	Brazil-based company prod...	2021	https://ambirealfood.com/		Cultivated	Meat	End product formulatio...
Animal Alternative Technologies	U.K.-based company creati...	2020	https://www.animalaltern...		Cultivated	Bioprocessing infrastru...	Bioprocess design
ANJY MEAT	Croatia-based company cre...	2021	http://anjymeat.com/		Cultivated	Meat	End product formulatio...
Another Fish	Canada-based company tha...	2021	www.another.fish		Cultivated	Meat	Seafood
Ants Innovate	Singapore-based deep tech...	2020	https://www.antsinnovate...		Cultivated	Meat	End product formulatio...
Appleton Meats	Canada-based company wo...	2016	https://www.crunchbase...		Cultivated	Meat	End product formulatio...
Ark Biotech	U.S.-based company that pr...	2021	https://www.ark-biotech.c...		Cultivated	Food processing infrast...	Bioprocess design
ArtMeat	Russia-based start-up worki...	2019	http://artmeat.pro/		Cultivated	Meat	Seafood
Atlantic Fish Co	US-based company creatin...	2022	https://www.linkedin.com/...		Cultivated	Seafood	End product formulatio...
Avant Meats	Hong Kong-based company...	2018	https://www.avantmeats.c...		Cultivated	Meat	Seafood
Because Animals	U.S.-based company makin...	2016	https://becauseanimals.c...		Cultivated	Other	Meat
Believer	Israel-based startup workin...	2017	https://www.future-meat...		Cultivated	Meat	Cell line development
Bene Meat Technologies	Czech Republic-based com...	2020	https://www.benemeat.co...		Cultivated	Bioprocessing infrastru...	Bioprocess design
Biftek	Turkey-based start-up work...	2018	http://biftek.co/		Cultivated	Meat	Cell culture media
BioBetter	Israel-based developing pla...	2015	www.biobetter.bio		Cultivated	Ingredients and inputs	Bioprocess design

Figure 4: Number of companies by technology focus



Source: GFI Company Database

In terms of technology, many of the cultivated meat companies that exist today began as vertically integrated. They manage most stages of the technology stack in-house, often looking to the life sciences industry for inputs such as cell culture media and bioreactors that have not yet been optimized for cultivated meat production. While many companies are still involved in multiple stages of the technology stack, as the cultivated meat industry matures, the B2B ecosystem will continue to develop as companies seek to specialize in one or two steps of cultivated meat production.



“Availability of industry-specific products and services is beginning to increase, and this accelerates progress among the product-focused cultivated meat companies. For instance, there now are a few players focused on growth factors, and some will be able to offer drastically higher volumes and lower cost compared to the traditional pharma/life science suppliers within the next 12-18 months. Availability of such inputs will de-bottleneck scale-up and cost-down. The biggest bottleneck to growth will be the ability of teams to plan with the volatile economic situation and lower capital availability. Efficiently using equity—and other financing sources where possible—to drive progress while de-risking the business as much as possible will be the name of the game.”

– Friederike Grosse-Holz, Director, Blue Horizon

Involvement by conventional meat and food companies





All of the top five U.S. meat companies as well as the top five U.S. consumer packaged goods (CPG) food companies are involved with alternative proteins in some capacity. As of 2022, the number two ranked CPG food company and the top three meat companies (by revenue) are involved in the cultivated meat industry.

Table 3: Conventional companies with involvement in alternative proteins

	    					    				
	CPG Companies					Meat Companies				
Investment	✓	✓	✓		✓	✓✓✓		✓✓		
Acquisition		✓	✓				✓✓			
Partnership	✓	✓	✓	✓✓				✓✓		✓
Manufacturing and R&D		✓	✓	✓✓	✓✓	✓	✓✓	✓	✓	✓

 Cultivated meat
  Fermentation
  Plant-based

Table 4: Conventional companies with involvement in cultivated meat

				
	CPG company	Meat companies		
Investment		✓		✓
Acquisition			✓	
Partnership	✓			
R&D and manufacturing	✓		✓	

- In 2021, **Nestlé** began a partnership with **Believer Meats** (formerly Future Meat Technologies) to develop products with plant-based ingredients and Believer's cultivated meat. When announcing the partnership, Nestlé also indicated that they were evaluating options for producing their own cultivated meat.
- **Tyson Foods** invested in cultivated meat companies **UPSIDE Foods** in 2018 and **Believer Meats** in 2021.
- **JBS** acquired cultivated meat startup **BioTech Foods** in 2022 and announced the development of a cultivated meat R&D center in Brazil. JBS completed the acquisition in May and announced that they had chosen Florianópolis, Brazil as the site of the center.
- **Cargill** has invested in nine cultivated meat deals to date.

Partnerships

Collaborations with key research, production, and distribution partners are essential for scaling the cultivated meat sector. Here are some of 2022's publicly announced partnerships:

Research and development

Large food companies or institutions with existing R&D infrastructure can serve as valuable partners to cultivated meat startups.

- Israel-based cultivated seafood startup **Wanda Fish** signed licensing agreements with **Tufts University**. Wanda Fish will support a two-year cultivated seafood research program in exchange for exclusive intellectual property access.
- Israel-based **SuperMeat** announced a strategic partnership with large Japanese food manufacturing company **Ajinomoto** to pool R&D capabilities to develop cultivated meat products.
- Singapore-based cultivated seafood company **Shiok Meats** signed a partnership with **Minh Phu Seafood**, Vietnam's largest conventional shrimp producer, to develop a combined R&D facility focused on cultivated shrimp.
- Cultivated meat company **Meatable**, based in the Netherlands, announced a "Future of Meat" innovation center with Singapore's plant-based butcher **Love Handle** to create hybrid meat products. The center is scheduled to open in 2023 and is supported by the **Singapore Economic Development Board**.

Product development

Given that most cultivated meat products will first launch as hybrid plant-based/fermentation products, there is a substantial opportunity for cultivated meat startups to partner with other alternative protein companies on joint product development.

- Israel-based cultivated meat company **Steakholder Foods** (formerly MeaTech 3D) announced that their subsidiary **Peace of Meat** signed a strategic agreement with mycoprotein company **ENOUGH** to develop hybrid cultivated and fermentation-based products.

Scale-up

Scale is the main obstacle to—and an opportunity for—lowering the price of cultivated meat. A number of partnerships in 2022 focused on scaling cultivated meat production, with companies sharing technology, infrastructure, and inputs.

- Major Israeli food producer **Tnuva** announced a collaboration with biotechnology company **Pluristem** to develop and commercialize cultivated meat products.
- One of Asia's largest food and biotech companies, **CJ CheilJedang**, is entering the cultivated meat industry in partnership with **KCell Biosciences**, a startup focused on cell culture media. The companies will construct a cell culture media facility in Busan, South Korea.
- **SuperMeat** signed a Memorandum of Understanding with large poultry company **PHW**. The companies plan to collaborate on the manufacture and distribution of SuperMeat's cultivated meat.
- **GOOD Meat** entered into a strategic partnership with ingredients supplier **ADM**, who will help optimize cell culture nutrients to accelerate GOOD Meat's production process.
- Singapore-based cultivated seafood startup **Umami Meats** partnered with Israel-based **Steakholder Foods** (formerly MeaTech) to apply their 3D printing technology to the development of Umami's cultivated seafood products.
- Singapore-based **Gaia Foods** (a subsidiary of cultivated seafood company **Shiok Meats**) and Switzerland-based **Mirai Foods** entered a strategic partnership to develop cultivated beef. The companies will collaborate on ingredients manufacturing and distribution, with plans to launch cultivated beef in Singapore and Switzerland.

Distribution

While cultivated meat is commercially sold in just one country in 2022 (Singapore), a number of companies landed new distribution partnerships that will allow consumers across regions to access cultivated meat products upon regulatory approval.

- San Diego-based cultivated seafood company **BlueNalu** collaborated with sushi restaurant operator **Food & Life Companies** to develop bluefin tuna for Food & Life Companies' 1,000+ restaurants across Japan, South Korea, Singapore, Thailand, mainland China, Hong Kong, and Taiwan.
- Cultivated chicken company **SuperMeat** signed a Memorandum of Understanding with **Migros**, Switzerland's largest retailer and leading meat manufacturer. Migros will invest in SuperMeat and leverage their distribution and manufacturing network to help SuperMeat scale their cultivated chicken.
- Mexico-based cultivated meat company **Micro Meat** announced a partnership with U.S.-based **Orbital Assembly**, a developer of space-based business parks with variable gravity, to install their meat production equipment in OA's Pioneer-class space stations.
- U.S.-based cultivated meat company **Orbillion Bio** announced a partnership with meat company **Luiten Food**. The collaboration aims to bring cultivated wagyu beef to Europe, pending regulatory approval. The partnership will provide Orbillion Bio with access to Luiten's 1,200 distribution points, and the companies plan to eventually develop manufacturing facilities in Europe.



For a full list of companies with initiatives in cultivated meat and seafood, visit [GFI's company database](#).

Hybrids

As costs decrease and production volumes go up, cultivated meat and seafood companies are well-positioned to launch commercially as soon as they secure regulatory approval. Once a regulatory path to market is secured, any near-term commercial launches will still be small-scale, with limited product availability and premium positioning owing to the relatively high cost of producing small volumes.

Hybrid products—cultivated meat and fat supplemented with plant-based or fermentation-derived proteins—can accelerate launches and make ingredients more accessible while improving the taste and sensory appeal of alternative protein products. Adding plant-based protein to cultivated meat not only decreases cost but may also add beneficial nutritional attributes like fiber.

Most companies preparing to go to market will enter with hybrid products that have a mix of cultivated and plant-based ingredients, a trend we expect to continue in the near future.



Now is the time for successful market players that have a voice in the market, and start ups to define common goals and to start working on products that could potentially define the market in the future. That is exactly what we envision with our strategic cooperation with MIRAI Foods. We want to develop Germany's first hybrid plant based/cultivated fat burger. We have been very successful at implementing vegan meat alternatives. But we have also understood that there is a proportion of consumers that is not ready to fully switch to a vegan diet. Hence, we think—if it's the sensory part that is holding consumers back—a hybrid product will be the optimal solution!

– Patrick Bühr, Head of Research & Development, Rügenwalder Mühle

Tastings

While cultivated meat is not yet on the market (except in Singapore, as of this report’s April 2023 publication), many companies hold private tasting events for policymakers, investors, journalists, and other stakeholders. Such sampling events continued in 2022, enabling more people to get a taste of the future of meat:



GOOD Meat brought their cultivated chicken to the global stage by organizing a tasting at this year’s COP27 event, with support from GFI APAC.

Photo: GOOD Meat

Jan 23	Israel-based SuperMeat held a <u>blind tasting event</u> of their cultivated chicken product, alongside conventional chicken, for chefs, journalists, and professional tasters.
Mar 30	MeaTech 3D and their subsidiary Peace of Meat held a <u>tasting event for investors featuring chicken nuggets</u> made from cultivated and plant protein ingredients.
Apr 1	SOSV and Apeiron Investment Group held the “ <u>Taste the Future</u> ” event featuring samplings of plant-based, fermented, and cultivated proteins.
Apr 14	Mzansi Meat <u>served</u> their cultivated beef burger at an event in Cape Town.
May 17	Celebrations during <u>Israel’s Independence day</u> featured samples of alternative protein products, including SuperMeat ’s cultivated product.

Jun 10	China-based cultivated meat startup Joese Future Foods debuted China's first <u>cultivated pork belly</u> at the New Technology Conference.
Aug 30	<u>Feed9Billion</u> and the Singapore Restaurant Week organized a "VVIP" cultivated-meat tasting dinner with dishes provided by Aleph Farms, Umami Meats, Avant Meats, and Shiok Meats .
Oct 10	Singapore's cultivated seafood company Umami Meats <u>debuted</u> their structured fish filet and fish cakes at Singapore's Agri-Food Week.
Nov 11	GOOD Meat brought their cultivated chicken to the global stage by organizing a <u>tasting</u> at this year's COP27 event, with support from GFI APAC.
Dec 7	ImpacFat offered <u>tastings</u> of their cultivated fish fat (incorporated into plant-based meat) at Big Idea Ventures' Demo Day in Singapore.
Dec 8	South Korea-based CellMEAT featured its <u>cultivated shrimp</u> at a tasting hosted at Sigolo, a restaurant in Seoul. The company announced they were ready to go to market pending regulatory approval.

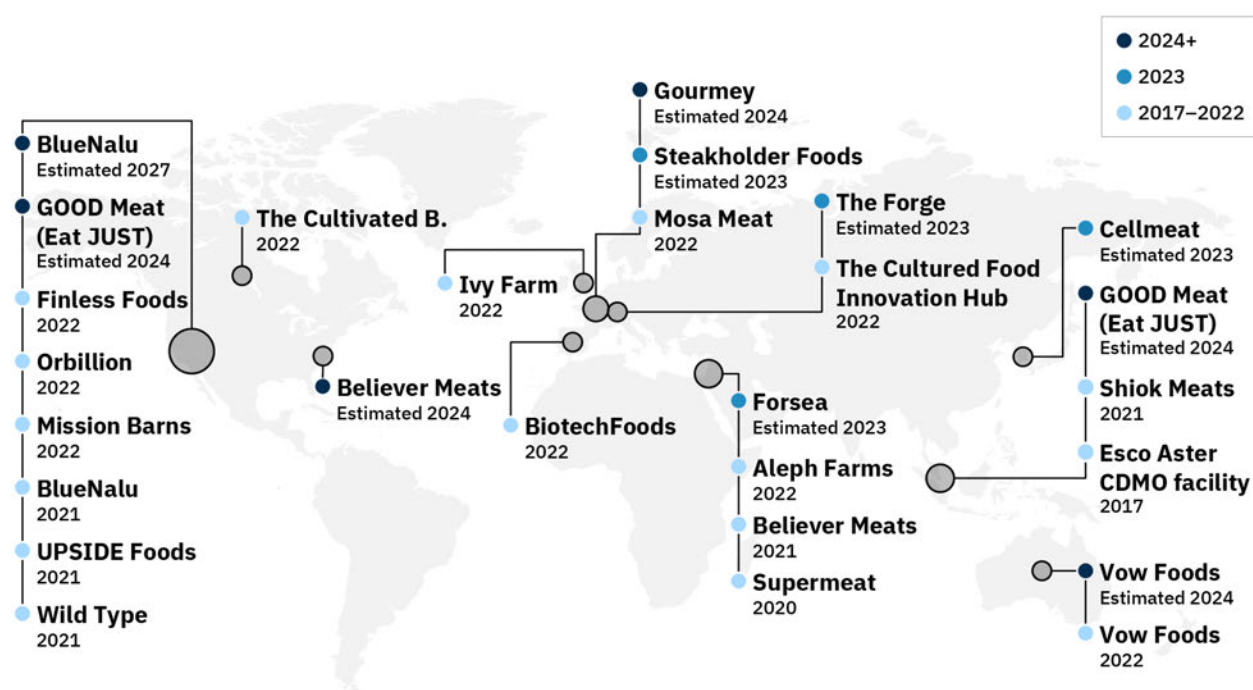
Facilities

The scale-up of a bioprocess, whether to produce biofuels, therapeutic antibodies, or cultivated meat, generally occurs in four phases: lab scale, pilot scale, demonstration scale, and commercial (industrial) scale. The 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 product yield.

Demonstration-scale and industrial-scale cultivated meat facilities will produce hundreds or thousands of kilograms of cultivated product annually. This means that, after securing a regulatory path to market, companies are likely to have the capacity to supply a limited number of restaurants in the subsequent one to three years, along with producing samples for regulators and key industry partners.

A number of companies opened, announced, or broke ground on new cultivated meat facilities in 2022, bringing the total known number of planned pilot-scale (or larger) facilities to 27 worldwide.

Figure 5: Current and future cultivated meat production facilities



Facilities that opened in 2022:

- Cultivated meat startup **Aleph Farms** moved their headquarters to Rehovot, Israel. The new HQ includes a pilot production facility, capable of producing 10 metric tons/year, and an R&D center.
- Germany-based bioengineering company **The Cultivated B.** announced the opening of a 130,000-square-foot cellular agriculture facility in Ontario, Canada, in partnership with **Ontario Genomics**, a government-funded nonprofit.
- Australian cultivated meat company **Vow** opened Factory 1, a facility capable of producing 30 tons of cultivated meat per year, which is the largest of its kind in the southern hemisphere.
- UK-based **Ivy Farm Technologies** opened a pilot plant capable of producing 2.8 tons of cultivated meat per year, the largest of its kind in Europe.
- India-based **FermBox** launched a new 40,000-liter state-of-the-art cell manufacturing facility in Karnataka, India, with single-use bioreactor volumes and multiple bioreactor suites ranging from four liters to 2,000 liters for every stage of development of cultivated meat products.

Facilities that broke ground in 2022:

- **GOOD Meat**, the cultivated meat subsidiary of **Eat Just**, broke ground on a new cultivated meat facility, located in Singapore, which will be capable of producing up to 50 tons of cultivated meat per year.
- **Believer Meats**, formerly known as Future Meat Technologies, broke ground on a 200,000-square-foot facility in North Carolina that will have the capacity to produce at least 10,000 metric tons of cultivated meat per year.

Facilities that were announced in 2022:

- Israel-based cultivated meat company **Steakholder Foods** (formerly **MeaTech**) plans to build a cultivated fat pilot plant capable of producing 20 tons per year in Antwerp, Belgium, where **Peace of Meat** (a subsidiary of MeaTech) is headquartered.
- **CellMEAT**, a cultivated seafood startup based in South Korea, is constructing a 3,600-square-foot facility in Seoul. It will have a mass production capacity of 100,000 kg per year and is projected to become operational in early 2023.
- **Gourmey**, a cultivated meat startup based in France, plans to construct a 46,000-square-foot commercial production facility and R&D center in Paris to manufacture and commercialize their first product line after raising a €48 million (\$47.1 million) Series A round led by **Earlybird Venture Capital**.
- One of the first cultivated meat companies, **Mosa Meat**, announced an expansion of their Maastricht-based pilot and R&D facility.

Industry associations and alliances

A number of new regional cultivated meat industry associations were formed in 2021. In 2022, several of these organizations joined forces to advance the global cultivated meat industry. The U.S.-based Alliance for Meat, Poultry, and Seafood Innovation, the APAC Society for Cellular Agriculture, and Cellular Agriculture Europe teamed up to launch a new global alliance.

Industry associations and alliances can support regulatory transparency, conduct and share consumer research, and secure alignment on nomenclature.

Consumer insights

It is critical to note that consumer research on cultivated meat products is being performed largely in a pre-launch environment. It is GFI's expectation that as products come to market and more consumers become familiar with the concept and the experience of eating cultivated meat, that results of consumer surveys and testing can improve in cultivated meat's favor.

Consumer awareness and familiarity

When it comes to consumers' familiarity with cultivated meat, research and responses vary, yet show some consistent trends. A high percentage (ranging from 38 to 64 percent) of consumers say they are not at all familiar with cultivated meat. A 2021 study showed that 59 percent of U.S. consumers said they were not at all familiar with cultivated meat, and only seven percent stated they were very or extremely familiar. Consumer research conducted in December 2022 by GFI and Embold Research found that only 32 percent of respondents reported having heard of cultivated meat before. [This familiarity gap leaves a huge opportunity for consumer education and exposure.](#)

Consumer willingness to try

On the measure of U.S. consumers' willingness to try cultivated meat, we again see varying data but a general trend. Based on consumer studies from 2017 to 2019 that all asked—in nearly identical ways—about consumers' "willingness to try" cultivated meat, just one in five respondents were not willing to try cultivated meat and more than 60 percent were willing to try. Many of these studies also demonstrate that after cultivated meat technology is explained to consumers, for example via an explanation of the cell culture process, the qualities of the product, and a brief explanation of social, public health, and environmental benefits, consumer support for cultivated meat increases. The effect of this consumer education is even higher for groups who report being very or extremely willing to try cultivated meat.

This same question was presented in the 2021 study mentioned above, but without the option of "unsure," and revealed similar results with one in five again not being likely to try cultivated meat, but this time 80 percent being at least somewhat likely to try cultivated meat. Provided an option to select "unsure," we might infer that results may align closely with the above.


The 2022 GFI and Embold Research also tested U.S. consumer willingness to try cultivated meat—it found that 45 percent said they were willing to try it, followed by 23 percent who would buy it. This underscores the importance of efforts to effectively market products and provide consumer education. We also noted that few consumers report a willingness to pay more for cultivated meat than for conventional meat, which emphasizes just how critical it is for the industry to make progress toward price parity. When asked explicitly about reasons for their interest in trying cultivated meat, respondents identified curiosity and novelty as the top motivators, followed by environmental reasons, animal welfare, and global food security.

Consumer research and demographic insights around the world

- In [FMI's Power of Meat 2022 report](#), meat-eating consumers (vegans, vegetarians, and pescatarians excluded) were surveyed, with 29 percent responding that they were willing to try cultivated meat and 31 percent neutral. Appealing to this consumer segment is critical as meat-eating consumers are the largest demographic—and the ultimate target demographic to win over with cultivated meat products.
- **When broken down by generation, many studies reveal meaningful shifts in willingness to try and buy cultivated meat, with each subsequent younger generation expressing a higher likelihood of both trying and purchasing.**
 - For example, the FMI report shows 27 percent of Gen Z are willing to try cultivated meat compared with 60 percent of Boomers stating they are unwilling to try cultivated meat.
 - In hypothetical scenarios, older consumers choose farm-raised beef over plant-based or cultivated more often [compared to younger consumers](#).
- In 2022, **GFI Europe** conducted a survey examining consumer attitudes in France, Spain, Germany, and Italy. The survey, which had 4,096 respondents, found that more than half of consumers report reducing their conventional meat consumption, and more than half of consumers were willing to buy cultivated meat. [Read more](#).
- Also in 2022, **GFI APAC** released first-of-its-kind data on consumer sentiments toward alternative seafood products in four key Asian markets: Singapore, Thailand, South Korea, and Japan. The results broadly showed that local consumers are curious about cultivated seafood but want such products to meet or exceed the taste, texture, “freshness,” and health benefits of conventional seafood—a standard most believe the sector has not yet achieved. [Dive in](#).
- A new report by **BCG** examines the cultivated meat landscape in the United Kingdom, including an exploration of the environmental, health, and economic benefits of cultivated meat and levers to grow the cultivated meat market. Report authors estimate that cultivated meat may reach price parity with conventional meat in the 2030s, noting that cell culture media costs must go down and bioreactor economics must improve in order to reach price parity. [Read the report](#).

Messaging appeal

The [research](#) conducted in December 2022 by GFI and Embold Research also tested the appeal of different messaging about the various benefits of cultivated meat. A message on health benefits was the most appealing message. It described that cultivated meat can be grown without added hormones, steroids, or antibiotics, in facilities with cleaner conditions



than conventional meat processing facilities, which reduces the risk of both foodborne illnesses and future pandemics. **This finding indicates that health messaging can be part of the toolbox when performing consumer education or marketing around cultivated meat.** Messages on climate change, environmental benefits, the taste and eating experience, and food security were the next most appealing messages, and it could be worth exploring which aspects of those messages are most effective.

Familiarity within the food industry:

Chefs at the ready to support cultivated meat's debut

Because cultivated meat will first be produced at small scale and at premium prices, it's likely that most companies will initially launch their products in a small number of restaurants. Price and volume aside, launching in restaurants can be an attractive go-to-market strategy because it allows for more consistency in the consumer experience. At restaurants, companies can better guarantee that their product will be prepared in certain ways.

Given the role of restaurants in the debut of cultivated meat, chef interest in cultivated meat is critical. Some companies have made notable strides in chef engagement: UPSIDE Foods is partnering with chef Dominique Crenn, co-owner and chef of Michelin-starred restaurant Atelier Crenn to develop dishes with their cultivated chicken, and GOOD Meat added chef José Andrés to their Board of Directors.

In addition, a 2022 survey commissioned by food-tech company **SuperMeat** and conducted by independent market research consultancy Censuswide found that 86 percent of the 251 chefs/foodservice professionals polled are interested in serving cultivated meat.

A 2022 survey conducted by **GEA Group** found that out of 1,000 professional chefs surveyed, 80 percent noted that they were familiar with cultivated meat. GEA noted: "The survey data suggest that many chefs are keenly aware that cultured meat and similar products might redefine how people will eat in the future, and they see the need to closely observe and keep up with such a fundamental trend."



After the recent announcements, cultivated meat has an opportunity to be cooked and served by the hospitality industry in the very near future. Word of mouth and first hand experience of encountering cultivated meat, will spread the word, creating further consumer demand and overcoming reservations of the concept. I believed in the product back in 2013, and with the abundance of recent funding, the future of cultivated meat within the hospitality industry is within reach.

– Richard McGeown, first chef to cook cultivated meat

Nomenclature

GFI and many industry leaders have aligned on the term “cultivated meat” to describe meat cultivated from animal cells as the leading naming convention. Multiple consumer studies and industry stakeholders support this term: 75 percent of 44 industry CEOs preferred the term in a [2021 GFI survey](#), and in 2022, 36 key industry stakeholders joined GFI APAC and APAC Society for Cellular Agriculture to sign a [Memorandum of Understanding](#) declaring “cultivated” as the preferred English-language term for cultivated food products.

Additionally, the GFI and Embold research demonstrates consumer preferences for using “cultivated meat” over “cell-cultured meat” and other terms.

- When asked which terms they would be comfortable seeing on an ingredient list on food packaging (select all that apply), “cultivated meat” performed the best out of all terms tested, with 33 percent of respondents selecting cultivated meat, while only 15 percent selected cell-cultured meat.
- When asked which names they could imagine using personally (select all that apply), 26 percent of respondents selected cultivated meat, while only six percent of respondents selected cell-cultured meat.
- When consumers were asked how effective different terms are at distinguishing between this type of meat and conventional meat, cultivated meat and cell-cultured meat performed similarly to each other and better than other terms. Overall, there is still ample room for consumer education on the distinction between this product category and conventional meat.
- Cultivated meat was also the most appealing term to consumers, but all terms scored much more highly on unappealing than appealing, again highlighting a need for category positioning and consumer education.

Overall, this research supports the continued use of “cultivated meat” by the industry. This term offers the strongest combination of accuracy, ability to differentiate, and direct consumer preference. Despite momentum building around “cultivated meat,” continued use and exposure will be critical to cementing it as the standard term.

More than meat: Promising applications for animal cell technology

While animal cell cultivation for the purposes of making food is primarily used for meat production, the technology has a number of additional applications beyond meat. Select highlights from companies using cell cultivation to produce milk, eggs, collagen, or other products include:

- **Me&**, which is based at the Hudson Institute of Medical Research in Melbourne, Australia, is developing cultivated breast milk.
- **Wild Earth**, a U.S.-based pet food company, developed a cultivated chicken broth for dogs, which is expected to launch to consumers in 2023.
- Israel-based startup **Wilk** announced a prototype of the world's first cultivated milk fat for yogurt.
- North Carolina-based **Jellatech** announced a prototype of cultivated collagen, which can be used across multiple industries including cosmetics, pharmaceuticals, and food.
- Israel-based cultivated meat company **Aleph Farms** also added cultivated collagen to their portfolio.
- Vancouver-based **Fiction Foods** is developing cultivated chicken eggs.
- India- and U.S.-based **Brown Foods** announced a prototype of cultivated dairy milk.
- San Francisco-based **VitroLabs** is developing cultivated leather.
- **Celleste Bio**, based in Israel, produces cultivated chocolate.
- **Clean Food Group**, based in the UK, is working on developing cultivated palm oil alternatives.
- **California Cultured** has developed prototypes for cultivated chocolate and coffee.

Like cultivated meat, these emerging cultivated product categories have the potential to disrupt their respective categories if the technology proves scalable and economically viable.

Adjacent markets may also serve as high-value opportunities for market entry, or opportunities to differentiate product portfolio and revenue while cultivated meat is still at relatively small scale and high cost.



Cultivated meat image library

News articles about cultivated meat often feature images of unrecognizable shapes in a petri dish, held by a blue-gloved hand. These images are not effective at grounding the reader in an accurate vision of cultivated meat production, which at scale occurs in a facility in many ways more similar to a brewery than a lab, nor the familiar and delicious-looking end product. GFI's [library of Creative Commons-licensed images of cultivated meat](#) seeks to advance a more authentic representation of both cultivated meat production and products and better position cultivated meat for broad consumer appeal.



If you have images you'd like to contribute, [share your photos with us](#).



*Are we missing something from this Commercial Landscape section?
Did we get something wrong? We'd appreciate your feedback via [this form](#).*





Section 2

Investments

Section 2: Investments

Overview

From 2010 to 2022, alternative protein companies raised \$14.2 billion, nearly doubling the amount invested on average every year, though with high variance from year to year. Following the first disclosed investment in cultivated meat and seafood in 2016, such companies have raised \$2.8 billion, with investments on average tripling every year. This trend of rapid growth slowed in 2022, with funding for both alternative proteins as a whole and cultivated meat and seafood companies slowing alongside a broad global deceleration in investment across multiple sectors.

Cultivated meat and seafood companies raised \$896 million in 2022, representing a deceleration of 33 percent year-over-year (YOY). This modestly outperformed the overall global venture funding decline of 35 percent YOY and outpaced funding for select sectors popular with venture capital funds, such as fintech where funding fell by 46 percent. Fewer investments took place amid challenging macroeconomic and market conditions, including falling public equity markets, steeply rising interest rates driven by elevated inflation, the ongoing pandemic, severe climate events, and the invasion of Ukraine. In fact, public equity markets fell by the most since the great financial crisis of 2008. Venture-capital-backed public companies performed especially poorly, with the PitchBook VC-backed IPO Index falling by more than 60 percent in 2022.

While this challenging market environment may continue for some time, the downturn itself and alternative proteins' status as an increasingly important ESG opportunity provide potential upside for investors and the industry. Deal valuations are starting to come down, and startups are more willing to make deal term concessions, shifting dealmaking in investors' favor. The alternative protein industry—and the cultivated meat and seafood category in particular—is still in its early stages, with ample opportunity for investors to enter the space or double down on their commitment. The \$896 million invested in 2022 represents nearly one-third of all-time investment. Moreover, ESG interest remains high and private impact funds have \$113 billion in dry powder (funds that have yet to be invested), creating a tailwind for alternative proteins, which are increasingly being viewed as an ESG-aligned sector.

The outlook for cultivated meat and seafood is bright. The U.S. FDA's completion of their first premarket review of a cultivated meat product (for UPSIDE Foods), and its indication of several additional reviews in progress, signaled a major de-risking event for investors. PitchBook expects this major milestone to drive record funding in 2023, drawing a parallel to the surge in investing following Singapore granting regulatory approval to a cultivated chicken product in 2020.



This positive outlook is also supported by 2022 investment data. Despite the challenging market environment, the largest deals for both a cultivated meat and a cultivated seafood company to date occurred in 2022 when **UPSIDE Foods** raised a \$400 million Series C and **Wildtype** raised a \$100 million Series B. Moreover, both APAC and

Europe saw higher cultivated meat investments in 2022 than in the year prior. In fact, in APAC, cultivated meat companies raised more capital in 2022 than in all prior years combined. In addition, the number of unique investors in cultivated meat and seafood grew by 19 percent to 679 total investors.



Alternative proteins are a scalable solution to global challenges

Despite alternative proteins' clear ESG benefits, they currently face underinvestment as a climate, biodiversity, public health, and food security solution. Countries have committed to halve emissions and protect 30 percent of global land and ocean ecosystems by 2030. With just seven years to go, investing in alternative ways of making meat, seafood, eggs, and dairy is essential. In their paper [What gets measured gets financed](#), the Rockefeller Foundation and Boston Consulting Group (BCG) identified alternative proteins as a critical climate mitigation solution and estimated that alternative proteins have an annual unmet funding need of more than \$40 billion. Both private investors and governments have a critical role to play to ensure that alternative protein companies have the funding they need to help alleviate the multiple global crises.

New ESG frameworks raise the bar on sustainability transparency of meat

In 2022, GFI and FAIRR developed a new, gap-filling set of ESG frameworks for the alternative protein industry that equip companies to assess and report environmental and social impacts of their business practices and their products, helping meet demand from investors, governments, and consumers for greater transparency.

The first-of-their-kind frameworks enable greater disclosures of the climate, water and land use, biodiversity, labor, and food security impacts of companies and their products, encouraging improvements in company practices and enabling comparisons between companies involved in alternative proteins and companies involved in animal protein products. The frameworks also enable investors to source high-quality ESG data from companies regarding their alternative protein offerings.

By 2025, an estimated third of global assets will be managed according to ESG principles. And while ESG reporting is currently voluntary, mandatory and globally standardized reporting is likely only a matter of time, with government-mandated climate reporting anticipated by 2025. As ESG considerations are increasingly integrated into risk mitigation and decision-making, a greater need exists for standardized industry-specific assessments that enable data validation and comparability. While such frameworks exist for many other industries, the new GFI & FAIRR ESG frameworks now play that role for the alternative protein sector.

Increased visibility of the long-term environmental and social impacts of alternative proteins compared with those of conventional proteins can catalyze further investments that meet global sustainability goals and accelerate the transition to a more secure and equitable protein production system.

Investors and companies interested in exploring how they can adopt the GFI & FAIRR frameworks to enhance their ESG assessment and reporting practices are encouraged to reach out to GFI's Corporate Engagement team for support.



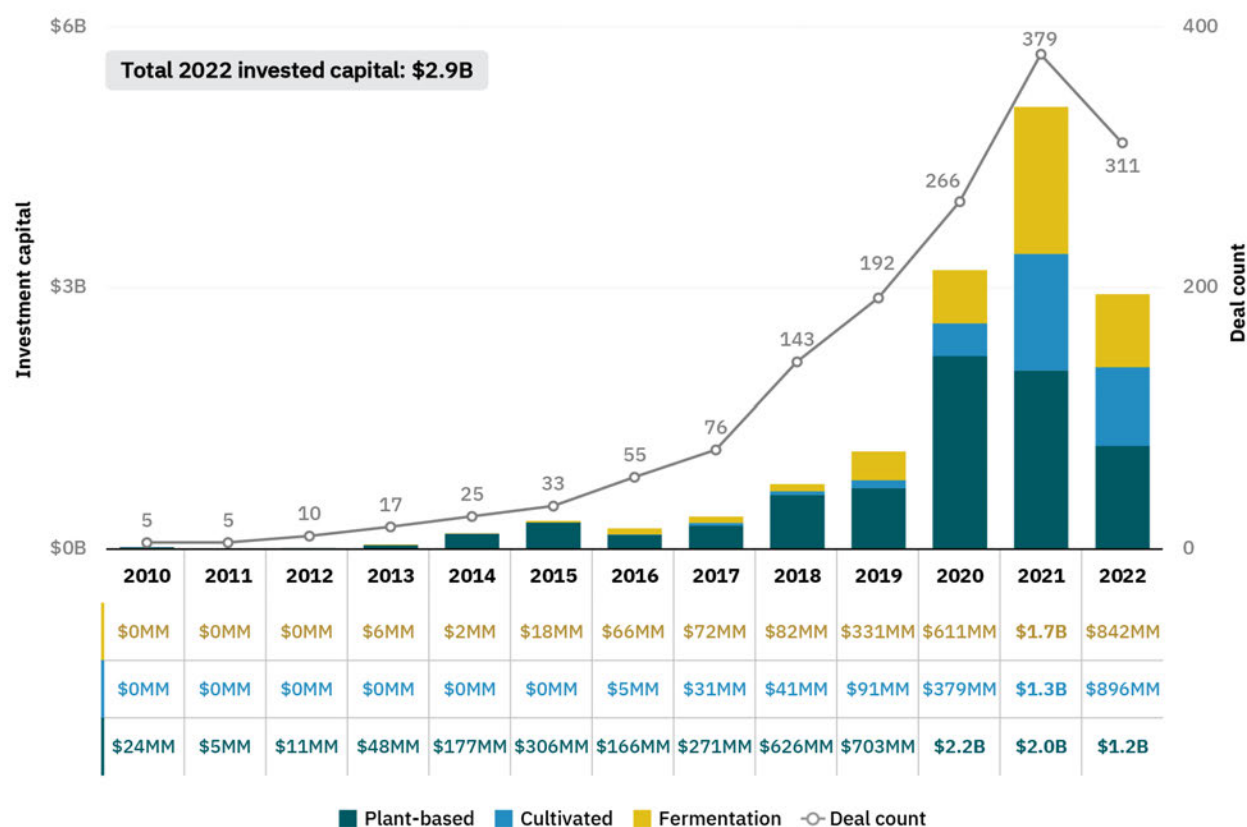
Table 5: 2022 investment overview

Invested capital	Largest investment	Unique investors
\$896 million in 2022 (32% of all-time investment) \$2.78 billion total (2016–2022)	\$400 million (UPSIDE Foods)	110 new in 2022 (19% growth from 2021) 679 total (2016–2022)
Invested capital deals	Growth stage deals (Series B and above)	Liquidity events
77 in 2022 294 total (2016–2022)	3 in 2022 12 total (2016–2022)	\$39.1 million in 2022 \$57.8 million total (2016–2022)

Source: GFI analysis of data from PitchBook Data, Inc.

Note: Data has not been reviewed by PitchBook analysts. See the [Methodology of investment calculations](#) section for GFI's data collection methodology and definitions of "invested capital." The total deal count includes deals with undisclosed amounts.

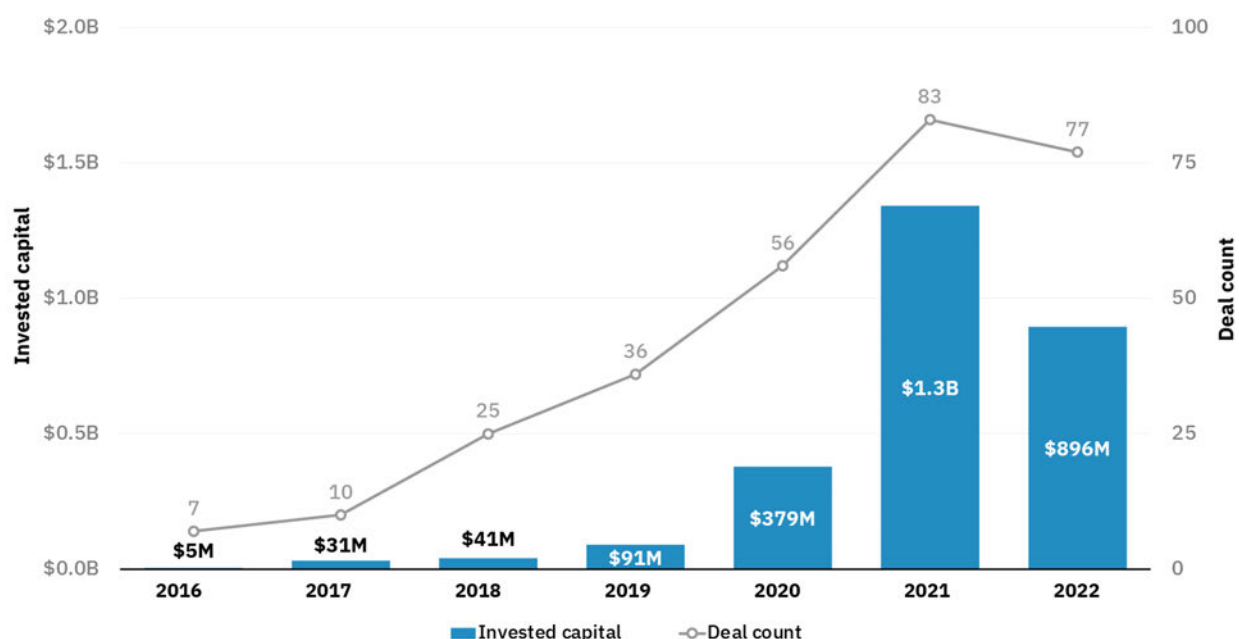
Figure 6: Annual investment in alternative proteins (2010–2022)



Source: GFI analysis of data from PitchBook Data, Inc.

Note: Data has not been reviewed by PitchBook analysts. The total deal count includes deals with undisclosed amounts.

Figure 7: Annual investment in cultivated meat and seafood (2016–2022)



Source: GFI analysis of data from PitchBook Data, Inc.

Note: Data has not been reviewed by PitchBook analysts. The total deal count includes deals with undisclosed amounts.

Methodology of investment calculations

GFI conducted a global analysis of cultivated meat investments using data from PitchBook Data, Inc. Our analysis uses a list we custom built in PitchBook of companies that focus primarily on cultivated protein products or on providing services to those who produce them.

We excluded the many companies that are involved in meat cultivation but not as their core business, such as **Merck KGaA, Darmstadt, Germany** as the funding these companies devote to cultivated meat is undisclosed. We also exclude alternative-protein-focused companies that are involved in cultivated meat and one or more additional protein categories if they are more focused on plant-based or fermentation, and include those companies in the category they are most involved in. Some companies use another alternative protein production platform to produce inputs for cultivated meat, for example using precision fermentation to produce growth factors. Those companies were included in this total as cultivated meat suppliers and excluded from our fermentation dataset. We included cultivated milk and egg companies as well as cultivated meat pet food companies, though they are not the primary focus of this report.

Some companies included in our list may also offer products or services that apply to another protein category. For example, **Finless Foods** is included in our cultivated meat and seafood dataset, but they also produce plant-based seafood. Meanwhile, the \$200 million that **Eat Just** raised in March 2021 for use across their product lines and the \$267 million raised for their GOOD Meat division in the funding round completed in September 2021 are categorized under cultivated

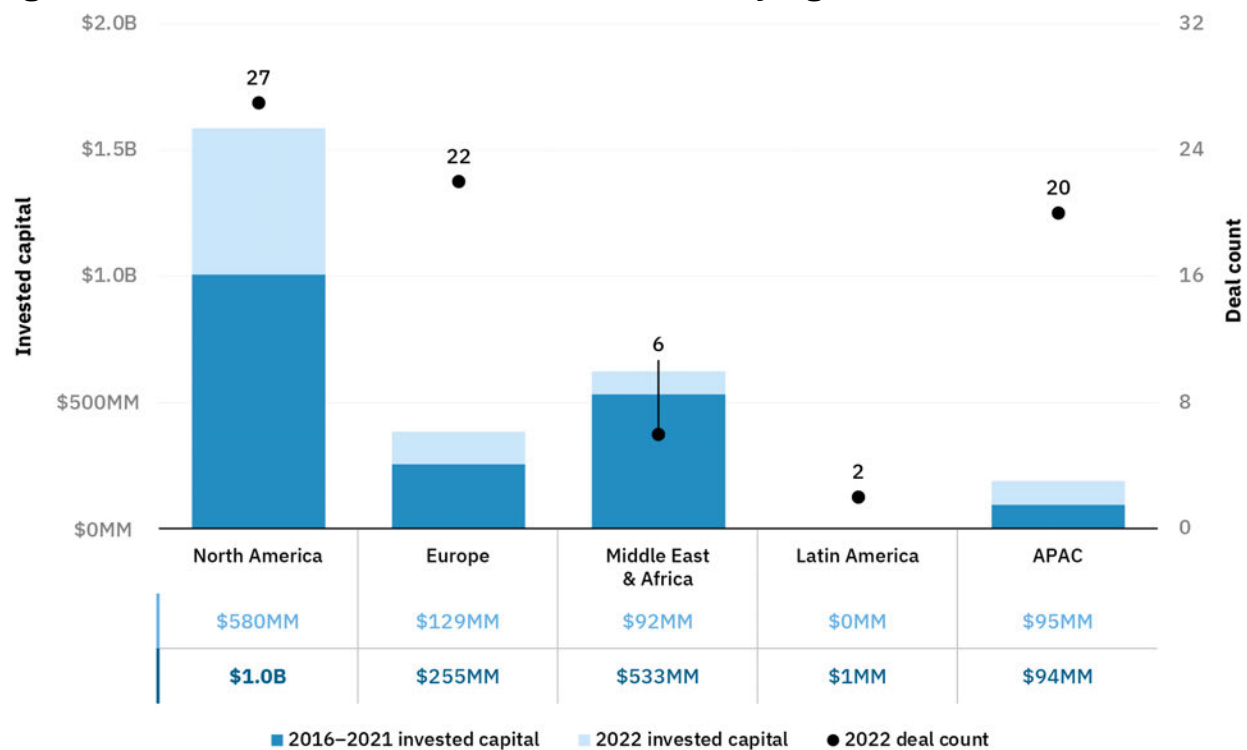
meat. All other Eat Just funds raised are categorized under plant-based (the company was founded as a plant-based egg company, and their business is focused on both plant-based eggs and cultivated meat today).

PitchBook profiled 132 cultivated meat companies, 114 of which have disclosed deals. Of these 114 companies, 102 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 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* comprise completed mergers, acquisitions, reverse mergers, buyouts, leveraged buyouts, and IPOs, while *other financing* comprises completed 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 and PitchBook continually improve our datasets.

Figure 8: Investments in cultivated meat and seafood by region (2016–2022)



Source: GFI analysis of data from PitchBook Data, Inc.

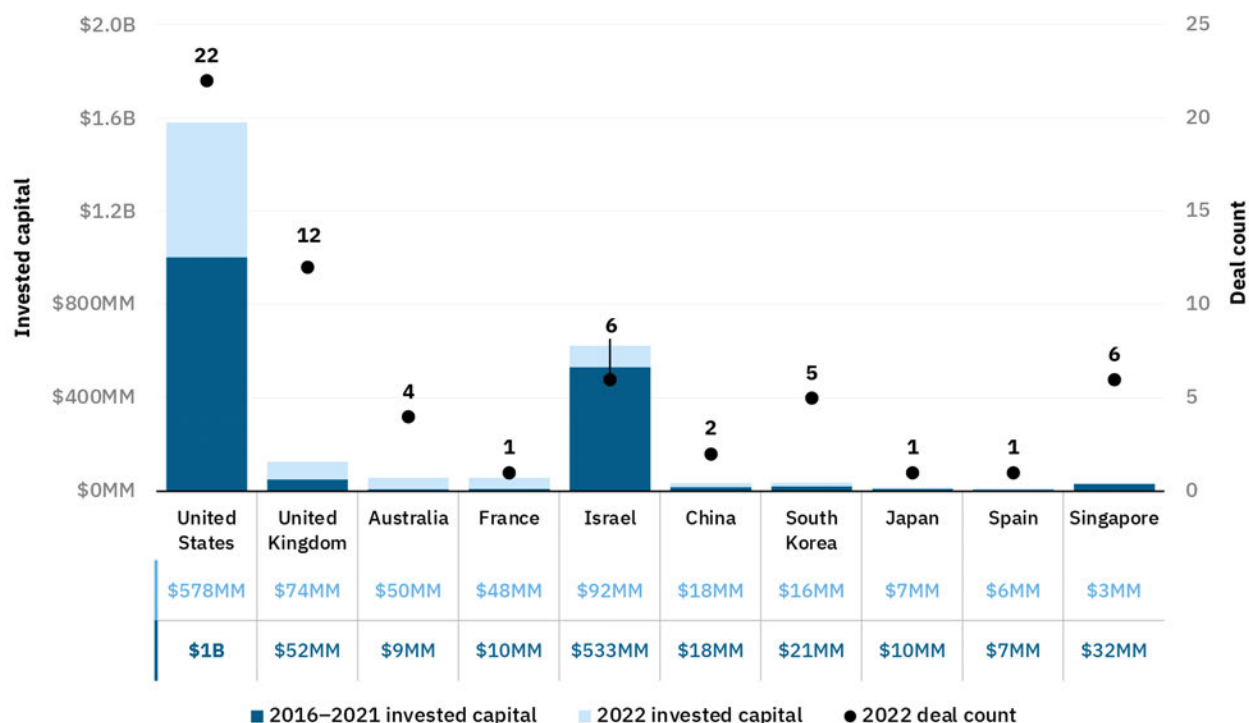
Note: Data has not been reviewed by PitchBook analysts. North America includes Canada and the United States only. Latin America includes Mexico, as well as South American and Central American countries. The total deal count includes deals with undisclosed amounts.



MUFG recognizes that alternative proteins, including cultivated meat, have the potential to address numerous anticipated global challenges, especially food insecurity and climate change. However, this potential is not adequately recognized, and the difficulties of securing sufficient financing may limit the industry's evolution, particularly for cultivated meat. MUFG is committed to empowering a brighter future for alternative proteins by utilizing our global resources to invest in the industry and support human capital development and partnerships.

– Ichika Sakon, Vice President of Industry Research and Creation Division at MUFG Bank

Figure 9: Investment in cultivated meat and seafood: Top 10 countries (2016–2022)



Source: GFI analysis of data from PitchBook Data, Inc.

Note: Data has not been reviewed by PitchBook analysts. The top 10 countries were selected based on 2022 invested capital. We are aware of additional investments in these countries, including China, that are not captured by our methodology. The total deal count includes deals with undisclosed amounts.

Table 6: Deal type summary statistics (2016–2022)

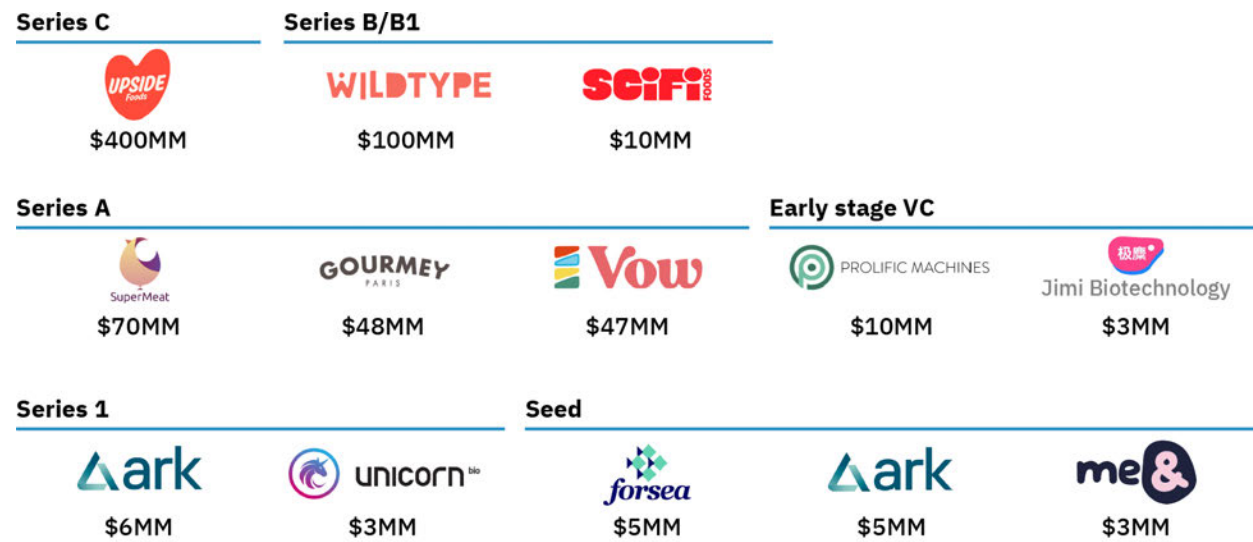
Deal type	Median 2016-2020	Median 2021	Median 2022	Maximum (all years)	Deal count (all years)
Seed	\$1.8MM	\$2.4MM	\$2.1MM	\$20.9MM	89
Series 1, 2	\$6.6MM	\$0.5MM	\$4.6MM	\$6.6MM	6
Early stage VC (uncategorized)	\$2.3MM	\$1.3MM	\$1.6MM	\$60MM	80
Series A, A1, A2	\$10.7MM	\$15.5MM	\$15.2MM	\$48MM	36
Series B, B1	\$131MM	\$34MM	\$55MM	\$347MM	9
Series C	N/A	N/A	\$400MM	\$400MM	1
Series F ¹	N/A	\$200MM	N/A	\$267MM	2

Source: GFI analysis of data from PitchBook Data, Inc. The total deal count includes deals with undisclosed amounts.

Note: 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, accelerator and incubator, capitalization, corporate, convertible debt, equity and product crowdfunding, joint venture, late-stage VC, and private equity rounds. It also excludes uncategorized rounds.

¹ The Series F rounds are those of Eat Just.

Figure 10: 2022 key funding rounds



Source: GFI analysis of data from PitchBook Data, Inc.

Note: Data has not been reviewed by PitchBook analysts. “2022 key funding rounds” includes investments in the 75th percentile or higher for each funding round category that includes more than three deals. For funding round categories that include three deals or fewer, all deals are included.

Table 7: Most active investors in 2022

Investor	Logo	Investor type	Headquarters	2022 cultivated meat deal count	Total deal count
Big Idea Ventures		Venture capital	New York, USA	14	36
SOSV / IndiBio		Venture capital	Princeton, USA	9	35
CULT Food Science		Venture capital	Vancouver, Canada	5	14
AgFunder		Venture capital	San Francisco, USA	4	5
Better Bite Ventures		Venture capital	Christchurch, New Zealand	4	5
Sustainable Food Ventures		Venture capital	Raleigh, USA	4	10
Agronomics		Venture capital	Douglas, UK	3	15
Brinc (Private Equity)		Accelerator / Incubator	Hong Kong, China	3	10
Cargill		Corporation	Minneapolis, USA	3	7
CPT Capital		Venture capital	London, UK	3	20
Milk & Honey Ventures		Venture capital	Tel Aviv, Israel	3	3

Source: GFI analysis of data from PitchBook Data, Inc.

Note: Data has not been reviewed by PitchBook analysts. “Most active investors in 2022” includes any organization that made three or more publicly disclosed investments in a cultivated meat company during calendar year 2022. The total deal count includes deals with undisclosed amounts.

Liquidity events

Two key liquidity events—also known as exits, representing the sale of an equity owner’s interest in a company typically through a merger, acquisition, buyout, or IPO—took place in 2022, hinting at what the future may hold for cultivated meat and seafood companies.

In a deal that was announced in 2021, but closed in 2022, **JBS**, the world’s largest meat company, acquired Spanish cultivated meat company **BioTech Foods** for \$39 million. Demonstrating their interest in cultivated meat, JBS also committed to building a new production plant in Spain for BioTech Foods and launching a Research & Development Center in Biotechnology and Cultured Protein in Brazil.

Meanwhile, signaling further industry maturity, cultivated meat company **UPSIDE Foods** acquired cultivated seafood company **Cultured Decadence** in January for an undisclosed amount, expanding their product capabilities.

We expect to see an increased number of mergers and acquisitions in the coming year as companies with stronger financial footing—incumbents and startups alike—acquire firms with valuable technologies, manufacturing processes, and talent that are struggling to maintain a financial runway in today’s challenging funding environment.



“While the economy has slowed down, innovation continues to accelerate in the alternative protein sector. Companies that start during this economic downturn will build efficient operations and have a running start as the economy improves again. Historically, some of the best companies have been started during difficult economic times including Airbnb, Uber and WhatsApp.”

- Gautam Godhwani, Managing Partner, Good Startup

Other financing

In addition to more traditional financing methods, some public companies pursue financing paths such as subsequent public share offerings and private investment in public equity (PIPE) deals.

The only cultivated meat and seafood company to have raised such financing in 2022 is **Steakholder Foods** (previously MeaTech), which is traded publicly on the NASDAQ stock exchange. The company raised an undisclosed amount of capital via a PIPE in June 2022. As cultivated meat and seafood companies mature and a higher number begin trading publicly, we will see a higher number of other financing rounds.

The Good Food Institute is not a licensed investment or financial advisor, and nothing in the State of the Industry Report series is intended or should be construed as investment advice.

Are we missing something from this Investments section?

Did we get something wrong? We'd appreciate your feedback via [this form](#).

Section 3

Science and technology

Section 3: Science and technology

Overview

Across the cultivated meat ecosystem, scientific and technological progress accelerated in 2022. Findings from research projects that began several years ago are now getting published in open-access journals and platforms, especially in areas related to cell lines, serum-free cell culture media development, and scaffolding. Research is also broadening, with studies involving global teams of experts in food safety, computational modeling, environmental and social sciences, and food and meat science.

As the industry matures, companies are publishing their findings and sharing resources, which helps build the foundation for future research endeavors. This section highlights some of the key scientific advancements and signals of 2022.

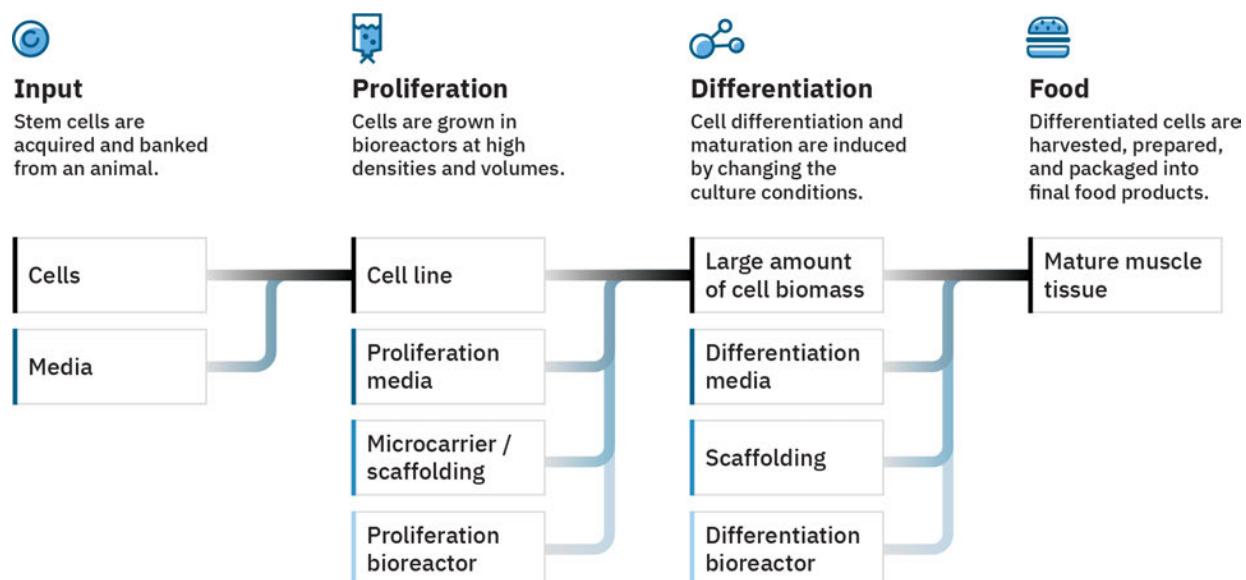
For a comprehensive introduction to the current state of the science in cultivated meat, visit GFI's [science of cultivated meat](#) page.

Research across the technology stack



Companies and academic laboratories continue to push the boundaries of cultivated meat research. Thanks to a small group of generous donors, GFI awarded research grants for 15 innovative projects focused on cultivated meat and seafood in 2022. See below for highlights from our grantees and other research teams across the technology stack.

Figure 11: Cultivated meat process flow



Cell lines

Definition: For cultivated meat and seafood to match the variety of conventional products on the market, high-quality cell lines from many species will be required. A variety of cell types may be applicable to cultivated meat, from pluripotent stem cells to adult stem cells capable of becoming fat, muscle, or connective tissues. Researchers are working to develop and characterize new cell lines and to better understand the properties of different cell types—growth potential, metabolism, media requirements, and effects on the properties of the final product—that will determine how suitable each cell type is for cultivated meat.

Want to learn more? Check out articles by GFI grantees [Masatoshi Suzuki](#) and [Ivana Gadjanski](#) on cell lines for cultivated meat, and by grantee [Mukunda Goswami](#) on uses for fish cell lines.

2022 research highlights:

A lack of readily available cell lines from relevant species and cell types has been an ongoing obstacle to scientific progress in cultivated meat. Fortunately, 2022 showed an uptick in research on cell line development.

Dr. David Kaplan's lab at Tufts University published a preprint article describing the Mack1 cell line, the first publicly available continuous myogenic (muscle) line from fish. This spontaneously immortalized Atlantic mackerel line is available for purchase by academic and nonprofit labs and can differentiate into muscle fibers as well as taking on an adipogenic-like (fat) phenotype depending on the media in which the cells are cultured. This study also provides a useful roadmap for future fish cell line development work and offers some new research tools for fish cell culture work. The Kaplan lab's mackerel work was an offshoot of a GFI-funded project on cell line development from Atlantic salmon, and his lab receives federal funding from USDA.

In a paper in NPJ Science of Food, Dr. Yusuke Tsuruwaka of Keio University and Dr. Eriko Shimada of Kyoto University and UC Davis described a fibroblast-like line established from the fin of a thread-sail filefish. One interesting feature of this cell line is its ability to be easily differentiated into a variety of lineages, including muscle and fat. This result warrants a fresh look at the transdifferentiation of fish cells, as it may indicate that finding appropriate cell lines from fish is substantially easier than we might have assumed based on results from mammals. Dr. Georgina Dowd's group at The New Zealand Institute for Plant and Food Research also described a spontaneously immortalized myofibroblast precursor line from Australasian snapper.

A paper from Professor Per Bruheim's group at the Norwegian University of Science and Technology describes the isolation of primary muscle cells from European lobster. This is the first published report of a primary muscle cell isolation from lobster, which provides a solid starting point for future studies of cultivated

crustaceans and for efforts to create immortalized lines. This paper also helps address the problem of a lack of validated antibodies for use in seafood species.

Finally, Dr. Kaplan's lab published a preprint paper describing a bovine (cow) cell line that was immortalized by expressing bovine TERT and CDK4. Academic or nonprofit groups interested in accessing the line should reach out directly to the research team.

Cell culture media

Definition: Cell culture media contains the nutrients and growth factors needed to cultivate cells outside the body. As the primary input into the cultivated meat process, it is currently the largest cost and environmental impact driver of cultivated meat production. Additional research is needed to derive animal-free formulations that match the metabolic requirements of each cell line, in addition to creating a supply chain of more affordable, animal-free, and food-grade ingredients.

Want to learn more? Check out this review article by GFI grantee David Block and discover how to differentiate cultivated seafood cells in this review by GFI scientists and colleagues.


2022 research highlights:

Traditionally, most lab-scale cell culture has relied on the use of serum, a complex mixture derived from animal blood that contains growth factors, other proteins, hormones, lipids, and nutrients. While serum is effective at maintaining cell health, its use in cellular agriculture is not viable at scale due to a number of challenges including limited availability, batch-to-batch variability, and poor sustainability. Research on serum-free media advanced in 2022, with publications from Mosa Meat demonstrating serum-free bovine muscle cell differentiation and proliferation and serum-free fat cell culture protocols that can be applied across species. Researchers at the Tokyo Women's Medical University devised a circular cell culture system in which microalgae could be used to consume the toxic metabolite ammonia while supplying nutrients to mouse muscle cells

grown in serum-free conditions. They also showed that microalgae could be used as a nutrient supplement for culturing bovine cells.

Formulation of cell culture media remains a challenge because each medium formulation will need to be adapted to the needs of the species and cell type being cultivated, as shown by scientists at UC Davis. To accelerate formulation optimization, the UC Davis team created an algorithm that can help researchers reduce the number of experiments needed to identify the ingredients required for cells grown under set conditions.

Growth factors are currently the highest-cost ingredient within cell culture media, and several studies demonstrated substantial progress on reducing their cost. For example,



a study funded by GFI and New Harvest demonstrated methods to produce and purify low-cost growth factors in bacteria. The study was also the first to test a variety of species-specific growth factors and found that some variants outperformed commercial versions. The research team's in-house production of growth factors resulted in a 255-fold (for FGF2) or a 720-fold (for TGF- β 1) lower cost than commercially available equivalents, and between a 4-fold and a 7-fold lower cost for the complete media. **These cost reductions were achieved with lab-scale production, indicating the potential for much greater cost reduction when produced at a commercial scale.**

Other proteins commonly used in the cell culture media such as albumin and transferrin are often added in such high quantities that they can account for the majority of media cost. **Researchers at Tufts University demonstrated that albumin proteins from plants such as rapeseed can functionally replace recombinant animal**


albumin at less than a tenth of the cost. Furthermore, researchers at the Austrian Center for Biotechnology showed that food-grade ingredients such as methylcellulose can play a stabilizing role in cell culture media similar to that of albumin, resulting in media formulations that require significantly lower quantities of costly growth factors and albumin proteins.

Finally, GFI-Europe and EIT Food awarded four grants to assist in lowering media costs through strategies such as hydrolysates from microalgae, improved thermostability of growth factors, and expression in plants or cell-free systems.

Take a deeper dive into the anticipated costs, production volumes, and regulatory considerations for growth factors in this analysis published by GFI in collaboration with Laurus Bio, Core Biogenesis, LenioBio, and the Future Ready Food Safety Hub.



Scaffolding



Definition: Many approaches to producing cultivated meat use some form of 3D scaffolding to provide structure to the final product; facilitate nutrient, oxygen, and waste transport; and provide cues that can help the cells differentiate and mature as desired. Research into scaffolding for cultivated meat focuses on identifying the best materials (or combinations of materials) and developing innovative manufacturing technologies for scalable and cost-effective scaffolds.

Learn more about scaffolding in this review article published by a team of GFI scientists and research fellows.

2022 research highlights:

A key milestone in 2022 was the publication of the first few papers tackling the challenge of creating structured cultivated seafood products. Researchers at Zhejiang University used a bioink-containing fish gelatin and alginate to bioprint structured constructs containing large yellow croaker satellite cells and adipose-derived stem cells.

Researchers at Keio University, Kyoto University, and UC Davis described the use of a mostly scaffold-free technique to produce a cultivated fish prototype, in this case from thread-sail filefish. The first phase of the Algae2Fish project—funded by GFI and led by Dr. Frederico Ferreira at the University of Lisbon—was published in 2022, documenting the successful fabrication of k-carrageenan-based scaffolds capable of being used as bioinks and supporting the growth of L929 mouse fibroblasts. The eventual goal of this project is to grow sea bass cells on this material and to incorporate electrospun fibers to guide cellular alignment.

Building on previous work on the use of textured vegetable protein (TVP) in cultivated meat scaffolding, Dr. Jinkee Hong's lab demonstrated that coating TVP with fish gelatin and agar improved the textural and cell adhesive properties of the scaffold. Dr. Shulamit Levenberg's lab explored the use of RGD-functionalized alginate as a scaffold for bovine muscle and fat cells. The researchers also took advantage of the reversible gelation properties of alginate to combine small pieces of scaffold laden with mature muscle or fat cells into a "marbled" construct.

There was significant progress on producing edible microcarriers (tiny beads that enable

cell attachment for growth in bioreactors) for cultivated meat. As part of a GFI-funded project, Dr. Marcelle Machluf's lab developed edible microcarriers composed of chitosan and collagen in a 9:1 ratio, which could support the growth of cells from mice, rabbits, sheep, and cows. The labs of Dr. Hanry Yu and Dr. Dejian Huang developed edible gelatin-coated alginate microcarriers capable of supporting the growth of pig, chicken, and mouse muscle cells as well as mouse fat cells. Dr. David Block's lab showed that edible filamentous fungal pellets could be used as microcarriers for both yeast and myoblasts. Dr. Yanan Du's lab created centimeter-scale cultivated pork meatballs by growing fat and muscle cells on porous gelatin microcarriers and then aggregating the cell-laden microcarriers using 3D-printed molds and transglutaminase. Supported by GFI, Dr. Amy Rowat's lab at UCLA demonstrated the use of edible grooved microcarriers to create a small, cookable cultivated meat patty. Dr. Rowat will continue her lab's investigation of edible microcarriers and cultivated meat research more broadly through a \$600k grant from USDA, a \$1 million BRITE Fellow award from the National Science Foundation, and research funding from the state of California. Dr. Mona Pedersen's lab explored the use of edible microcarriers from food industry by-products for use in growing satellite cells for cultivated meat. Finally, a group from the Cultivated Meat Modeling Consortium published a preprint paper describing their work to computationally model the growth of cells on microcarriers in a stirred-tank bioreactor.

Bioprocess design

Definition: The bioprocess for cultivated meat encompasses production lines of bioreactors outfitted with sensor equipment, integrated with cell-harvesting and food-processing equipment, and designed with automation in mind. Production lines can be constructed in various ways, and research is needed to determine the best-suited bioreactors and technologies required to create and scale a spectrum of cultivated meat product types.

Learn more about bioprocessing in this review article by GFI grantee Che Connon and colleagues.

2022 research highlights:

Once a research group has developed appropriate cell lines and cell culture media, they can begin to scale up their bioprocess. In 2022, scientists from **Believer Meats** published details on their pilot-scale process, showing very high cell densities of over 100 million cells per milliliter (360 grams per liter) under continuous perfusion culture, **which is the highest density reported in any cultivated meat research paper to date.**

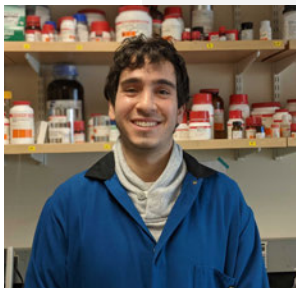
However, many laboratories remain in the research and development phase of deriving cell lines and optimizing cell culture media, and much of the published work to date in bioprocessing is conceptual or model-based. For example, researchers at the University of Tennessee published a review article covering computational fluid dynamics modeling for cultivated meat, which can be

used to better understand bioreactor design and predict cell performance during scale-up. Another study by researchers at University College London characterized the properties of a novel bioreactor impeller design that can provide a low-shear environment for mixing cells, an important factor in the scale-up of animal cell cultures. In its inaugural request for proposals, the Cultivated Meat Modeling Consortium funded a team of U.S. researchers to develop genome-scale metabolic models of porcine (pig) cells, which can be used to optimize cell culture media formulations.

Additional studies that incorporate bioprocess models are discussed below in sections on environmental impact and progress toward price parity.



Check out our research grants page to explore grant opportunities and meet the scientists leading open-access cultivated meat research. You can also find external funding opportunities via our research funding database.



I think the most significant drivers of progress, on the academic side, have been the establishment of cell lines, like immortalized bovine satellite cells, and published serum-free media formulations for relevant cells, from academia and companies like Mosa Meat. I think the biggest bottleneck will be developing cost-efficient ways to study how to scale bioprocesses. I'm particularly excited to see how sensors can impact approaches towards scale-up.

– Michael Saad, PhD candidate

Research on environmental and social impacts

Several studies published in 2022 increased our understanding of the environmental and socioeconomic impacts of cultivated meat production and generated new food safety insights.

Environmental impact

To understand the environmental impact of production, scientists use life cycle assessment (LCA) to quantify the energy and materials required across the entire value chain to produce a given product. In 2022, two LCAs for cultivated meat were published.

The first study examined production in hollow fiber bioreactors using lab-scale data collected from researchers at the University of Bath. The study identified key ways to reduce the environmental impact of cell culture media, including increasing the metabolic efficiency of cell lines, sourcing amino acids from plant hydrolysates, and using renewable energy at the production facility and throughout the supply chain.

A second LCA was published by researchers at The Ohio State University using pilot-scale data from cultivated meat producer SCiFi Foods. The study was the first to assess a hybrid burger product (composed of 17 percent cultivated bovine cells, 10 percent soy protein isolate, seven percent coconut oil, and other ingredients). Producing data that showed similar environmental benefits as plant-based burgers currently on the market, the study found that compared to a conventional beef burger, the hybrid burger could:

- **Generate 87 percent fewer greenhouse gas emissions.**
- **Require 90 percent less land.**
- **Require 96 percent less water.**



In early 2023, an LCA that incorporated data from more than 15 companies involved in the supply chain for cultivated meat was updated and published in the *International Journal of LCA*. The study, which was previously published as a white paper in 2021, found that cultivated meat is nearly three times more efficient than chicken production—the most efficient form of conventional meat. This efficiency translates to cultivated meat requiring far less land and results in less air pollution, acidification of soils, and marine eutrophication. The study demonstrates that the majority of emissions are Scope 1 and 2, which means that governments could significantly reduce cultivated meat’s carbon footprint by providing incentives to use and source renewable energy at these facilities. If renewable energy is implemented in production, cultivated meat can have a similar or potentially lower carbon footprint compared to highly optimistic future scenarios for any form of conventional meat production.

Table 8: Environmental impact comparison between cultivated meat produced with renewable energy and optimistic future scenarios for conventional meat:¹

	Cultivated meat compared with conventional chicken	Cultivated meat compared with conventional pork	Cultivated meat compared with conventional beef ²
Carbon footprint	3% increase	44% reduction	Up to 92% reduction
Land use	64% reduction	67% reduction	Up to 90% reduction
Air pollution	20% reduction	42% reduction	Up to 94% reduction
Soil acidification	69% reduction	78% reduction	Up to 98% reduction
Marine eutrophication	75% reduction	87% reduction	Up to 99% reduction

¹ Nineteen different environmental indicators were analyzed in the study. Cultivated meat performs better than conventional meat on most, but not all indicators. Notable indicators where cultivated meat has a similar, or in some cases, higher expected impacts include cumulative energy demand, blue water use, and freshwater eutrophication. For all of these categories, some uncertainty exists and values are also dependent on practices implemented by the manufacturer (e.g., cooling practices greatly influence energy use and wastewater treatment practices will affect eutrophication impacts) or scarcity of local resources in the case of blue water use. Refer to Table B.2 for the full impact comparison.

² This varies according to whether comparisons are with beef from dairy cattle or with beef from cattle raised exclusively for meat.

Socioeconomic impact

In *Nature Food*, an international team of researchers assessed expert views on the impact of plant-based and cultivated meat on job transitions in Brazil, Europe, and the United States, finding that **these fields offer an opportunity for many new, high-paying jobs in these regions**. On the same topic, researchers at Rowan University and Penn State University examined how “thick” and “thin” food justice frameworks—frameworks that emphasize fundamental overhauls to our food system versus those focused on working within the current economic system—can be used to inform the cultivated meat sector on how it can best contribute toward a more sustainable and just food system.

Research on food safety, nutrition, and public health

Food safety

In 2022, the [Food and Agriculture Organization of the United Nations \(FAO\)](#) released reports summarizing research on cultivated meat terminology, production, and regulatory frameworks. The FAO also convened two meetings to [identify safety hazards in production](#) and to [share insights amongst cultivated meat manufacturers](#). FAO produced a [video tour featuring Aleph Farms](#), which demonstrates how safety is ensured in their pilot facility. FAO released [a report](#) in April 2023 detailing the output of the food safety hazard identification conducted.

Other notable news includes the Singapore Food Agency's [update to their guidance on novel foods](#) and documentation from the completion of [FDA's premarket evaluation of UPSIDE Foods' cultivated chicken](#), which contains enormous insight into the safety evaluation of cultivated meat.

Nutrition and public health

Because cultivated meat is grown directly from animal cells in a process similar to how the cells grow in a living animal, we expect it to be nutritionally similar to conventional meat. However, just as with animals, the composition of cultivated cells will depend on how they are raised and what they are fed, so there will be potential to optimize nutritional profiles.

A paper from Dr. Young-Hwa Hwang's lab analyzed the [nutritional and taste characteristics](#) of chicken and bovine satellite cells. They found substantial differences between the amino acid composition of their cultured cells and that of conventional meat, highlighting the need for optimization of media composition and differentiation/maturation protocols for cultivated meat.

As part of the premarket consultation process, UPSIDE Foods submitted data on their cultivated chicken's content of amino acids, fats, and other nutritionally important components, showing that their product had a similar nutrition profile to conventional chicken.

Table 9: UPSIDE Foods cultivated chicken and conventional chicken*(g/100g, normalized to 20 w/w% solids, unless otherwise noted)*

	USDA chicken breast	Serum-containing CPM			Serum-free CPM		
		Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3
PROXIMATES							
Moisture	73.9	80.4	81.0	81.3	78.1	73.1	74.1
Protein	22.5	13.9	15.1	14.6	15.3	20.1	18.7
Fat	2.6	1.6	1.6	1.3	2.2	4.4	4.0
Ash	1.1	0.8	1.0	0.9	2.8	4.1	3.2
Calories (kCal/100g)	120.0	83.4	80.3	77.6	87.4	119.9	110.4

Table 10: UPSIDE Foods cultivated chicken and conventional chicken*(g/100g, normalized to 20 w/w% solids, unless otherwise noted)*

	USDA skinless light chicken	USDA all chicken	Serum-containing CPM			Serum-free CPM		
			Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3
FATS & FATTY ACIDS								
16:0 Palmitic	0.3	1.2	0.3	0.3	0.2	0.3	0.3	0.3
16:1ω7 Palmitoleic	0.1	0.3	0.03	0.03	0.03	0.2	0.3	0.4
18:0 Stearic	0.1	0.4	0.3	0.3	0.3	0.2	0.2	0.2
18:1 Oleic*	0.4	1.9	0.3	0.3	0.3	0.6	0.7	0.9
18:2ω6 Linoleic	0.2	0.9	0.1	0.1	0.1	0.03	0.03	0.05
20:4 Arachidonic*	0.1	0.1	0.2	0.2	0.2	0.01	0.02	0.02
Total Saturated	0.4	1.6	0.6	0.6	0.6	0.5	0.5	0.6
Total Monounsaturated	0.5	2.3	0.4	0.4	0.3	0.9	1.0	1.4
Total Polyunsaturated	0.4	1.3	0.6	0.6	0.6	0.1	0.2	0.2
Total Fat	1.9	6.0	1.7	1.8	1.7	1.7	1.9	2.4
Cholesterol (mg/100g)	45.4	54.8	185.3	321.5	289.9	360.8	359.6	429.9

**Analysis noted as undifferentiated*

Table 11: UPSIDE Foods cultivated chicken and conventional chicken

(g/100g, normalized to 20 w/w% solids)

	USDA skinless light chicken	USDA all chicken	Serum-containing CPM			Serum-free CPM		
			Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3
AMINO ACIDS								
Alanine	1.0	0.8	0.8	0.8	0.8	0.7	0.6	0.7
Arginine	1.1	0.9	1.2	1.2	1.2	0.9	0.7	0.9
Aspartic Acid, Asparagine	1.6	1.3	1.6	1.5	1.6	1.2	1.0	1.1
Cysteine	0.2	0.1	0.3	0.3	0.3	0.2	0.2	0.2
Glutamic Acid, Glutamine	2.6	2.1	2.2	2.0	2.0	1.7	1.4	1.6
Glycine	0.8	0.7	0.9	0.9	1.0	0.8	0.6	0.7
Histidine	0.6	0.4	0.5	0.4	0.5	0.4	0.4	0.5
Isoleucine	0.9	0.7	0.8	0.8	0.7	0.6	0.5	0.5
Leucine	1.4	1.1	1.2	1.2	1.2	1.0	0.9	1.0
Lysine	1.5	1.2	1.0	1.1	1.0	0.9	0.8	0.9
Methionine	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.2
Phenylalanine	0.7	0.5	0.7	0.7	0.7	0.6	0.5	0.6
Proline	0.7	0.6	0.9	0.9	0.9	0.7	0.6	0.6
Serine	0.6	0.5	0.8	0.8	0.8	0.6	0.5	0.6
Threonine	0.8	0.6	1.0	1.0	1.0	0.6	0.5	0.6
Tryptophan	0.2	0.2	0.3	0.3	0.2	0.2	0.1	0.2
Tyrosine	0.6	0.5	0.7	0.7	0.7	0.5	0.4	0.5
Valine	0.9	0.7	1.0	0.9	0.9	0.7	0.6	0.7

Table 12: UPSIDE Foods cultivated chicken and conventional chicken*(mg/100g, normalized to 20 w/w% solids, unless otherwise noted)*

	Ground chicken	Serum-containing CPM			Serum-free CPM		
		Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3
MINERALS							
Calcium	4.9	27.4	29.6	70.8	8.5	5.9	6.2
Copper	0.04	0.1	0.1	0.0	0.1	0.2	0.2
Iron	0.6	0.5	0.8	0.4	4.4	6.1	5.4
Potassium	288.0	60.4	80.6	45.9	966.0	1130.0	1010.0
Magnesium	22.0	8.4	12.2	8.7	18.3	18.8	17.1
Manganese	0.01	0.03	0.5	0.04	0.03	0.06	0.05
Sodium	164.0	214.0	263.0	196.0	129.0	92.6	95.6
Phosphorus	138.0	159.0	196.0	141.0	593.0	702.0	616.0
Selenium	0.02	0.02	0.02	0.01	0.03	0.02	0.02
Zinc	1.1	1.5	2.5	1.5	2.0	1.9	1.8
Moisture (g/100g)	72.0	80.0	72.0	73.0	71.0	72.0	73.0

Table 13: UPSIDE Foods cultivated chicken and conventional chicken*(mg/100g, normalized to 20 w/w% solids)*

	USDA skinless light chicken	USDA all chicken	Serum-containing CPM			Serum-free CPM		
			Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3
VITAMINS								
Niacin (B3)	7.8	4.8	1.3	2.0	0.4	4.4	5.4	5.3
Pantothenic acid (B5)	0.8	0.7	0.6	0.8	1.9	1.6	1.5	1.3
Pyridoxine (B6)	0.5	0.3	0.3	0.4	2.2	1.0	1.7	1.8
Vitamin A	9.0	17.0	39.0	56.0	22.0	23.0	65.0	65.0

The use of antibiotics in livestock grown for conventional meat production is a significant driver of antimicrobial resistance (AMR), which threatens the usefulness of antibiotics in human medicine. [GFI's science and technology team published a commentary piece and accompanying blog post discussing cultivated meat's potential to help address the threat of AMR.](#) We considered the pros and cons of antimicrobial use during the production phase of cultivated meat and argued that antimicrobial-free production is not only possible but the most practical option—though antibiotics may be used sparingly in the initial stages of cell isolation and cell line development. The documentation submitted to FDA by UPSIDE Foods confirmed that antimicrobials were used only during preproduction cell line development of UPSIDE's chicken.

Scientific ecosystem growth

In 2022, [GFI's Alt Protein Project \(APP\)](#)—an international student movement dedicated to seeding alternative protein education, research, and innovation programs at top research universities—[welcomed 20 new student groups](#), including groups in Asia, Africa, and Australia. This ecosystem-building program now spans 36 chapters across 17 countries and five continents.

In 2022, students of the Chapel Hill Alt Protein Project developed and launched one of the first courses focused on taking a deep dive into the science of cultivated meat. The course is now entering its second term in the biology department, just one example of how students [build momentum for alternative proteins](#) on university campuses around the world. APP students also play a key role in [inspiring faculty members](#) to become more involved in cultivated meat research, which opens the door for even more students and researchers to get involved in addressing key scientific and technological bottlenecks.



Learn more about how researchers can join the race to develop cultivated meat in this [Nature Biotechnology publication](#) by GFI scientist Seren Kell.

Collaboration and [open-access research](#) are essential to the continued success of the cultivated meat industry. One reason for optimism on this front is the number of original research papers on cultivated meat that have recently been published by—or with collaborators from—for-profit cultivated meat companies or input suppliers, including **Aleph Farms** ([Zagury et al.](#), [Ianovici et al.](#)), **BioTech Foods** ([Paredes et al.](#)), **Mosa Meat** ([Melzener et al.](#), [Dohmen et al.](#), [Messmer et al.](#), [Kolkmann et al.](#), [Park et al.](#), [Mitić et al.](#)), **SCiFi Foods** ([Kim et al.](#)), **Believer Meats** ([Pasitka et al.](#)), and **Millipore Sigma** ([Xiang et al. 2022](#)). [Publications from industry leaders are a promising sign that even those with commercial interests recognize that no single company is going to solve the challenge of scaling cultivated meat alone. It is possible—and necessary—to balance the need to protect some intellectual property with the desire to contribute to the rising tide of progress that will lift all boats.](#)



We believe that cultivated seafood (and meat) is a generational shift and one that will take many stakeholders to bring to the mainstream market. Given the task ahead of us to bring cultivated fish to consumers with the right sensory profile and price, we believe that finding the right partners is critical to developing the right technology stack and scaling it to meet global demand.

— Mihir Pershad, Founder & CEO, Umami Meats



Progress toward price parity

Projecting the future costs of cultivated meat production at such early stages in the industry is challenging, but models can provide a starting point for identifying cost drivers. In 2022, two techno-economic analyses were published that examined production costs in a hypothetical commercial-scale facility with various process assumptions.

Researchers at UC Davis published a study that examined the relationship between production cost and bioreactor size and type. The study assessed costs if cultivated meat were manufactured in 42 m³ or 210 m³ stirred-tank reactors or a 260 m³ air-lift reactor, finding that large-scale production could result in a cost range of \$17 to \$35 per kg of cultivated meat, with further cost reduction potential if media costs were lowered. The study demonstrated the cost savings—on the order of \$5/kg—associated with simpler bioreactor designs, such as

air-lift reactors, versus stirred-tank reactors, which have more complexities in how they mix cells and liquids. Overall, this study highlighted the importance of economies of scale in achieving cost-competitive cultivated meat, as larger bioreactors mean fewer facilities and lower labor and overhead costs.

A second study from researchers at Oklahoma State University assessed the cost of production in a smaller facility, hypothetically located in San Francisco. The study examined scenarios related to facility downtime, staff salaries, cell culture media cost, and maintenance costs, with the baseline scenario finding that cultivated meat could cost \$63 per kg. Overall, the research highlighted that cell culture media, bioreactors, and labor are expected to be the largest cost drivers.



Progress toward taste parity

A key piece of the puzzle in optimizing any product is continuously testing and iterating on the process used to make it. In the case of a food product, this means constant tasting.

For ongoing taste tests, regulations that ensure safety, without being too onerous, are essential. In 2022, the Dutch House of Representatives adopted a resolution recommending the government enable tastings of cultivated meat under controlled conditions, and Singapore updated its regulatory requirements for novel foods, providing additional clarity on what is required to hold tastings for such products, which include cultivated meat. Straightforward processes that allow cultivated meat companies to hold tastings of their products will help the industry get to taste parity faster.

Some academic studies of cultivated meat are beginning to report data on the flavor characteristics of their prototypes. In 2022:

- Researchers from Dr. Young-Hwa Hwang's lab at Gyeongsang National University cultivated satellite cells from chickens and cows and used an electronic tongue system to assess a variety of taste characteristics. The differences they identified may guide research priorities into the optimization of media formulations and differentiation regimes for the purposes of optimizing taste characteristics.
- Dr. Jinkee Hong's lab, based at Yonsei University, used gas chromatography-mass spectrometry (GC-MS) to compare the aroma-active compounds in scaffolds with and without cultivated cells, and used an electronic tongue to compare the taste of the cell-laden scaffolds to that of conventional beef. Adding cells to the textured vegetable protein (TVP) scaffolds decreased the amount of lemon, earthy, and mushroom flavor-associated compounds while increasing the amount of compounds associated with flavors that included creamy, fatty, and meaty. The cultivated beef samples showed higher saltiness and lower sourness but were otherwise quite similar in both taste and aftertaste, in comparison to conventional beef.
- Researchers from Believer Meats, The Hebrew University of Jerusalem, and The Volcani Center reported results of both blind and non-blind taste tests comparing their hybrid chicken prototype—consisting of extruded soy protein and cultivated chicken fat—with soy protein alone and conventional chicken. The research team found that 67 percent of tasters preferred the hybrid chicken product over an equivalent plant-based product made with soy protein alone. In a second experiment where tasters were asked to rate the plant-based and hybrid chicken products in comparison to a reference sample of conventional chicken, participants indicated that the hybrid product was more similar to the conventional chicken in having a higher level of “chicken flavor” and having less excessive saltiness and aftertaste.

With increasing numbers of papers producing cultivated meat prototypes in an academic setting, we expect to see more of these experiments as researchers home in on methods to produce cultivated meat with the best possible flavor profiles.

On the alternative seafood flavor front, 2022 was an exciting and prolific research year:

- A newly published review discussed the challenges of getting the flavor just right in cultivated seafood products.
- A systematic review of the volatile compounds important for seafood flavor identified compounds likely to be important for general “seafood-like” aromas as well as species-specific aromas.
- A new paper described the screening of several species of microalgae as potential flavoring ingredients for plant-based seafood, with comparison to macroalgae, or seaweed. The team identified three microalgae species that seemed especially promising and that outperformed the five species of macroalgae tested on many of the analyzed metrics. However, they did detect a grassy aroma and bitter taste, which might require further optimization of growth or processing conditions to remove. While the primary focus of this study was plant-based seafood, this knowledge will ultimately be important for all three pillars of alternative seafood—plant-based, cultivated, and fermentation-derived.

GFI received several excellent proposals in response to our April 2022 Request for Proposals, one of the priority topics of which was the creation of flavor components for alternative seafood. We awarded \$1.1 million in funding to five promising projects in that priority area. One of those projects is led by Dr. Sirli Rosenvald, whose team is tackling the challenge of accurately recreating the aroma of salmon.

Resources for scientists

GFI supports the cultivated meat industry by creating open-access tools and resources that make scientists' jobs easier. Free tools and resources launched or substantially updated in 2022:

- **Literature library.** Newly launched in 2022, GFI's [alternative protein literature library](#) tracks key publications about—or substantially relevant to—all three pillars of alternative proteins. The resource also includes a “foundational reading” section for each alternative protein pillar for those just entering the field or who want to ground themselves in the current state of research across the field.
- **State of the science.** Given how fast the science of alternative proteins is evolving, GFI now releases a [science snapshot](#) every four months. Check our [YouTube channel](#) and [blog](#) for future timely updates on the latest in alt protein science.
- **Student resource hub.** In 2022, GFI published a significant set of [resources to support student leaders](#) in their efforts to build vibrant research ecosystems for alternative proteins at their universities. **If you want to see a course or major on alternative proteins at your university but aren't sure how to make that happen, or if you're looking for tips on how to approach a potential research advisor with a research idea, the Alt Protein Project resource hub is your go-to place.**
- **Solutions database.** Over the past year, GFI continued to add content to our [solutions database](#) with the help of two research fellows, Kim Lu and Dr. Eileen McNamara. This database captures ideas for research projects, commercial ventures, or ecosystem solutions that have the potential to accelerate the development and commercialization of alternative proteins. If you're looking to get involved or looking for a new project, you will likely find ideas and inspiration here.
- **Science of cultivated meat.** GFI continued expanding and improving our technical explainers for several areas related to cultivated meat, including a [technical deep dive on cultivated meat end products](#) and updates to the [science of cultivated meat](#) and [cultivated meat scaffolding](#) information on [gfi.org](#).

*Are we missing something in the Science & Technology section?
Did we get something wrong?
We'd appreciate your feedback
via [this form](#).*

Section 4

Government and regulation

Section 4: Government and regulation

Overview

As cultivated meat research and development advances around the world, governments are becoming increasingly aware that innovation can provide a more sustainable source of protein for a growing global population. In addition, disruptions to food supplies caused by climate change, Russia's war in Ukraine, an ongoing pandemic, and other global events have heightened governmental awareness of the need to ensure more resilience in food production.

Because of cultivated meat's great potential to help address food security, climate, and global health challenges, governments have initiated or increased funding for cultivated meat research and development, as well as for commercialization and infrastructure. Governments have also taken important steps toward alignment on regulation and safety.

This increase in public support for cultivated meat around the world signals a growing acknowledgment that cultivated meat production can protect the global food system against external shocks, improve sustainability through lower emissions and less pollution, and create jobs and economic value by revolutionizing the food system. As research and development in the field continues to yield breakthroughs and commercialization advances, increased public funding from governments around the world will be critical to advance the field of cultivated meat at the pace and scale needed to meet global goals.

Following is a list of public funding developments and regulatory progress from 2022 from across the globe.

Global public funding

Europe

Publicly available information indicates that Europe led the world in funding for cultivated meat research and development in 2022. The Netherlands, Europe's leading agricultural exporter, announced a world-record-breaking €60 million (\$64.6 million) investment toward building a full cellular agriculture ecosystem. Calling out the climate and sustainability benefits as well as the sector's potential to generate

billions per year in earning capacity for the Netherlands by 2050, Cellulaire Agricultuur Nederland will work to scale cultivated meat infrastructure and ensure a socially just and well-paid workforce transition.

Other European governments have likewise moved to develop domestic expertise in cultivation science. Norway's research council announced a five-year, €10 million program (\$10.7 million) to develop cellular agriculture capacity and solve problems like

cost and scalability. Similarly, the United Kingdom's Biotechnology and Biological Sciences Research Council set aside £20 million (\$21.5 million) for capacity building, research, innovation, and business-led commercialization in the alternative protein industry, including cultivated meat. The Spanish Foreign Trade Institute granted €750,000 (\$808,000) to a biotechnology company to study cultivated meat industrialization, including cell line development.

North America

In North America, public funding in the United States for cultivated meat research increased at both the federal and state level. In September, the Biden Administration released the Executive Order on Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy, in which the president directed the heads of relevant agencies to create reports on the American biotechnology sector, including one from U.S. Department of Agriculture (USDA) on cultivating alternative food sources. The announcement was followed by a nearly \$6 million appropriation for alternative protein research to the USDA's Agricultural Research Service, representing a \$1 million increase over the previous year. Earlier in the year, California became the first U.S. state to invest in cultivated meat research with a \$5 million allocation for alternative protein research in the state budget. The funding will go to three University of California institutions, two of which are focused on cultivated meat including a UCLA lab (and GFI grantee) that announced

an open-access breakthrough in meat cultivation this year.

Canada also invested in cultivated meat development and commercialization through Ontario Genomics, a government-funded nonprofit, which collaborated with German bioengineering company The Cultivated B. in developing a 130,000-square-foot bioreactor manufacturing facility. The new facility will provide a domestic supply of bioreactors, and as a term of the collaboration, the company will set aside 20,000 square feet of the facility for an innovation hub. Ontario Genomics also collaborated with the Canadian Food Innovation Network in administering AcCELLerate-ON, a CAD\$900,000 competition for cellular agriculture-focused food and beverage projects, for which three of the 2022 winners focused on cultivated meat and seafood.

Middle East

In the Middle East, Israel demonstrated its leadership in advancing cultivating meat, finalizing an \$18 million research consortium first announced in 2021. This is the largest government-backed cultivated meat consortium to date, involving the country's top food producers and top academic labs. The Israeli Innovation Authority continued to invest in domestic cell cultivation, funding a grant for Israeli company SuperMeat to develop an open-access, high-throughput screening system for cultivated meat inputs. Once established, this system will allow the entire industry to quickly determine ingredient viability.

Asia

The number of Asian nations directing public funding toward cultivated meat also increased. China's first-ever bioeconomy five-year plan includes a call to explore alternative proteins as novel foods ("synthetic proteins" was used in the original document, which includes foods produced from animal cell culture technologies and fermentation), while its 2022 agricultural five-year plan includes references to cultivated meat and other "future foods" for the first time. South Korea awarded a \$15 million grant to Space F, a cultivated meat startup, in partnership

with Seoul National University, CJ Group, Daesang Corporation, and Lotte Corporation as part of the Ministry of Trade, Industry and Energy's Alchemist Project for high-level technologies. The grant will focus on scaling and perfecting the equipment needed for cultivated meat commercialization. In the last days of 2022, the Singapore Israel Industrial R&D Foundation, a collaboration between the two countries' entrepreneurial development agencies, awarded a joint grant to Israel-based Steakholder Foods and Singapore-based Umami Meats to develop 3D-printed cultivated fish.

Global regulation

The sale of cultivated meat and seafood depends on a clear and efficient regulatory path to market, and companies and governments must work together to develop appropriate pathways. Singapore currently remains the only country where cultivated meat products have been fully approved for sale to consumers. But that may soon change. In November 2022, FDA completed the first-ever premarket evaluation of a cultivated meat product (see U.S. federal regulation section below). Other nations and regions have also made significant strides toward approving these products in recent years.



Australia and New Zealand

Australia and New Zealand have asserted that their bilateral and joint food regulatory system is equipped to deal with new foods produced through cellular agriculture, including cultivated meat, under the existing Novel Foods Standard. To gain premarket approval for a novel food, a company must submit an application to Food Standards Australia New Zealand (FSANZ). The

approval process is expected to take at least 14 months. Vow Food recently announced that it has applied to FSANZ for approval of the company's cultivated quail. If approved, it would be the first cultivated meat product available in Australia and New Zealand.

Additionally, Australia and New Zealand regulate genetically modified foods in ways that could apply to cultivated meat products or fermentation-derived ingredients if they are produced using certain genetic modification technology. FSANZ and Health

Canada, Canada's regulator, are collaborating on applications of genetically modified food safety assessments components. One agency will take the lead, while the other acts as a peer reviewer, streamlining the process and saving costs for both the applicant and the agencies. These are encouraging signs to streamline regulatory processes, while maintaining each regulator's independence to provide the final approval. All foods in Australia and New Zealand are also governed by the Food Standards Code, which regulates food safety and labeling.



Brazil

In Brazil, the General Food Office at the National Health Agency (ANVISA) and the Animal Products Inspection Department within the Ministry of Agriculture have jurisdiction over cultivated meat. Although the country has yet to set forth a regulatory framework, ANVISA is in the process of collecting and analyzing information on the food safety and labeling aspects of cultivated meat and developing a regulatory framework. The government plans to conduct a premarket authorization process for cultivated meat products. Companies will need to apply for authorization, and the agencies will conduct a safety evaluation, possibly under the country's current novel foods framework.



Canada

Health Canada's Food Directorate has jurisdiction over cultivated meat. The Canadian government has stated that it intends to regulate cultivated meat products under its existing novel foods regulations and is not considering new regulatory approaches. The authorization of a novel food requires a premarket submission with detailed information about the product. The approval process for these foods includes three parts: 1) a letter of no objection for human food use through the novel food assessment process, 2) a premarket assessment for new animal feed, regardless of whether the product is intended for use as animal feed, and 3) an environmental assessment.



China

China has defined the development direction of biotechnology and bioeconomy, which includes proteins manufactured via cell cultivation technology.

In 2021, the Chinese government announced a three-year R&D project, which includes sub-projects in cultivated meat research, under the Green Biological Manufacturing National Key R&D Program that supports projects in a number of sectors, including an estimated ¥20 million (\$2.9 million) in funding to develop alternative proteins. In addition, in late 2021, China's Ministry of Agriculture and Rural Affairs released a highly anticipated five-year plan that serves as a blueprint for strengthening innovation in a number of emerging technologies,

including the manufacturing of cultivated meat and other “future foods.”

In 2022, President Xi Jinping emphasized the need to obtain energy and protein from plants, animals, and microorganisms and establish a “Greater Food Approach” during the 13th Chinese People's Political Consultative Conference, which pointed out the clear direction for the development of biotechnology and bioindustry in China. Synergistically, the National Development and Reform Commission issued the “14th Five-Year Plan for the Development of Bioeconomy” in May 2022, which proposed the exploration and development of novel foods such as alternative proteins, and the iterative upgrading of the food industry, reducing the pressure on environmental resources brought by the conventional breeding industry.

In April 2022, the China Cellular Agriculture Forum held its first event, inviting experts and cultivated meat producers to discuss a number of issues including the regulation and labeling of cultivated meat. In June 2022, the Chinese Academy of Engineering published a book, *Research on the Development Strategy of Biologically-Cultivated Meat*, based on the results of a strategic consulting project started in 2020. In December 2022, government officials from the U.S. FDA and China’s National Center for Food Safety Risk Assessment discussed cultivated meat regulation at an online event organized by the AgFood Future Center of Excellence and the Agriculture Food Partnership. In addition to attending global meetings and communications on cultivated meat’s regulation, the regulatory authority is actively promoting the safety assessment of

cultivated meat, such as forming a cultivated meat experts working group to understand the current progress in the industry.



European Union

In the European Union, cultivated meat produced without the use of genetic modification is regulated as a novel food. At the same time, products developed using genetic engineering may instead fall under the regulation on genetically modified food and feed. Companies must apply to the European Commission for premarket authorization of all cultivated meat products. The European Food Safety Authority (EFSA) then conducts a safety evaluation for each product. (Companies may engage in limited consultations with EFSA before submitting an application.) If the results of EFSA’s safety evaluation are favorable, the European Commission, along with representatives from EU member states, has the authority to grant final approval. Approvals apply across all EU member states, and the process is estimated to take between 18 months and three years to complete. As of December 2022, no company has applied to EFSA for approval of a cultivated meat product.

Although the EU did not see any regulatory milestones in the past year, in July 2022, MEPs Tilly Metz and Ulrike Müller held a panel discussion on cultivated meat in the European Parliament. The discussion included panelists from Mosa Meat, CE Delft, GFI Europe, and other stakeholders, who provided information on the production, regulation, and benefits of cultivated meat. As more policymakers learn about and

educate their peers on the benefits of cultivated meat and other alternative proteins, conditions improve for future regulatory progress and pathways.



United Kingdom

Although the United Kingdom is no longer part of the European Union, it has thus far retained the EU novel food regulation and its regulation on genetically modified food and feed. As in the European Union, cultivated meat products will require premarket authorization, and companies must apply for authorization from the UK Food Standards Agency (FSA) using these [guidelines](#).

In 2022, the FSA conducted research on consumer acceptance of alternative proteins, including cultivated meat, and launched a review of the UK novel food regulation to identify and evaluate a range of potential regulatory models for novel foods. Thus, while the EU framework currently remains in place, we may see a new system for evaluating cultivated meat products in the future.



Israel

Israel has long been a leader in its national support for alternative proteins, especially cultivated meat. In 2020, Israeli prime minister Benjamin Netanyahu became the [first head of government to try a cultivated meat product](#). In 2021, Israeli president Isaac Herzog became [the first president in the world to taste cultivated meat](#). And in 2022, with help from GFI, Israel celebrated

its 74th Independence Day with a UN event focused on the country's leadership on alternative proteins. A few months later, GFI Israel partnered with the Israeli Ministry of Foreign Affairs to host an event attended by 60 global ambassadors that called for other countries to promote their own alternative protein strategies.

The National Food Control Service (FCS) within the Ministry of Health has regulatory authority over cultivated meat produced and marketed in Israel. Israel has yet to set forth a formal regulatory framework for cultivated meat, but has stated that cultivated meat will be considered a novel food subject to premarket authorization. The FCS has dedicated a team of experts to evaluate what should be included in the country's safety assessments for cultivated meat. In addition, in September 2022, Israel's Ministry of Health and the UN FAO [convened](#) researchers and developers to discuss various aspects of cultivated meat and dairy, including food safety and regulation.



Japan

In 2022, the Japanese government announced that the Ministry of Health, Labor, and Welfare will assemble a team of subject matter experts to study the food safety aspects of cultivated meat, to help determine the best regulatory path. Tokyo University of Agriculture has been commissioned by the Cabinet Office's Food Safety Committee to examine risk assessment methodologies for cultivated meat. In February 2023, the Ministry of Agriculture, Forestry and Fisheries announced its "Vision of promoting food-tech" and associated roadmap which includes

cultivated food. In order to develop a robust cultivated meat market, Japan needs to understand and formalize safety requirements for the cultivated food industry.

In addition to government research groups, the Japan Association for Cellular Agriculture (JACA), an industrial organization active since December 2019, submitted an industrial guideline and policy recommendation to relevant ministries and politicians in November 2022. The document covers definitions of cultivated foods, food labeling, and food safety under the current law. Additionally, it proposes relevant

Japanese nomenclature for cultivated food, and suggests setting up an intellectual property framework for source cells from branded foods like “Wagyu”. JACA established a legal entity in November 2022 to accelerate activity towards achieving social consensus on Japan’s needs in preparation for the emerging cellular agriculture industry. JACA also leads the Cellular Agriculture Working Team, under a public-private partnership for food-tech, hosted by the Ministry of Agriculture, Forestry and Fisheries.

“Foodtech, including cellular foods, is an important technology from the perspective of realizing a sustainable food supply. We have to support efforts that contribute to solving the world's food problems.”

– Fumio Kishida, Prime Minister of Japan, at a meeting of the House of Representatives Budget Committee



Korea

In late 2022, the Korean Ministry of Food and Drug Safety released technical amendments to its food standards code for public comment, covering “alternative meat” products. Under the current regulatory structure, cultivated meat R&D and tasting events are allowed, but commercial production and sale are not. An official definition for cell culture meat —“agricultural product” or “processed food”—will determine which ministry will oversee industry policy. It is widely anticipated that Korea will analyze regulations in other leading markets such as the United States and Japan prior to implementing formal regulation.



Singapore

Singapore treats cultivated meat as a novel food requiring premarket authorization. In November 2020, the Singapore Food Agency (SFA) became the first national regulator to green-light the sale of a cultivated meat product, approving GOOD Meat’s cultivated chicken for use as an ingredient in the company’s chicken bites. SFA has since approved additional cultivated meat products from GOOD Meat. And, in early 2023, SFA approved the use of serum-free media in the production of GOOD Meat’s products, which will allow the company to further scale up production and reduce costs.

In addition, in 2021, SFA granted scientific manufacturing firm Esco Aster a license to manufacture cultivated meat products from cells that have gone through the regulator's safety assessment review. This will give cultivated meat companies the option to produce their products in a facility that has already received approval from regulators. For now, companies looking to sell cultivated meat in Singapore must still receive pre-authorization from SFA for each product.

In September 2022, SFA updated their guidance on novel food safety assessments,

which outlines the information cultivated meat companies must submit to the regulator when seeking approval for their products. The guidance does not detail the standards manufacturers will need to satisfy to obtain approval; however, SFA welcomes companies to contact the agency early and often in the R&D process. Companies interested in selling cultivated meat products in Singapore should be aware that SFA's regulatory approvals take approximately nine to 12 months once all required information is submitted to the agency.



“The Singapore Food Agency (SFA) adopts a science-based risk assessment and management approach to food safety consistent with international standards. Food safety is SFA’s principal consideration and it must also be a principal consideration when companies develop food products. To ensure that food innovations like novel food are safe for consumers, SFA introduced a novel food regulatory framework in November 2019. The framework requires companies to conduct safety assessments of their products, put in place systems and processes for food safety assurance, and seek pre-market allowance for novel foods that do not have a history of use as food.

To further facilitate the regulatory approval process, we have developed platforms such as the Novel Food Virtual Clinic, to engage novel food companies and help clarify any queries they may have regarding the approval process. We encourage companies to engage SFA early in their development process to ensure safe products from a joint partnership in food safety.”

– Tan Lee Kim, CEO, Singapore Food Agency



United States

Federal regulation

In November 2022, the U.S. FDA completed its first premarket consultation for a cultivated meat product, giving UPSIDE Foods the “green-light” for their cultivated chicken. UPSIDE is the first company to complete FDA’s rigorous consultation process, demonstrating that their product is as safe as conventional chicken. To complete a consultation with FDA, companies must submit data and information to the agency documenting the product’s safety, which is reviewed and evaluated along with the company’s entire production process. Once FDA has the required information and completes its evaluation, the agency informs the company that they have no further questions or concerns regarding the safety of the product. FDA’s responses and additional information regarding their consultations are available on the agency’s website.

UPSIDE’s successful completion of the consultation process paves the way for consumers to access cultivated meat in U.S. restaurants and through retail sales. However, there are additional regulatory steps before the company can sell their cultivated chicken. All cultivated meat producers must register their facilities with FDA, and companies producing cultivated terrestrial meat, poultry, or catfish must also obtain a grant of inspection from USDA. USDA inspectors will oversee the processing, packaging, and labeling of these products

and will verify that cultivated meat products are safe, wholesome, and unadulterated (free from contamination). FDA will retain jurisdiction over the processing, packaging, and labeling of cultivated seafood.

Neither FDA nor USDA has set forth rules or guidance for labeling cultivated meat products, but both agencies have sought public comment on labeling and nomenclature. In the meantime, USDA will review and pre-approve labels for cultivated terrestrial meat, poultry, and catfish on a case-by-case basis. FDA does not pre-approve labels for any foods, but rather exercises their enforcement authority when regulators become aware of improperly labeled foods.

State litigation

A handful of states have enacted “label censorship” laws that restrict cultivated meat from being labeled as “meat.” The laws ban terms such as “burger,” “sausage,” and “chicken” on products that are not made from an animal carcass. GFI and other groups have challenged these laws in court on the grounds that they violate the First Amendment and other constitutional provisions. These challenges may help clear the way for accurate labeling of cultivated meat. No new label censorship bills have recently passed, but litigation against existing laws continued in several states.

- In **Louisiana**, GFI and co-counsel Animal Legal Defense Fund (ALDF) have sued the state on behalf of Tofurky, arguing that the state’s label censorship law violates First Amendment free speech principles and the Fourteenth Amendment right to due process. In March 2022, the court granted Tofurky’s motion for summary

judgment and enjoined Louisiana from enforcing the law, concluding that it “impermissibly restricts commercial speech.” The state has appealed the decision, and that appeal is pending.

- In **Arkansas**, a federal district court judge granted Tofurky a permanent injunction, preventing the state from enforcing its label censorship law against the company on the ground that it violates Tofurky’s First Amendment right to free speech. The court also held that one provision of the law is unconstitutionally vague on its face and may not be enforced against any company.
- In **Oklahoma**, ALDF brought a new challenge to the state’s label censorship law on behalf of plaintiffs Tofurky and the Plant Based Foods Association after a judge had denied a motion to prevent enforcement of the law. The new complaint argues that Oklahoma’s law is vague, overly burdensome, and preempted by federal law. At the time of this report, the case remains pending in federal court.
- In **Missouri**, a federal district court declined to grant Tofurky and GFI a preliminary injunction (a halt on enforcing the law while the case is pending) on the grounds that Missouri’s label censorship law was not likely to apply to Tofurky’s product labels. In 2021, a federal appeals court upheld the ruling. The litigation is continuing in federal district court.

Global coordination

The importance of alternative proteins as a scalable solution for global problems including the climate crisis, biodiversity loss, public health risks, and food insecurity is not lost on various multilateral organizations. A number of these organizations are beginning to work on the global regulation and trade of alternative proteins and have expressed increasing support for continued protein innovation.

COP27

More so than any year prior, food, agriculture, and alternative proteins seized the spotlight at the 2022 United Nations Climate Change Conference (COP27) in Sharm El-Sheikh, Egypt.

GFI Asia Pacific (APAC) co-organized a historic, first-of-its-kind cultivated meat

dinner for global leaders. Current and former senior officials from 10 nations joined GFI APAC managing director Mirte Gosker and Singapore Minister for Sustainability and the Environment Grace Fu for the meal. GFI also served as one of nine co-hosts of the first-ever Food Systems Pavilion at COP27, and worked to ensure alternative proteins were highlighted in panels on smart protein

policy and financing, climate investment, food security, deforestation, and sustainable diets. Throughout the entire two weeks of the conference, the Israel pavilion championed alternative protein innovation as a key climate solution and “taste of the future.”

Near the end of COP27, the UN FAO issued a [new report on bioeconomies](#), with a solid nod toward the role of food in humanity’s future: “In addition to climate mitigation gains, new food sources could reduce pressure on forests and land used for feed, support the preservation of biodiversity and planetary health, and contribute to preventing forms of malnutrition in developing countries.”

FAO/WHO

The UN FAO and the World Health Organization (WHO) convened an [expert consultation](#) on cultivated food products and food safety considerations, attended by two GFI scientists, in Singapore in November 2022 to collect the most up-to-date information and best practices available on cultivated meat (and other cultivated products) with a focus on food safety. The document will be shared with national food regulators and will help determine where further work is needed to support global regulation of these foods. FAO also [released resource papers](#) on terminologies, regulatory frameworks, and the general cultivated meat production process.

Codex Alimentarius Commission

The Codex Alimentarius Commission is an international body run jointly by the UN FAO and WHO. It includes 188 member countries and the European Union as well as a number of official observer organizations, including GFI. The Commission promulgates voluntary standards and guidelines for food safety, trade, and regulation in a publication called the *Codex Alimentarius*.

In March 2022, the Codex Secretariat issued a circular letter seeking comment from member countries and observers on developments related to new food sources and production systems (NFPS), which includes alternative proteins. Members and observers, including GFI, submitted comments outlining the regulatory status of alternative proteins worldwide while raising potential regulatory and trade issues. The topic of NFPS was discussed at the 45th convening of the entire Commission (CAC45) in November 2022. An additional circular letter is expected in 2023 soliciting comments identifying possible issues related to NFPS that the current Codex structure and procedures could not address, and the topic is expected to be discussed again at CAC46 later in the year.

*Are we missing something from the Government & Regulation section?
Did we get something wrong? We’d appreciate your feedback via [this form](#).*



Section 5

Forecast

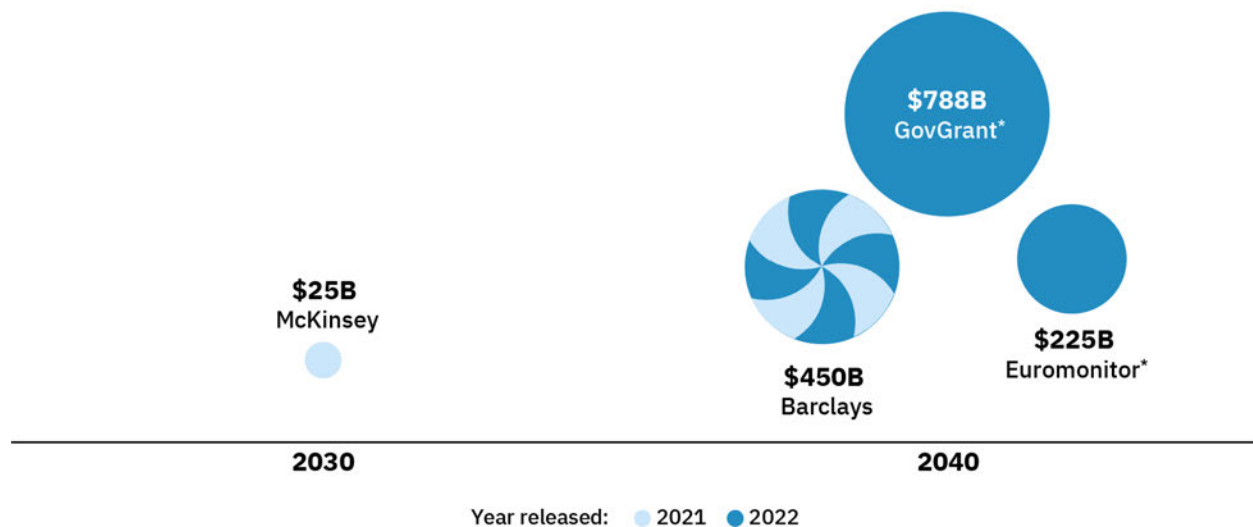
Section 5: Forecast

Cultivated meat forecasts

Multiple cultivated meat market forecasts released in 2022 predict double-digit shares of the global meat market by 2040. [Euromonitor](#) forecasted that cultivated meat would comprise 10 percent of the global meat market, Barclays' market share estimate held steady at 20 percent, and [GovGrant](#) projected that cultivated meat would capture 35 percent of total meat sales by 2040. The section below discusses the shared features of alternative protein forecast models in greater detail.

Figure 12: Cultivated industry forecasts by year released

**Some forecasts projected the share of the total market rather than the industry size in dollars. For those forecasts, we estimated the dollar size of the cultivated meat sector using Barclays' forecast for the total 2040 meat market.*



The most obvious factor working in cultivated meat's favor is the fact that it is the same as conventional meat at the cellular level. In 2022, the average plant-based meat product did not match conventional meat's sensory experience. Cultivated meat—in the form of fully cultivated products or hybrid plant-based and cultivated meat—may help bridge the taste and texture gap. [McKinsey &](#)

[Company](#) identified hybrid meat as a likely near-term path for manufacturers to lower costs and improve efficiencies.

Even if cultivated or hybrid products make strides toward achieving identical tastes and textures to conventional meat, the growth of the market will depend on consumer acceptance of the novel food products.



According to [research](#) conducted by GFI and Embold Research, nearly half of U.S. adults would consider trying cultivated meat, with that number rising to 60 percent in the 18–34 year-old age range. [Euromonitor](#) data shows a similar trend of younger generations’ openness to new food technologies, as well as younger consumers being more likely to eat plant-based meat alternatives for the environment or for animal welfare—motivations that could also prompt switches to cultivated meat. This bodes well for the long-term prospects of the industry, especially if production costs continue their anticipated decline over the longer term.

But the eventual size of the cultivated meat sector relies on more than consumer acceptance of these products. To expand reach on store shelves and restaurant plates, an entire production and distribution infrastructure must be developed, and has already been started. Investment continues to flow into the cultivated meat space from public companies, venture capitalists, and governments around the world. The cultivated meat sector brought in \$896 million of funding in 2022, lifting the all-time total to \$2.8 billion. Plus, the “green-light” of UPSIDE Foods’ cultivated chicken from FDA represents a significant de-risking event that could result in fresh capital inflows. At the end of 2022, the world’s top two CPG and top three meat companies (by revenue) were all active in the cultivated meat industry. Startups and B2B companies continue to improve the costs and efficiencies of [cell lines](#), [cell culture media](#), [bioreactors](#), and [3D printing and scaffolding](#).

Despite this progress, roadblocks remain to cultivated meat capturing significant market share in the near term. Production costs for cultivated meat are still [well above](#) those for conventional meat—likely north of \$100/kg—and regulatory review limits the rate at which new products can be introduced. Expensive cell culture media, suboptimal bioreactor design and availability, and limited access to suitable cell lines also curb near-term growth prospects.

Meanwhile, conventional meat consumption is [vast and growing](#). Continuing on this path, with business-as-usual ways of producing meat, will make it impossible to meet global climate goals, restore biodiversity, improve food security, and protect public health. With just seven years until 2030, the milestone year by which governments have agreed to cut global emissions by half, there is an urgent need to shift toward alternative proteins. Cultivated meat can play an important role in this shift as the only alternative protein pillar that offers consumers a product identical to animal meat at the cellular level.

So, where is the cultivated meat market headed? In 2023, U.S. consumers may get their first taste of cultivated chicken. The FDA has indicated that more regulatory reviews are on the way for multiple cultivated meat companies, and financial data provider PitchBook [predicts](#) that, as cultivated meat approaches its U.S. market debut, funding in the space will reach new heights. As more cultivated meat products gain regulatory approval, plant-based producers will be able to use cultivated inputs to create hybrid products, which could enhance the sensory experience of plant-based meat and other alternative protein products.

A global shift to cultivated meat production is not inevitable, though. It can happen with advances in science, significant investments in infrastructure and manufacturing capacities, clear regulatory paths to market, and delicious, nutritious, affordable products that win over more and more consumers. In 2022, a number of companies, investors, researchers, universities, and governments leaned into cultivated meat in new and notable ways.

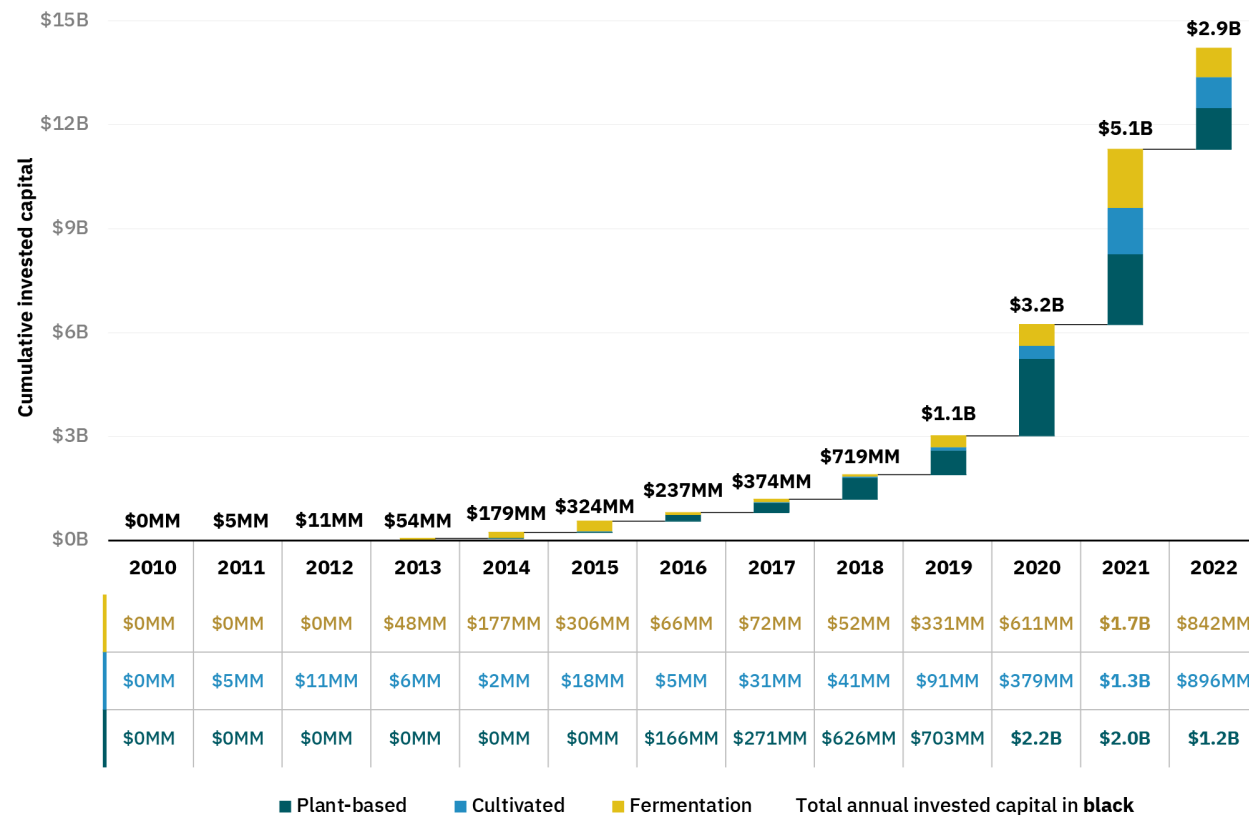
This growing momentum, and the increased recognition of the global stakes, is making possible a “meat without the animal” future. The next few years are critical, with giant strides needed by all sectors—public, private, academic, and philanthropic—to create an industry capable of transforming how meat is made around the world.

A deeper dive into alternative protein market forecasts

The FAO projects that the global meat market will grow from 360 million metric tons (in 2022) to 455 million metric tons by 2050. Cultivated, plant-based, and fermentation-derived proteins represent an opportunity to significantly reduce risks and improve the efficiency of meat production while offering consumers the meat-eating experience they crave.

Over the past decade, the promise of alternative proteins spurred billions of dollars in investment, led to rapid growth in the plant-based meat market, and increased funding and activity in cultivated meat and fermentation-derived proteins. From 2017 to 2022, the global plant-based meat and seafood market grew 118 percent from \$2.8 billion to \$6.1 billion, according to Euromonitor data. All-time investments in cultivated, fermentation-derived, and plant-based proteins approached \$3 billion, \$4 billion, and \$8 billion, respectively, by the end of 2022.

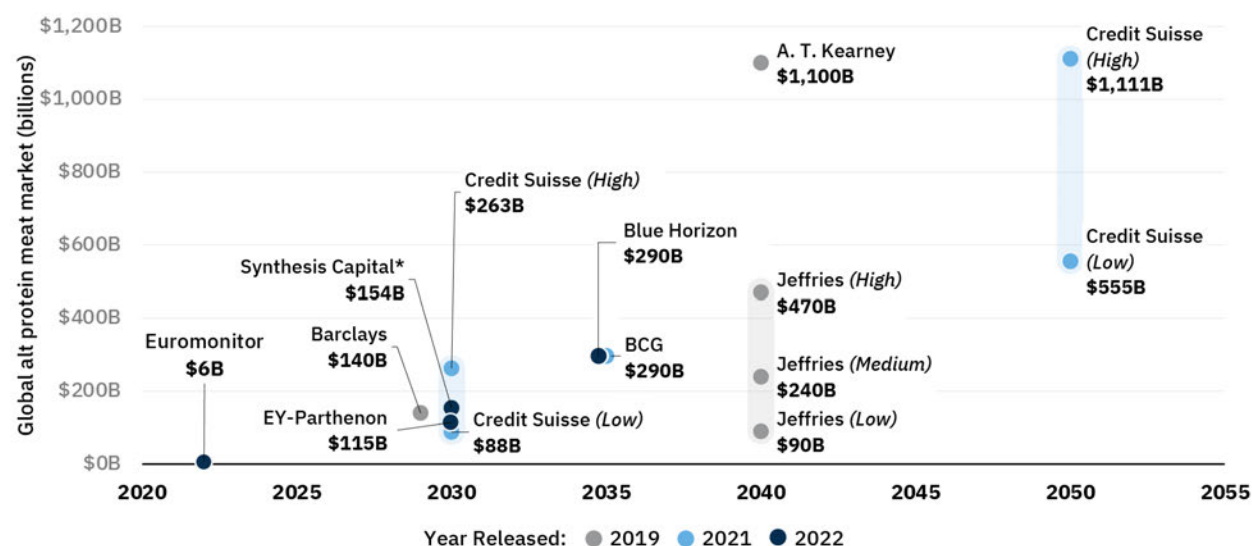
Figure 13: Cumulative and annual alternative protein invested capital, by pillar



Despite the relative newness of the alternative protein sector, industry forecasts followed the trend of rapid growth, with estimates for a 2040 total market size ranging widely from \$90 billion to \$1.1 trillion. Reasons these forecasts vary are manifold, but they include large variances in key drivers such as customer adoption rates and policy environments. What these forecasts tend to share is mapping out growth paths built on relatively rapid compound annual growth rates.

But in 2022, the short-term outlook for alternative proteins shifted from the rapid growth expectations of prior years. Global overall venture funding fell in response to changing macroeconomic conditions, and alternative protein companies were not immune to this decline. The alternative protein sector with the largest market presence—plant-based proteins—didn’t receive investment capital that reached the highs of recent years. On average, alternative protein forecasts limited their upside relative to those published in years prior (see Figure 12 that shows 2022 forecasts versus prior-year estimates), as the market landscape tempered expectations for consistently high double-digit year-over-year growth rates. This change was most pronounced in forecasts specific to the plant-based market, but total alternative protein projections also took a more modest approach.

Figure 14: Total alternative protein forecasts by year released



**Some forecasts projected share of the total meat market rather than the industry in dollars. For those forecasts, we estimated the dollar size of the alternative protein sector using EY's forecast for the total 2030 meat market.*

Source: GFI synthesis of multiple reports

The fact that 2022 forecasts had lower ceilings than those published in earlier years—even though multi-decade outlooks should be relatively impervious to short-term market conditions—raises questions about the benefits of examining the specific outcomes of any single projection. With methods, scope, and publication date varying widely by forecast, in the next section we focus on the more useful assumptions, growth factors, and roadblocks shaping projections rather than the topline numbers frequently pulled for headlines.

Examining the structure of alternative protein market forecasts

In many cases, the assumptions and inputs of a projection can be more informative than the output itself in navigating the potential impacts of technological developments and policy changes in emerging industries. Often, the key question facing forecasters is less “How will this market develop?” and more “In what type of world will this market develop?” The decisions made on the front end of the forecasting process—about how industry participants will respond to changes in the market, what will drive growth or impede progress, and how market expansion will occur—are the focus of this section.

So, what are the most common assumptions found in alternative protein market forecasts?

Common forecast assumption:

Taste and price parity are essential.

Nearly every forecast implies that improved product features such as taste and price parity with conventional meat will drive the adoption of alternative proteins. Blue Horizon Ventures, for example, affirmed that health, taste, and price are key to boosting demand, while Synthesis Capital discussed a tipping point at which rational consumers switch to alternative proteins based on product cost and quality. These assumptions are backed by research: Multiple studies show that taste and price are essential drivers of alternative protein demand. Achieving taste and price parity for alternative proteins is at the heart of GFI’s theory of change—give people the meat they love, made in far more sustainable ways, that costs the same (or less) and tastes the same (or better) than conventional meat. But it’s important to remember that product improvements don’t occur in a vacuum. In reality, taste and price improvements are likely necessary but perhaps not sufficient on their own for market growth. Factors like product variety, availability, and consumer acceptance are also needed to manifest the more robust visions for the future of alternative protein market share. To compete with conventional meat, alternative proteins must reach taste and price parity, but they also need to encompass the entire selection of conventional meat products, be available wherever conventional meat is sold, and be coveted by consumers.

**Common forecast
assumption:**

**Consumer adoption is a
limiting factor to market
growth.**

Most alternative protein market forecasts see growth as dependent on consumers wanting and buying alternative protein products, with market penetration naturally following. Jefferies, for example, identifies consumer tastes and adoption as key drivers of market growth, and Boston Consulting Group states that growth relies on consumers being convinced of taste, texture, and price competitiveness in relation to conventional meat. These views complement the commentary above on the importance of consumer preferences. While taste parity, price parity, and consumer adoption are all necessary, they aren't alone sufficient for achieving market growth—companies must also be able to adequately meet increased market demands for the industry to see growth. While some projections identify manufacturing capacity as a bottleneck, consumer adoption remains the key metric in most overall estimates. This may not be surprising, given how large a share the plant-based category represents in several of these models, and how today, consumer adoption is a central bottleneck to the plant-based industry. Indeed, many plant-based companies with products on the market today elected to cut costs in 2022 and lower their near-term growth expectations—as such, consumer adoption and manufacturing capacity are fitting leading considerations in this economic environment. The scope of manufacturing capacity scale-up needed is sizeable—\$27 billion in capital expenditure by 2030—for plant-based meat to reach even a six percent share of the global meat market.

**Common forecast
assumption:**

**Innovation brings more
innovation, investment
brings more investment.**

Alternative protein forecasts generally assume the direction of the alternative protein market is up and to the right: Investment leads to better, more affordable products and technological breakthroughs that continue this cycle, spurring growth and leading to more investment. EY identifies an ever-increasing need for technological innovation in protein production, and Kearney states that it is all but inevitable that alternative proteins will capture substantial market share. The common practice of using compound annual growth rates as forecasts only adds to the sense of a predestined march toward 100-percent market share. While the general assumption of steady growth largely matches overall historical precedents, the growth depicted in many models doesn't tell the full story. First, rapid double-digit growth rates year-over-year can make sense for an emerging category where bringing one or two facilities online or launching a handful of new products can double revenue. Additionally—and particularly in times of macroeconomic upheaval—it's important to understand that inconsistent growth patterns can be common in emerging industries. When seeking to project realistic long-term outcomes, it's critical to acknowledge that outcomes can take hard turns in either direction with even the smallest of perturbations affecting a market. Take renewable energy and electric vehicles: Just a few short years ago, these technologies struggled to compete in the market. At the time, both were written off as unlikely ever to compete with fossil fuels and gas-powered cars. But as governments continued to expand market access, prices fell faster than most experts expected. Sales of solar energy reached one percent penetration in 2015. Sales of electric vehicles reached that same percent in 2017. Today, the biggest automobile manufacturers in the world are pledging to produce 100 percent electric vehicles by 2035, and according to the International Energy Agency, renewable energy will be the backbone of a carbon-free energy system of the future.

Industry drivers

Next, what are the most common industry-supportive factors identified in existing forecasts?

Supportive factor identified across forecasts:

Consumer acceptance will increase as products improve.

Many consumers already recognize the climate, health, and animal welfare benefits of alternative proteins, but for those products currently available in the marketplace, taste and price metrics often still fall short compared to conventional products. Industry stakeholders recognize additional opportunities for progress, and alternative protein market outlooks point to product innovation as a driver of future growth.

Supportive factor identified across forecasts:

Public and private investment will help lower costs, improve products, and raise awareness of alternative proteins' role at the center of the plate.

While investment dollars in 2022 slowed from record spending in 2020 and 2021, the multiyear trajectory still points upward. Key partners remain committed to alternative proteins' potential—and cultivated meat specifically, as evidenced by **UPSIDE Foods'** \$400 million Series C raise, **Wildtype's** \$100 million Series B round, and the Dutch government's €60 million investment in cultivated meat. In addition, public support grew, with governments around the world increasing support for alternative proteins overall in notable ways, from an uptick in public policymaking and R&D funding to FDA's green light of a cultivated chicken product in the U.S. Investment and progress to date are no guarantee of future growth, but sustained support for new technologies and ventures bodes well for the future of the industry.

Industry roadblocks

Finally, what do alternative protein market projections frequently identify as limiting factors to market growth?

Roadblock identified across forecasts:

Current price premiums and a general lack of taste parity with animal products hamper alternative protein brands' abilities to attract new consumers to the space.

Most products on the market today are plant-based, sold at a premium, and don't fully recapitulate the experience of eating conventional meat. Cultivated meat is expected to help close the taste gap for alternative protein products (including hybrids), but its initial market introduction will be small scale and at a premium price. Inflationary pressures only add to the barriers of high prices, as many consumers look for opportunities to cut costs in their grocery and restaurant budgets. Plus, complex manufacturing processes, limited availability of key ingredients, and cost to scale certain products exacerbate the current price premium and act as speed bumps to the development of the alternative protein market. That said, a clear path remains for reducing prices and improving product quality, and cultivated and fermentation-derived products may ultimately play a key role in closing these gaps.

Roadblock identified across forecasts:

Regulation for some alternative protein product categories is new, and it's possible that regulatory hurdles could slow industry growth.

Immense progress has been made on the path toward a fair and open regulatory environment for alternative proteins. In 2022, the U.S. FDA gave the "green-light" to UPSIDE's cultivated chicken, paving the way for the first cultivated meat product to be sold in the United States. A U.S. court ruled that Louisiana's label censorship law targeting plant-based proteins was unconstitutional. But with nearly any new product or technology, the risk of challenging the status quo almost always skews toward more reactive rules and regulations, not fewer.

Since this section largely synthesizes the findings of external forecasts, the three distinct alternative protein pillars are occasionally grouped under the larger alternative protein umbrella. But in reality, each pillar exists in a different stage of development and faces its own unique set of opportunities and challenges for growth.

Cultivated meat is on the cusp. Products have the potential to offer consumers the same meat-eating experience as conventional meat, which could present a breakthrough opportunity for mass adoption of alternative proteins. Yet the vast majority of consumers globally have yet to taste cultivated meat. Before taste and price considerations enter the picture, industry participants must make continued investments in R&D, infrastructure buildout, and regulatory processes to ensure consumers are even able to try cultivated meat. Considering the investment and regulatory progress made in 2022, the coming years will prove critical for the development of this market. As more products receive regulatory approval from governments around the world—and companies continue to improve and scale their offerings—the potential of a “meat without the animal” future will draw closer to reality.

Expert predictions

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



"Within 1–3 years, I expect to see many more market launches at small scale, followed by some early sales through higher volume but still premium outlets in food service or retail. Further progress on scale-up and cost-down will be accelerated by B2B companies like the aforementioned growth factor producers; their impact will really become visible in the next 1–3 years."

– Friederike Grosse-Holz, Director, Blue Horizon



"Cultivating cells is now a known art, the global cultivated meat industry players are now fixated on achieving price parity. Over the next few years, we will see unprecedented progress in the areas of media ingredients, bioreactor design, and process engineering. We will witness cross-border collaborations, like we are used to seeing in space exploration."

– Subramani (SuBBu) Rich, Founder, Fermbox



"In the 10–20 year timeframe, cultivated seafood will become an essential segment of the seafood category, enabling consumers to continue to eat culturally important, heritage fish species while preserving and restoring depleted wild fisheries. In the short term, we believe cultivated seafood will predominantly be found in smaller volumes in premium segments of the market and will be served through hospitality channels. As production volumes scale, these products will become broadly available at competitive prices."

– Mihir Pershad, Founder & CEO, Umami Meats



"In the long term, I expect to see cultivated meat hybrid products that are readily available to consumers and higher-end whole cut cultivated meat products. In the short term, I expect that those hybrid products will be available in limited capacity, which I think will be huge for the field in terms of beginning to directly interact and face consumers."

– Michael Saad, PhD candidate



"Projections are always difficult—especially in times in which we experience huge shifts in the market and uncertainties in consumer response. However, I believe that cultivated meat will become a vital part of our future diet and in 10 years' time it will hopefully be available around the world in order to maximize its sustainability potential. Until then, a few regions in the world will be more open and will be able to serve cultivated meat earlier."

– Patrick Bühr, Head of Research & Development, Rügenwalder Mühle



"Cultivated meat, dairy, and other fats for me will be the tipping point...I honestly believe it will be as important a technological advance for food as the Internet was for communication."

– Alexis Gauthier, Michelin-starred chef

Conclusion

Conclusion

Exciting developments propelled the alternative protein field, including cultivated meat and seafood, forward in 2022. The sector still has miles to go, however, to reach its full potential. We offer three summary reflections to take into the year ahead:

1

Keep the long view in sight.

The alternative protein industry is still very early in its development. At this moment in time, it's promising to see increasing recognition among both the public and private sectors of the potential of alternative proteins to meet long-term global goals in the areas of climate, public health, biodiversity, and food security. Advances in cultivated meat technologies are happening fast, as more researchers and funding flow into the field. The policy and regulatory landscape is just starting to take shape. Consumers want sustainable options, but they don't want to compromise on taste, price, or convenience. Navigating and building the path to scale and adoption will take years.

2

A global protein transformation will require strong, system-wide participation.

Companies can lead by delivering tasty, affordable alternative protein products to mainstream consumers, representing a significant market opportunity given growing consumer interest in sustainable foods. The research community can lead by encouraging more scientists, from diverse disciplines and at different points in their careers, to jump into the alternative protein field. The world's governments can lead if they invest in critical R&D to advance alt protein science, manufacturing incentives to help scale-up, and policies that level the playing field to allow alternatives to compete on taste, price, and convenience. Doing so can address the industry's biggest technical challenges, inspire additional research, create new opportunities for growth, and ensure these sustainable foods can benefit everyone.

3

Believe change is possible.

At GFI, we bring determination and informed optimism to our work because we know a better food future is achievable. We see these same traits in those who pushed the field forward this year, many of them highlighted in this report. Across sectors and regions, there is a growing understanding of the importance of finding viable alternatives to industrial animal agriculture, and huge opportunities for companies who get involved in this space. Just as the world is changing how energy is produced, we need to change how meat is made. Alternative proteins can satisfy growing demand, reduce pressure on the planet, and enable a more sustainable, secure, and just food future. Alongside other advances and innovations, alternative proteins—including cultivated meat and seafood—can help write the next chapter for food and agriculture around the world.

To those who are in this work already, we hope GFI's 2022 State of the Industry Report: Cultivated meat and seafood gives you a more detailed look at this rapidly evolving sector. For those new to the field, welcome. Stay a while, grow with us, and change the world.

Acknowledgements

Authors

Dr. Claire Bomkamp, Michael Carter, Madeline Cohen, Daniel Gertner, Emma Ignaszewski, Sharyn Murray, Maille O'Donnell, Ben Pierce, Dr. Elliot Swartz, Sheila Voss

Editors

Liz Fathman, Tara Foss, Emma Ignaszewski, Maille O'Donnell, Sheila Voss

Additional acknowledgments

GFI would like to thank these additional colleagues for their insights and contributions.

Jessica Almy, Caroline Bushnell, Raquel Casselli, Kelli Croomsigt, Rachel Faulkner, Bruce Friedrich, Emily Giroux, Joe Gagy, Mirte Gosker, Ryan Huling, Ann Ittoop, Doris Lee, Carlotta Lucas, Heather Mount, Aviv Oren, Nicole Rocque, Ilya Sheyman, Dr. Liz Specht

Cover image courtesy of Shiok Meats.

©2023 The Good Food Institute. All rights reserved.

Permission is granted, free of charge, to use this work for educational purposes.

The Good Food Institute is not a licensed investment or financial advisor, and nothing in the state of the industry report is intended or should be construed as investment advice.

About GFI

The Good Food Institute is a nonprofit think tank working to make the global food system better for the planet, people, and animals. Alongside scientists, businesses, and policymakers, GFI's teams focus on making plant-based and cultivated meat delicious, affordable, and accessible. Powered by philanthropy, GFI is an international network of organizations advancing alternative proteins as an essential solution needed to meet the world's climate, global health, food security, and biodiversity goals. To learn more, please visit www.gfi.org.



Fuel the future of food at gfi.org/donate



Join GFI's email lists at gfi.org/newsletters