SENTIENCE POLITICS

Cultured Meat: An Ethical Alternative To Industrial Animal Farming

Policy paper

Industrial livestock production presents a growing problem on a global scale in terms of animal welfare, environmental sustainability, and human health. One solution might be cultured meat, in which animal tissue is grown in a controlled environment using cell cul-ture technology, thereby making the raising and killing of animals for food unnecessary. This approach shows great potential of meeting all the requirements of a humane, sustain-able and healthy form of meat production. However, a great deal of scientific, technical, cultural and legislative challenges must be overcome before cultured meat can reach cost-competitiveness. Lack of funding is the main barrier to further development, and consid-erable upfront investment is needed for cultured meat to attain commercially viable retail prices. We therefore strongly support increased funding of cultured meat initiatives. This entails, in order of priority: research and development of technology suitable for mass pro-duction, promoting fact-based public discussion regarding the technology and its societal implications, and eventual marketing of end products to consumers.

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Introduction

Each year, more than 60 billion sentient animals[1] are reared in industrial conditions in order to produce meat. This global enterprise is currently the planet's main source of human pandemic diseases[2–5] and likely among its greatest concentrations of human-inflicted suffering.[6–8] Curbing this ongoing moral catastrophe should thus be of high concern for people aiming to effectively help as many sentient beings as possible.[6,9–12] Moreover, animal agriculture contributes to climate change and makes inefficient use of a significant portion of our available resources.[13]

Addressing this massive challenge would ideally involve a worldwide shift to a vegetarian lifestyle, but such a leap is unlikely to take place in our lifetimes. Humans around the world namely place a high value on meat in terms of taste, nutrition, and tradition, evidenced in part by a clear rise in global meat consumption over the past half century—a trend strongly associated with economic growth in newly industrializing countries.[14–16] Despite the vegetarian movement having witnessed steady growth in recent years, its growth pales in comparison to the global demand for meat, which is predicted to increase by 73% within 2050.[17] Meanwhile, plant-based meat substitutes may, despite decades of costly improvements, not be sufficiently effective at replacing meat in people's diets.[18] It would thus be a significant gain if we were able to introduce a cruelty-free replacement for meat with the ability to rival conventional livestock-production.

One solution may be *cultured meat*, an innovative way of synthesizing meat from animal tissue samples. Compared with conventional methods of meat production —which involve the breeding, raising, feeding, and slaughter of animals—cultured meat instead involves using a cell sample to grow desired tissue in a controlled environment, making use of biotechnology originally developed for medical research and organ transplants. Proponents of cultured meat argue that this technology holds considerable promise as a replacement for conventional meat. Indeed, cultured meat seems likely to offer vast benefits in terms of animal welfare,[19,20] environmental impact,[21–23] and even human health.

The concept of producing meat intended for human consumption outside of a complete living organism has been a subject of speculative interest since at least 1931,[24] but proof of concept has existed in various forms only since the early 2000's.[25] Cultured meat technology is still in its experimental stage and has so far been limited to producing a small number of processed meat items in laboratory settings for demonstrative purposes.[26,27] Current research is focused on refining production methods in order to lower cost, improve scalability, and minimize dependence on animal sources.

In this paper, we begin by presenting the rationale behind developing animal-free meat products. Moving on, we explore cultured meat and its ethical, economic, environmental, and human health implications. We then review the most pressing challenges facing public acceptance and technical feasibility of cultured meat production. Finally, we conclude by proposing a number of funding recommendations.

Current impact of livestock-based meat

Environmental

Greenhouse gas emissions: The main causes of climate change are usually attributed to transportation and housing. This, however, ignores another significant contributor: according to the UN Food and Agriculture Organization (FAO), animal agriculture is responsible for 14.5% of the world's total greenhouse gas (GHG) emissions.[28] It is thus as harmful to the environment as the combined impact of every motor vehicle in the world, which account for roughly 15% of emissions.[29] Methane, whose global warming potential is 25 times greater than that of carbon dioxide,[30] makes up 44% of the animal industry's total emissions. Most of this methane is emitted by ruminants such as cows, sheep, and goats as a natural by-product of their digestive processes. The United Nations Environment Programme (UNEP) maintains that a reduction of greenhouse gas emissions of at least 50% by 2050 is necessary in order to avoid the worst impacts of climate change.[31]

Resource inefficiency: The global surface area required for livestock farming—including land used for grazing and feed production—currently takes up around 70% of all arable land on the planet, and 30% of its total ice-free land surface.[2] The rate at which livestock animals convert feed to energy and protein, meanwhile, is extremely inefficient; cows, for example, normally convert less than 5% of their protein and energy intake into edible meat.[14] Taking into account the water consumption for production, more than 15,000L of water are needed for 1kg of beef.[32,33]

Water pollution: The livestock sector uses a great deal of water for feed production, animal rearing, and sanitation. Water recycled from livestock manure is currently responsible for around 33% of global nitrogen and phosphorous pollution, 50% of antibiotic pollution, and 37% of toxic heavy metals contaminating the world's freshwater. Additionally, around 37% of pesticides that end up in global freshwater supplies have their origin in the production of animal fodder.[2]

Human health

Infectious disease transmission: Livestock pose a significant disease risk to humans. Around 60% of all known human diseases and 75% of the most damaging emerging diseases are zoonotic (animal-transmitted) in origin.[2,3] Most pathogens of recent concern—including mad cow disease (called *new variant Creutzfeldt–Jakob disease* in humans) and all forms of influenza (swine, avian, etc.)—are transmitted through livestock in particular.[4,5] Increases in global demand for animal products have already led to intensification of industrial livestock farming,[2,34] and this trend is expected to magnify as millions of households are lifted out of poverty in developing countries.[16] This has greatly increased overall risk of zoonotic disease transmission between livestock and humans.[2,35]

Antibiotic resistance: In animal agriculture, antibiotics are widely used in sub-therapeutic doses in order to promote animal tissue growth, and as a low-cost preventative bio-security measure against the aforementioned disease transmission problem. However, this practice—which has resulted in significant antibiotic contamination of waterways[36]—terways[36] – is now considered a leading cause of the global rise of antimicrobial-resistant (*multiresistant*) pathogen strains.[37–39] The World Health Organization considers this one of today's biggest threats to global health.[38,40,41]

Animal welfare

Non-human sentience: There is a scientific consensus regarding animal sentience and their capacity to suffer[42] and this is officially recognized in EU legislation.[43] The opposing view that conscious experience is only possible in human brains is not supported by current evidence.[44,45] It follows that any *needless* suffering inflicted upon animals under human care, whether through direct action or inaction/neglect, is ethically unacceptable and must be stopped.

Suffering in factory farms: Intensive animal farming is inescapably associated with systematic disregard for their welfare.[46–48] Animal farming is already very inefficient in terms of land and sustenance resources,[49,50] and high market demand for meat thus results in farmers striving to make all aspects of production more cost-effective. Maintaining the well-being of animals is often time-consuming, yet not strictly necessary to produce meat at an affordable level. The result is that animal welfare measures are commonly reduced to an absolute minimum or largely ignored in factory farms.[7,46–48,51–54] An example of this effect is the "broiler chicken", a chicken breed optimized for morbid obesity and rapid maturation. Kept in intensive farming conditions throughout the industrialized world, these birds frequently experience lifelong suffering[46,55] from their legs collapsing under their own morbid weight[11,12] and from chronic sickness due to poorly ventilated, overcrowded and/or tightly confined living conditions.[55]

Poor legal protection: Despite U.N. and EU guidelines to ensure animal welfare,[43,56] actual legislation on a national level is often weak and/or poorly enforced.[46,55] Moreover, established laws are routinely disregarded by manufacturers;[57] in Europe alone, at least 80% of piglets are routinely subjected to painful mutilations like tail amputations and castration — both without anesthesia.[51,58] This ignores EU directives requiring that member states "... shall, since animals are sentient beings, pay full regard

to the welfare requirements of animals", including their freedom from pain, injury, discomfort and distress.[43] It is not uncommon for large meat producers to resist public inspection of their farms and slaughterhouses, and part of what is currently known about animal abuse in the meat industry is thus a result of investigations by animal charities, both undercover[57,59] and in cooperation with farming contractors.[60]

Cultured meat in comparison

Environmental impact

Predictive environmental analyses: Assessing the resource efficiency of industrial processes that don't yet exist involves making many informed assumptions, many of which will later turn out incorrect. Life cycle analyses have so far predicted that cultured meat would require 99% lower land use and 82 – 96% lower water use than its animal agriculture equivalents.[21] Subsequent analyses have placed energy use predictions much higher due to the large amounts of electrical energy that would be needed to provide sufficient heat to the culturing process.[22] Overall, however, cultured meat is expected to be significantly more resource efficient than animal agriculture, especially when predictions of future meat consumption are taken into account.[23]

Environmental pollution: The aforementioned life cycle analyses predict that cultured meat would produce 78 – 96% less greenhouse gas (GHG) emissions than conventional meat.[21] Replacing all meat production with cultured meat could reduce EU emissions by two orders of magnitude.[61] Excluding animals from meat production would also eliminate the need for manure disposal and management, which currently involves the use of manure lagoons.[62] Cultured meat would replace these highly problematic sources of pollution with closely monitored and quality-controlled filtration systems.[27] Again, these are speculative figures and should be regarded as such.

Human health

Sterile production: Due to the aseptic and strictly controlled environment required for its production, producing meat from cell cultures is safer than conventional production through animal husbandry.[63] Conventional risks of zoonotic infection are bypassed when no live animals are directly involved in production.[64–66] The only current producer of cultured meat reports that antibiotics are not required during production.[27] In line with current medical standards, initial tissue samples from biopsies require screening for infectious agents before eventual use in cultured meat production. The end product is thus safer during storage, preparation and consumption than its conventional counterparts.

Composition of end product: Another benefit of strict manufacturing control is that it allows for significant modification of the final product during production (as opposed to relying mainly on post-production processing) at levels currently unattainable in conventional meat production.[67] A wide range of alterations to the final product's nutritional composition, taste, and texture is thus made available by e.g. co-culturing with other cell types or introducing additives during the culturing process.[68] Genetic modification[64] can be used for the same purpose, but runs the risk of rejection by consumers due to public concern over safety.

Commercial

Product safety: The fact that it is virtually impossible to grow cultured meat outside of a sterile environment could make it a preferred alternative for many consumers who are worried about food safety.[69] In particular, the roughly 65% of European consumers who are worried about biological risks (contamination from antibiotics and zoonotic diseases) may prefer cultured meat over other options.[70] However, the same surveys also showed technological risks (chemical additives and cloning) as being of higher concern among consumers than biological risks. It is therefore uncertain whether promoting food safety will benefit cultured meat acceptance among consumers.

Innovative product attributes: Strict control over the manufacturing process would allow for products to be nutritionally fortified[64,67,68,71,72] and contain less unhealthy fat.[66] This may present an opportunity to meet consumer demand for healthier foods[70] and to help prevent undernourishment in poorer populations. Producers could also experiment with a range of characteristics that consumers would find interesting, such as novel flavors, colors and textures.[73]

Culturing also allows for the production of exotic or otherwise rare animal meats[65,71] which, in addition to being of potential commercial interest, may replace much of the legal[73] and illegal[74] markets for exotic animals.

Improved ethical profile: European consumers express an increasing concern over the impacts of meat production on food safety, the environment, and animal welfare.[69,70,75–80] There is some evidence of consumers being willing to pay extra for safety-labelled products due to this concern, particularly regarding products from well-known brands.[81] In recent years, animal welfare in particular is identified as a deciding factor for consumers in evaluating the ethical profile of brands, with cost being the main barrier to buying more products regarded as ethical in this regard.[82–84] Thus, already-established meat producers may find a chance to improve public perception of their brand, in terms of food safety and animal welfare, by adopting cultured meat technology.[85] Indeed, at least one leading international brand is already considering this opportunity.[86]

Market expansion potential: In the event that cultured meat overtakes normal production methods in terms of production cost-effectiveness, we should also expect a proportional decrease in the market value of meat products, opening up for significantly lower retail prices on meat products.[62] This presents a potential win-win: more low-income consumers would be able to afford meat products with a higher nutritional and caloric density than many staple foods currently provide, and producers would in turn benefit from the increased revenue following expansion into this huge new target market.

Animal welfare

No need for slaughter: Perhaps cultured meat's greatest potential benefit over conventional production is the fact that it does not rely on slaughtering animals at any point in the manufacturing process. Each of the individual parent cells involved in cultured meat production can multiply a vast number of times, and each donor animal possesses billions of such cells in their body. The number of animals required for tissue samples are thus orders of magnitude less than for conventional meat production. Depending on the method and type of cell used, a single "parent cell" could theoretically supply the annual global demand for meat products before needing replacement.[87] However, natural variations in characteristics between cell samples (i.e. those extracted from living animals) renders them impractical for use in early phases of basic research. It is therefore more likely that genetically modified cell lines would be used during the initial research phase, as these cells are more homogeneous between batches. They would not, however, be necessary for use in actual food production. Even so, a genetically altered cell line could be made physically immortal, meaning that a single tissue sample from one livestock animal would theoretically be enough to meet endless future demand.

Minimal harm: Cells can be collected by drawing a small amount of stem cells from an animal using a biopsy needle, a type of syringe. This common medical procedure takes only a few minutes, can be performed under local or full anaesthesia, and poses little risk of long-term complications[88] — altogether causing negligible harm compared to what animals in the meat industry are normally forced to endure on a lifelong basis.

Concerns over culture medium: "Feeding" nutrients to cell cultures is achieved by means of a *culture medium*, a sterile liquid containing essential macro-nutrients (sugars, amino acids) and micro-nutrients (vitamins, minerals) for the growing cells. At the moment, foetal bovine serum (FBS) is a key component of the standard culture medium used in biotech labs all over the world. Since obtaining this ingredient requires slaughtering a pregnant cow and draining blood from the heart of its live, un-anesthezised fetus—a decidedly inhumane process[89]—it has so far posed a major problem for the ethical profile of cultured meat. Its use in biomedical tissue engineering so far, however, has largely been a result of its abundance as a by-product of animal agriculture, and it would simply not be practically feasible to use it for mass production of cultured meat even if one wanted to. Ideal culture media should, in any case, be completely free of animal-sourced ingredients, and prototypes of FBS-free culture media based on plants, fungi and microalgae have already been demonstrated.[26,90–95] Microalgae production has also been accounted for in speculative life cycle analyses of large-scale cultured meat production systems.[22,61] While further refinement is needed

for plant-based media to compete with the effectiveness of FBS, they nonetheless prove that ingredients sourced from slaughtered animals are not a requirement for cultured meat production. Moreover, the fact that FBS is used in practically all the world's biotech labs in spite of its often heterogeneous composition between batches (which often leads to inconsistent data if more than one batch is used in a given study) means that there is already a strong incentive in the biotech industry to develop highly consistent culture media which can be mass-produced from raw materials.[92]

Challenges to cultured meat development

Current status

Funding for basic research: Much of the basic biotechnology research needed to mass produce cultured meat has yet to be done, including studies on optimal cell lines and culture media.[96] As of September 2016, there exists only one specialized laboratory devoted to developing cultured meat, operated by the non-profit New Harvest in Leiden, NL.[97] Beyond this, there are as yet no scientific disciplines, departments or institutes devoted entirely to the research and development of "biofabrication" or "cellular agriculture" as distinct areas of study.[98] Most research into cellular agriculture to date has thus been undertaken as isolated projects and have consequently not been met with widespread academic interest. This point is illustrated by the fact that all cultured animal products of recent fame (ground beef, leather, milk, etc.) have been manufactured in laboratory conditions, using costly techniques adapted ad-hoc from related fields in biotechnology that normally exist in relative isolation. Ongoing initiatives with promising long-term strategies are currently held back by a severe lack of funding.

Few researchers: Contrary to what is often portrayed in news media coverage, very little scientific attention is being given to the research and development of cellular agriculture—including cultured meat—as of March 2016. One expert estimate places the number of entirely devoted researchers at about 5 individuals worldwide, with another 50-100 known researchers in related fields expressing varying degrees of interest in working on cellular agriculture.[96]

Lack of regulatory preparedness: Although some European countries have mentioned cultured meat in the context of novel foods,[99–101] the relative infancy of the science behind it means that current food industry regulations are generally not prepared for commercial production at any significant scale.

Genetic modification: Genetic modification (GM) is not strictly necessary at any point in the production of cultured meat. It may, however, be needed during initial phases of research (see: *Concerns over culture medium*), as well as potentially ensuring economic viability at some point in the future, and should thus not be ruled out as a potential tool.[96] Any use of GM in the production of cultured meat should necessarily involve rigorous transparency and openness to public inquiry to alleviate any concerns related to the safety of GM foods.

Product mimicry: Two cultured meat products have been publicly demonstrated so far: one hamburger[102] and one meatball.[103] Both were made from beef cells; however, the team behind the meatball are also developing pork cells,[104] and another team in Israel are working on avian cells from chickens.[105] The two beef products were described as unambiguously meat-like in taste, yet lacking in certain qualities like moisture and fat. The teams behind each demonstration report that existing technology can be used to improve taste, texture and nutritional composition.[27,94] Difficulties in replicating complex textures such as steak, chicken breast, and bacon have so far limited textures to that of mince meat. Significant improvements are needed to overcome these difficulties, yet only one study is going on at the moment.[106] Improving ground beef products to the point of market-competitive texture is much less challenging and therefore remains the primary focus for now.[26,27] This approach seems most likely to secure cultured meat a place among popular meat products on store shelves, which will be crucial in gaining acceptance for all subsequent cultured products as soon as they are introduced.

Culture medium: Although prototypes of animal-free culture media exist and have been used to produce muscle tissue,[26,71,90,94,95] progress in this area is severely hindered by the fact that optimal cell lines have not yet been found, as individual cell lines often require distinct medium formulations to prolif-

erate.[96,107] Biomass from *microalgae* seems the preferred source for the nutrients needed in culture media; however algae production at scales large enough to meet the requirements of cultured meat poses a number of technical challenges, many of which (including the scaling up of bioreactors) are currently being tackled for applications in seemingly unrelated fields such as biofuels[108,109] and animal feed.[110]

Energy requirements: One recent life cycle analysis (LCA) of cultured meat production found that, while land and water use are expected to be far lower than all other forms of meat production, its energy requirements would be extremely high compared with previous estimates.[22] However, the analysis extrapolated data based on assumptions of technology that does not yet exist and contradicts previous findings, making it far from conclusive.[111] Whether or not the energy requirements present a problem depends on the efficiency of renewable energy sources, which may improve in the future thanks to rapid developments in solar power and other renewable energy sources.[66,112,113]

Cost: The only private company making cultured beef as of June 2016 reports a production cost of about €36,200/kg,[27] representing an 18-fold price reduction compared with the €650,000/kg burger unveiled in 2013. One leading researcher announced in late 2015 that, under ideal conditions, combining pharmaceutical bioreactor technology to existing tissue culture techniques can already reduce costs to €60/kg of cultured ground beef.[26] It should be noted that, while the cost of cultured meat should aim to match that of regular meat, the current market average of meat[114] is artificially low as a result of heavy government subsidizing of animal agriculture.

Public perception

Media coverage: News media have generally presented cultured meat in a positive light, and have tended to highlight its environmental benefits.[115] The summer of 2013 witnessed three highly publicized, independent promotion events: in June, a TED talk on cultured meat and leather;[116] in August, a public endorsement and $300,000 funding announcement by Google co-founder Sergey Brin,[117] followed by a televised broadcast of the first public tasting of cultured meat.[102] Cultured meat has since been presented at the World Economic Forum in 2015,[26,94] and a US-based cultured meat start-up was launched in early 2016 to widespread interest from news and social media alike.[103] However, news stories often portray incorrect stages of development, giving unrealistic impressions of the extent of progress within the field.[96] An Israel-based cultured meat start-up was launched in April 2016,[105] and as of September, it had managed to raise double its initial crowdfunding goal of $100,000.[118]

Consumer attitudes: A small-scale survey of Dutch consumers found that, when asked if they were willing to try cultured meat once it becomes available, being given information about its environmental benefits caused positive responses to increase from 25% to 43%, a near-doubling compared with basic informing about the technology itself.[119] Recent online polls conducted on social and news media sites have shown that 7 out of every 10 respondents would like to try cultured meat once it becomes available.[120–122] Efforts are being made to re-brand cultured meat as "clean meat" in order to better convey important qualities of cultured products, especially its prospective environmental impact and lack of animal pathogens and drug residues.[104]

Common objections to cultured meat

"Cultured meat is unnatural, and therefore unhealthy/dangerous/undesirable."

This argument rests on the assumption that what is natural is good, and what is unnatural is bad. However, examples such as natural disasters and surgery show that this equalization is dubious: Something can be natural and bad, or unnatural and good. Thus, calling cultured meat "unnatural" does not imply that it is undesirable. Also, it is unclear why cultured meat in particular is unnatural, but animal agriculture is not. There is currently very little resemblance between nature and industrial meat production in terms of how animals are bred, housed, fed, and slaughtered. Arguments of this kind may thus be better understood as critiques against inherent qualities of *industrialization itself*, rather than any of its specific uses. Although cultured meat may be "artificially" produced, the end result is just as "real" as conventional meat, and poses no greater health risk; on the contrary, since it is manufactured in a controlled environment, cultured meat is far less likely to contain any of the the food-borne pathogens,

pharmaceutical residues, and/or unhealthy fats of "regular" meat.

"Cultured meat represents no ethical progress as long as fetal bovine serum is used."

This is correct; only cultured meat that is produced without the use of animal-derived culture media is ethically acceptable. Scientists working in the field of biofabrication agree that FBS has no place in the future of cultured meat.[96] Its use so far is a result of its abundance as a by-product of livestock production, and the fact that its applications in biomedicine have been several orders of magnitude smaller than what will be needed for cultured meat. We consider the development of animal-free culture media a necessity for cultured meat development, and we strongly promote all efforts to achieve this goal.

"Although cultured meat may be a short-term solution, it does not change underlying attitudes towards animals or the environment, and is therefore bad in the long term."

It is indeed important to address underlying speciesist attitudes, as this determines how nonhuman animals will be treated in the future. However, the development of cultured meat does in fact indirectly contribute to a long-term change in social norms and attitudes. The behavioural fact of meat eating is an obstacle to unbiased moral reasoning that cultured meat could greatly reduce. By eliminating the need to defend everyday behaviour, cultured meat makes it psychologically easier to care about nonhuman animals both on an individual and on a political level. Thus, cultured meat could facilitate the transition from today's heavily speciesist society to a more antispeciesist one in the future. In general, however, any ideal solution would need to combine attitude- and behavior-improving approaches with technological ones in order to ensure lasting change.

"There is no need to develop cultured meat when plant-based meat alternatives already exist."

Significant progress is indeed being made in the field of plant-based meat alternatives, and many such products are rising in popularity in the West. However, this is not the case in countries such as China, where the traditional use of plant-based protein sources are rapidly being replaced by meat, particularly from pigs and chickens.[16,123,124]

Conclusions

It appears that, by gradually replacing animal agriculture, large-scale production of cultured meat could greatly reduce animal suffering, human disease risk, and environmental problems. Achieving this will nevertheless be an extremely difficult, costly and time-consuming challenge, requiring several years' worth of concerted effort across multiple disciplines before cultured meat can rival conventional meat products. However, cultured meat research has received very little attention so far, making it relatively easy to conduct basic research that may later prove catalytic to further development. This, in combination with its potentially extraordinary return on animal and human welfare in the long term, convinces us that accelerating cultured meat is a worthwhile investment at this time.

We therefore strongly support efforts to:

1. **Fund and promote academic interest in cellular agriculture**

   Due to its high uncertainty, pioneering science should ideally take place within the low-risk research climate of academia, with funding provided by governments and non-profits to ensure that findings become publicly available. This will enable widespread adoption and refinement of techniques across scientific disciplines worldwide. It is our understanding that, at this time, the following research focus points are of particular importance: optimal cell lines, plant-based culture media, scaling-up of bioreactors, and perfusion systems for growing complex muscle tissue.

2. **Increase public awareness about the benefits of cultured meat**

   Once a solid research foundation exists, entrepreneurs will be able to experiment with scaling and marketing of cultured products to consumers. It is possible that the ensuing market could expand rapidly if significant public interest in cellular agriculture already exists by this time.

3. **Facilitate cultured meat development through policy changes**

   It is possible that government subsidies and increased national budgets for bio- and agrotechnology research can accelerate the development of cultured products. Once economically viable, cellular agriculture will also require new regulatory frameworks in each country where production is to take place. Early involvement from political organizations may ease the intricate political work that is needed in both cases.

Funding recommendations

New Harvest

This small, transparent[125] nonprofit works to establish cellular agriculture as a distinct field in biotechnology. They do this by funding and coordinating catalytic research, fostering communication across relevant fields in academia, business and politics, and running public awareness campaigns. Despite having a short track record due to their small size, they appear to be involved to varying degrees in all recent and ongoing cultured meat projects, and are currently scaling up in order to accommodate a growing workload. It is our understanding that New Harvest has a concrete, prioritized, and actionable strategy, which includes short-term plans to develop cell lines and culture media through research grants and scientific counseling, as well as long-term plans to establish academic, political and social support of cellular agriculture.[96]

Perfect Day, Clara Foods

Initiated by New Harvest, these two companies are using cellular agriculture to produce milk and eggs, respectively. Neither of these commodities require living cells or tissue in the final product, making them far simpler to mass produce using current technology than any other cultured animal product. They thus present an opportunity for cultured foods to secure a place in consumer markets relatively soon, which is likely to aid consumer acceptance of cultured meat products once they are available for consumption.[18]

Algae biofuels

It is our understanding that cultured meat cannot be produced economically without ready access to large amounts of the raw biomass that is needed to grow muscle tissue. This biomass would necessarily have to be more resource-efficient than the crops currently used to produce animal feedstocks. Microalgae seems the preferred source for this biomass, and while microalgae are already produced industrially to some extent, the algaculture industry itself is still in its infancy and thus needs significant scaling up before it can meet the requirements of mass-produced cultured meat. Consequently, it seems that rapid establishment of a large algae biomass industry is needed to supply the eventual development of cultured meat on a large scale. The majority of ongoing innovation in this field is taking place in the biofuels industry, an emerging sector whose solutions for combating climate change and food shortage seem favorable in the long term.[66] We thus recommend funding towards the acceleration of algae biofuels as a potential win-win for speeding up the large-scale development of cultured meat.

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