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United States Department of Agriculture
Food Safety and Inspection Service
Room 2534 South Building
1400 Independence Avenue SW
Washington, DC 20250-3700

RE: FSIS-2020-0036
Advance Notice of Proposed Rulemaking: Labeling of Meat or Poultry Products Comprised of or Containing Cultured Animal Cells

The Good Food Institute (GFI) appreciates the opportunity to comment on the crucial issue of labeling foods comprised of or containing cultured animal cells ("cultivated meat"). GFI is a nonprofit think tank and open-access resource hub developing the roadmap for a sustainable, secure, and just protein supply. We identify the most effective solutions, mobilize resources and talent, and empower partners across the food system to make plant-based and cultivated meat ("alternative proteins") accessible, affordable, and delicious. GFI's team of scientists, entrepreneurs, and policy experts supports research and innovation in alternative proteins—including cultivated meat and poultry products—to meet consumer demand and feed a growing world. GFI also supports fair public policy that places conventional and alternative proteins on a level playing field.

Workable and nondiscriminatory labeling rules are crucial to bringing cultivated meat and poultry products to market. The Food Safety and Inspection Service's (FSIS) proactive approach to gathering information from key stakeholders before proposing labeling requirements is an essential step in the development of a clear regulatory path for these products. Any labeling rules or guidance that USDA promulgates for cultivated meat and poultry products will have a substantial impact on the cultivated protein industry and on consumer choice. USDA's labeling rules will also preempt any state laws that conflict with or exceed the federal framework.[1] In addition, as you have recognized, FSIS's regulatory decisions will need to align with any Food and Drug Administration (FDA) guidance governing the labeling of cultivated seafood products under that agency's jurisdiction. Given the broad implications of

[1] As FSIS noted in the ANPR, "[w]ith limited exceptions, U.S. states or territories may not impose requirements within the scope of the [FMIA and PPIA]—such as labeling requirements—that are in addition to, or different from, the requirements established by the Acts or their implementing regulations (21 U.S.C. 678 and 476e)." Label preapproval decisions that FSIS makes under the framework set forth in the ANPR will also preempt any different or additional state labeling requirements.

FSIS's decision-making here, GFI urges FSIS to adopt a sensible and fair approach to labeling that neither discriminates against cultivated products nor sows consumer confusion. A flexible regulatory framework that allows companies to accurately describe their products using a variety of terms would put cultivated meat products on a level playing field with their conventional counterparts. Providing consumers with accurate and helpful information about cultivated products will also increase consumer choice, and protect consumer health and welfare.

In this comment, GFI sets forth essential background information on the cultivated meat and poultry industry, then proceeds to answer the questions set forth in the advance notice of proposed rulemaking (ANPR).

Background

Cultivated meat and poultry products will offer consumers greater choice at the grocery store and will help the United States meet the increasing demand for protein from a growing population. Although cultivating tissue from animal cells is a new method of creating meat and poultry products, it does not necessarily require new labeling rules or new standards of identity. New processes and methods for producing meat and poultry products do not always necessitate new labeling requirements. FSIS has generally promulgated new labeling requirements only when a new process or method materially alters the finished product[2] or where it raises different or increased food safety risks. For example, as noted in the ANPR, FSIS created a new standard of identity for mechanically separated poultry in 1995 because it found that the process of mechanically separating poultry tissue from bone resulted in products "whose form and consistency materially differ from" poultry products separated by hand.[3] In fact, FSIS determined that mechanically separated poultry products have such a different form than their traditional counterparts that they "are no longer recognizable as 'chicken' and 'turkey.'"[4]

But not all new production methods result in drastic product differences. For example, in 2004 FSIS found that advanced meat recovery (AMR)—a newer method for separating meat tissue from bone—results in a product "comparable to meat derived by hand deboning…"[5] Accordingly, FSIS determined that new labeling requirements were not necessary and that meat products produced through AMR could be called "meat" under 9 C.F.R. § 301.2. FSIS did, however, alter the definition of "meat" to ensure that products labeled as meat do not contain significant portions of bone or other related components, which helped ensure that meat from AMR systems containing too much of these components would not be sold for human consumption. Similarly, after FDA determined that meat from cloned animals poses no

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[2] As explained in the ANPR: "In assessing the labeling of meat and poultry products developed using new methods or technologies, the Agency typically focuses on the biological, chemical, nutritional, and organoleptic characteristics of the finished product."

[3] USDA-FSIS, Poultry Products Produced by Mechanical Separation and Products In Which Such Poultry Products Are Used, 60 Fed. Reg. 55962-01 (Nov. 3, 1995).

[4] *Id*.

[5] USDA-FSIS, Meat Produced by Advanced Meat/Bone Separation Machinery and Meat Recovery (AMR) Systems, 69 Fed. Reg. 1874-01 (Jan. 12, 2004).

additional food safety risks beyond those associated with meat from bred animals, USDA declined to impose new labeling requirements on meat or poultry from clones or their progeny.[6]

With this background in mind, GFI urges FSIS not to impose new labeling requirements for cultivated meat and poultry products unless those products are materially different from their conventional counterparts, consistent with longstanding FSIS policy. In addition, to the extent products are materially different, FSIS should not mandate or prohibit a *specific* term or terms on product labels at this early stage of product development. Although the industry is expanding rapidly, the technology, methods, and processes behind cultivated meat and poultry products are still being developed. We do not yet know the full scope of products that cultivated protein companies will produce and market. Many products are expected to be biologically, chemically, nutritionally, and organoleptically identical to their conventional counterparts, while others may differ significantly. Companies are also developing hybrid products that combine conventional and cultivated meat and poultry, as well as products that combine cultivated meat and poultry with plant-based protein. The diversity of items that will enter the marketplace cautions against mandating or prohibiting specific names and terms at this early phase.

Moreover, given that cultivated meat and poultry products have yet to hit grocery store shelves, consumer understanding of these products and the terms used to describe them is still developing. It would be unhelpful to both consumers and the industry to mandate the use of specific names or terms that consumers do not yet recognize and use. Likewise, prohibiting the use of truthful and non-misleading terms and credence claims on product labels would inhibit cultivated protein companies' ability to accurately describe their products to consumers.

A flexible framework that allows companies to truthfully describe their products using a variety of terms would be optimal at this early stage of product development and sale. Flexibility will allow companies to craft accurate labels and give consumers time to develop an understanding of the terms used to describe cultivated products and what they mean. While there is value in establishing clear guidelines for the labeling of cultivated products, it would be premature to establish strict naming conventions before cultivated products have even hit the shelves. Historically, labeling requirements have not *created* consumer expectations; rather, they have codified existing ones[7] to ensure consumers continue to receive the products they have come to expect.[8] Consumer expectations regarding cultivated meat and poultry products have not yet solidified and cannot be accurately measured at this time, so there is nothing to codify. As the ANPR notes, "consumers have not yet had experience reading these types of labels." Once consumers have had the chance to read cultivated product labels and purchase these

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[6] FDA, *Animal Cloning and Food Safety*, FDA Consumer Updates (Aug. 10, 2018), https://www.fda.gov/consumers/consumer-updates/animal-cloning-and-food-safety ("Food labels do not have to state that food is from animal clones or their offspring. FDA has found no science-based reason to require labels to distinguish between products from clones and products from conventionally produced animals.").

[7] For example, both mechanical separation and advanced meat recovery system technologies had been used in the marketplace for some time before FSIS finalized its respective rules for products produced using these process.

[8] *See* 35A Am. Jur. 2d Food § 16 ("Regulations pertaining to standards of identity are designed to prevent the sale, under traditional names, of products bearing no resemblance to the items commonly sold under those names.").

products in stores, we will have a better understanding of consumer expectations and preferred nomenclature.[9] Mandating specific terms or creating standards of identity for cultivated food that consumers do not yet understand would be counterproductive and run contrary to FSIS precedent. Likewise, prohibiting the use of terms that consumers already understand will only cause confusion and limit consumer choice.

FSIS also need not rush to choose specific product names or qualifying terms at this juncture because the interim process for label approval set forth in the ANPR is sufficient to ensure that all cultivated meat and poultry products are accurately labeled. This process will allow FSIS to review new cultivated product labels on a case-by-case basis. Many of these products will be indistinguishable from their conventional counterparts and should be allowed to be identified with terms traditionally used to describe slaughtered meat and poultry products. Other products may have distinctions that require additional, descriptive terms to explain their contents to consumers. In either case, cultivated meat producers will be motivated to clearly distinguish their products from slaughtered meat and poultry products. Cultivated protein companies are not yet able to produce and sell their products at the same low prices as conventional products. They will need to justify higher prices to consumers by describing how these new products differ from conventional ones. We expect that companies will use a variety of terms and phrases to differentiate their products. During the label review process, FSIS will have the opportunity to scrutinize these choices and determine whether the language chosen accurately describes the product before it ever reaches consumers.

Finally, any labeling rule FSIS does promulgate must not restrict truthful speech or mandate unnecessary disclosures. The First Amendment protects non-misleading commercial speech. It safeguards not only the right of speakers to share truthful information but the right of consumers to receive accurate commercial information.[10] Blanket bans on speech are strongly disfavored.[11] Furthermore, if the government plans to restrict truthful commercial speech, it must demonstrate that the proposed restriction narrowly and directly advances a substantial government interest.[12] Courts will strike down rules that restrict more speech than is reasonably necessary, particularly when less restrictive means of achieving the government's objective are available.[13] Here, less restrictive means might include reviewing product labels for accuracy or requiring a qualifying statement in the ingredient list, rather than imposing a blanket ban on the use of a particular term. When it comes to First Amendment issues, courts generally favor more speech, not less.[14] Compelled commercial speech may also violate the First Amendment, however, where the mandated speech is not necessary to protect the public.[15] Labeling rules mandating disclosures that do not directly protect public health and welfare risk violating the First Amendment.

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[9] Consumers are excited to try cultivated protein products and we expect significant levels of consumer interest once these products are available for purchase in grocery stores. *See, e.g.*, The Good Food Institute, *2020 State of the Industry Report: Cultivated Meat*, 20 (2021) (attached as Exhibit A).
[10] *Va. State Bd. of Pharmacy v. Va. Consumer Council*, 425 U.S. 748, 757 (1976).
[11] *Zauderer v. Off. of Disc. Counsel of S. Ct. of Ohio*, 471 U.S. 626, 649 (1985).
[12] *Central Hudson Gas & Elec. Corp. v. Public Serv. Comm'n of New York*, 447 U.S. 557, 566 (1980).
[13] *See, e.g., Ocheesee Creamery LLC v. Putnam*, 851 F.3d 1228, 1240 (11th Cir. 2017).
[14] *Id.*
[15] *See Int'l Dairy Foods Ass'n v. Amestoy*, 92 F.3d 67, 74 (2d Cir. 1996) ("We are aware of no case in which consumer interest alone was sufficient to justify requiring a product's manufacturers to publish

In sum, GFI urges FSIS to remain flexible in its approach to labeling cultivated meat and poultry products and avoid creating rules that will quickly become outdated as the industry evolves. GFI offers specific responses to the agency's questions below.

Questions

1. **Should the product name of a meat or poultry product comprised of or containing cultured animal cells differentiate the product from slaughtered meat or poultry by informing consumers the product was made using animal cell culture technology? If yes, what criteria should the agency consider or use to differentiate the products? If no, why not?**

Under most circumstances, no. Cultivated meat and poultry producers will likely want to differentiate their products from slaughtered meat and poultry products and should be permitted to do so. FSIS need not, however, *require* that all cultivated meat and poultry product names differentiate the products from their conventional counterparts. Differentiation or qualification of cultivated products should not turn solely on whether there are any scientifically measurable differences between the cultivated product and its conventional counterpart, but on whether those differences are material. As discussed above, FSIS does not generally require new labeling requirements on products derived from a new processing method if the new method does not increase safety risks or result in a product that significantly differs from conventional analogs, either biologically, chemically, nutritionally, or organoleptically. As the ANPR states, "FSIS has authority to establish standards of identity for meat and poultry products to help ensure such products have the characteristics expected by consumers," and the overarching public policy behind labeling regulations "is above all to protect the health and welfare of consumers."[16] Accordingly, new labeling rules should only be promulgated when necessary to protect the health and welfare of consumers and avoid confusion.

Under current labeling rules, conventional meat and poultry products may have scientifically measurable differences but are not required to be labeled differently unless they fall outside of the normal range covered by a given standard or common or usual name.[17] This same logic should apply to cultivated products. Cultivated meat products as a class have not been shown to differ significantly from their conventional counterparts in any specific way. In fact, the goal of many cultivated protein companies is to cultivate products that are physically identical to their conventional counterparts. If they succeed, and their products fall within the range of products covered by FSIS's existing labeling rules, there is no reason to mandate differentiation.

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the functional equivalent of a warning about a production method that has no discernable impact on a final product. . . . Absent [] some indication that this information bears on a reasonable concern for human health or safety or some other sufficiently substantial governmental concern, the manufacturers cannot be compelled to disclose it.").

[16] *G. A. Portello & Co. v. Butz*, 345 F. Supp. 1204, 1208 (D.D.C. 1972).

[17] The term "meat loaf," for example, can refer to any cooked "product in loaf form made from comminuted meat. Mechanically Separated (Species) may be used … To facilitate chopping or mixing, water or ice may be used in an amount not to exceed 3 percent of the total ingredients used." This definition allows for a range of species to be used, for the use of mechanically separated meat if desired, and for the use of water or ice up to a certain percent of the total ingredients. 9 C.F.R. § 319.216.

Many conventional meat and poultry products are named based on either a set standard of identity or a common or usual name. If there is no material difference between the conventional product and the cultivated product, the standard of identity or common or usual name of the conventional product would be the clearest way to convey the essential characteristics of the cultivated product to consumers. Calling two products with the same range of physical properties by two different names based on how they were processed could cause consumer confusion and make it more difficult for consumers to understand how to prepare cultivated meat and poultry. It is also critical for consumers to understand that cultivated meat will contain the ***same allergens*** as conventional meat from the same species. Product labels should not distinguish cultivated meat from slaughtered meat to such a degree that consumers fail to understand that cultivated products contain allergens and could pose serious health risks to consumers with meat or poultry allergies.

In the absence of a standard of identity or common name, a "truthful descriptive designation" that "clearly and completely" identifies the product should be permitted as the product name.[18] Existing regulations permit conventional meat and poultry products without a standard of identity or common name to be named with any truthful designation that accurately describes the product. The same rule should apply to cultivated products. There will likely be some cultivated meat and poultry products that differ from the conventional products already on the market. If a cultivated product materially differs from its conventional analog, FSIS should permit the product to be labeled with an accurate, descriptive name. Language on the product label should be tailored to account for the specific differences in the particular product at issue. Differentiating language need not necessarily appear in the product name, but could instead be included elsewhere on the product label, depending on the magnitude of the difference(s) between the cultivated product and its conventional counterpart.

If FSIS chooses to *mandate* language differentiating cultivated products from conventional ones, that language must not unfairly stigmatize cultivated meat and poultry. Any required language must also be truthful and scientifically accurate. And, under the First Amendment, it must be specifically tailored to achieve a substantial government interest.[19]

2. **What term(s), if any, should be in the product name of a food comprised of or containing cultured animal cells to convey the nature or source of the food to consumers? (e.g., "cell cultured" or "cell cultivated.") (a) How do these terms inform consumers of the nature or source of the product? (b) What are the benefits or costs to industry and consumers associated with these terms?**

As consumers have not yet had the opportunity to read cultivated meat and poultry labels, it is too soon to determine which terms will be most easily understood by consumers. To date, little research has been conducted on consumer understanding of cultivated meat and poultry labels. By the time cultivated meat

[18] 9 C.F.R. § 317.2(c)(1), (e); *see id.* § 381.117(a).

[19] Under *Central Hudson*, the government must assert a substantial interest that will be served by its speech regulations. *Cent. Hudson*, 447 U.S. at 566. The regulations must be narrowly drawn to achieve that interest and the government must show that they "will in fact alleviate" the asserted problem "to a material degree." *Edenfield v. Fane*, 507 U.S. 761, 771 (1993). Moreover, the regulations cannot be "more extensive than is necessary to serve" the government's interest. *Cent. Hudson*, 447 U.S. at 566.

and poultry products are widely available and reach price parity with conventional products, however, much more information will be available on consumer understanding because shoppers will have had the opportunity to browse and buy these products.

Until consumer understanding of cultivated product labels develops further, FSIS should allow producers to disclose any differences between cultivated products and their conventional counterparts using a range of appropriate terms or explanatory language, so long as the language is clear, truthful, and not misleading. Mandating specific terms in product names at this juncture would put the metaphorical cart before the horse. Consumers may end up referring to cultivated products using entirely different terms from those mandated by regulation. Forcing cultivated meat and poultry companies to use terms no one understands could also diminish consumer choice if these companies decide to leave the United States in search of more friendly markets abroad. Furthermore, mandating unknown terms would unfairly discriminate against cultivated products. If cultivated meat and poultry products bear names that mean nothing to consumers while their conventional counterparts are allowed to use well-understood names, consumers are likely to purchase the latter rather than buy products they cannot easily identify. Finally, restricting or mandating the use of certain terms before consumers have had the chance to evaluate them may run afoul of the First Amendment.

Although GFI does not advocate for mandating a specific term to differentiate all cultivated meat and poultry products at this early stage, we use the term "cultivated" in reference to this category. "Cultivated" is GFI's preferred term because it balances an accurate description of the process for creating meat and poultry by growing animal cells in a cultivator with consumer appeal.[20] The term "cultivated" focuses on how the process of creating the product is different from the process behind slaughtered meat. Furthermore, the term "cultivated" is not commonly used in other food-making processes so it is unlikely to be confused with conventional meat products or other foods. "Cultivated" is also a neutral term that is not disparaging to either conventional products or those grown from cells. A recent survey conducted by GFI indicates that a growing number of companies that create proteins from animal cells also favor the term "cultivated," with 60 percent preferring the term in the regulatory context.[21]

(c) If meat or poultry products comprised of or containing cultured animal cells were to be labeled with the term "culture" or "cultured" in their product names or standards of identity (e.g., "cell culture[d]"), would labeling differentiation be necessary to distinguish these products from other types of foods where the term "culture" or "cultured" is used (such as "cultured celery powder")?

Labeling differentiation *may* be necessary to distinguish such products. It is too soon to know how consumers would interpret these specific terms with respect to meat and poultry products. The terms "culture" and "cultured" are already used to describe various products, including yogurt and kombucha.

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[20] *See* The Good Food Institute, *Meat Cultivation: Embracing the Science of Nature* (Jan. 2020) (attached as Exhibit B).

[21] Bruce Friedrich, *Cultivated Meat: A Growing Nomenclature Consensus*, GFI Blog (Sept. 29, 2021), https://gfi.org/blog/cultivated-meat-a-growing-nomenclature-consensus/ (attached as Exhibit C). While 75 percent of companies generally prefer the term "cultivated," 60 percent responded that they prefer the term "cultivated" in the regulatory context.

These terms are also associated with aquaculture. Nevertheless, these terms *could*, without further differentiation, be sufficient to identify cultivated meat and poultry products from other types of food *if* consumers learn the significance of these terms with respect to meat and poultry (for example, from repeatedly hearing these terms discussed or seeing them in product advertisements). Further consumer research after cultivated meat and poultry products have been labeled, marketed, and sold would be necessary to fully answer this question.

3. **If a meat or poultry product were comprised of both slaughtered meat or poultry and cultured animal cells, what unique labeling requirements, if any, should be required for such products?**

Whether unique labeling requirements are necessary would depend on whether a specific product at issue increases food safety risks for consumers. Currently, there is no reason to believe that hybrid products, comprised of both slaughtered and cultivated meat or poultry, would physically differ from conventional products as a class. If a specific hybrid product *is* materially different from its conventional counterpart, differentiating language may be appropriate and should be tailored to account for the specific difference(s) in that particular product. Differentiating language could be included in the ingredient list or elsewhere on the product label.

4. **What term(s), if used in the product name of a food comprised of or containing cultured animal cells, would be potentially false or misleading to consumers? For each term, please provide your reasoning; AND**
5. **What term(s), if used in the product name of a food comprised of or containing cultured animal cells, would potentially have a negative impact on industry or consumers? For each term, please provide your reasoning.**

There are several terms that, if used, would potentially mislead consumers, reduce consumer choice, and unfairly harm the cultivated protein industry.

Lab-grown: The term "lab-grown"[22] would be false and misleading if applied to cultivated products as a class. Almost every novel food is first created and refined in a laboratory. But when produced at scale, foods are not *manufactured* in a laboratory. So too with cultivated meat and poultry. The cultivated products consumers will purchase at the grocery store are unlikely to be grown in a laboratory but rather will be cultivated in plants or factories akin to breweries.

"Lab-grown" could also negatively affect consumer choice because consumers may wrongfully believe that cultivated products available for purchase are grown in or come from animals bred or raised in a lab. One study of naming conventions for cultivated seafood found that the term "lab-grown seafood" carried significant negative sentiment.[23] Given the potential for this term to confound and dissuade

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[22] A Georgia state statute passed in 2020 requires all cultivated meat produced or sold in the state to be labeled "lab-grown," "lab-created," or "grown in a lab." Ga. Code Ann. § 26-2-152.

[23] *Defining a Category: Using Behavioral Science to Further Product Naming Conventions*, Yale School of Management Insights Blog (Jul. 9, 2021), https://som.yale.edu/blog/defining-category-using-behavioral-science-to-further-product-naming-conventions.

consumers, its required use on cultivated product labels would negatively impact the cultivated protein industry.

Imitation: In a petition to FSIS, the United States Cattlemen's Association argued in favor of "imitation labeling" on cultivated meat products.[24] But "imitation" has a narrow regulatory definition that does not apply to cultivated meat and poultry. The term "imitation" is reserved, by law, for products that resemble existing products but are nutritionally inferior.[25] There is no reason to believe cultivated meat and poultry products as a class will be nutritionally inferior to their conventional counterparts. Some cultivated products may be completely novel and differ from conventional products in many ways, including nutritionally. But novel products are not "imitations" of existing products, particularly if they differ across multiple characteristics.[26] Thus, applying the term "imitation" to cultivated products would be inaccurate and would contravene existing precedent regarding what does and does not constitute an imitation food.

"Imitation" is also a highly stigmatizing word that, by definition, is associated with "inferior" food products. Requiring this term on product labels would unfairly stifle cultivated product sales and mislead consumers. A consumer reading the word "imitation" on a cultivated product label may wrongfully believe that the product is not wholesome or nutritious. Similarly, consumers may incorrectly assume that these products do not contain real cells from the animal specified, or are completely synthetic. The latter misunderstanding raises grave concerns, as consumers with meat or poultry allergies may assume that "imitation" products are allergen-free.

Synthetic: The term "synthetic" is a highly inaccurate term for a food product that is composed of the same type of cells from the same species as its slaughtered analog. Meat and poultry products cultivated in a bioreactor are not *synthesized* from chemicals or other ingredients; instead, they are *grown* from existing animal cells.

The term synthetic is stigmatizing and would negatively impact the cultivated protein industry's ability to sell its products despite the fact that those products may be biologically, chemically, nutritionally, and organoleptically identical to their conventional counterparts. Consumers may wrongfully believe that products labeled "synthetic" are derived from chemicals or other manufactured ingredients rather than

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[24] *See* U.S. Cattlemen's Association, Petition for the Imposition of Beef and Meat Labeling Requirements, FSIS No. 18-01, at 4–6, 8–9 (Feb. 9, 2018).

[25] Although the regulations implementing the FMIA and PPIA describe when the term "imitation" must be used, the term is not defined in either statute or in the relevant implementing regulations. *See* 9 C.F.R. § 317.2(j)(1); 9 C.F.R. § 381.1(b). The USDA, however, generally follows "the FDA definition of imitation when reviewing meat and poultry product labels." *Grocery Mfrs. of Am., Inc. v. Gerace*, 755 F.2d 993, 1002 (2d Cir. 1985), *aff'd sub nom. Gerace v. Grocery Mfrs. of Am., Inc.*, 474 U.S. 801 (1985). The FDA defines "imitation" as a food that "is a substitute for and resembles another food but is nutritionally inferior to that food." 21 C.F.R. § 101.3(e)(1).

[26] *See, e.g.*, *Coffee-Rich v. Kansas State Bd. of Health*, 388 P.2d 582, 586-87 (Kan. 1964) (distinguishing novel non-dairy creamer from dairy cream based on their differing properties); *see also* FDA, Application of Term "Imitation," 38 Fed. Reg. 2138, 2138 (Jan. 19, 1973) (imitation provision not enacted to address novel foods but rather "to protect the consumer from uninformed purchase of an inferior substitute product, which could be mistaken for a traditional food product").

from real animal cells. Consumers may also wrongfully believe these products do not contain real animal cells, raising serious concerns for those with meat and poultry allergies.[27]

6. **Should names for slaughtered meat and poultry products established by common usage (e.g., Pork Loin), statute, or regulation be included in the names or standards of identity of such products derived from cultured animal cells?**

Yes, FSIS must allow cultivated meat and poultry products to use names that have been established by common usage, statute, or regulation. Many cultivated meat and poultry products will have similar or even identical physical characteristics as their conventional counterparts and should be prepared in a similar manner. The use of common or codified terms to describe such cultivated products will thus be necessary to avoid consumer confusion. Prohibiting these terms on cultivated product labels where they would provide useful information to consumers may violate the First Amendment. Consumers have a right to receive accurate commercial information.[28] Moreover, blanket bans on particular speech are strongly disfavored. In commercial-speech disputes, "the preferred remedy is more disclosure, rather than less."[29]

Names for slaughtered meat and poultry products established by common usage or by law should also be permitted in the names of cultivated products to ensure that consumers with meat and poultry allergies understand the contents of cultivated products.

Finally, the use of common and codified names must be permitted if cultivated meat is to be regulated fairly. Allowing conventional meat and poultry products to use product names that consumers already understand while imposing new naming requirements on cultivated products would discriminate against cultivated protein companies in favor of those selling conventional options. Under this scenario, consumers would be highly likely to choose a slaughtered product over its cultivated counterpart based on name recognition alone. This unnecessary dichotomy would create an unlevel playing field for cultivated products.

(a) If so, is additional qualifying language necessary? What qualifying terms or phrases would be appropriate?

No, qualifying language would not always be necessary. Additional qualifying language would only be necessary where there are material differences between the cultivated product and the slaughtered product or where the cultivated product raises different or increased food safety risks.

Nevertheless, cultivated protein companies plan to differentiate their products from slaughtered animal products for a number of reasons, including to attract consumers to their products and to account for the

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[27] The terms "bioengineered" and "genetically engineered" would also be inaccurate if applied to cultivated meat and poultry products as a class. Certain cultivated meat products could be bioengineered to change various properties, or to remove allergens, but this term does not accurately describe all, or even most, cultivated meat products. Any cultivated products that *are* bioengineered will be required to comply with the existing bioengineered foods disclosure standard. *See generally* 7 C.F.R. § 66.1 *et seq.*

[28] *Va. State Bd. of Pharmacy*, 425 U.S. at 757.

[29] *Bates v. State Bar of Ariz.*, 433 U.S. 350, 375 (1977).

initial price premium for cultivated meat and poultry. But it is too early to determine which terms best inform consumers of the process used to create cultivated products. Terms including cultivated, cell-cultivated, or cell-cultured would potentially be appropriate, as would phrases such as "cultivated from [species] cells." Which of these terms best aligns with consumer expectations will depend on how consumers (and advertisers) ultimately refer to cultivated products. Offering guidance regarding acceptable terms, without mandating or restricting specific terms, would be most appropriate at this juncture. Any terms that a company seeks to use in the name of a cultivated meat or poultry product will first need to pass FSIS muster, as the agency will evaluate new product labels on a case-by-case basis. This premarket label review will allow FSIS to protect consumers from untruthful descriptions and claims while allowing the market for cultivated proteins to develop.

(b) Do these names, with or without qualifying language, clearly distinguish foods comprised of or containing cultured animal cells from slaughtered products?

If a cultivated product does not materially differ from its conventional counterpart or present different or greater food safety risks, then it would be unnecessary and potentially unconstitutional to require such a distinction.

If FSIS determines that a distinction *is* required, the agency should wait until consumer understanding has coalesced around a particular term (or terms) before deciding how companies must distinguish cultivated meat and poultry products from slaughtered products. FSIS should also consider whether qualifying language could appear in the ingredient list (e.g., "cultivated pork") or the product description (e.g., "grown from porcine cells"), rather than in the product name. These less restrictive requirements would be less likely to violate the First Amendment.

7. Should terms that specify the form of meat or poultry products (such as "fillet", "patty", or "steak") be allowed to be included in or to accompany the name or standard of identity of foods comprised of or containing cultured animal cells? (a) Under what circumstances should these terms be used?

Yes, FSIS should allow the use of form terms to describe cultivated meat and poultry products. In defining terms such as "fillet" and "patty," USDA regulations have focused on the final *product*, not on the *process* of creating that product from animal cells.[30] Thus, terms that specify form should be permitted if the final cultivated product has the qualities and characteristics that consumers understand the form term to describe. Using familiar form terms will help consumers understand the properties of the cultivated product they are purchasing and how to prepare it. In sum, if the cultivated product takes a similar form as the conventional product—the form that the average consumer expects—there is no reason to restrict use of a form term just because the product was cultivated from cells rather than cut from a slaughtered animal.

The common use of form terms to describe a variety of meat, poultry, seafood, and plant-based products demonstrates that form terms are not restricted to slaughtered animal products, or even to animal products generally. "Portobello steak" and "cauliflower steak" commonly refer to thick cuts of

[30] *See, e.g.*, 9 CFR § 381.160 (defining a patty as a product containing poultry and binders or fillers, and that may include skin and fat not in excess of natural proportions).

vegetables. The term "steak" informs consumers of the shape and thickness of the product and indicates that it can be prepared and served in a similar manner to a conventional beef steak. "Veggie burger," "black bean burger," "salmon burger," and "turkey burger" all describe chopped or small pieces of food compressed into a disk shape. The use of the term "burger" indicates a number of helpful pieces of information to consumers, such as the fact that the food is not a whole cut, that it can be cooked on a grill or in a pan, and that it can be easily consumed on a bun. Given the historical use of form terms to describe a diverse array of foods, preventing the use of such terms to describe cultivated meat and poultry products, where those terms are not misleading, would unfairly prejudice cultivated products and may run afoul of the First Amendment.

(a) What information would these terms convey to consumers?

Form terms convey information regarding the texture, structure, shape, and thickness of a product.[31] They may convey how to prepare the product or help a consumer determine which product to purchase for a specific recipe or application.

8. Should FSIS establish a regulatory standard of identity under its authorities in the FMIA and the PPIA (21 U.S.C. 607(c) and 457(b)) for foods comprised of or containing cultured animal cells?

No, FSIS should not create a new standard of identity for foods containing cultivated animal cells for several reasons. First, USDA's existing standards of identity largely describe the characteristics of final products, not the processes used to create them. Only when a process or production method materially alters a product or raises increased safety risks is a new standard of identity potentially appropriate. Current standards for many meat and poultry products also allow for some variation in the final product, within a stated range.[32] Thus, existing standards of identity should be sufficient to encompass cultivated products that otherwise fall within the standards' definitions. Many cultivated meat and poultry products are expected to be biologically, chemically, nutritionally, and organoleptically similar, or even identical, to their conventional counterparts and thus will not warrant new standards of identity.

Second, the cultivated protein industry is rapidly evolving and new products are regularly being created and refined. Inflexible standards of identity that set specific parameters for cultivated food products would be unworkable and would likely need to be updated frequently to keep abreast of technological changes. If they are not regularly updated, restrictive standards of identity could stifle innovation[33] and even send cultivated protein companies abroad.

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[31] *See, e.g.*, 9 C.F.R. § 319.261 (defining meat loaf as "a cooked meat food product in loaf form made from comminuted meat").

[32] Ham patties, for example, "may not contain more than 35 percent fat, by analysis." 9 C.F.R. § 319.105. This means products otherwise meeting the definition can fall anywhere in a range of 0-35% fat.

[33] FSIS and FDA have explained that "[e]stablishing regulations that do not stifle innovations in food technology and allow for technological alternatives and advancements in food processing would improve manufacturing efficiency and lessen costs which may be passed on to the consumer." FSIS & FDA, Food Standards: General Principles and Food Standards Modernization, 70 Fed. Reg. 29,214, 29,222 (May 20, 2005).

Finally, as noted previously, it is too soon to evaluate the entire scope of cultivated meat and poultry products that will come to market and how consumers will refer to those products. FSIS does not generally create consumer understanding by establishing standards of identity for new foods. Rather, FSIS codifies consumer understanding by setting standards of identity for foods with established names. That way, consumers purchasing items with commonly understood names can be assured that they are buying products that have the particular characteristics or contents they have come to expect. Creating a standard of identity now, before any products are commercially available or any consumers have had the opportunity to evaluate them, would be premature. If new products are introduced in the future that do not meet any existing standards of identity or common terms, and consumers come to recognize those products by specific names, new standards of identity may be appropriate for those products at that time.

(c) If so, what are the benefits and costs to industry if the standard of identity is established? Please provide quantitative and qualitative feedback in your response and explain the basis of any quantitative estimates.

Creating a new standard of identity that is not familiar to consumers could unfairly disadvantage cultivated products, which would have to compete with conventional meat products bearing names that are already familiar to consumers. This disadvantage could push cultivated protein companies to produce or sell their products in countries with more flexible labeling requirements, rather than in the United States. This, in turn, would reduce consumer choice.

(d) If so, what are the consumer benefits and costs to the standard of identity recommended?

Creating a new standard of identity could confuse consumers who are unfamiliar with the terminology used. If consumers do not understand cultivated meat and poultry labels, they cannot make an informed choice when purchasing food. An unfamiliar standard of identity that differs from the words used to describe cultivated products in advertising communications or in common parlance could also lead to consumer misunderstanding.

Furthermore, if a new standard of identity is created that excludes terms historically used to describe conventional meat products, such as “beef” or “pork,” a consumer with a food allergy could consume an allergen, not understanding that these products are composed of the same type of animal cells as slaughtered meat and will cause the same allergic reaction.

9. What nutritional, organoleptic (e.g., appearance, odor, taste), biological, chemical, or other characteristics, material to consumers’ purchasing and consumption decisions, vary between slaughtered meat or poultry products and those comprised of or containing cultured animal cells?

At this stage, it is impossible to identify nutritional, organoleptic, biological, chemical, or other differences that apply across all cultivated meat and poultry products. These products are still in development and we do not yet know which test products will be scaled and sold to the public. When these products do enter the market, some will be almost identical to their conventional counterparts, whereas others may be purposefully altered to remove allergens, change texture and taste, or otherwise make the product more appealing to consumers. Although it is difficult to predict the characteristics of

cultivated products as a class, FSIS's premarket review process will allow the agency to evaluate cultivated product labels on a case-by-case basis and ensure that these items are properly labeled.

10. **Should any of the definitions for "meat", "meat byproduct", or "meat food product" found in 9 CFR 301.2 be amended to specifically include or exclude foods comprised of or containing cultured animal cells?; AND**
11. **Should any of the definitions for "poultry product" or "poultry food product" found in 9 CFR 381.1 be amended to specifically include or exclude foods comprised of or containing cultured animal cells?**

The regulatory definitions for "meat," "meat byproduct," and "meat food product" are broad enough to encompass cultivated meat products. "Meat" is defined as "the part of the muscle of any cattle, sheep, swine, or goats which is skeletal or which is found in the tongue, diaphragm, heart, or esophagus..."[34] Cultivated meat consists of skeletal muscle and fat cells (grown in a cultivator) derived from animals amenable to the FMIA. USDA defines "meat byproduct" as "[a]ny part capable of use as human food, other than meat, which has been derived from one or more cattle, sheep, swine, or goats."[35] Although we currently expect all cultivated meat products to fall within the definition of "meat," in the future, cultivated meat companies may choose to create cultivated products that would instead fall within the definition of "meat byproduct." Cultivated sweetbreads or tripe, for example, would fall under the existing definition of "meat byproduct." "Meat food product" means "[a]ny article capable of use as human food which is made wholly or in part from any meat or other portion of the carcass of any cattle, sheep, swine, or goats…"[36] Any product capable of use as human food that is made wholly or in part from cultivated meat would fall within this definition. In sum, all three definitions should apply equally to cultivated meat products as they do to conventional meat products.

Likewise, the current regulatory definitions for "poultry product" and "poultry food product" are sufficient to cover cultivated poultry products. The regulations indicate that poultry products encompass nonliving carcasses or parts of a poultry species or products made wholly or partially from such carcasses or parts. Cultivated poultry products are made from cells that were originally taken from parts of a poultry animal and are nonliving at the time they are packaged and labeled for sale.

If FSIS determines that any of these definitions is not sufficient to encompass cultivated meat or poultry, then that definition should be amended to explicitly include food comprised of or containing cultivated animal cells derived from a species amenable to the FMIA or PPIA. Failing to include cultivated meat and poultry in these definitions would be scientifically inaccurate given the identity between fat and muscle tissue cultivated from animal cells and fat and muscle tissue removed from a slaughtered animal. Moreover, failure to define cultivated meat and poultry products as meat and poultry would lead to consumer confusion and raises serious concerns for consumers with animal product allergies. Given the USDA's broad mandate to protect consumer health and welfare under the FMIA[37] and PPIA,[38] including

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[34] 9 C.F.R. § 301.2.
[35] *Id.*
[36] *Id.*
[37] *See* 21 U.S.C. § 602.
[38] *See* 21 U.S.C. § 451.

cultivated meat and poultry within these regulatory definitions is a prudent decision and one that is supported by the text of the statutes.

12. **Should FSIS-regulated broths, bases, and reaction flavors produced from cultured animal cells be required to declare the source material in the product name, ingredient sublisting, or elsewhere on the label?; AND**
13. **Should the presence of cultured animal cells in further processed products regulated by FSIS, such as a lasagna made with cell cultured beef cells as an ingredient, be qualified on the product label? If so, how should this be qualified?**

Under many circumstances, no. If there are no material differences between the cultivated product ingredient and its conventional counterpart, additional labeling requirements would be unnecessary. But if a product containing cultivated animal cells materially differs from its conventional counterpart or presents different or increased food safety risks, then new labeling requirements may be appropriate. Such labeling requirements could appear in the ingredient listing or elsewhere on the product label. For example, a lasagna made with cultivated beef could include as an ingredient "beef cultivated from cells" rather than simply "beef."

14. **What label claims are likely to appear on FSIS-regulated products comprised of or containing cultured animal cells? Should FSIS develop new regulations or guidance on such claims to ensure they are neither false nor misleading?**

FSIS need not develop new regulations mandating or restricting the use of specific claims at this time. FSIS should instead permit cultivated meat and poultry product labels to include truthful claims. Companies should be permitted to accurately describe their cultivated products and explain to consumers how these products differ from other products in a way that is clear and not misleading. A blanket ban on credence claims for cultivated products, or a ban on new types of claims that have not been previously approved on product labels, would restrict truthful commercial speech. Consumers have a First Amendment right to receive accurate commercial information, and truthful claims would fall into that protected orbit.

FSIS already permits a variety of voluntary statements and special claims on product labels so long as they are truthful.[39] Some of these claims have generic approval, while others require premarket review.[40] If FSIS is concerned about the variety of new claims that cultivated protein companies may wish to make on their labels, it could issue guidance reiterating that claims must be adequately supported by evidence and detailing options for providing this evidence to FSIS. The agency has previously published guidelines on documentation needed to substantiate claims such as animal raising claims for label submissions.[41] Similar guidelines could be used to clarify the documentation that companies must

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[39] For example, FSIS considers the inclusion of "non-misleading symbols, statements, or logos that industry may want to include on labeling to inform consumers of the presence of potential food allergens in meat, poultry, or egg products." FSIS, *Allergens- Voluntary Labeling Statements*, FSIS-GD-2013-0010 (June 2013), https://www.fsis.usda.gov/guidelines/2013-0010.

[40] *See generally* 9 C.F.R. § 412.1(c), (e).

[41] *See, e.g.*, FSIS, *Guideline on Documentation Needed to Substantiate Animal Raising Claims for Label Submissions* (Dec. 2019).

provide to support certain credence claims on cultivated meat and poultry product labels (*e.g.*, environmental stewardship claims). Given that FSIS plans to conduct premarket review of all cultivated meat and poultry labels, any credence claims included on these labels will be scrutinized before the product reaches consumers.

Request for Economic Data and Consumer Research

Attached please find the following exhibits containing relevant industry and consumer information:

Exhibit A: The Good Food Institute, *2020 State of the Industry Report: Cultivated Meat* (2021).

Exhibit B: The Good Food Institute, *Meat Cultivation: Embracing the Science of Nature* (Jan. 2020).

Exhibit C: Bruce Friedrich, *Cultivated Meat: A Growing Nomenclature Consensus*, GFI Blog (Sept. 29, 2021), https://gfi.org/blog/cultivated-meat-a-growing-nomenclature-consensus/.

Exhibit D: Elliot Swartz, *Anticipatory Life Cycle Assessment and Techno-Economic Assessment of Commercial Cultivated Meat Production* (Mar. 9, 2021), https://gfi.org/wp-content/uploads/2021/03/cultured-meat-LCA-TEA-policy.pdf.

Conclusion

GFI thanks FSIS for the opportunity to submit comments and appreciates the agency's efforts to provide clear regulatory guidance for innovative cultivated meat and poultry products. GFI respectfully requests a meeting with FSIS to discuss the implications of labeling rules for these products. We look forward to a continued dialogue on the important issues raised in this ANPR.

Respectfully submitted,

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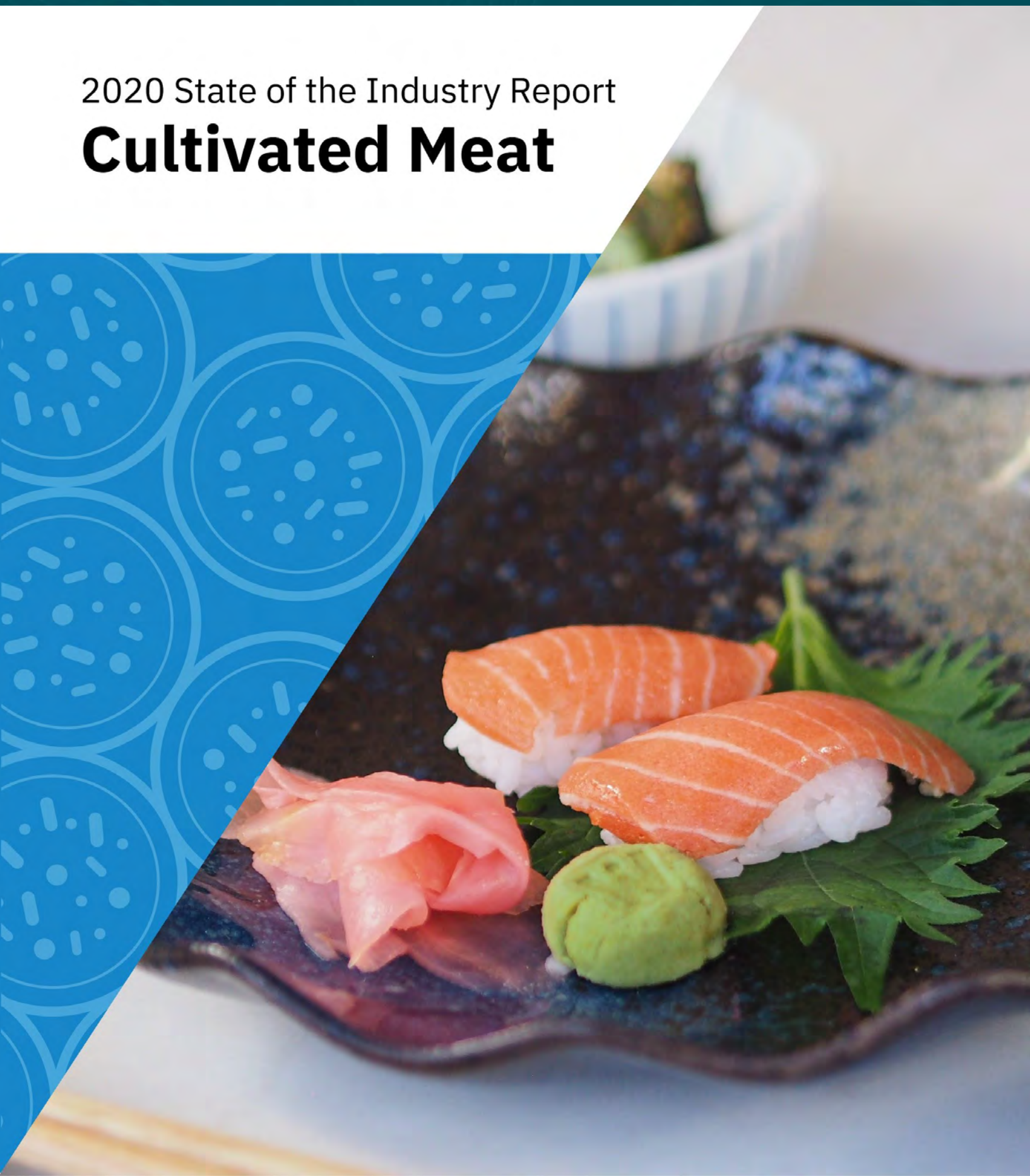
Exhibit A

Good Food Institute

2020 State of the Industry Report

Cultivated Meat



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

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

Executive summary

Image credit: New Age Meats

Executive summary

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

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

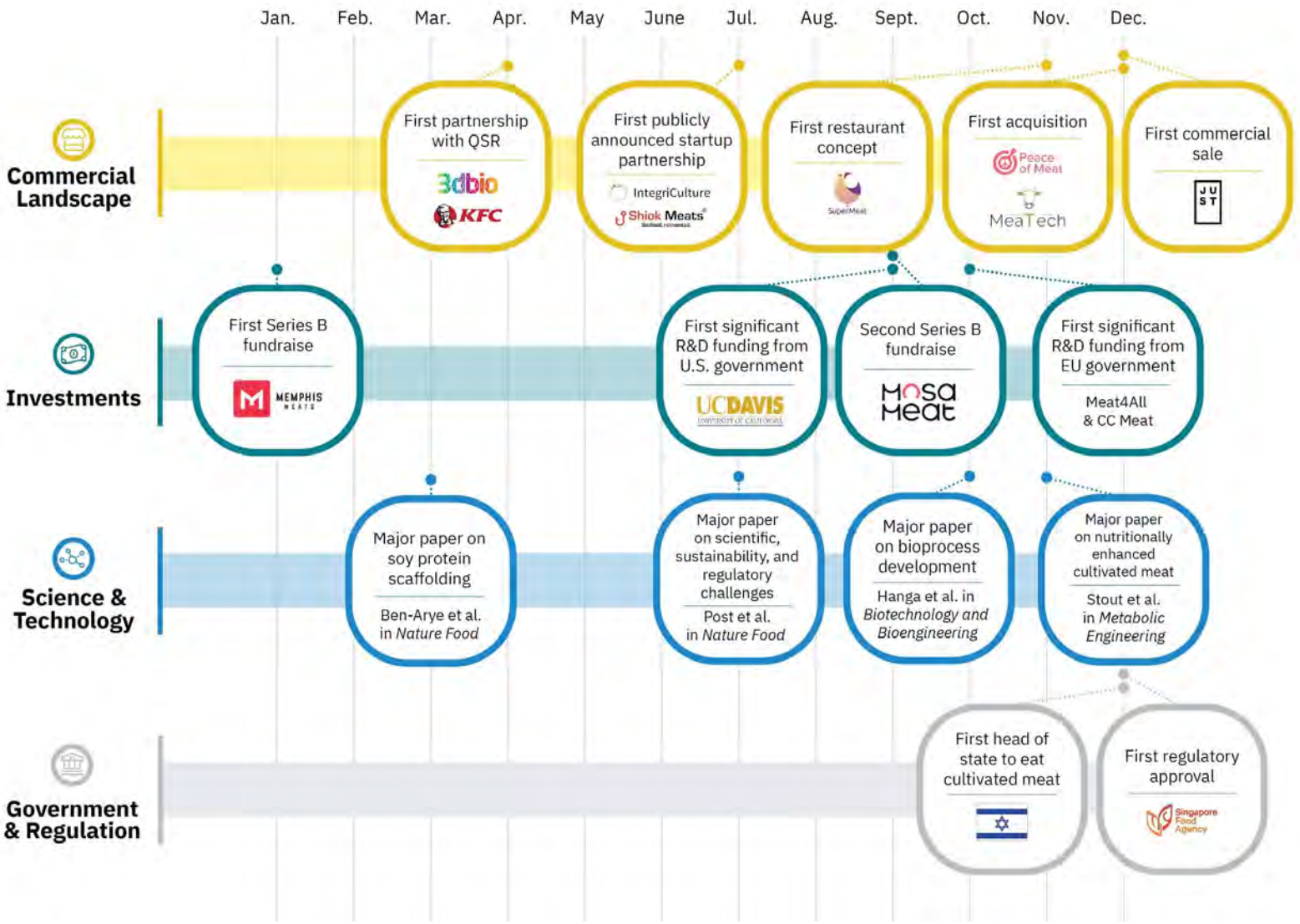
Investment in the nascent field topped $350 million in 2020, nearly double the previous cumulative investment in the industry. 2020 saw the industry's first Series B funding rounds as well as the first substantial public-sector R&D funding in both the United States and the European Union. Within the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

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

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

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

Figure 1: 2020 cultivated meat year at a glance



Introduction

Image credit: Avant Meats

Section 1: Introduction

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

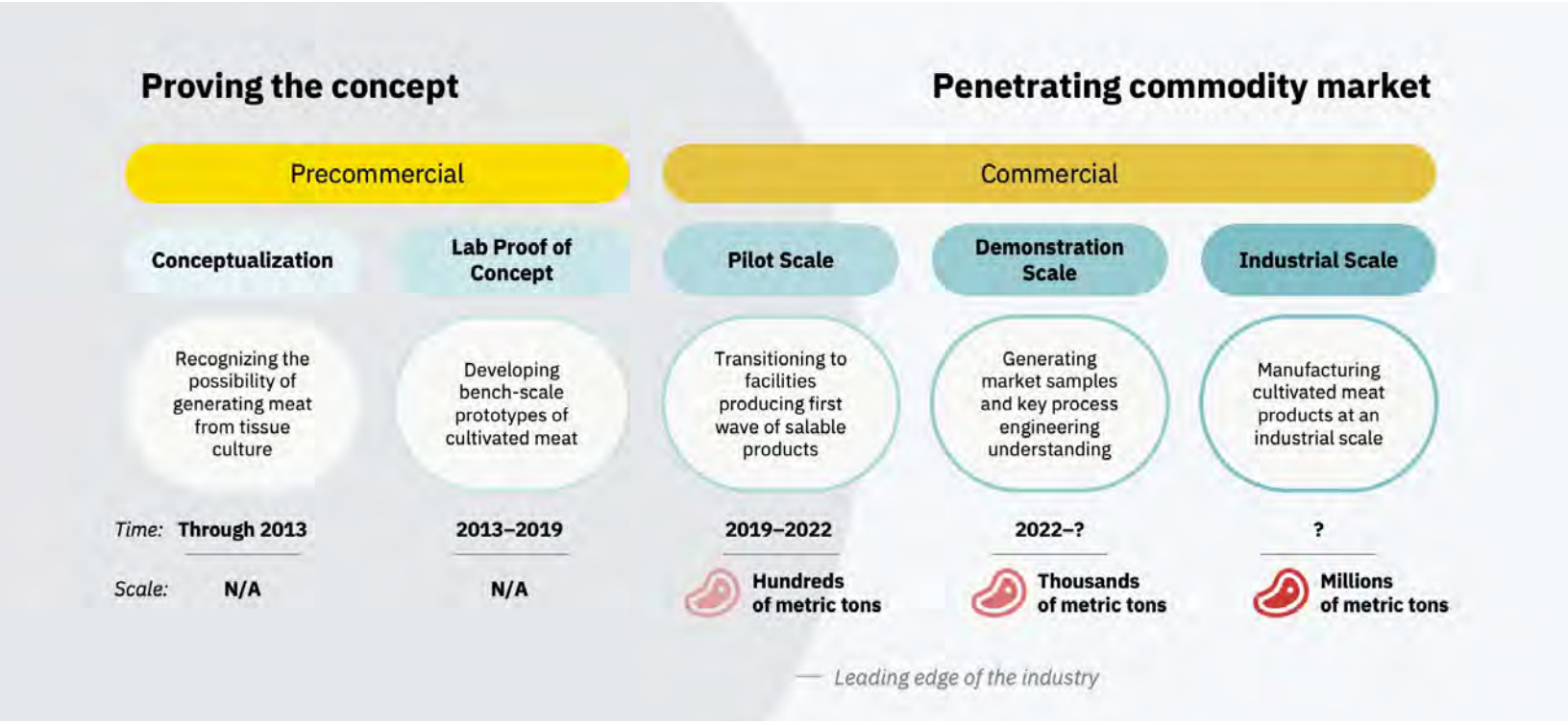
Meat, traditionally sourced from slaughtered animals, has for thousands of years been a staple in societies around the world. 2020 marked a **milestone** in its history as cultivated meat made its debut on a restaurant menu. While **Eat Just's** regulatory approval and sale of cultivated chicken in Singapore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

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

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

—Bruce Friedrich, executive director at The Good Food Institute

Figure 2: Leading edge of cultivated meat production



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

Commercial landscape

Image credit: Memphis Meats

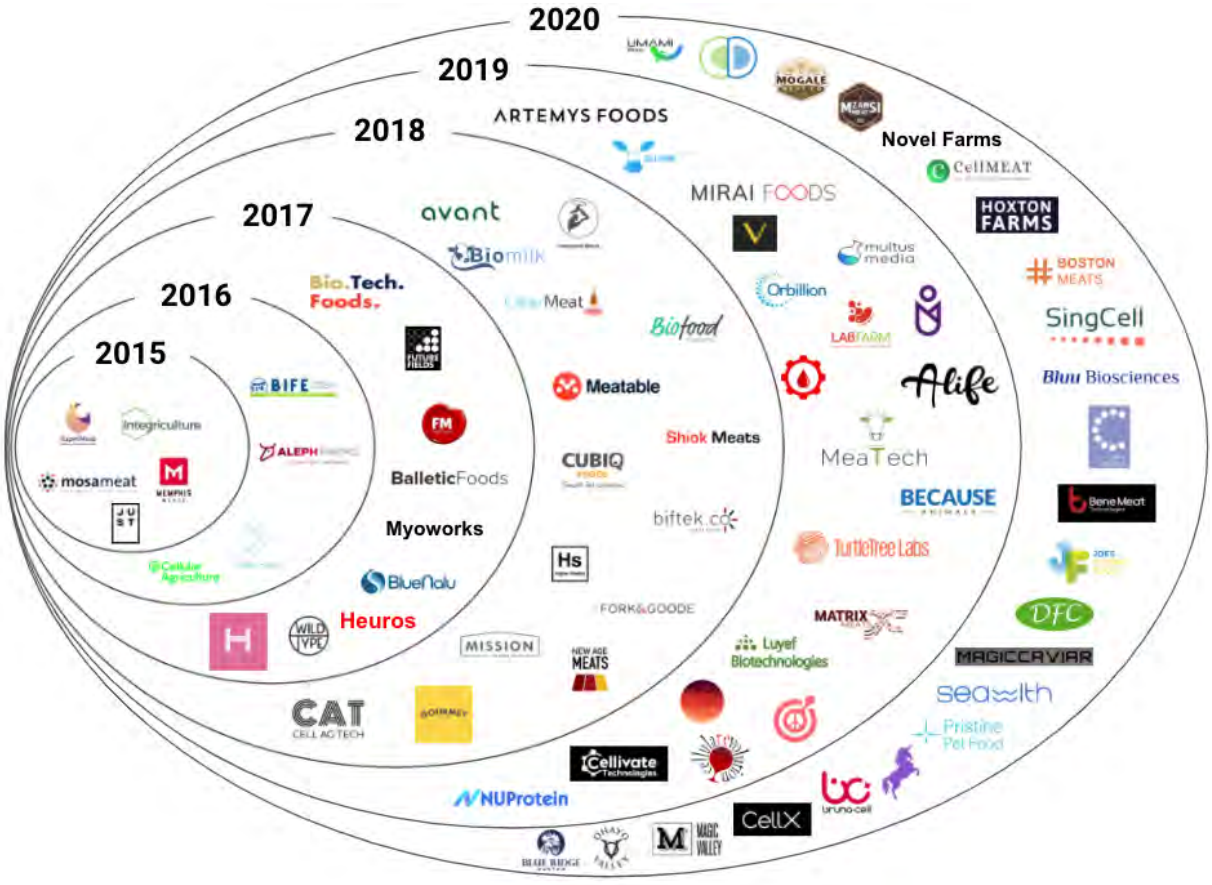
Section 2: Commercial landscape

Overview

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

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

Figure 3: Commercial landscape expansion



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

A note on Covid-19

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

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

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

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

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

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

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

Major developments

First commercial launch

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

Tasting events

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

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

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

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

New entrants

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

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

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

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

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

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

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

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

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

Table 1: Cultivated meat ventures

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

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

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

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

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

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

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

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

Partnerships

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

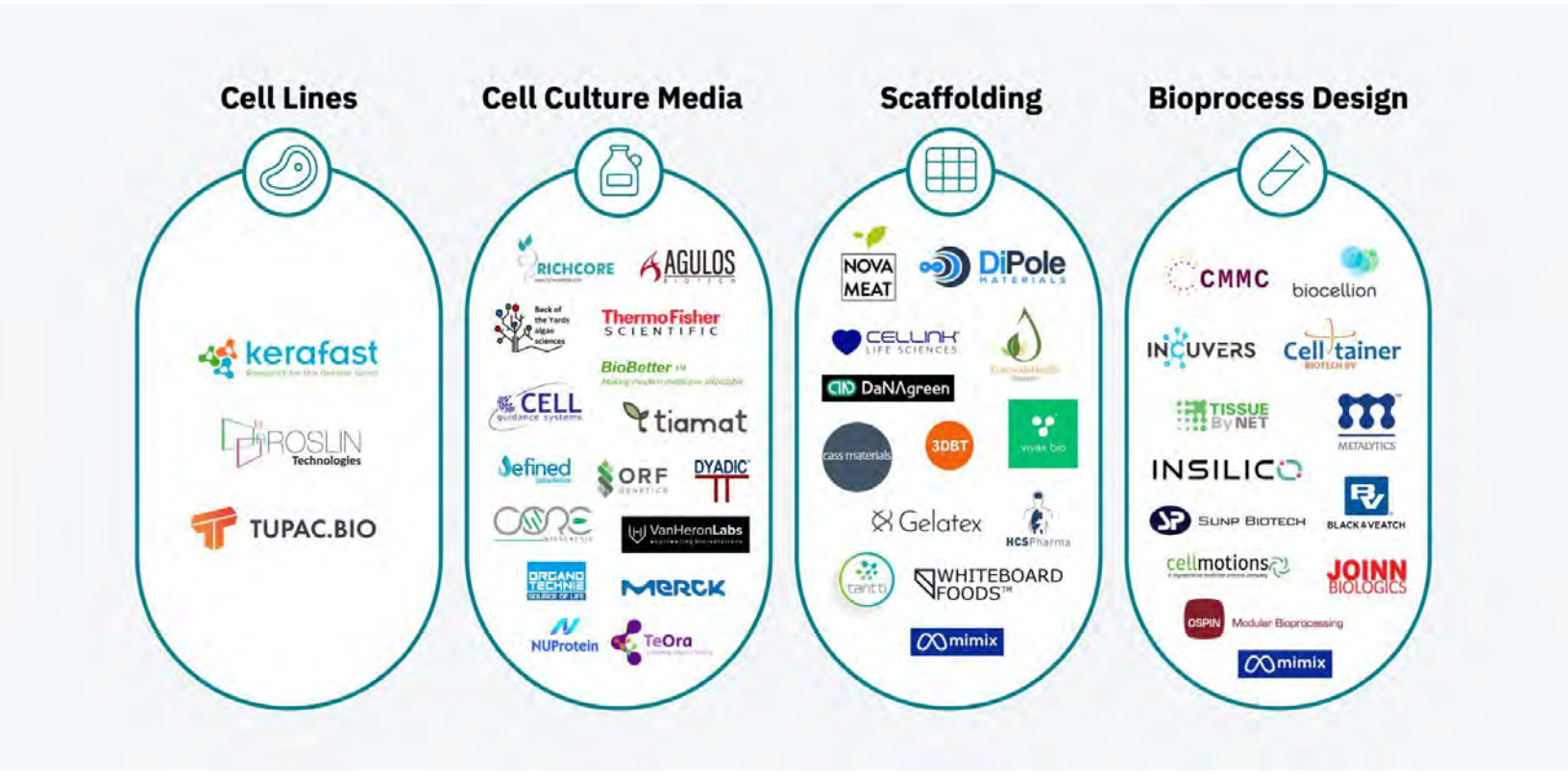
- In a potential harbinger of consolidation in the cultivated meat industry, the startup **MeaTech acquired Peace of Meat**, a cultivated fat developer.
- **Integriculture and Shiok Meats announced a collaboration** to scale up production of Shiok's cultivated shrimp meat. Integriculture is adapting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

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

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

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

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



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

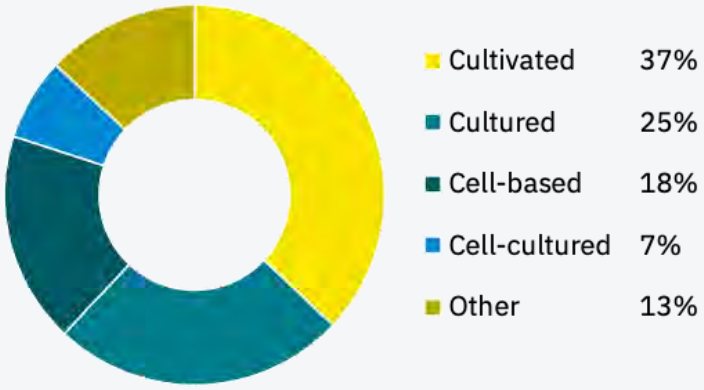
More than 40 additional companies have publicly announced formal projects or product/service offerings along the cultivated meat technology stack. Many of these companies are active in the life sciences industry and can provide critical inputs, infrastructure, and expertise to cultivated meat startups.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

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

Box 2: Nomenclature usage among startups

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

Analysis of nomenclature use among startups

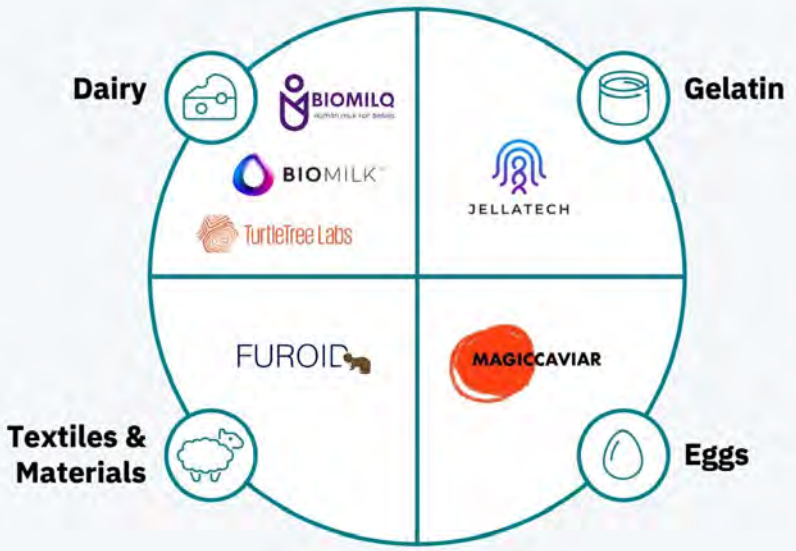


GFI analyzed the websites, LinkedIn profiles, and media statements of all known cultivated meat startups globally. For cases in which companies used more than one term, GFI made a determination of primary nomenclature based on prominence and frequency in public-facing materials.

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

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

Figure 5: Emerging applications for animal cell culture technology



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

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

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

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

Investments

Image credit: HigherSteaks

Section 3: Investments

Overview

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

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

The cultivated segment further matured and diversified in 2020:

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

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

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

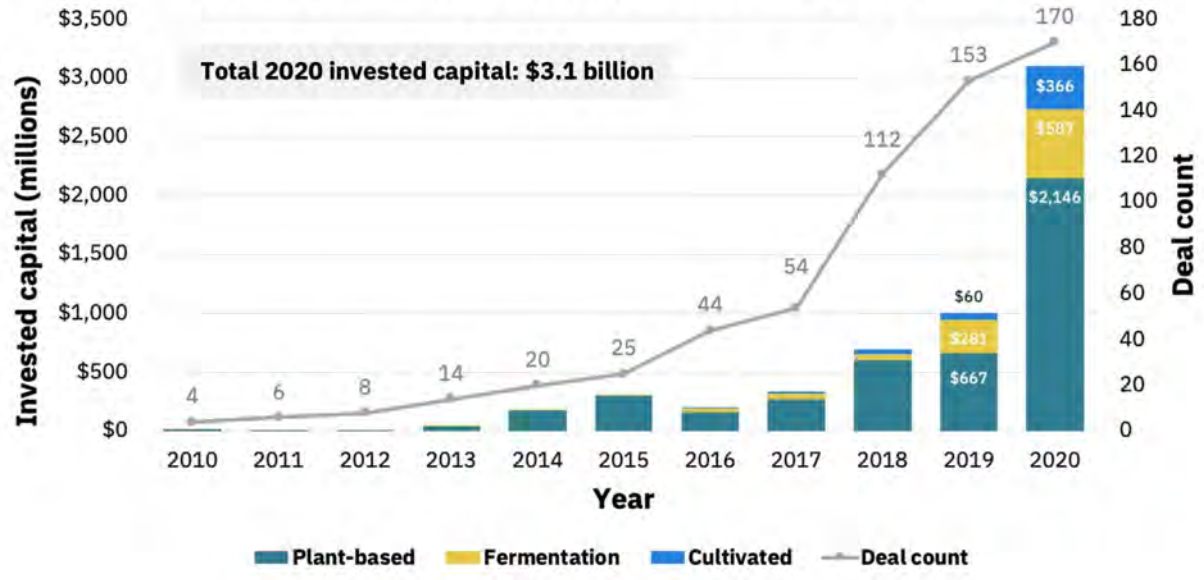
Table 2: 2020 investment overview

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

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

PitchBook

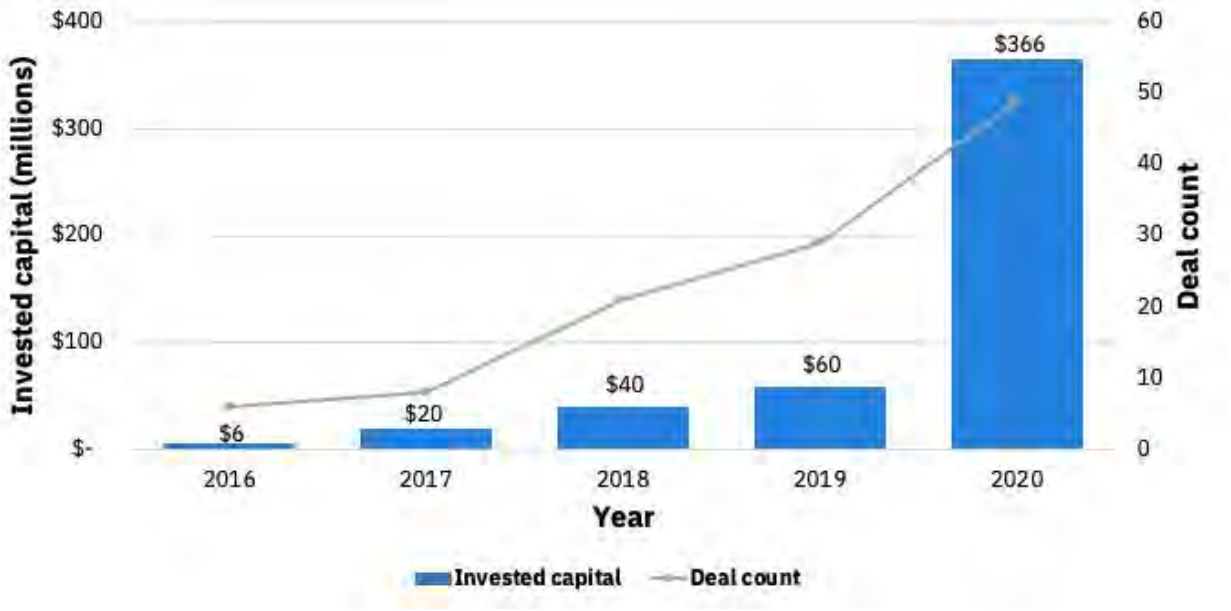
Figure 6: Annual alternative protein investment backdrop (2010–2020)



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

PitchBook

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



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

PitchBook

Box 3: Methodology of investment calculations

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

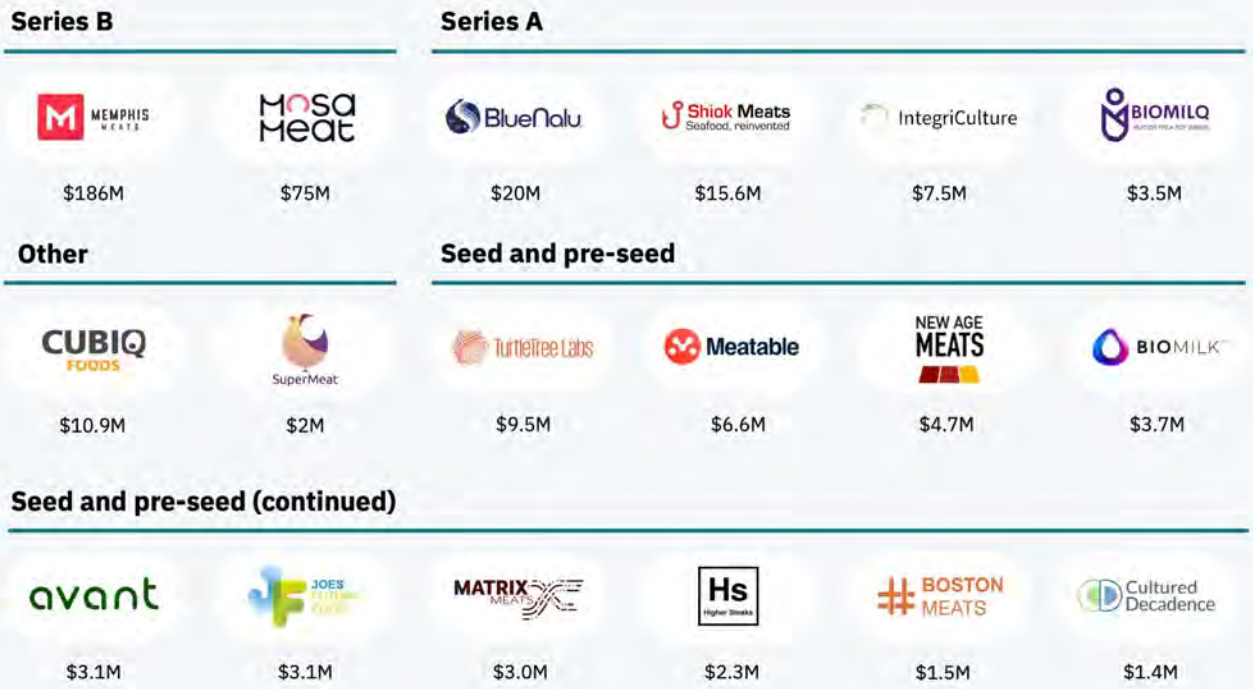
For the purposes of this report, *invested capital/investment* comprises accelerator and incubator funding, angel funding, seed funding, equity and product crowdfunding, early-stage venture capital, late-stage venture capital, private equity growth/expansion, capitalization, corporate venture, joint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

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

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

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

Figure 8: 2020 key funding rounds



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

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

Table 4: Most active investors in 2020

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

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

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

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

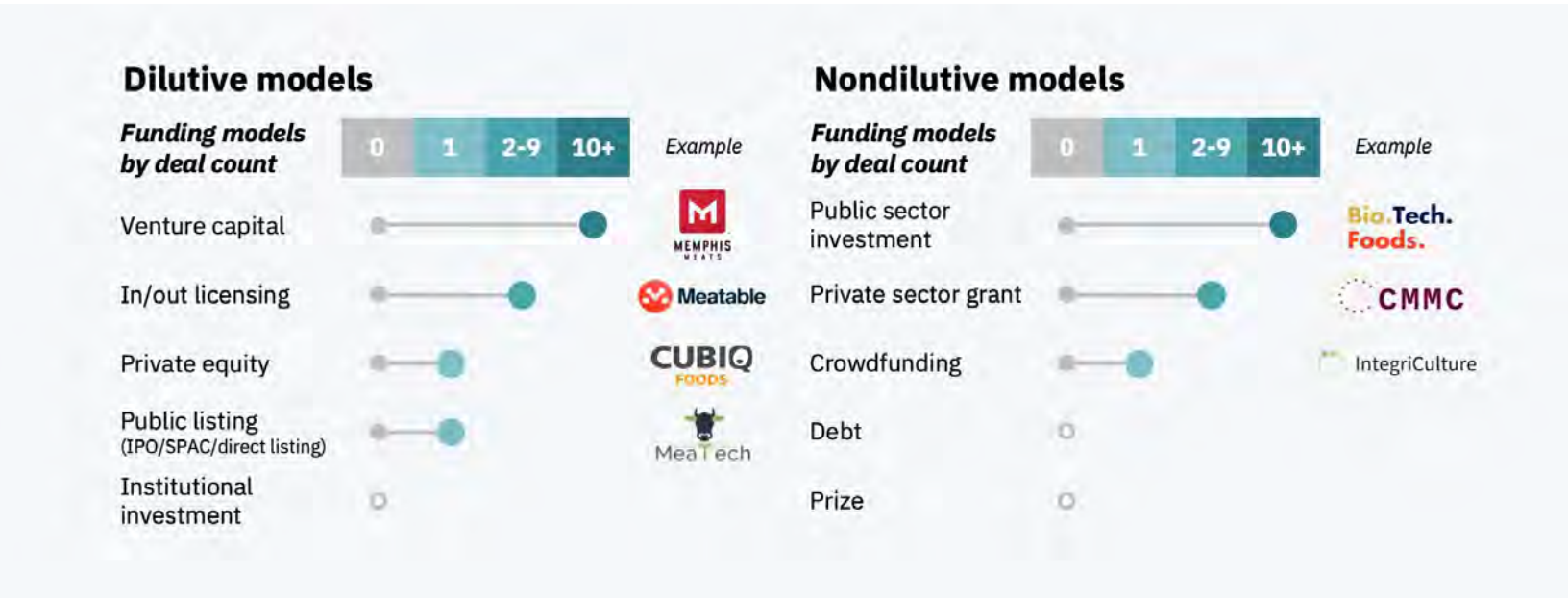
PitchBook

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

Box 4: Publicly available investment vehicle

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

Figure 9: Funding models by deal count



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

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

Public sector investment

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

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

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

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

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

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

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

Science and technology

Image credit: BlueNalu

Section 4: Science and technology

Overview

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

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

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

Techno-economics

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

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

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

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

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

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

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

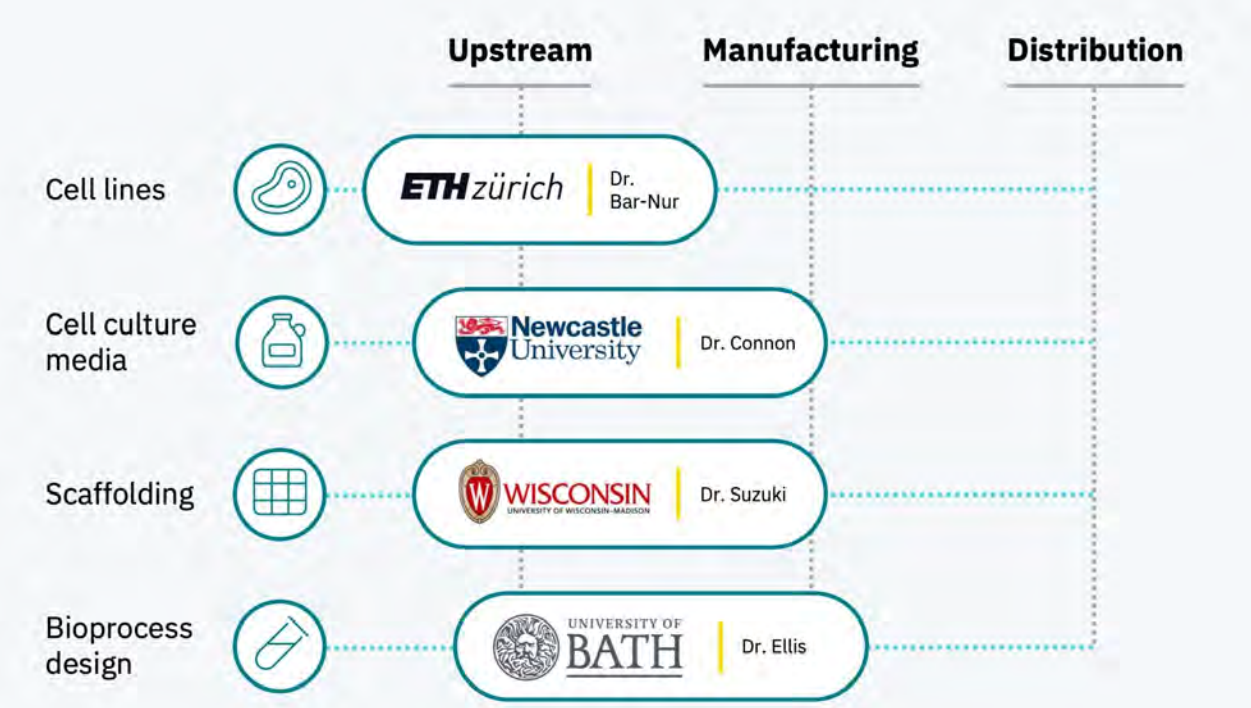
Ongoing research across the technology stack

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

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

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

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



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

Cell lines

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

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

Cell culture media

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

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

Scaffolding

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

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

Bioprocess design

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

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

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

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

—Paul Burridge, Burridge Lab at Northwestern University

Box 5: Top journals cover cultivated meat research

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

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

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

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

Formation of a transdisciplinary research center

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

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

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

Box 6: New tools in 2020

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

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

Proliferation of cellular agriculture nonprofits

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

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

Government and regulation

Image credit: Shiok Meats

Section 5: Government and regulation

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

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

European Union

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

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

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

Israel

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

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

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

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

Japan

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

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

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

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

Singapore

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

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

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

United States

Federal regulation

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

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

State litigation

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

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

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

Box 7: Cultivated meat image library

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

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

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

Conclusion and forecast

Image credit: SuperMeat

Section 6: Conclusion and forecast

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

These are among the many developments in 2021 so far:

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

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

Expert predictions

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

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

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

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

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

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

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

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

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Cover image courtesy of **Wildtype**.

About GFI

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

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

Our programmatic priorities:

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

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

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

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

Stay in the know with GFI's email newsletters at **gfi.org/newsletters**.

Find business resources and insights at **gfi.org**.

Fuel the future of food at **gfi.org/donate**.

gfi Good Food Institute

Exhibit B

THE GOOD FOOD INSTITUTE

Draft Project Report

Meat Cultivation: Embracing the Science of Nature

Published June 2019
Updated January 2020

Summary

In order to more effectively translate research into practice, this project sought to fill a specific gap in understanding related to best approaches for communicating with segments of the public about meat produced through cellular agriculture.

The project goal was to develop transparent, familiar, science-forward messages and nomenclature for communicating with non-technical audiences.

The project was informed by empirical research and science communication theory. In particular, the project used the key framing concepts important to public engagement and gaining consumer trust. This involved developing audience-centered messages based on narratives, transparency, and familiarity.

The project method involved a cycle of ideation, message design, empirical consumer testing, and revisions in order to develop evidence-based communication tools for the emerging public discussion of cellular agriculture with non-technical audiences.

Project outcomes include a set of recommended communication tools including a narrative text, a graphic analogy, and insights into the benefits and challenges of various nomenclature choices. The communication tools may be useful for a variety of stakeholders, including advocacy groups, cellular agriculture companies, investors, and media.

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Introduction

Novel Technologies in the Public Sphere

The production of meat via cellular agriculture is a novel technology not yet widely known in the public sphere. Science topics discussed in the public sphere are typically categorized as either *controversial* (a hotly debated topic, such as genetic engineering) or *emerging* (not yet widely known). Once a topic becomes controversial, it is typically difficult to change public opinion about the topic. It is much easier to form public opinion as a science topic emerges. This increases the likelihood that novel technologies become widely accepted rather than become controversial.

Meat produced through cellular agriculture is in a critical period of opportunity as an emerging technology where public awareness is relatively low. Previous research suggests there will be a strong group of innovators and early adopters (Diffusion of Innovations; Rogers, 2003) for meat produced through cellular agriculture (Bryant et al. 2019; Bryant & Barnett 2018) and demand may even outpace supply. However, long-term market success is dependent upon forming positive awareness among early and late majority groups (Rogers, 2003) early on, so they will be primed for purchasing when supply increases and costs decrease.

In order to achieve desired outcomes related to consumer decision-making about scientific topics, it is important that communication strategy is rooted in evidence. Effective science communication efforts grounded in evidence inform consumers before public opinion has solidified.

Science Communication Literature

Information Deficit Model

Early efforts to communicate with segments of the public about science were based on the Information Deficit Model. The Information Deficit Model posits that the public is generally ignorant about scientific issues, and that increasing scientific literacy will also increase public approval of scientific breakthroughs as well as funding for scientific research and development (Weigold, 2001). However, this model has been shown to be largely insufficient: bridging the public's knowledge gap and generating positive attitudes are both more complex than simply teaching new information. Studies show that individuals assign meaning to new information based on their current attitudes and beliefs (Craik & Lockhart, 1972; Shanks, 2010). This is especially pronounced when individuals don't understand incoming information (Posner & Rothbart, 2002). In short, building knowledge is necessary but is insufficient for forming attitudes. New information must be presented both in an engaging format and in a framework that enables people to incorporate the new information into their existing belief and value systems.

Effective science communication is largely informed by the larger field of communication studies. Common models of communication posit that successful communication occurs in a transactional process wherein senders and receivers achieve mutual understanding. Effective message design begins by determining the target audience, as targeting messages to specific groups is more effective than appealing to the general population. Selecting a credible message source and an engaging communication channel are among the most important considerations. Finally, framing the message to reach a target audience with a certain style of presentation or emphasis on certain topics over others can increase effectiveness.

Framing refers to the way that information is presented, and how this presentation subsequently influences how it is interpreted and used. The way in which the information is presented will affect the audience's interest in paying attention to the message, level of engagement, and interpretation of meaning (Goffman, 1974). Framing can also be used to emphasize some considerations or topics over others (Nisbet, 2009). In contrast to the deficit model, using message frames, such as narratives, has been shown to effectively engage with segments of the public on scientific topics.

In this current project, we focused on refining several types of message frames through the use of narrative, with a consideration for our target audience and communication channels. Below, we provide a brief overview of several types of framing that we incorporated into the project. Following this section, we provide a description of our project goals, methods, and results.

Narrative Framing

Narrative framing considers messaging style, and specifically the degree to which a message uses narrative to present facts and other relevant information. Framing new scientific information in narrative form, including visual storytelling (Sundin et al., 2018), both engages audiences and makes it easier for them to learn the story's embedded messages. Stories are inherently influential in changing beliefs and attitudes (Dahlstrom, 2014; Lane et al., 2013; National Academy of Sciences, 2014; Schank & Abelson, 1995). Individuals can more easily process and remember information that they learned in story form (Graesser et al., 2002; Greenhalgh, 2001; Scott et al., 2013) because the cognitive process when engaged with a narrative is uniquely heuristic and low-energy-intensive (Bruner, 1985; Kahneman, 2013). Overall, stories are easier to understand (Dahlstrom, 2014) and lead to greater understanding and remembering than science information presented in a statistical or traditionally presentation format (Moore et al., 1999). For these reasons, research has tested narratives in numerous scientific contexts and found that the use of story effectively influences beliefs about scientific topics such as vaccines, HIV/AIDS, and environmental issues (Brodie et al., 2001; Vaughan, Rogers, Singhal, & Swahili, 2000; Dahlstrom, 2010).

Transparency

Underpinning much of science communication's effectiveness is the process of building consumer trust through transparency. Not only does honesty about scientific uncertainties increase audience's perceived trust in a communicator (Frewer et al., 2002; Johnson & Slovic, 1995; National Research Council et al., 2012), but importantly, this trust influences whether one wants to learn from a message source (Lupia, 2013; National Academies of Sciences, Engineering, and Medicine, 2016; Renn & Levine, 1991). People also tend to want to learn from sources who share goals and interests with them (Lupia, 2013; National Academies of Sciences, Engineering, and Medicine, 2016; Renn & Levine, 1991) and who have expertise in the field (Lupia, 2013; Renn & Levine, 1991).

Uncertainty Framing

Closely related to transparency, uncertainty framing considers the degree to which uncertainty is emphasized or avoided in messaging. Where applicable, acknowledging uncertainty can increase trust and credibility (e.g., Frewer, 2004; Johnson & Slovic, 1995). Acknowledgement of uncertainty is not necessarily a barrier to action (e.g., Morton et al. 2011), and may increase acceptance of a technology (Frewer et al., 1998).

Familiarity

Presenting new scientific information in relation to familiar concepts makes it easier for people to learn. Moreover, prior familiarity with a novel technology is a key predictor of consumer acceptance. For example, a recent survey of U.S., India, and China consumers found that, across all three countries, those who are already familiar with meat produced through cellular agriculture expressed greater purchase interest (Bryant, Szejda, Parekh, Deshpande, & Tse, 2019). Several surveys of consumer perceptions of meat produced through cellular agriculture have indicated that naturalness is a key concern for consumers (Bryant & Barnett, 2018). However, direct messaging attempts to persuade consumers that meat produced through cellular agriculture is natural have been found to be ineffective (Anderson, 2018). Anchoring new technologies in concepts that are already familiar may help to make novel technologies more understandable and avoid triggering a naturalness concern.

Project Goals

In accordance with the FDA's fundamental risk communication recommendations, messages are considered adequate if they enable effective action, and therefore messages should be accessible, understandable, and contain the necessary information to aid decision-making (Fischhoff, Brewer, & Downs, 2011, p. 19). Communication strategies should be continually tested to ensure their effectiveness (Fischhoff, Brewer, & Downs, 2011; Kahan, 2013 ; Maynard & Scheufele, 2016).

As a project group, our goal was to build a set of communication tools that are understandable, engaging, factual, and ultimately useful in building consumer trust in and acceptance of the technology. Our key message design considerations were to build familiar and transparent messages that are useful for consumers to make informed decisions about their food choices.

Through the application of theory and a cycle of message design and empirical testing, the project aimed to develop evidence-based communication tools to communicate with non-technical audiences about the emerging scientific topic of cellular agriculture. An evidence-based strategy will help support our communication practice by ensuring that we are achieving the intended outcomes. The resulting communication tools may be useful for a variety of stakeholders, including advocacy groups, cellular agriculture companies, investors, and media.

Project History and Method

September 2018: GFI Cellular Agriculture Nomenclature Study

In the summer and fall 2018, GFI conducted a four-phase research project to better understand consumer perceptions of nomenclature used to describe meat produced through cellular agriculture (Szejda, 2018; Szejda, Dillard, & Urbanovich, 2019). The project began with a stakeholder survey, which generated 74 names to consider for further testing. A second survey assessed a shorter list of 31 names in terms of consumer perceptions of appeal and descriptiveness. Finally, two sets of online experiments tested five names (clean meat, cell-based meat, craft meat, cultured meat, and slaughter-free meat). The name "slaughter-free meat," was the only name that scored well in all of the desired outcomes (appeal, descriptiveness, differentiation, likelihood of trying, and likelihood of purchase). However, the name "slaughter-free" was not selected for widespread use, as it did not meet the need for neutral framing important to stakeholders.

Fall 2018 - Spring 2019: GFI/Mattson/Memphis Meats Messaging and Nomenclature Ideation

Following the GFI nomenclature project and inaugural GFI conference, Mattson reached out to GFI with an offer to lead a pro bono cellular agriculture naming project on behalf of GFI and the cellular agriculture industry. The primary workgroup included representatives from Mattson (Barb Stuckey, Al Banisch), GFI (Keri Szejda, Mary Allen, Annie Cull), and Memphis Meats (Maria Macedo, Steve Myrick). Based on Memphis Meats' suggestion, the team widened the project scope to include the development of a successful narrative framework to bring this new category to market.

The group agreed that one of the most important goals in the message strategy would be to anchor messages in the familiar and to build consumer trust through transparency. For nomenclature, the group agreed that an optimized name would follow from this messaging strategy and would need to meet multiple criteria: 1) appeal, 2) the neutrality of the term for multiple stakeholder groups, 3) descriptiveness, and 4) ability to differentiate the category from conventional and plant-based meat.

In December 2018, Mattson presented four possible messaging narratives to the project team. GFI and Memphis Meats aligned on the narrative that best communicated the science and technology underpinning cellular agriculture ("science as discovery"). GFI and Memphis Meats provided detailed feedback on the selected narrative, and Mattson then refined the narrative and designed a plant propagation analogy graphic to increase familiarity. In January 2019, the workgroup met to review the narrative and analogy, and then to ideate name options. In addition to the primary project team, an additional six Mattson staff joined the group for an ideation session. The workgroup generated over four hundred names before filtering down to the top names based on the nomenclature criteria.

March 2019: GFI Mixed-Methods Consumer Survey & Focus Groups

In March 2019, GFI made minor revisions of Mattson's draft narrative and analogy. Following the revisions, GFI designed and executed a survey to elicit consumer feedback on the narrative, analogy, and top options for nomenclature. The survey (N = 161) sampled from general U.S. population (matched to age and gender). GFI then worked with researcher Dr. Courtney Dillard to design focus groups to more deeply understand public perception on these topics. Dr. Dillard conducted four focus groups in March 2019 to obtain deeper insights into consumers' perception of the narrative, graphic, and nomenclature (Dillard & Szejda, 2019). Each of the four focus groups consisted of 6-7 college students in Portland, Oregon (N = 27). Focus group participants expressed a diverse range of political views, and skewed toward a younger age group (primarily 18-21 years), majority female (59%), and majority omnivore. For further details, see the focus group report.

As the purpose of these two studies was to inform the next phase of message design, we highlight here only topline results. To view the specific narrative text and graphic used in this stage of the study, see Appendix A and B. The consumer survey and four focus groups obtained similar results. Consumers' desired messaging aligned with the stated goal of the working group, which was to develop transparent, familiar, science-forward messages and nomenclature for communicating with non-technical audiences about meat produced through cellular agriculture.

Survey Results

Key findings from open-ended survey responses:

- Overall, consumers were positive toward the narrative but expressed a desire for more straightforward information.
- They specifically expressed an aversion to messaging that had a marketing feel.
- They also stated a desire for more information about attributes important to them, most commonly: taste, affordability, and safety.
- In general the analogy made sense to consumers as a familiar concept, but many felt that the graphic was oversimplified and that the comparison between plant cuttings and animal cells was a stretch.

Quantitative ratings of names from survey:

- *Cultivated meat* and *cultured meat* scored most favorably in terms of appeal (2 = somewhat appealing, 3 = moderately appealing)
- *Cell-cultured meat*, *cell-based meat*, *cell-raised meat*, *cultivated meat*, *made meat*, *cellstock meat*, and *cultured meat* scored the most favorably in terms of descriptiveness (3 = moderately descriptive, 4 = very descriptive)

Table 1. Mean Name Criteria Ratings from March 2019 Survey

Name	Appeal	Accurately descriptive
Cultivated Meat	2.49	3.43
Cultured Meat	2.34	3.21
Made meat	1.96	3.39
Nanopastured meat	1.87	2.64
Cell-based meat	1.82	3.79
Cell-cultured meat	1.76	3.88
Cell-raised meat	1.75	3.65
Propagated meat	1.68	2.81
Cellstock meat	1.68	3.31

Focus Group Results

Key findings from focus groups:

- After reading the narrative, participants readily understood that the product was not plant-based.
- Some participants indicated that because it was a new concept, a categorization system (i.e., conventional meat, plant-based meat, cell-based meat) would help them readily categorize it.
- Participants raised questions around cost, health benefits and risks, sensory characteristics (taste, appearance), environmental impact, specifics of the production method, and appeal concerns.
- Some participants showed skepticism, noting there was a focus on benefits with an oversimplification of the process.
- For both the narrative and graphic, participants provided specific recommendations about words, phrases, and images that resonated or should be changed
- Participants evaluated five potential names, considering appeal, neutrality, and descriptiveness criteria. Most of the responses to *cultivated* meat were positive, there were a range of responses to *cultured* meat and *cell-based* meat, and most of the responses to *cell-cultured* meat and *propagated meat* were neutral or negative.

Following these March 2019 survey and focus group studies, GFI significantly revised the narrative and analogy to incorporate consumer feedback. As a follow up, the GFI Science and Technology team provided a consultation to ensure the accuracy of the message content.

May 2019: GFI Mixed-methods Consumer Survey

In a continuation of the message design and empirical testing cycle, in May 2019 GFI conducted a final round of consumer testing to determine the degree to which the revised narrative and analogy graphic meet consumer needs. The survey also gauged consumer perceptions of four names still under consideration: *cultivated* meat, *cell-cultured* meat, *cell-based* meat, and *cultured* meat.

GFI obtained the sample from Positly, with a total of 183 respondents matched to the US population by age and gender. Respondents were ineligible if they took part in previous GFI studies on cellular agriculture. Participants provided open-ended feedback to the narrative ("What is your general reaction to this narrative?" "What other information would you need in order

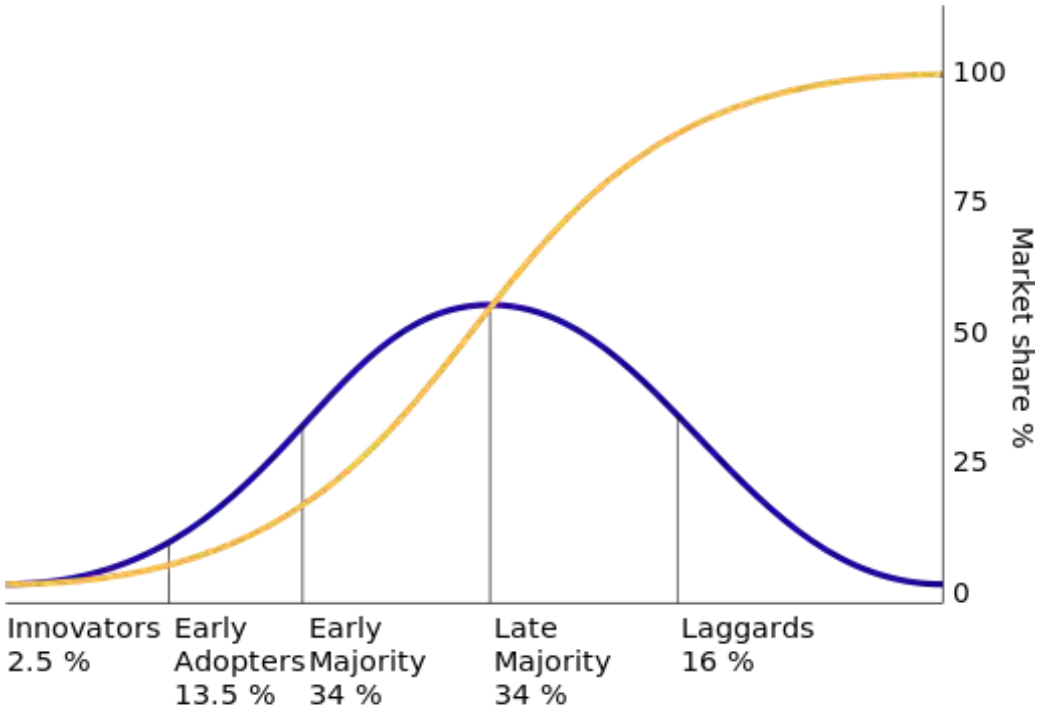
to decide whether this is for you?") and the analogy graphic ("What is your general reaction to this analogy?" "What questions do you have?"). To view the specific narrative text and graphic used in this stage of the study, see Appendix C and D. On a 1-5 scale, participants rated each of the four terms in terms of their appeal, descriptiveness, differentiation from conventional meat, and differentiation from plant-based meat. Higher scores indicate more positive responses (i.e., for appeal, 1 = not at all appealing, 2 = somewhat appealing, 3 = moderately appealing, 4 = very appealing, 5 = extremely appealing).

Consumer Segmentation Results

Analysis of open-ended responses indicated that consumers could be segmented into three main groups: enthusiastic supporters (18%), those in the skeptical but intrigued middle (68%), and those opposed on moral grounds (14%). In light of the emergence of these three groups, we recommend targeting the largest and most malleable consumer segment: the skeptical but intrigued group in the middle. In the Diffusion of Innovations framework (see Figure 1; Rogers, 2003), these consumers are likely to represent the early and late majority segments. The enthusiastic supporters are excited and comfortable with change; they are likely to be the innovators and early adopters. Individuals in the opposition segment are resistant on moral grounds and are less likely to be influenced by messaging.

Figure 1 shows the (blue) bell curve of the typical distribution of a population across adopter categories. This normal distribution is typically observed across different innovation contexts - as long as they are successful. The (yellow) S curve shows the increasing market share as successive groups of consumers adopt the innovation.

Figure 1. Adopter categorization on the basis of innovativeness



Source: Wikimedia Commons. Based on Rogers, E. (1962). Diffusion of innovations. London, NY: Free Press.

For each group, we used a Diffusion of Innovation lens to briefly describe what is known about each type of consumers. We then follow with a summary of each category's typical responses.

1. Enthusiastic supporters: Innovators and early adopters consumer segment (18%)

Group description (based on analysis of open-ended responses):

- The enthusiastic consumers are already supportive or quickly became supportive after learning about the technology.
- This consumer group didn't feel like they needed more information to know whether the products were right for them.

Exemplary comments:

- "I think it is brilliant, and solves many of the central objections that have been raised regarding the sustainability of current agricultural production."
- "I think it sounds great and I am excited for the technology."
- "I love it. I am hopeful we can stop the slaughter of millions of animals, stop deforestation, and find more productive uses for land."
- "I think it is a good idea to help address the need for more food with less animals killed."

Effective influence strategies (Diffusion of Innovations framework):

- Innovators desire novelty and their interest is easily sustained. Simply raising awareness is the best way to influence the innovators.
- Early adopters are often thought leaders in their community and are comfortable with change. Again, convincing this group is not necessary, but explaining the new technology in understandable ways and showing them ways to implement it is helpful.

2. Skeptical but intrigued middle: Early and late majorities consumer segment (68%)

Group description (based on analysis of open-ended responses):

- Consumers in the middle group were a bit skeptical and sometimes had a slight disgust response, but were overall intrigued by the benefits offered by the technology.
- This consumer group expressed interest as well as a strong desire for more information.
- The most common types of information desired by this group were related to the product's taste, affordability, and safety for humans.

Exemplary comments:

- "Cool but weird."
- "This sounds kinda freaky, but I'm on board."
- "At first I was skeptical about cultivated meat but after the process was compared to what happens in a greenhouse and it was mentioned that it would require the use of less natural resources I felt a bit more positive about the process. Also, noting that the FDA and USDA would jointly regulate to ensure safety I felt way more positive about cultivated meat and would/will consider purchasing and consuming."
- "My reaction is mostly positive. While this is definitely an unconventional way to produce meat and seems a little weird, it sounds like it's cheaper and better for the environment than the traditional method of raising cattle."
- "I think it is an interesting concept. I can see how it could be valuable but I think it sounds very weird and would be hard for me to get used to."

Effective influence strategies (Diffusion of Innovations framework)

- Individuals in the early majority take time to consider the decision to change and need evidence of the innovation's worth. Conversion stories are often effective for this group. They need to try the innovation for themselves before committing.

- The late majority members are described as skeptical. Though reluctant to change, they will adopt an innovation after it becomes more observable and is the social norm. Influencing this segment involves demonstrating observable benefits, such as taste, price, safety, and social acceptance.

3. Opposed on moral ground: Laggards consumer segment (14%)

Group description (based on analysis of open-ended responses):

- The opposed consumers had visceral, values-based negative responses.
- This group's opposition was primarily based on religious grounds, but a smaller sub-segment was opposed based on naturalness unrelated to religion.
- This consumer group did not express any openness to learning more.

Exemplary comments:

- "I don't think this is okay. It's like playing with what God intended when it comes to animals and food."
- "Too close to playing God in my opinion."
- "That is not within the boundaries of what should be done, gross."
- "There is no way I would eat this unless it is the last food on Earth. It does not matter how well it is monitored or regulated."
- "The intellectual concept make sense but it is so unnatural according to the laws of nature that I am sickened by it... Thanks for the nightmare."

Effective influence strategies (Diffusion of Innovations framework)

- The laggard group is more traditional and extremely avoidant of change.
- Influencing this group requires showing how the innovation is in alignment with the group's values and experiences.

Narrative Results

Overall the narrative was well received by the "enthusiastic supporters" and the "skeptical but intrigued middle". The responses in this latest round of testing indicated that the narrative was on-target in terms of revisions requested by consumers in previous rounds of testing. Whereas consumers previously interpreted the narrative as oversimplified, lacking sufficient science information, and having too much of a marketing feel, the consumers in this latest round of testing experienced the narrative to be on-target in terms of the depth and type of information needed.

Analogy Results

Overall the analogy was also well received by the "enthusiastic supporters" and the "skeptical but intrigued". In general, the comparison between plant cultivation and meat cultivation successfully anchored the new concept in a familiar idea, making it more understandable for these consumers. However, many did not see the analogy as a perfect comparison between plants and animals. Consumers felt there was more complexity involved in cultivating meat, and they desired more information about the production process. One way to meet consumers' stated needs for more information would be to change the visual from a static graphic to an interactive infographic, in which interested readers can easily click and access more detailed information as desired on a topic-by-topic basis.

Exemplary positive reactions:

- "It seems nice and simple and not gross."
- "This is a good analogy because it is simple and takes something that people can easily understand in order to explain something new that people might be skeptical about. It normalizes something novel and probably would make people more willing to accept it."
- "Makes the concept totally understandable."
- "It is simple and logical. Does not make the process seem that scary."

Exemplary neutral and negative reactions:

- "Makes sense.. kinda."
- "This analogy seems good. The animal part seems much more technological but I'm sure that is because of the newness of the science."
- "The idea is there, but I don't think meat works the same way as plant cuttings."
- "Taking a cutting from a plant is understandable. To do the same with an animal, you would have to take a leg and stick it in the ground. It's just not the same."
- "It's not perfect because a plant cutting just creates a new plant, as compared to cow cells tuning into just meat without the animal."

Nomenclature Results

We tested four names in this final step of nomenclature testing: *cultivated meat*, *cell-cultured meat*, *cell-based meat*, and *cultured meat*. The four primary criteria were: 1) appeal, 2) the neutrality of the term for multiple stakeholder groups, 3) descriptiveness, and 4) ability to differentiate the category from conventional and plant-based meat. The names were selected based on these criteria after several ideation and empirical testing cycles, including four quantitative assessments and four qualitative assessments. Below are the consumer ratings from this final testing phase.

- Appeal:
    - The names *cultivated meat* and *cultured meat* were somewhat to moderately appealing to consumers.
    - *Cell-based meat* and *cell-cultured meat* were close to somewhat appealing to consumers.

- **Descriptiveness:**
    - *Cultivated meat* and *cultured meat* were moderately descriptive.
    - *Cell-based* and *cell-cultured* were moderately to very descriptive.

- **Differentiation from conventional meat:**
    - *Cultivated*, *cell-based*, and *cultured* were moderately differentiating.
    - *Cell-cultured* was moderately to very differentiating.

- **Differentiation from plant-based meat:**
    - All terms were moderately differentiating.

Table 2. Mean Name Criteria Ratings from GFI May 2019 survey

	Cultivated	Cell-based	Cell-cultured	Cultured
Appeal	2.73	1.83	1.74	2.50
Accurately descriptive	3.27	3.50	3.70	3.04
Differentiates from conventional meat	2.86	3.27	3.51	2.90
Differentiates from plant-based meat	2.78	3.06	3.21	2.86

Note: All measures were rated on the following scale:
1 = "not at all", 2 = "somewhat", 3 = "moderately", 4 = "very", and 5 = "extremely".

Comparison of 2019 Nomenclature Results to 2018 Survey Study

Multiple terms are currently in use by cellular agriculture companies, scientists, and advocacy groups. For comparison purposes, we note in Table 2 appeal and descriptiveness ratings of key names from GFI's 2018 nomenclature study. An important difference between the two studies was that participants in the 2018 study read a brief product description prior to rating the terms, whereas participants in the 2019 study read the meat cultivation narrative and viewed the graphic analogy.

Table 3. Comparison of Name Criteria Ratings from 2018 and 2019 Survey Studies

	Cultivated	Cell-based	Cell-cultured	Cultured	Clean**	Slaughter-free**
2018 Appeal*	2.27	1.91	1.85	2.30	3.03	2.63
2019 Appeal	2.73	1.83	1.74	2.50	-	-
2018 Descriptive*	3.41	3.94	3.88	3.20	2.80	3.78
2019 Descriptive	3.27	3.50	3.70	3.04	-	-

Notes: All measures were rated on the following scale: 1 = "not at all", 2 = "somewhat", 3 = "moderately", 4 = "very", and 5 = "extremely".

**Participants in the 2018 study were exposed to the following description: "One recent breakthrough in food innovation allows us to produce meat in a new way. This meat is identical at the cellular level to conventional meat. This meat is real meat grown directly from animal cells. It is produced in a clean facility, similar to a brewery. The process does not involve raising and slaughtering farm animals. The final product has an identical taste and texture to conventional meat. This type of meat offers significant benefits for human health, the environment, and animal welfare. Several companies have already successfully produced and taste-tested this type of meat. The products will be available for retail purchase in 1-5 years."*

***Although clean meat and slaughter-free meat both performed well in appeal, they were not selected for further testing in the current project due to not meeting the neutrality criterion.*

June and September 2019: Stakeholder Meetings

Following the last round of consumer testing, GFI engaged stakeholders in several presentations and workshops. In June 2019, the project team presented the research results to a group of cellular agriculture companies on a video call. The project team obtained feedback on the narrative, graphic, and nomenclature during the video call and afterward via a follow-up survey.

At The Good Food Conference in September 2019, Mattson presented the project results to stakeholders in two separate conference sessions. A pre-conference session included investors and 18 cellular agriculture companies. A lunchtime conference session included a broader group of approximately 100 conference participants. Participants in both sessions provided hand-written feedback directly on printed handouts of the narrative and graphic.

After reviewing the consumer testing results and holding these stakeholder meetings, Mattson and The Good Food Institute made a joint decision to adopt the term "cultivated meat" going forward, as did some of the most active investors in the cellular agriculture, including New Crop Capital and Stray Dog Capital. GFI's rationale is outlined in a blog post (Friedrich, Sep 2019).

Following the conference, GFI researchers reviewed the detailed stakeholder session notes and the feedback from the printed handouts in order to fine-tune the narrative text and graphic image. The recommended communication strategies presented in the next section are the final revised documents that incorporate all rounds of consumer testing and stakeholder feedback.

Recommended Communication Strategies

The project group recommends the adaptation and use of two communication tools: a narrative and graphic visual. These tools completed the cycles of ideation, application of science communication theory, message design, and empirical testing. The tools can be adapted to meet the needs of individual organizations. For instance, cellular agriculture companies may want to add a message source from their organization (i.e., add characters to the narrative), taking care to demonstrate expertise in the topic and shared interest with the audience. Educational groups, advocacy groups, or regulatory agencies could also adapt and use these tools. The graphic visual could be adapted to become an interactive infographic to allow for more detailed information as needed.

The tools presented below were revised after the final consumer survey and feedback from participants at The Good Food Conference in September 2019. To view the versions tested in the May 2019 consumer surveys, see Appendix A and B.

Tool 1: Narrative

We can now diversify and strengthen the protein supply by producing meat in a new, more efficient way. Rather than raising and slaughtering animals, we can cultivate meat directly. This starts with the basic building block of all life—the cell.

From a small sample of animal cells, we can grow the same beef, pork, poultry, and seafood we enjoy eating today. In conventional animal farming, cell growth occurs in an animal. **But we can grow the same cells in what is known as a cultivator.**

The cultivator facilitates the same biological process that happens inside an animal by providing warmth and the basic elements needed to build muscle: water, proteins, carbohydrates, fats, vitamins, and minerals. **Cultivating meat is similar to growing plants from cuttings in a greenhouse, which provides warmth, fertile soil, water, and nutrients.**

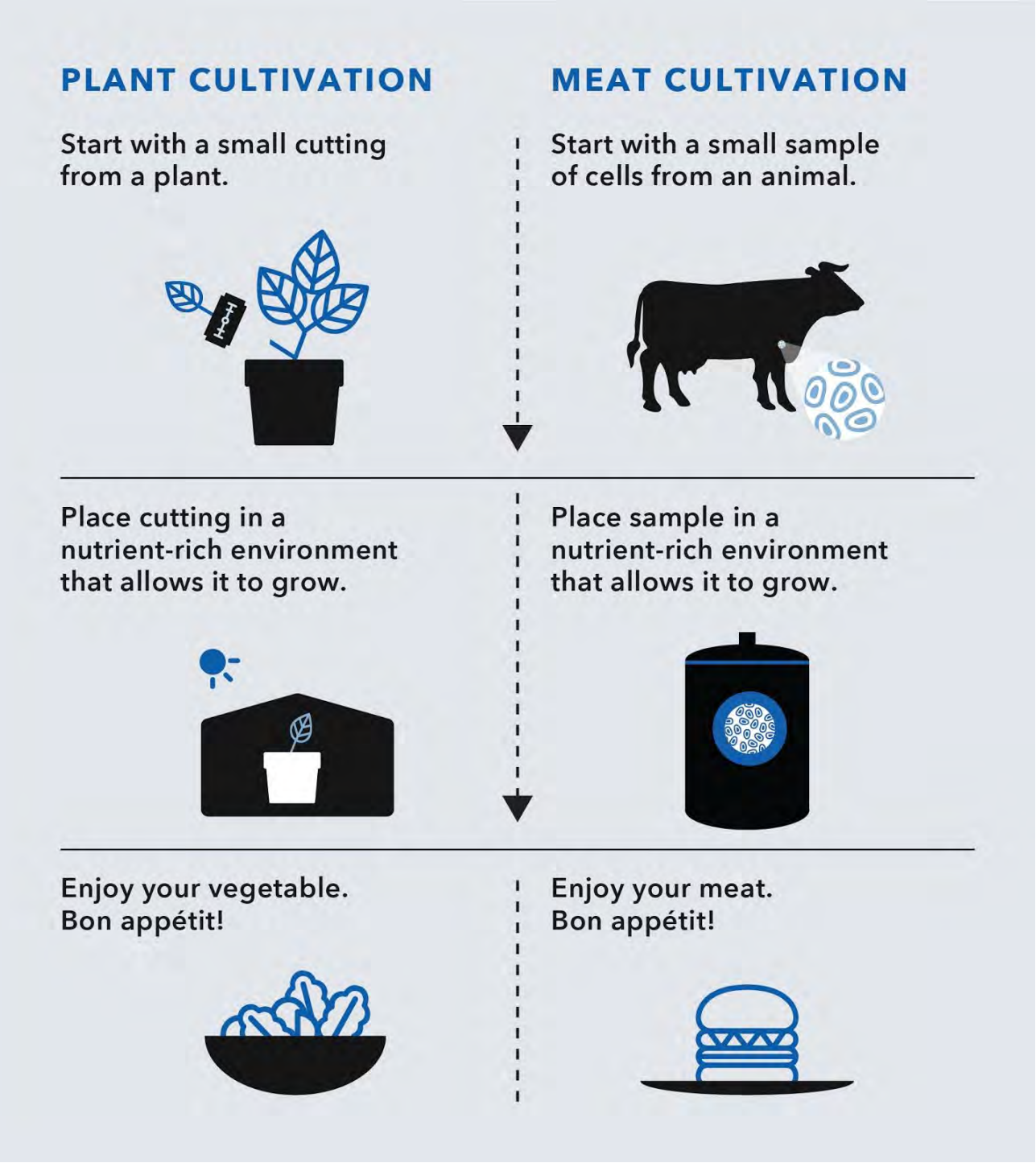
This new method of meat production enables the natural process of cell growth but in a more efficient environment. The result is an abundance of cultivated meat, identical to conventional meat at the cellular level but free of pathogens and other contaminants. Cultivated meat looks, tastes, and cooks the same.

Compared with conventional meat production, meat cultivation is less resource-intensive, decreasing methane emissions, deforestation, biodiversity loss, water use, water pollution, antibiotic resistance, and foodborne illnesses.

Innovators around the world are working to bring cultivated beef, poultry, pork, fish, and seafood to market at a competitive price point. The FDA and the USDA will jointly regulate this new form of meat production in the United States.

Meat cultivation will expand the protein options available to consumers, providing the meat so many people desire, just produced in a new and sustainable way.

Tool 2: Graphic Representation of the Cultivation Analogy



Benefits and Challenges with Nomenclature Choices

Our project involved several phases of nomenclature ideation and testing. We agreed upon four primary criteria for the category name: 1) appeal, 2) the neutrality of the term for multiple stakeholder groups, 3) descriptiveness, and 4) ability to differentiate the category from conventional and plant-based meat. Each name meets the neutrality criteria essential for gaining acceptance among stakeholder groups but poses benefits and challenges with respect to consumer appeal and descriptiveness/differentiation. Please refer to Table 1 for the mean name criteria ratings in the GFI May 2019 survey results section.

Use of Cultivation Language

In addition to these criteria, project members agreed that successful nomenclature would best emerge from the creation of a successful narrative rooted in evidence-based communication strategies. As discussed in the review of the science communication literature, bringing an emerging technology to market requires a different strategy than marketing existing food products. The use of narrative is a key framing strategy, since information about novel technologies must be presented in a format that actively engages thought and aids consumers in incorporating the new information into their existing belief and value systems. Consumer acceptance of newly emerging science topics is best driven by messaging that builds trust and credibility. This can be achieved through transparency and acknowledging uncertainties, demonstrating shared interests and the expertise of the message source, and anchoring the unfamiliar in already understood concepts.

Using these principles, the project group created a narrative and visual message with consideration for the target audience ("skeptical but intrigued middle"). The project group agreed that framing messages around the idea of meat cultivation was neutral, appealing, descriptive, and familiar. The following are examples of language choices in the narrative that engage the familiar and appealing concept of cultivation:

- Rather than raising and slaughtering animals, we can cultivate meat.
- But we can grow the same cells in what's known as a cultivator.
- The cultivator facilitates the same biological process that happens inside an animal by providing warmth and the basic elements needed to build muscle: water, proteins, carbohydrates, fats, vitamins, and minerals.
- Cultivating meat is similar to the way we help plant cuttings to take root in a greenhouse that provides warmth, fertile soil, water, and nutrients.

Whether or not the term "cultivated meat" is selected as a category descriptor, we recommend the broader use of cultivation-related language as a way to bring this category to market in an understandable, familiar, and appealing way that resonates with consumers.

Additional Factors Necessary for Market Success

Ideally a name would meet all four criteria, optimizing appeal while also achieving necessary levels of neutrality, descriptiveness, and differentiation from conventional and plant-based meat.

It is also useful to consider the most important target audience when considering a name. In this project, we identified the "skeptical yet intrigued middle" as the most crucial for diffusing this new innovation through society. This early and late majority consumer segment expressed a strong desire for transparency and straightforward scientific information in messaging. From this standpoint, selecting a technical name (*cell-cultured meat*, *cell-based meat*) may have utility in building their consumer acceptance, even though the name itself is not as immediately appealing as other name options (*cultivated meat*, *cultured meat*).

In addition to taste and price, safety concerns were high for this group. Selecting a name that matches commonly used regulatory terms (and down the line, labeling terms on product packages) may also contribute to greater consumer acceptance (and generate less confusion).

Due to the established use of the term *cultured fish* in the aquaculture fishing industry, we view the terms *cultivated*, *cell-cultured* and *cell-based* as more viable names as they are applicable to all types of meat produced through cellular agriculture (beef, pork, poultry, fish and seafood).

In Table 4, we note the benefits and challenges associated with each name.

Table 4. Summary of benefits and challenges with name choices

Category Name	Cultivated Meat	Cell-based Meat	Cell-cultured Meat	Cultured Meat
Products	Cultivated beef, pork, poultry, fish, and seafood	Cell-based beef, pork, poultry, fish, and seafood	Cell-cultured beef, pork, poultry, fish, and seafood.	Cultured beef, pork, poultry. N/A: cultured fish and seafood*
Benefits	Cultivation is a trusted, understandable, and familiar concept that flows well with the narrative and analogy.	Cell-based is an established term in the cellular agriculture industry.	Cell-cultured is an established name in the scientific community and used in regulatory literature.	Cultured is an established term used by academic and advocacy groups and used by one cellular agriculture company.
	Cultivated meat scored moderately descriptive and differentiating.	Cell-based scored moderately descriptive and differentiating from other types of meat.	Cell-cultured scored highest in descriptiveness and differentiation from other types of meat.	Cultured scored moderately descriptive and differentiating from other types of meat.
	In both qualitative and quantitative assessments, cultivated scored highest in consumer appeal. Focus groups participants stated that this term presented no confusion with plant-based meat.	A transparent, technical name may generate acceptance for the target consumer segment.	A transparent, technical name may generate acceptance for the target consumer segment.	Cultured was somewhat to moderately appealing. A transparent, technical name may generate acceptance for the target consumer segment.

Challenges	Though cultivated meat was moderately descriptive and differentiating from other types of meat, cell-cultured and cell-based scored higher.	Cell-based is lower in appeal and would need to be balanced with other familiar and appealing messaging strategies. From a technical standpoint, cell-based may not sufficiently differentiate from other types of meat (which are also composed of cells).	Cell-cultured is lower in appeal and would need to be balanced with other familiar and appealing messaging strategies.	Cultured meat presents some challenges as it is a duplicate food term (e.g., cultured yogurt, cultured fish). *Cultured fish is an established term in the aquaculture industry and therefore is not a viable name for fish and seafood produced through cellular agriculture.

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About GFI

The Good Food Institute is a global nonprofit building a sustainable, healthy, and just food system. Our scientists, entrepreneurs, lawyers, and policy experts are harnessing the power of food innovation and markets to accelerate the transition of the world's food system to plant-based and cultivated meat, eggs, and dairy.

THE GOOD FOOD INSTITUTE

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GFI IS A NONPROFIT 501(C)(3) ORGANIZATION

Appendix A: Narrative tested in March 2019 Consumer Survey and Focus Groups

Saving Nature Through Discovery

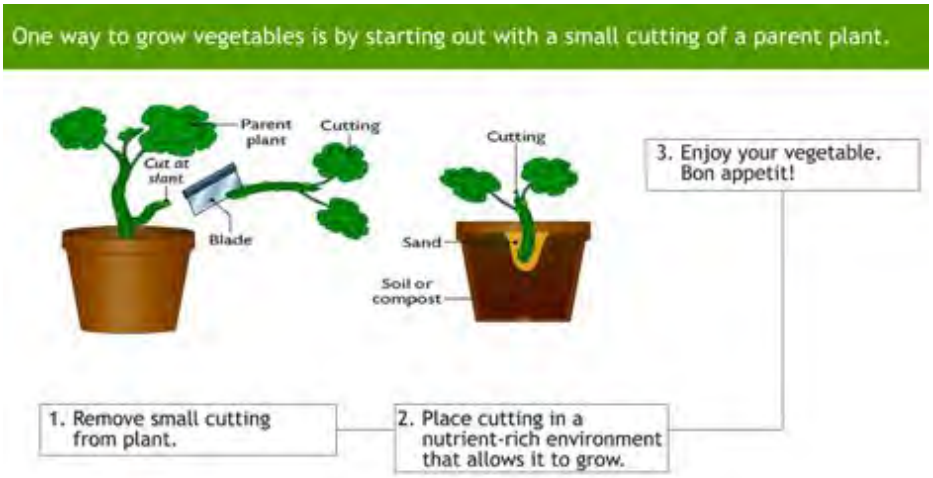
Our Purpose:
Mother Nature is feeling the weight of humanity. She is being asked to feed more and more people with fewer and fewer resources. This pressure is unsustainable, and if we don't do something to help, the way we live and eat will be changed forever.

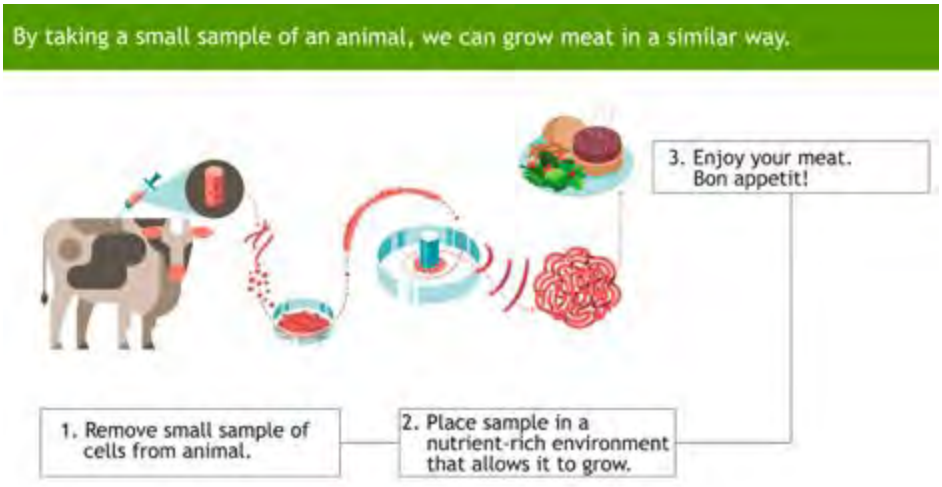
Our goal is to develop, through science and technology, safe ways to help Mother Nature do her thing with less social, environmental, and economic burden.

Our Solution: Embracing the Science of Nature
There will always be a desire for conventional animal farming. As a complement to it, there's now a new way to take a few cells from those living farm animals and grow them into familiar meat, poultry, and fish products in something called a cultivator. The cultivator creates an environment that allows for cell growth… like the fertile soil, water, and nutrients used to help plant cuttings take root.

- The inputs for these meats are simply the basic building blocks of meat and life itself: amino acids and simple sugars.
- This meat grows the way animal cells multiply naturally. We harness the wonders of nature but do it in a different environment.
- The result is an abundance of pure, wholesome meat that was made with a fraction of the natural resources, without the need for antibiotics, and without having to raise and slaughter animals.

Appendix B: Graphic analogy tested in March 2019 Consumer Survey and Focus Groups





Appendix C: Narrative tested in May 2019 Consumer Survey

Meat Cultivation: Embracing the Science of Nature
We can now diversify and bolster the protein supply by producing meat in a new way. Rather than raising and slaughtering animals, we can cultivate meat. This is done by starting with the basic building block of all life - the cell.

Beginning with a small sample of animal cells, we can directly grow the cells into the same meat, poultry, and fish products we enjoy eating today. In conventional animal farming, cell growth occurs in an animal. But we can grow the same cells in what's known as a cultivator.

The cultivator facilitates the same biological process that happens inside an animal by providing warmth and the basic elements needed to build muscle: water, proteins, carbohydrates, fats, vitamins, and minerals. Cultivating meat is similar to the way we help plant cuttings to take root in a greenhouse that provides warmth, fertile soil, water, and nutrients.

This new method of meat production harnesses the wonders of nature but does it in a different environment. The result is an abundance of pure meat, identical to conventional meat at the cellular level. It looks, tastes, and cooks the same.

Compared to conventional meat production, meat cultivation requires only a fraction of the natural resources, decreasing the rate of methane emissions, deforestation, antibiotic resistance, biodiversity loss, and foodborne illnesses. Because this new method of production requires fewer resources, it should ultimately be possible to cultivate meat at a lower cost.

Innovators around the world are working to bring this new way of producing beef, poultry, pork, fish, and seafood to market at a competitive price point. The FDA and the USDA will jointly regulate and ensure the safety of this new form of meat production in the United States.

Appendix D: Graphic analogy tested in May 2019 Consumer Survey

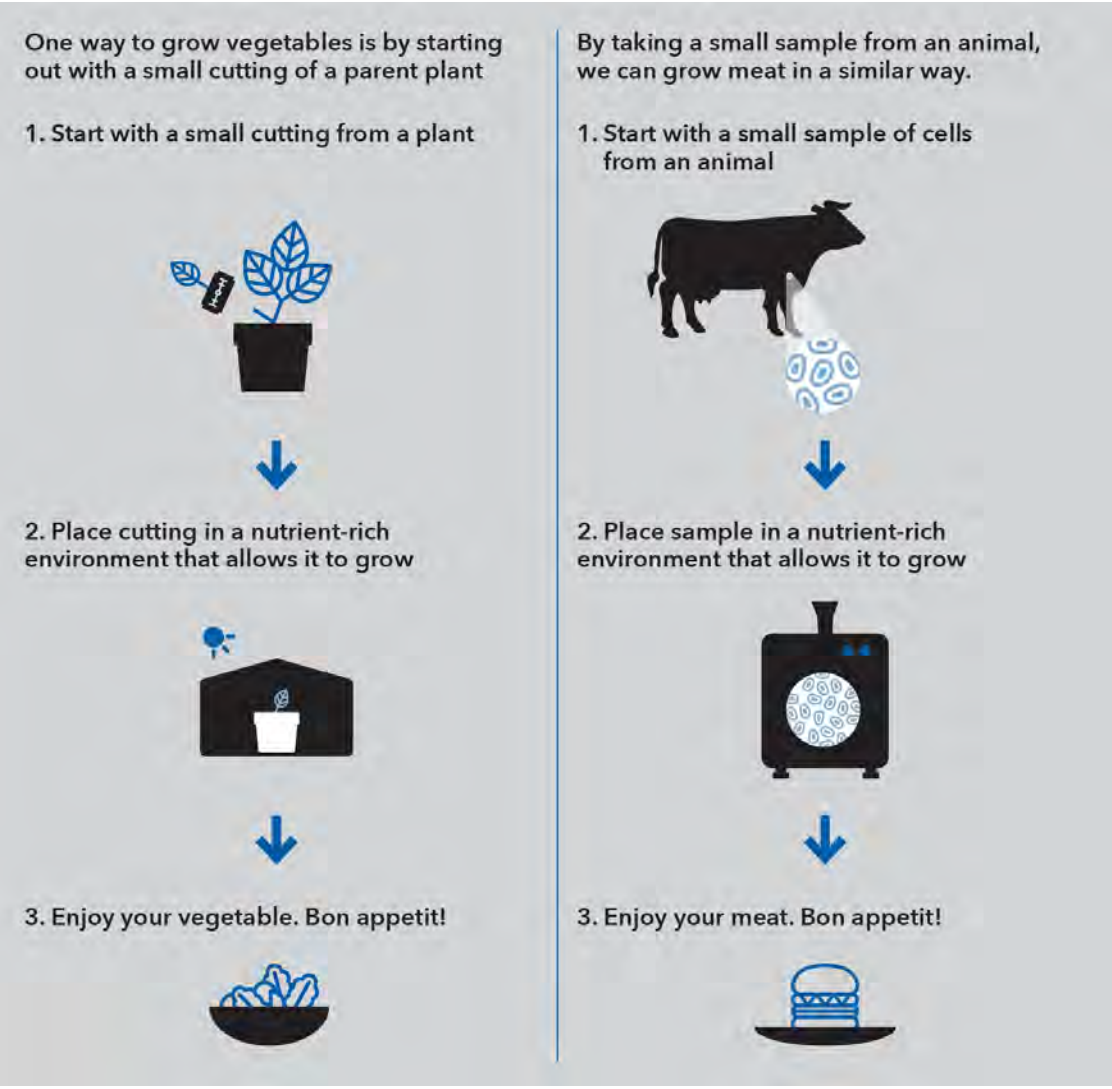


Exhibit C

Cultivated meat: A growing nomenclature consensus

GFI Founder and CEO Bruce Friedrich explores the increased sector alignment around the preferred category name for meat produced through cellular agriculture.

September 29, 2021 | Bruce Friedrich |

Consumer and industry preferences

that the strongest term for meat produced through cellular (rather than conventional) agriculture is "cultivated meat," as I discussed in some depth here.

UPSIDE CEO Uma Valeti noted, "This made sense to us, since we'd already been referring to 'cultivating meat in cultivators.' I like the consistency."

Fork & Goode CEO Niya Gupta said, "I like 'cultivated meat' because it's generic, like 'organic.' It can cover a very complex process that we have to be transparent about."

Since that work, quite a few companies have been using "cultivated meat" as their primary nomenclature. For GFI's 2020 industry report, our analysis indicated that 37 percent of companies were using "cultivated," 25 percent of companies were using "cultured," and 18 percent of companies were using "cell-based." The final 20 percent were using a variety of other terms to describe their meat production process.

That has changed—a lot.

STATS

44
Companies participating

75%
Companies prefer "cultivated"

20%
Companies prefer "cultured"

Companies now prefer "cultivated meat" by a wide margin

In September 2021, we polled company CEOs on their preferences and found a significant shift, with 75 percent of the 44 companies that replied preferring "cultivated." "Cultured meat" comes in second at 20 percent, and everything else trails by quite a lot.* One of the previous favorites, "cell-based," is preferred by just one company.

"It seems pretty clear to us that cultivated meat is the best option, for the reasons spelled out by GFI, and we're glad to see what looks like a growing consensus," said Eat Just CEO Josh Tetrick. "It would be great if we could get as many of us rallying around one term as possible, and we think that term should be cultivated."

"Cultivated meat is a bit friendlier, foodier, translates into some of our key European languages, and signals a bit more of the caring / precarious process needed to keep cells happy," explained Tim van de Rijdt, Chief Business Officer at Mosa Meat and President of Cellular Agriculture Europe. "Thus far, it's also been the preferred modifier among the 13 members of Cellular Agriculture Europe."

"We agree that cultivated meat is the way to go, and aligning as a sector will help us all be more effective,"Aleph Farms CEO Didier Toubia said."Based on the research we've performed, cultivated will fulfill the requirements for differentiating the product and appealing to consumers."

Top investors in the space, from Stray Dog Capital to Unovis VC to Agronomics to Synthesis Capital and more also prefer "cultivated." Synthesis Capital co-founder Rosie Wardle explained, "We have been using cultivated for the past few years consistently, and we find that it immediately resonates with people. In our opinion, cultivated meat has become the consensus nomenclature among investors."

So too McKinsey, UC Davis' Cultivated Meat Modeling Consortium, Bill Gates' Breakthrough Energy (and Bill in his new book, *How to Avoid a Climate Disaster*), and Alt-Meat, the unofficial chronicler of all things alternative meat (Alt-Meat was founded by the meat industry journalists who run *MeatingPlace Magazine*). And (of course) GFI — with more than 135 full time staff across our U.S. and affiliate organizations in India, Israel, Brazil, APAC, and Europe.

So why "cultivated"?

As Eat Just's Tetrick said, "cultivated meat is the best option."

In addition to the fact that it translates best into key European languages, as noted by Tim van de Rijdt from Cellular Agriculture Europe, it's also the documented best term for consumer acceptance, which is critically important this early in the life of a new industry.

The two most widely cited studies of nomenclature have been the work that UPSIDE and GFI conducted with Mattson and a seafood study from Rutgers that was funded by BlueNalu. Both studies found that "cultivated" outperformed "cultured" and "cell-based" across consumer appeal metrics. In the Mattson focus groups, nearly every participant responded positively to "cultivated," and the plurality selected it as their top choice. Focus group associations for "cultivated" included farming, naturalness, and caring.

The Rutgers study found that "cultivated seafood" outperformed "cultured," "cell-based," and "cell-cultured" across positivity, nutrition, imagined taste, likelihood to purchase, and naturalness. On the other hand, "cell-based" and "cell-cultured" performed better for differentiation from conventional seafood. "Cell-based" and "cell-cultured" were also more likely to be seen as the product of genetic engineering. So if your goal is to say as loudly as possible, "This is different from what you are used to eating," you may prefer "cell-based" or "cell-cultured" over "cultivated seafood."

Similarly, the Mattson focus group found that "cell-based" was the most associated with science. ("I don't want to eat a science project," said one participant.) But the real fatal flaw of "cell-based," in our view, is that it doesn't actually differentiate: Conventional meat is also cell-based.

And what about "cultured meat," the term that's been in use the longest of the three? "Cultured" does almost as well with consumers as "cultivated," though it does conjure up the image of a petri dish for some people (which is why Mattson Chief Innovation and Marketing Officer Barb Stuckey wanted to find a new name in the first place). In the Mattson focus group, her concerns were corroborated, with multiple participants noting that "cultured" conjured up labs and hospitals and others saying it sounds aged or old.

More critically, though, cultured already has a meaning in food—consumers could easily get confused and think "cultured" meat is salted, aged, or subjected to some other culturing practice. As USDA noted explicitly in its request for public comments on naming, there are already "other types of foods where the term 'culture' or 'cultured' is used (such as 'cultured celery powder')."

"If we, as an industry, want to help people understand what we do, it's essential that we are clear ourselves—and this starts with using consistent terminology," said Jess Krieger, founder and CEO of Ohayo Valley."'Cultivated meat' conjures images of agriculture and natural processes, is biologically correct, and isn't used by any major food type—it's a great name for us to stand behind as an industry."

RESOURCE

Cultivated meat nomenclature project

We developed a set of science-forward, evidence-based communication tools, rooted in familiar language, to help explain meat cultivation to non-technical audiences.

Learn more

** Because four companies expressed preference for more than one term, we had 49 total responses across 44 companies.*

Header image courtesy of Upside Foods

Bruce Friedrich

FOUNDER & CHIEF EXECUTIVE OFFICER

Bruce Friedrich directs GFI's strategic planning and execution in the United States and globally. **Areas of expertise:** alternative proteins generally, GFI's global programs and strategy, bicycling in heavy traffic.

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Exhibit D

Good Food Institute

A summary of recommended stakeholder actions

Anticipatory life cycle assessment and techno-economic assessment of commercial cultivated meat production

MARCH 09, 2021

Elliot Swartz, Ph.D.
Senior Scientist
The Good Food Institute

Executive summary

A life cycle assessment (LCA) and techno-economic assessment (TEA)[1] modeling a future large-scale cultivated meat[2] production facility show that by 2030, cultivated meat could have reduced overall environmental impacts, a lower carbon footprint, and be cost-competitive with some forms of conventional meat. This is generally true whether cultivated meat is produced using conventional energy mixes or renewable energy, but the reduction in environmental impacts and carbon footprint is greatest when cultivated meat is produced using renewable energy. In addition to the degree to which renewable energy is sourced at future facilities and the degree of decarbonization throughout the supply chain, the key factors that accomplish these outcomes are maintaining high-density cell cultures, efficiently using and sourcing cell culture media, and relaxing payback times for facility capital costs.

The LCA and TEA reports are the first of their kind to be informed by data inventories collected from active industry partners—over 15 companies involved in the cultivated meat supply chain, including five cultivated meat manufacturers contributed data and expertise. The study design, data analysis, and writing of the reports was performed independently by CE Delft.

The LCA accounts for uncertainty in the cultivated meat production process by conservatively assuming high energy use at the facility. Despite this conservative estimate, the LCA shows that even when compared to an extremely optimistic benchmark projecting reduced environmental impacts of conventional animal agriculture by 2030, cultivated meat produced using renewable energy:

- Reduces global warming impacts by 17%, 52%, and 85-92% compared to conventional chicken, pork, and beef production, respectively.[3]
- Is 3.5x more efficient than conventional chicken at converting feed into meat, consequently reducing land use by 63%, 72%, and 81-95% compared to conventional chicken, pork, and beef production, respectively.
- Can be cost-competitive, with production costs modeled as low as $6.43 per kilogram ($2.92 per pound).

While the reports aim to reflect how cultivated meat may be produced in the year 2030, data gaps persist and assumptions may change over the next decade as the nascent cultivated meat industry matures. The findings in these reports should not be interpreted as representing unchanging truths or

[1] Read the LCA and TEA reports from CE Delft (www.cedelft.eu). LCA (https://www.cedelft.eu/en/publications/2610/lca-of-cultivated-meat-future-projections-for-different-scenarios) and TEA (https://www.cedelft.eu/en/publications/2609/tea-of-cultivated-meat-future-projections-of-different-scenarios).
[2] Cultivated meat is genuine animal meat or seafood produced by directly cultivating animal cells. To learn more about cultivated meat, visit (https://gfi.org/science/the-science-of-cultivated-meat/).
[3] The favorable results from these conservative comparisons indicate that the environmental benefits of cultivated meat are expected to be highly robust.

the absolute lower boundaries for the costs and climate impacts of cultivated meat. However, the insights from these reports should be used to effectively address existing technical and economic bottlenecks[4] and serve as guidance for stakeholders to further the adoption of cultivated meat.

Key stakeholders such as governments, investors, nonprofits, and other policymakers can develop an ecosystem that fosters innovation, supports the deployment of cultivated meat, and capitalizes on its potential to mitigate massive global challenges related to climate change, antibiotic resistance, and other areas of human, animal, and planetary health. To achieve this, we recommend stakeholders to:

- Significantly increase investments in open-access R&D.
- Enact science-based policies for capitalizing on the carbon opportunity of land use.
- Incentivize new infrastructure.
- Develop a robust and equitable workforce for the cultivated meat industry.

We additionally highlight commendable actions already being taken within the cultivated meat industry and point to examples from other sectors and published studies that may inform the best path forward. These reports collectively highlight the enormous potential for cultivated meat as being a sustainable and affordable protein option for a growing population.

Cultivated meat cost and efficiency

Production cost (model low end)	**$6.43/kg $2.92/lb**	**Input efficiency** (compared to ambitious benchmarks for conventional chicken)	**3.5x**

Cultivated meat environmental impact comparison (when produced via renewable energy)

	Cultivated meat compared to ambitious benchmarks for conventional chicken	Cultivated meat compared to ambitious benchmarks for conventional pork	Cultivated meat compared to ambitious benchmarks for conventional beef
Global Warming	**17% reduction**	**52% reduction**	**Up to 92% reduction**
Land Use	**63% reduction**	**72% reduction**	**Up to 95% reduction**

[4] For more on technical bottlenecks and future directions, read our technical summary (https://gfi.org/wp-content/uploads/2021/03/cultured-meat-LCA-TEA-technical.pdf).

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Study design

The life cycle assessment (LCA) and techno-economic assessment (TEA) model a hypothetical commercial-scale cultivated meat production facility operating in the year 2030. The facility is capable of annually producing 10 kilotons of minced cultivated meat (like hamburger or ground turkey).[5] To build the model, inventory data were obtained from 15 different companies active in the cultivated meat supply chain, including five cultivated meat manufacturers.

The LCA considered all inputs and outputs upstream of the product leaving the facility. In the LCA, two energy mixes were modeled for cultivated meat production: a conventional energy mix based on stated policies for 2030 and a sustainable energy mix produced with 50% solar, 50% on-shore wind, and heating derived from geothermal heat.

For conventional meat production, an intensive, West-European system that is significantly below global averages for carbon footprint was assumed.[6] To represent ambitious improvements in environmental impacts for conventional meat production by 2030, various assumptions were made: sustainable energy would be deployed at farm and feed production facilities, there would be reduced ammonia emissions through increased outdoor grazing, reduced methane emissions obtained through feed additives, and no land-use change associated with soy used in feed. **These assumptions further reduce the carbon footprint of conventional beef by 15%, pork by 26%, and chicken by 53%.** These ambitious benchmarks were set to ensure robust conclusions could be drawn from environmental impact comparisons.

The TEA considered the capital expenditures (equipment and installation costs) and operating costs (electricity, heat, water, labor, media, and other inputs) that contribute to the cost of cultivated meat production. All equipment in the facility was assumed to be food-grade rather than pharmaceutical-grade, and process costs were benchmarked to the food sector. Cost estimates were given uncertainty ranges from -20% to +40%.

The study design, data analysis, and creation of the model facility was performed independently by CE Delft. For more details on the study design, we refer the reader to the LCA and TEA reports.

[5] Note that the terminology “cultivated meat” includes seafood and organ meats (e.g., foie gras).
[6] Poore and Nemecek, 2018. See page 28 of the LCA report for further details.

Key findings and insights

The LCA and TEA collectively show that by 2030 cultivated meat could have reduced overall environmental impacts, a lower carbon footprint, and be cost-competitive with some forms of conventional meat. The key takeaways from the LCA (summarized in Table 1) and TEA are listed below, with subsequent follow-on action-oriented recommendations discussed later.

Eating this form of meat	instead of this conventional meat	reduces this environmental impact category by approximately this much			
		Particulate Matter Pollution[7]	Global Warming[8]	Human Toxicity[9]	Land Use
Cultivated meat (sustainable energy)	Beef (cattle)	93%	92%	92%	95%
	Beef (dairy)	85%	85%	89%	81%
	Pork	49%	52%	47%	72%
	Chicken	29%	17%	-2%	63%
Cultivated meat (conventional energy)	Beef (cattle)	90%	55%	92%	94%
	Beef (dairy)	79%	22%	89%	79%
	Pork	29%	-258%*	50%	70%
	Chicken	1%	-445%*	4%	60%

Table 1. Reproduced from Table 5 in the LCA report. Numbers represent the percentage change from the cultivated meat sustainable energy scenario. The environmental impact score is driven by Particulate Matter Formation (47% of score), Global Warming (33% of score), Human Toxicity (10% of score), and Land Use (6% of score), with other categories making up the remaining 4%. *The LCA conservatively assumes high energy use at the cultivated meat facility, which is representative of an upper estimate (see Technical Summary).[10] Conventional meat production is modeled as an optimized form of production, which has a significantly reduced carbon footprint compared to global production averages (see Study Design and Figure 3 of the LCA report).

[7] Particulate matter formation refers to the mixture of solid particles and liquid droplets found in the air. It is quantified in terms of kg $PM_{2.5}$-eq and can be thought of more simply as air pollution. For animal agriculture, particulate matter formation is driven primarily by ammonia from manure and fertilizer use. For cultivated meat, it is driven by the creation of sulfur dioxide and other fine particulates from electricity generation, raw material mining, and feedstock processing upstream in the supply chain. Refer to Figure 13 of the LCA report for further details.

[8] Measured in kg CO_2-eq. For comparison to conventional beef production, cultivated meat's global warming benefits are best viewed as short-term, as beef's impacts are driven primarily by methane.

[9] Human toxicity is a metric that expresses the potential harm of a unit of chemical released into the environment. It is quantified in terms of kg 1,4DCB-eq (DCB being dichlorobenzene). For animal agriculture, it is driven primarily by manufacturing and application of fertilizers and pesticides. For cultivated meat, human toxicity is driven by mining and raw material processing for electricity production and infrastructure, as well as fertilizer and pesticide use for raw materials (i.e., soy, corn) used in the cell culture medium. To learn more about human toxicity potential, see (https://core.ac.uk/download/pdf/52101237.pdf).

[10] (https://gfi.org/wp-content/uploads/2021/03/cultured-meat-LCA-TEA-technical.pdf).

1. **Reduced environmental impacts:** Even when compared to an extremely optimistic scenario projecting reduced environmental impacts of conventional animal agriculture by 2030, cultivated meat produced using renewable energy outperforms all forms of conventional meat production in cumulative environmental impacts (including air pollution, land use, and carbon footprint).[11] Cultivated meat can reduce global warming impacts by 17%, 52%, and 85-92% compared to conventional chicken, pork, and beef production, respectively. Given the conservative comparisons in the LCA, the reduced environmental impacts of cultivated meat are expected to be highly robust.

2. **Fewer inputs required:** Cultivated meat is 3.5x more efficient than conventional chicken (the most efficient form of conventional meat production) at converting feed into meat. Consequently, cultivated meat reduces land use by 63%, 72%, and 81-95% compared to conventional chicken, pork, and beef production, respectively. If substitution of cultivated meat instead of conventional meat occurs in diets, the reclaimed land can be restored and rewilded to sequester more carbon or repurposed for renewable energy or human food production, increasing cultivated meat's environmental and food security benefits.

3. **Cost competitive: Modeled as low as $6.43 per kg ($2.92 per pound), cultivated meat could compete with some conventional meats on costs by 2030.** The LCA and TEA analyzed the production of a ground meat product containing 100% cultivated meat. However, many manufacturers are looking at using cultivated meat as an ingredient in plant-based or cultivated blends as a way to more thoroughly biomimic the conventional animal meat experience. Blended or "hybrid" products are anticipated to have reduced costs and environmental impacts, but further analyses are needed to confirm this.

4. **A need for new infrastructure:** The model facility producing 10 kilotons of cultivated meat annually has an estimated cost of $450M USD. Relaxed payback time criteria over the lifetime of the facility will be critical to obtaining competitive prices for cultivated meat. A menu of financing strategies and incentives will need to be made available to install new infrastructure at all scales. The TEA highlights the large business opportunity to develop and manufacture more affordable, fit-for-purpose cultivators for cultivated meat production.

[11] Environmental impacts were measured by calculating the carbon footprint expressed in greenhouse gas equivalents and the ReCiPe Endpoint and Midpoint methods, a metric that tallies 18 different environmental impact categories into a single score. ReCiPe was developed by the Dutch government as a means to improve life cycle analyses. To learn more, see (https://www.leidenuniv.nl/cml/ssp/publications/recipe_characterisation.pdf).

5. **Government support of cultivated meat will create new high-paying job opportunities in both rural and urban areas.** The TEA finds that the model facility is expected to provide approximately 130 to 200 high-paying jobs, depending on its process efficiencies, with other opportunities becoming available elsewhere in the supply chain. Cultivated meat can be produced in facilities located in rural and urban areas. The selection of a facility's location will likely be dependent in part by access to renewable energy or ease of generating renewable energy, access to raw materials (e.g., glucose from corn and amino acids from soy used in cell culture media), access to specialized labor and distribution channels, and final facility size.

6. **Further cost and environmental impact reductions are possible:** The LCA and TEA studies analyzed sets of favorable but realistic scenarios that decrease the costs and environmental impact from a baseline cultivated meat production scenario with a specified set of assumptions. These studies should not be interpreted as representing absolute lower boundaries for costs or climate impacts. Rather, they should be used as a roadmap for identifying potential improvements outside of what has been analyzed. These include the creation of more efficient or automated cultivation processes, cell culture medium recycling, improved efficiencies and methods of production for growth factors, and the importance of sourcing or generating affordable renewable energy. These and other technology development opportunities are further discussed in our sister summary for technical audiences.[12]

7. **The commercial success of cultivated meat has additional benefits.** While important, a narrow focus on emissions can miss out on other positive externalities that accompany cultivated meat if it succeeds in the marketplace and substitutes for conventional meat in diets. These benefits include mitigation of antibiotic resistance, foodborne illness, and zoonotic disease risk associated with conventional animal agriculture, restoration of terrestrial and marine habitats, and a decreased rate of biodiversity loss.

Recommendations

Successful and rapid development and deployment of cultivated meat will require contributions across stakeholder groups — from the greater public to scientists, entrepreneurs, investors, governments, and nonprofits. Below is a list of actions that stakeholders can take to realize the many potential benefits of large-scale cultivated meat production.

Policy recommendations: Governments hold many levers for accelerating cultivated meat technology development and deployment.

[12] (https://gfi.org/wp-content/uploads/2021/03/cultured-meat-LCA-TEA-technical.pdf).

1. **Governments should increase public funds for R&D into cultivated meat technology.** Cultivated meat is still in development and whitespace opportunities to address critical knowledge gaps and optimize scale-up processes are abundant.[13] For example, the LCA and TEA highlight that further cell characterization is needed to inform medium composition and scale-up strategy, media recycling and growth factor optimizations are useful ways to lower costs and boost productivity, and sufficiently upscaled perfusion cultivators tailor-made for meat production and harvesting do not yet exist.[14] A growing number of interdisciplinary students and scientists who see the potential in cultivated meat technology and are eager to address these challenging questions simply do not have access to funding opportunities to pursue their ideas. If funding is acquired, access to essential resources such as animal cell lines remains bottlenecked, further hampering progress.[15]

   Since 2005, global governments have only funded approximately $6.5M into open-access cultivated meat research[16] — a tragically deficient amount of dollars compared to the opportunity cultivated meat holds. Governments must double down on technologies such as cultivated meat that have the ability to address multiple sustainable development goals in one fell swoop. Governments must also be forward-thinking and realize that the benefits from publicly-funded cultivated meat technology development would see compounding returns on investment over decades. For example, cost reduction and scale-up optimizations in cultivated meat are expected to advance other burgeoning industries such as biologics, cellular therapeutics, and regenerative medicine. And access to cultivated meat can lead to the creation of new hybrid food products that familiarize consumer palettes with other alternative proteins, making them more likely to regularly consume those products. Importantly, a sustained injection of public funding provides training for the future workforce that will build the more resilient food system needed for a growing population.

   Thus far, government funding into open-access cultivated meat research has fallen far short of what is needed. But the tides are beginning to turn as confidence in cultivated meat increases. For instance, the Spanish Centre for the Development of Industrial Technology has backed a project proposing lipid modifications to cultivated meat products as a means to reduce colon cancer and dyslipidemia,[17] Belgium's Ministry of Innovation has provided funding for a public-private partnership to commercialize cultivated foie gras,[18] the United States' National

[13] Visit our solutions database for a full breakdown of challenges facing alternative proteins. (https://gfi.org/alternative-protein-solutions/).
[14] (https://gfi.org/wp-content/uploads/2021/03/cultured-meat-LCA-TEA-technical.pdf).
[15] Read about efforts to expand access to cell lines (https://gfi.org/resource/expanding-access-to-cell-lines/).
[16] Funding numbers compiled internally at GFI. Numbers represent an estimated lower bound and do not include funding from nonprofits or government funding for private industry projects.
[17] (https://www.foodnavigator.com/Article/2021/01/20/Spanish-government-invests-5.2-million-in-cultured-meat-project)
[18] (https://kweekvlees.be/news-articles/diervrije-foie-gras-binnenkort-op-ons-kerstmenu/)

Science Foundation awarded an interdisciplinary academic team to work on developing cell lines, low-cost cell culture media, structuring for whole-cut products, and sensory analysis of end products,[19] and the Japanese Science and Technology Agency has earmarked $20M for cultivated meat research. Additionally, the EU, Japan, Israel, and Singapore have all invested undisclosed amounts into cultivated meat companies.

The time is ripe for governments to seize the opportunity and reap the benefits of becoming global leaders in cultivated meat technology.

A spotlight on Singapore

Forward-thinking countries such as Singapore have already taken charge in establishing an ecosystem to support cultivated meat. As a small island nation that imports over 90% of its food, Singapore views cultivated meat research and commercialization as a critical part of achieving its mission to produce 30% of its food locally by 2030 and, in turn, disarming the looming food security threat it faces. To foster an innovative research community, Singapore leverages its Agency for Science, Technology, and Research (A*STAR), a federally-backed suite of research institutes that aligns competitive advantage with national needs. A*STAR has received S$144M to support its "30 by 30" mission and will use these funds to support cultivated meat research with an eye toward industry collaborations and building up the local talent pool.[20,21]

Singapore aims to create a funnel of innovation by increasing access to venture partners, incubating startups interested in the Asian market,[22] integrating with a strong local biopharma, food, and specialty chemicals manufacturing ecosystem, and supporting technology transfer that greases the wheels for spin-offs and licensing agreements. Additional undisclosed government incentives aim to promote partnerships between local industries, talent, and manufacturing infrastructure. Finally, Singapore has been proactive in establishing a favorable regulatory environment for cultivated meat companies (discussed in (4) below).

Any region, but especially those with high food security threats and high per-capita meat consumption (e.g., Hong Kong, Taiwan, United Arab Emirates, Israel) should look to Singapore as a model for their future food strategy and implementation. Efforts taken by Singapore have already begun to pay off (see section (4) below for more), with the small nation already home to five startups involved in cultivated meat as of writing. Importantly, food security can be

[19] (https://gfi.org/blog/nsf-cultivated-meat-grant/)
[20](https://www.channelnewsasia.com/news/singapore/singapore-to-invest-s-144-million-in-research-on-food-security-11386270#:~:text=Singapore%20has%20identified%20key%20areas,own%20nutritional%20needs%20by%202030.)
[21] (https://www.a-star.edu.sg/ibn/research/cultivated-meat-technologies)
[22] (https://vegconomist.com/society/singapore-emerges-as-the-food-tech-ecosystem-of-asia/)

enhanced by the flexibility of cultivated meat technology, which permits the production of seafood inland and could increase access to meat products in regions with limited access to traditional supply chain or cold chain infrastructure.[23]

2. **Governments should incorporate cultivated meat into their climate change policies and other sustainability policy strategies.** Producing meat through cultivation will help governments achieve net-zero pledges more easily by reducing agricultural emissions associated with conventional meat and poultry production beyond what is possible with interventions in the conventional meat industry (e.g., using feed additives to reduce methane emissions). The LCA shows that if the cultivated meat industry were to rely on sustainable energy versus a business-as-usual energy scenario without additional policy change, then the cumulative environmental impacts of cultivated meat production and its carbon would decrease by approximately 80% and 60%, respectively. But a similarly large benefit is not achievable through decarbonization of conventional animal agriculture. This is because the majority of the climate impact of cultivated meat is concentrated in energy use at the production facility, whereas the climate impacts of conventional animal agriculture are spread across methane and nitrous oxide emissions, land-use change, as well as energy use for the farm, feed, and slaughterhouse facilities.[24]

   Decarbonizing the energy grid in line with Paris Agreement objectives without making changes to how we produce meat would leave a growing percentage of the global carbon budget for limiting warming to 1.5ºC attributable to animal agriculture. Estimates suggest that in business-as-usual scenarios depicting animal agriculture growth as meeting an increasing global meat demand, it could account for up to 80% of the remaining annual carbon budget by 2050.[25] Thus, **governments committed to achieving net-zero emissions through decarbonization of their energy sector can achieve a greater rate of emissions reduction if they also increasingly replace their meat sourcing or production with cultivated meat** (or other alternative proteins)**.** Governments will also see a significantly greater absolute reduction in emissions by switching their meat production to cultivated meat or other alternative proteins such as plant-based meats. Put simply, a transition to cultivated meat aligns with shared global incentives to reduce carbon emissions as fast as possible (alignment in other areas of global need is discussed in “Additional benefits of cultivated meat” below).

[23] Newton, 2021.

[24] According to the FAO, fossil fuel consumption across the conventional livestock supply chain only accounts for ~20% of emissions. (http://www.fao.org/3/i3437e/i3437e.pdf, page xii).

[25] GRAIN: Emissions Impossible, 2018. (https://www.grain.org/article/entries/5976-emissions-impossible-how-big-meat-and-dairy-are-heating-up-the-planet)

Carbon opportunity cost of land use

Another critical area of focus for governments to achieve emissions reductions is related to the carbon opportunity cost of land use. Conventional animal agriculture is the number one cause of global deforestation and biodiversity loss.[26] Between 2001-2015, an estimated 45.1 million hectares (Mha) of forest — an area larger than Paraguay — was converted into cattle pasture. This accounted for 36% of all agriculture-linked tree cover loss worldwide.[27] Another 8.2 Mha was deforested for soy production in South America, where an estimated 80% goes to animal feed, often for export or to feed cattle that are then exported.[28,29,30] This means that many regions (often wealthier) effectively externalize the impacts of their high meat consumption onto other countries, piling climate equity issues on top of emissions related to land-use-change and biodiversity loss in precious rainforests.

Mitigating this loss of land and rewilding it to sequester additional carbon or repurposing it for renewable energy and human food production offers one of the largest long-term levers for slowing climate change and its impacts. The LCA shows that cultivated meat is approximately 3.5x to 16x more efficient than conventional meat production (Table 2). Consequently, cultivated meat reduces land use by 81-95% compared to conventional beef, 72% compared to pork, and 63% compared to chicken (Table 1). In the LCA, this carbon opportunity is not accounted for. **If cultivated meat is substituted in diets and included in governmental climate mitigation strategies that effectively capitalize on the carbon opportunity of land use, then cultivated meat's climate benefits will become significantly greater.[31]**

To highlight this opportunity, a study by Hayek *et al*. found that shifts to primarily plant-based diets by 2050 could sequester an equivalent of 99-163% of the carbon emissions budget for limiting warming to 1.5ºC by implementing changes in global food production and sequestering carbon via ecosystem restoration.[32] With a land footprint identical to tofu production, a switch to cultivated meat likely offers a similar level of opportunity. **The extraordinary potential to sequester large amounts of carbon through changes in land use are therefore not limited to**

[26] Machovina, 2015; Dudley, 2017.

[27] World Resources Institute: Deforestation linked to agriculture (https://research.wri.org/gfr/forest-extent-indicators/deforestation-agriculture).

[28] *Ibid*

[29] Approximately 80% of soybeans grown in the Amazon are used in animal feed (https://globalforestatlas.yale.edu/amazon/land-use/soy).

[30] Approximately 11.3 Mha of forest was lost due to importation of animal meat and animal feed crops into the EU from 1990-2014 (Fuchs, 2020).

[31] "Carbon farming" methods such as reduced tillage, planting of cover crops, and applying fertilizers rich in carbon offer additional possibilities to sequester carbon (https://northsearegion.eu/carbon-farming/what-is-carbon-farming/).

[32] The range of 99-163% represents scenarios where consumers shift to a global 70% reduction in meat consumption from business-as-usual scenarios (99% figure) to a fully vegan diet with no animal-sourced foods (163% figure). This is consistent with a 66% chance of limiting warming to 1.5ºC. (Hayek, 2020).

grand shifts toward plant-based diets — consumers could still eat meat if it is produced in a different way.[33]

Meat Type	Feed Conversion Ratio (kg in per kg out)
Cultivated meat	0.8*
Beef (beef cattle)	5.7**
Beef (dairy cattle)	12.7**
Pork	4.6
Chicken	2.8

Table 2. Reproduced from Table 6 in the LCA report. *The feed conversion ratio is < 1 because of the difference in water content between inputs and outputs. **Does not include human inedible grasses in the calculation.

Putting all options on the table may increase the likelihood of large-scale consumer shifts toward more sustainable foods, which has historically been difficult to achieve by suggestion alone. Future studies should aim to quantify carbon opportunity costs in lands and soils following consumer switches to diets with varying percentages of cultivated meat and other alternative proteins. Analyses related to soil desiccation due to groundwater loss are also recommended.[34] Quantification of the add-on effects related to a decreased animal agriculture footprint on land such as reduced eutrophication, pesticide usage, and limiting the rates of deforestation and biodiversity loss would also be valuable to examine.

3. **Governments should provide incentives to attract new infrastructure projects and provide mechanisms to finance them. Incentives can also be used to accelerate consumer adoption of cultivated meat and limit negative externalities of conventional meat production.** One key aspect of becoming a global leader in cultivated meat production is to attract new infrastructure projects that will provide their populations access to cultivated meat and new job opportunities (discussed in (5) below). The facility modeled in the TEA has expected capital costs of approximately $450M USD (-20% to +40%). To meet just 0.3% of global meat production, 100 similarly-sized facilities would need to be constructed.[35] This

[33] In the meantime, scientific consensus has emerged, which recommends a dramatic decrease in global animal meat consumption to meet climate goals. (Springmann, 2018; Clark, 2020; EAT Lancet Commission Report: https://eatforum.org/content/uploads/2019/07/EAT-Lancet_Commission_Summary_Report.pdf).
[34] Blue water (found in surface and groundwater reservoirs) use was quantified in the LCA. When using sustainable energy, cultivated meat uses up to 78% less blue water than beef production. See Figure 15 of the LCA report for further details.
[35] It should be expected that cultivated meat manufacturers will pursue both scale-up (i.e., beyond the size of the facility used in the model) and scale-out strategies (i.e., making copies of smaller or similarly-sized facilities as the one used in the

underscores the need for a lot of new infrastructure (including an assessment for refurbishing potential) and mechanisms for financing those projects.

Looking to other industries in cleantech or alternative proteins can provide valuable insights into how governments — at international, national, and sub-national levels — can support cultivated meat. In the US, Nevada was chosen as the manufacturing site for Tesla's gigafactory due to years of exemptions granted on sales and property taxes on top of other tax credits, which over the next 20 years could total $1.3B.[36] A project of this scope is far from happening in cultivated meat, but governments and economists can begin mapping the costs, benefits, and risks of similar tax incentive-driven deals for cultivated meat facilities as the industry matures. The allure of creating new manufacturing jobs — especially for regions that have seen losses to globalization — is likely to be enough to incentivize the pursuit of similar deal structures.

Governments can also provide debt financing for large infrastructure projects, and more mature segments of the alternative protein industry are already beginning to see this play out. The appeal of the rapidly expanding plant-based meat industry has begun to incentivize governments to provide federal debt financing for new infrastructure that boosts their local economies, helps meet sustainability goals, and can enhance traceability of ingredients or products, which is increasingly being demanded by consumers. For instance, Canada's climate is ideal for growing legumes such as peas that are heavily used in plant-based meat production. The government has stepped in to finance new facilities[37] and provide funding for R&D and other commercial activities related to the growth and processing of legumes and other crops.[38] As the cultivated meat industry matures, it should encourage governments to step up to provide similar support.

Other forms of consumer- and business-centric incentives can accelerate the pace of adoption of a new technology, which is often competitively disadvantaged by incentive structures that favor the incumbent industry. For example, Norway is the runaway leader in electric vehicle adoption due to an accumulation of incentives that began to be implemented over 20 years ago.[39] Incentives range from decreased annual registration taxes, free parking, access to bus lanes, 0% import tax, and 0% VAT taxes on electric vehicle purchases (compared to 25% tax on fossil fuel cars), which led to price parity of electric vehicles being achieved significantly

model) depending on their business model and ultimate goals. Success of pilot-scale operations over the next two years will be crucial in dictating near-term strategies for planned increases in scale.

[36](https://www.theverge.com/2016/2/8/10937076/tesla-gigafactory-battery-factory-nevada-tax-deal-elon-musk)

[37] The government of Canada has recently provided financing of $100M for a new pea and canola protein processing facility. (https://www.newswire.ca/news-releases/boosting-canada-s-reputation-as-a-global-leader-in-plant-proteins-865970517.html).

[38] Canada's Protein Industries Supercluster (https://www.ic.gc.ca/eic/site/093.nsf/eng/00012.html).

[39] For a full timeline, see (https://wallbox.com/en_us/how-norway-became-a-global-ev-leader).

earlier than other regions. Of course, not all car-buying incentives align with meat production and purchasing, but import- and export-based trade incentives (e.g., for end products or raw materials used as feed in cell culture media) as well as incentives for restaurants, food assistance programs, and large food suppliers (e.g., school systems, hospitals, and militaries) to replace conventional meat with cultivated meat or other alternative proteins make sense.

4. **Governments should create transparent and robust regulatory frameworks that foster innovation in the cultivated meat industry.** Governments across the globe that are weighing cultivated meat technology must strike the careful balance of establishing regulatory frameworks that ensure consumer safety and product quality while not imposing unnecessary red tape. Currently, the lack of detailed regulatory guidance in many countries poses a challenge for cultivated meat manufacturers getting to market as well as for suppliers of inputs and equipment in meeting industry specifications.

   In December of 2020, the Singapore Food Agency's proactive engagement with industry and science-based regulatory approach led to the first approved sale of a cultivated meat product — a cultivated chicken bite product manufactured by US-based Eat Just, Inc. Shortly thereafter, the first consumer sale was made in a restaurant setting.[40] For the manufacturing of its product, Eat Just has partnered with Singapore's local Food Innovation and Resource Center.[41] With local infrastructure and regulations already in place, Singapore is poised to be at the top of the list for other cultivated meat manufacturers to debut their products. A clear and robust regulatory environment and flourishing R&D environment coupled with local infrastructure and talent make it likely that Singapore will remain a hub of further cultivated meat innovation for years to come.

   At the same time, pressure on regulators in other regions is mounting.[42] The Singaporean regulatory process took two years to complete; but with a framework in place, additional approvals are expected on shorter timelines — and shorter timelines are important to a nascent industry primarily backed by venture capital. Countries that have not yet considered how cultivated meat fits into their existing regulatory frameworks or regions where approval processes are expected to be long-lasting could see slower entry of cultivated meat into their markets.

[40](https://gfi.org/blog/cultivated-meat-singapore/)
[41](https://www.bloomberg.com/news/articles/2020-12-02/singapore-becomes-first-country-to-approve-lab-created-meat)
[42] As of writing, GFI is aware of Canada, Australia/New Zealand, the UK, and the EU as all currently having an applicable regulatory framework relevant to cultivated meat, the US, Japan, and Israel with an expressed interest in cultivated meat with regulatory updates expected soon, and India, Brazil, and China as monitoring global progress with an eye to creating a path to market.

While the Singapore Food Agency has released guidance for cultivated meat manufacturers,[43] the public information is not yet comprehensive and to our knowledge, most conversations between regulators and manufacturers take place on a case-by-case basis. **Governments, regulatory authorities, and cultivated meat manufacturers should openly release any comprehensive regulatory frameworks, requirements, or datasets (when applicable) they have established or generated.** Increased transparency serves multiple purposes: it can increase consumer trust whilst informing cultivated meat manufacturers and others along the supply chain (including facility construction firms and suppliers of cell culture media, scaffolds, cultivators, and other equipment) of the unique requirements of cultivated meat manufacturing, which are expected to lie at the nexus of established food and biopharma regulatory guidances.

Nonprofits might also have a role to play in the regulation of cultivated meat. For instance, nonprofits may seek to develop recommendations for best practices related to cultivated meat manufacturing and ensuring consumer food safety.[44] They may organize stakeholders to align regulatory consensus across different regions such that cultivated meat manufacturers are not faced with a completely new set of requirements when entering a new market. And nonprofits could serve a role in coordinating the development of industry standards that become implemented throughout the cultivated meat industry.

5. **Governments should support cultivated meat as a means to create new high-paying job opportunities in both rural and urban areas.** Cultivated meat permits the decoupling of meat production from primarily rural areas, and production in urban areas may come with several socioeconomic implications. The analogy between rural and urban cultivated meat facilities as being similar to beer brewing is likely to hold, with smaller-scale “microbrewery” facilities (less than the size in the TEA) located primarily in urban areas and large- to mega-scale facilities (the same size or larger than in the TEA) located in more rural areas. The economics along the scaling spectrum need to be further studied, but it is likely that facilities located in both rural and urban areas will exist in the future.

   As described in the technical summary, cultivated meat manufacturers may be motivated to construct facilities in regions that lower the costs and environmental footprint of cultivated meat production by, for example, locating in regions with readily-accessible renewable energy.[45] Co-locating a cultivated meat production facility in a region with access to raw

[43] Singapore Food Agency guidance (https://www.sfa.gov.sg/docs/default-source/food-import-and-export/Requirements-on-safety-assessment-of-novel-foods_23-Nov-2020.pdf)
[44] New Harvest, a nonprofit focused on advancing cellular agriculture, has funded a project that outlines safety considerations. (Ong, 2021).
[45] See (https://gfi.org/wp-content/uploads/2021/03/cultured-meat-LCA-TEA-technical.pdf).

materials or raw material processing infrastructure (typically in rural areas) could also make sense. However, governments may be motivated to have a say in facilities' locations as a means to provide new job opportunities for rural or underserved communities.

For example, the TEA estimates that a facility of the size modeled in the report would staff ~200 individuals including operators, lab technicians, managers, and maintenance personnel at an average salary of $100,000.[46] Although some jobs in the facility would be highly skilled (particularly R&D technicians and managers), operating equipment, other general floor work, and maintenance would likely be attainable to blue-collar workers that hold similar positions in other food processing facilities. In addition to higher pay, worker conditions are likely to be less hazardous than modern chicken and pig farms and slaughterhouses.[47] Working communities can also benefit from reduced odors, cleaner air, and less polluted waterways because cultivated meat could reduce pollution by 29% to 93% compared to conventional meat production methods (Table 1). Other job opportunities elsewhere in the supply chain such as distribution, manufacturing cultivators, and growing and processing cell culture media input materials[48] can also provide new options for livelihoods in rural and underserved communities, although further economic analyses are needed to assess this.

Governments may construct programs that provide training assistance for transitioning workers into new opportunities within the cultivated meat industry. And nonprofits can educate current meat production workers about how to best mitigate occupational risk as well as students about the skills they would need to be well-positioned for a job in the industry.

As suggested in (1) above, increased government funding of open-access R&D at universities and translating novel research and technology into the commercial sector will be a crucial component to the success of cultivated meat. However, many scientist-entrepreneurs are often forced to move to urban areas with concentrated capital to raise funds and start their businesses. But this trend (which has also been impacted by COVID-19) may change, brought on by the growing opportunity to capitalize on foodtech research performed at predominantly rural, ag-centric universities. For example, Big Idea Ventures, which has funded many cultivated meat and alternative protein companies, recently launched a $125M fund specifically aimed at translating food technology development at agricultural universities into

[46] Assumes 24 hour, 7 days-per-week of operations. With optimized processes, the facility's footprint becomes smaller and the number of full-time employees drops to ~130.
[47] For information on slaughterhouse conditions, see Oxfam America "Lives on the Line." (https://s3.amazonaws.com/oxfam-us/www/static/media/files/Lives_on_the_Line_Full_Report_Final.pdf). For conditions related to modern pig and chicken farming, see Leonard, 2014.
[48] Corn and soy are primary inputs for the cell culture media in the LCA and TEA reports, although other input sources such as algae, yeast, fungi, or other crops are also possible.

the rural communities where they are located.[49] Investors, therefore, can start a positive feedback loop for cultivated meat technology development by bridging the gap between university research and commercialization that leads to new business and job opportunities that elevate both urban and rural communities.

6. **Governments and nonprofits should assist farmers and other workers involved in the animal production supply chain in transitioning toward cultivated meat and other alternative protein technologies.** Governments, nonprofits, and other stakeholders have a critical role to play in ensuring an equitable transition of meat production toward cultivated meat and other alternative proteins, which is likely to take shape primarily over the next two decades.

   Cells, like animals, need to eat and the amino acids, sugars, and other feedstock raw materials used in cell culture media must be grown by participants upstream in the supply chain. While the LCA and TEA assume soy hydrolysate as a primary source of amino acids, there is no clear consensus on what crops or other sources (e.g., algae, fungi, cyanobacteria) may serve best as primary inputs, from the perspectives of cost, sustainability, and meeting the metabolic needs of the diverse cells used in cultivated meat production.[50] These same materials may also be used as scaffolding materials in cultivated meat, as feedstock inputs for fermentation of animal proteins or biomass, or as inputs for plant-based meats. Farmer participation in the cultivated meat raw material supply chain offers but one way to participate in the new meat economy built on alternative protein technologies.

   Nonprofits have already begun to support farmers in transitioning to the burgeoning plant-based meat and dairy industries.[51] Similar concepts have been proposed for cultivated meat production. For example, animal breeders (e.g., of Wagyu beef) could earn royalties from unique cell lines used in production or ready-made technology kits could allow farmers to continue to manufacture meat on their farms at smaller scales. There is uncertainty around the economics of such concepts and further studies are needed to assess the tractability of these and other transition concepts.

   Basic thermodynamics and feed conversion data displayed in Table 2 suggest that there is simply less feed needed for cultivated meat than what is needed to create an equivalent amount of meat through conventional production. But farmers will need incentives to change how they use their land. Governments can fuel the transition of farmers involved in the

[49](https://www.foodnavigator-usa.com/Article/2021/01/29/Big-Idea-Ventures-launches-125m-fund-to-help-fund-food-ag-startups-commercializing-groundbreaking-IP-developed-at-universities)

[50] See (https://gfi.org/wp-content/uploads/2021/03/cultured-meat-LCA-TEA-technical.pdf).

[51] Examples include the Transfarmation (https://thetransfarmationproject.org/) and Refarm'd (https://en.refarmd.com/) projects.

conventional animal agriculture supply chain through tax credits on the generation of positive externalities (e.g., land repurposing for carbon sequestration, decreased air and water pollution, or habitat restoration) and penalties on negative externalities, providing subsidies or debt forgiveness to farmers that grow feed for alternative proteins, or otherwise compensating from transition-state losses.

Finally, agricultural systems are complex and differ by region. Any policy or support structure must be equitable in how it affects actors in the current as well as the future food ecosystem. We encourage researchers to leverage data in the LCA and TEA to inform further region-specific studies to best map the actions and policies needed for a smooth transition to cultivated meat and other alternative proteins.

For further discussion of how alternative proteins may affect farmers, we refer the reader to Newton & Blaustein-Rejto, 2021.[52]

Other nonprofit recommendations

1. **Nonprofits should incorporate the recommendations throughout this report as key pillars of their climate and global health policy objectives.** As the LCA and TEA reports highlight, realizing the lower environmental footprint, competitive costs, and other positive externalities of cultivated meat are best achieved in tandem with decarbonization in the energy sector and elsewhere throughout the industrial supply chain. As discussed below (see "Additional benefits of cultivated meat"), the success of cultivated meat is not limited to improvements in environmental impacts, but can also mitigate key global health issues such as antibiotic resistance and the threat of zoonotic disease. Thus, support of cultivated meat technology aligns with the incentives shared by climate and global health nonprofits and should be incorporated into their objectives.

Other investor recommendations

1. **Impact and strategic investors can leverage their expertise to assist cultivated meat manufacturers in reaching their sustainability goals.** Investors in global cultivated meat companies are skewed toward those aimed at targeting a specific relevant category (e.g., foodtech or cleantech) or accomplishing a certain shared mission (e.g., addressing climate change). Investors and cultivated meat companies alike can use insights from the LCA and TEA to craft strategic plans toward accomplishing shared sustainability goals.

[52] Newton, 2021.

For example, Israel-based Aleph Farms has already pledged net zero emissions by 2025 for its cultivated meat production process, has hired a Head of Sustainability, and has assembled a sustainability advisory board (amongst other actions) to accomplish the goal.[53] **Investor groups with expertise in other areas of cleantech can and should assist cultivated meat companies in executing on sustainability goals.** Additionally, investors could require that a cultivated meat manufacturer raising funds commits to certain sustainability goals prior to investing. This would align all parties on sustainability goals and drive competition amongst cultivated meat manufacturers toward achieving them.

Additional benefits of cultivated meat

Key stakeholders have many additional reasons for backing cultivated meat. A narrow focus on carbon emissions is reductionist[54] and fails to capture the add-on effects of a transition to cultivated meat. The LCA and TEA studies increase confidence in cost-competitive, large-scale cultivated meat production with reduced climate impacts being achievable by the end of the decade. Although outside of the scope of these two reports, cultivated meat has the potential to address other large global challenges related to human, animal, and planetary health if it were to take significant market share away from conventional meat and seafood production. **We encourage stakeholders to seriously examine cultivated meat adoption as a means to mitigate these issues.** Additional analyses of value, which may also be region-specific, are listed below.

1. **Effects on oceans and marine habitats.** With over 90% of wild fisheries classified as overfished or harvested at maximal capacity and the additional negative externalities associated with the fishing (e.g., human rights violations, bycatch, overfishing, plastic pollution) and aquaculture (e.g., antibiotic use, coastal habitat destruction) industries, the adoption of cultivated seafood can help take the burden off of the oceans and allow them to recover.[55] LCAs for wild-caught and aquacultured seafood can be performed and compared to cultivated seafood to better understand its potential environmental and supply chain benefits. Further analyses are recommended to understand how the adoption of cultivated seafood may mitigate other aforementioned externalities.[56]
2. **Effects on biodiversity.** The expansion of conventional animal agriculture externalizes numerous impacts that influence biodiversity loss and accelerate extinction rates. These externalities include the massive extents of cleared land, especially in South and Central American rainforests, for cattle and soybean production used in animal feed,[57] manure and

[53](https://www.prnewswire.com/news-releases/aleph-farms-going-carbon-neutral-by-2025-301045130.html#:~:text=REHOVOT%2C%20Israel%2C%20April%2022%2C,entire%20supply%20chain%20by%202030).
[54] See (https://newrepublic.com/article/159153/climate-change-dismiss-meat-emissions-wrong).
[55] See (https://gfi.org/resource/an-ocean-of-opportunity/).
[56] Halpern, 2021.
[57] Pendrill, 2019. World Resources Institute: Deforestation linked to agriculture (https://research.wri.org/gfr/forest-extent-indicators/deforestation-agriculture).

nutrient runoff that has led to over 500 dead-zones of oxygen-depleted waters worldwide,[58] and increased use of pesticides, fungicides, and herbicides. Business-as-usual scenarios for animal agricultural expansion suggest that nearly 88% of terrestrial vertebrates would lose habitat to agricultural expansion by 2050.[59] Insights from the LCA suggest that all of these impacts would be dramatically decreased with adoption of cultivated meat and future analyses may aim to quantify the effects cultivated meat could have on rates of biodiversity loss.

3. **Effects of decreased microbiological counts on final products.** Due to the nature of its manufacturing process, cultivated meat is expected to have minimal bacteria present on the final product.[60] Additionally, many of the most common causes of foodborne illness related to animal slaughter (e.g., *E. coli, Campylobacteria, Salmonella)* are not expected to be present in cultivated meat. Thus, cultivated meat should significantly reduce the incidence rates of foodborne illness caused by meat and seafood consumption and could reduce meat and seafood waste due to bacteria-mediated spoilage.
4. **Effects of meat and seafood production without antibiotics.** Antibiotics are not anticipated to be used in cultivated meat production[61] and a switch to cultivated meat could thus save on the over 200,000 tons of annual antibiotic use expected to be attributed to animal agriculture by the year 2030.[62] The potential human health, terrestrial and marine ecotoxicity, and economic benefits are massive in light of the growing prevalence of antibiotic resistance, poor incentive environment for the discovery of new antibiotic drugs in biopharma, and poor disposal practices of hazardous antibiotic mycelial residues.[63]
5. **Mitigation of zoonotic disease and global pandemic risk.** COVID-19 has demonstrated that the human population is still vulnerable to devastating pandemics. Approximately 75% of new and emerging infectious diseases are zoonotic in origin,[64] and the vast majority of these originate in livestock or other domesticated and intensively farmed animals.[65] The consequences of a significant shift to cultivated meat production should be examined seriously as a means to mitigate the risk of zoonotic disease originating from intensively farmed animals.

These suggestions represent a non-exhaustive list of the potential add-on effects of a transition to cultivated meat. We encourage cross-disciplinary teams within governments, academia, industry, and nonprofits to explore the implications of future scenarios where cultivated meat is a mature industry with accelerating market share.

[58] Dudley, 2017.
[59] Willams, 2020.
[60] Rigorous data to support these claims are currently limited. Additional data is anticipated to become available upon the regulatory approval of additional cultivated meat products or ongoing academic research.
[61] The first approved CM product in Singapore is produced without antibiotics (https://goodmeat.co/).
[62] Van Boeckel, 2017.
[63] Chen, 2017.
[64] (https://www.who.int/neglected_diseases/diseases/zoonoses/en/).
[65] COVID-19 is zoonotic in origin but is not directly attributable to intensively farmed animals.

Conclusion

The LCA and TEA reports are the first ever reports in the cultivated meat literature to be informed by industry. With data and insights from more than 15 different companies, we believe these studies point to the power of collaboration and paint the most complete picture of the costs and environmental impacts of large-scale cultivated meat production to date. To accelerate the development, deployment, and adoption of cultivated meat, key stakeholder groups must invest more resources into cultivated meat technology, foster innovative environments, and enact policies that nurture growth while permitting an equitable shift toward cultivated meat and other alternative proteins. The LCA and TEA suggest that cultivated meat can stand alone as a technology platform and, together with other alternative proteins, become a sustainable and cost-effective means of providing protein to a growing population. Success of cultivated meat in the marketplace holds tremendous potential to offset the negative externalities of conventional meat and seafood production while aligning with other global initiatives to improve human, animal, and planetary health. This summary's recommendations represent a starting point for thinking more deeply about strategic actions and implementation of smart policies by stakeholder groups that will advance cultivated meat. Refined and region-specific analyses built on the foundation of the LCA and TEA reports will also be crucial in establishing the best path forward.

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Elliot's work at GFI focuses on accelerating the cultivated meat industry by analyzing the intersection of diverse scientific disciplines with cultivated meat, leading key GFI-sponsored research projects in cultivated meat, and educating scientists, the public, and other industry stakeholders. Elliot holds a Ph.D. in neuroscience from UCLA where he worked with induced pluripotent stem cells to model human neuromuscular disease.

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