

FREQUENTLY ASKED QUESTIONS CELLULAR AGRICULTURE

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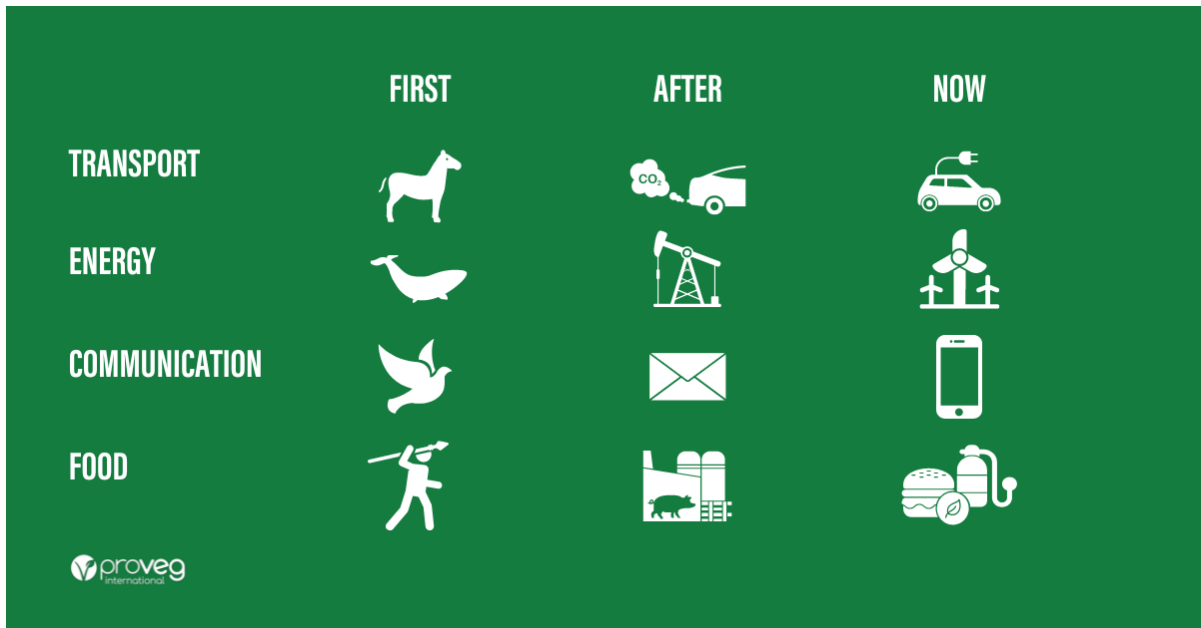
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Cellular agriculture

1. What is cellular agriculture?

Cellular agriculture refers to the production of animal-based foods from cell cultures rather than from the raising and slaughter of animals. This approach involves cell cultivation or precision fermentation to produce meat, fish, eggs, and dairy. The resulting products are identical to conventional animal products. After hunting and the domestication of animals for food, cellular agriculture looks set to become the third phase of human sourcing of animal protein.



2. How is cultivated meat and dairy produced?

Cell cultivation: meat and seafood

In order to produce cultivated meat and seafood, cells are first sampled from animals through a painless biopsy. These cells are then placed in a bioreactor and fed with everything they need to grow (nutrients, amino acids, fatty acids, vitamins, etc.) The same process can be used to produce a variety of meat and seafood products.



Precision fermentation: dairy and eggs

In order to produce milk or egg proteins, the relevant genetic information is introduced into a culture of microorganisms, such as fungi or yeast. These microorganisms then grow milk or egg proteins in bioreactors. The proteins can then be harvested by separating them from the microorganisms. The resulting cultivated milk or egg proteins can be used for a variety of dairy and egg products.



3. How big is the sector?

Cellular agriculture is an emerging field born of the desire to produce tasty, healthy, and sustainable animal-based foods.

More than 100 startups around the world are currently working on developing cultivated meat, eggs, and dairy products, including salmon, chicken nuggets, beef burgers, ice cream, cheese, and more. A growing number of these startups are moving from research to opening pilot facilities. In 2021, the startup Believer opened a pilot facility in Israel, claiming to be able to produce 500 kg of cultivated meat products a day.¹ Later in the same year, Upside Foods opened its EPIC centre in Emeryville (US) in order to produce cultivated meat.² In 2022, UK cultivated-meat startup Ivy Farm officially opened a cultivated-meat pilot plant near the campus of Oxford University's Engineering Department.³

Universities across the world are increasingly contributing to research on cellular agriculture. In 2022, the Wageningen University & Research announced that it was developing a Cellular Agriculture programme, including courses on precision fermentation, cultivated meat, and the societal and sustainability aspects of cellular agriculture.⁴ The same year, Maastricht University announced that it was starting a research line on cellular agriculture.⁵ In the US, Tufts University has established a centre for cellular agriculture in order to accelerate research in the field.⁶ In Germany, a professorship of Cellular Agriculture was established in September 2022 at the TUM School of Life Sciences Technical University of Munich, with the main focus being the development of biotechnological processes and concepts.⁷

Governments are also stepping into the field of cellular agriculture by supporting research. In April 2022, the Israel Innovation Authority invested \$18 million in a cultivated-meat research consortium that aims to reduce the manufacturing costs associated with cultivated meat production, while also investigating scaling opportunities.⁸ In January 2022, China included cultivated meat and other alternative proteins in its five-year agricultural plan, which aims to support its long-term development goals.⁹ In April 2022, the Dutch government announced that it had awarded €60 million to support the creation of a national cellular-agriculture ecosystem as part of the country's National Growth Fund. This is the largest-ever investment in cellular agriculture by a national government and represents a first step towards a larger growth plan which includes €252–€ 382 million being invested in cellular agriculture.¹⁰

Thus far, the cellular-agriculture sector has attracted **€4 billion in investments**, including investments from major global meat producers.¹¹ Tyson, one of the world's largest processors and marketers of chicken, beef, and pork, invested in the cultivated-meat company Future Meat Technologies in 2018 and in Upside Foods in 2017, 2018, and 2020, while Bell Food Group, one of Europe's leading meat producers and suppliers of ready-to-eat products, invested in the cultivated-meat company Mosa Meat in 2018 and 2020.

Expected benefits

4. What are the health benefits of cellular-agriculture products?

Cellular-agriculture products have the potential to be safer and healthier than conventional animal-based products. With no animal husbandry involved, there would be a vastly reduced risk of contamination from pathogens such as *Listeria*, *E. Coli*, or *Salmonella*, as well as a decrease in the risks of zoonotic diseases such as mad cow disease, swine flu, avian flu, and COVID-19.

Cellular agriculture also has the potential to reduce the use of antibiotics. Today, the widespread use of antibiotics in conventional agriculture to prevent diseases due to animal confinement, and to accelerate animals' growth, is the main driver of antibiotic resistance in humans.¹² According to the World Health Organization, antimicrobial resistance represents "an increasingly serious threat to global public health that requires action across all government sectors and society",¹³ with up to 10 million deaths predicted annually by 2050.¹⁴ Cellular agriculture could provide an effective solution to help mitigate this major risk to human health.

In addition, growing cultivated animal-based products offers the potential for improving nutritional composition. For example, cultivated meat products could be cholesterol-free.

Safety assessment of the first cultivated-meat product approved in Singapore

In 2020, the Singapore Food Agency (SFA) approved the consumption and commercialisation of Eat Just's cultivated-chicken product. The approval came after rigorous review and safety assessments by the SFA's Novel Food Safety Expert Working Group, comprised of experts in food toxicology, bioinformatics, nutrition, epidemiology, public health policy, food science, and food technology.

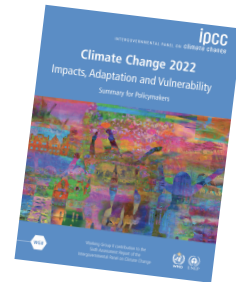
The SFA analysed the nutritional value of Eat Just's cultivated chicken and found it to be comparable to conventional poultry meat. "Safety and quality validations demonstrated that harvested cultivated chicken met the standards of poultry meat, with extremely low and significantly cleaner microbiological content than conventional chicken. The analysis also demonstrated that cultivated chicken contains a high protein content, diversified amino acid composition, high relative content in healthy monounsaturated fats and is a rich source of minerals."¹⁵

5. What are the environmental benefits of cellular agriculture?

Cellular agriculture presents a host of sustainability benefits. While it's too early to know the precise environmental footprint of cellular agriculture products, the latest life-cycle assessment showed that cultivated beef could result in a 92% carbon-footprint reduction (if renewable energy is used in the production process), a 95% reduction in land use, and a 78% reduction in water requirements, compared to conventional beef production.¹⁶ That being said, the cellular agriculture space is still in its infancy and more research is needed to determine the long-term environmental impact of cellular agriculture, especially as the technology continues to evolve and production methods are refined.

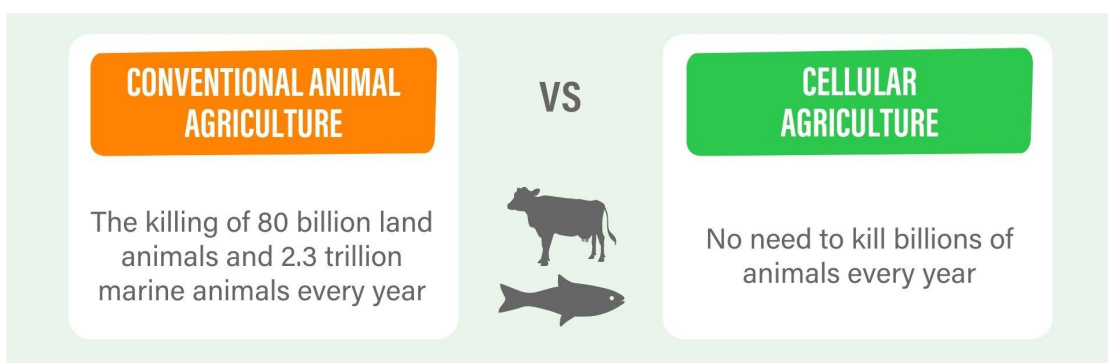
One of the clearest potential environmental gains in cellular agriculture concerns the land dedicated to animal agriculture, as freed-up land areas could be used for reforestation, biodiversity protection, and rewilding, all of which would allow nature to regenerate and absorb more CO2. Moreover, animal waste and pesticides used in animal agriculture would be avoided, which could lead to a reduction in soil pollution, ocean dead zones, ground-water contamination, and algal blooms. Local cultivated-production facilities could also lead to a reduction in ground transportation and shipping pollution.

In 2022, the IPCC report listed **cultivated meat and cellular agriculture as ways to limit pressures on finite natural resources** (Ch. 5, Page 158). Given the global scale of the challenge, as well as the urgent need for change, it is imperative that all promising options to make our food system more sustainable are explored. According to the latest IPCC reports, it is now or never for a transition to a low-carbon economy and society.



6. Are animals still needed?

Contemporary factory farming causes great suffering to more than 75 billion land animals,¹⁷ around 37-120 billion farmed fish, and 800 million-2.3 trillion wild fish.¹⁸ Cellular agriculture could result in a dramatic reduction in animal use and slaughter, and presents a major step towards improving animal welfare. Since there would be no need to kill animals for meat and animals would not be needed to produce eggs and dairy proteins, cellular agriculture could spare tens of billions of animals a life of suffering, annually. Cellular agriculture could also contribute to wildlife preservation since cultivating wild-animal meat, ivory, and other coveted products from endangered species could help to reduce poaching and hunting.



Is Fetal Bovine Serum (FBS) still necessary?

In order to multiply and differentiate as they would inside of an animal, cells are grown in a nutrient-rich medium containing the same amino acids, proteins, sugars, vitamins, and growth factors that are found in the animal's blood. For the past decades, researchers that advanced the field of medical tissue engineering have relied on FBS. However, despite offering perfect conditions as a growth medium, FBS has serious ethical and economic downsides: it requires blood from animals and it is excessively expensive, rendering large-scale production at a reasonable price impossible. As such, current research is focusing on replacing FBS with plant-based alternatives. In 2019, Mosa Meat claimed to have successfully created the first animal-free medium and published a peer-reviewed paper in 2022, revealing how it achieves muscle differentiation in cultured meat without the use of FBS. Other companies such as [Upside Foods](#), [CellMEAT](#), [Future Meat Technologies](#), [MeaTech](#), [IntergriCulture](#) also say that they have successfully switched to FBS-free growth mediums.

Consumer perspectives

7. Why develop cultivated products when there are plant-based alternatives?

While a purely plant-based diet is the most sustainable option, when it comes to taste, ease, and perceptions, plant-based alternatives do not currently appeal to all consumers. This is due to perceptions of lower sensory and gustatory attractiveness compared to conventional animal-based products. Additionally, it is difficult for many consumers to change the eating habits that they have developed over the course of a lifetime.¹⁹ This is why cellular agriculture offers a promising complement to plant-based alternatives for the many consumers who find it particularly challenging to change their dietary behaviours and preferences or who are unwilling to do so.

Offering products that people already know and enjoy, but without the negative impacts on the environment, human health, and animal welfare, could be a key factor in improving our food system. Making the ethical choice the easy choice can reduce the psychological and social efforts required for behavioural and hence systemic change. Given the global scale of the challenge as well as the urgent need for change, a broad portfolio of promising solutions is needed.

In addition, hybrid products combining plant-based and cultivated ingredients can help develop tasty, healthy and sustainable products that will also potentially be cost-effective. This new product category shows much promise in terms of texture and taste. For instance, adding cultivated fat to a plant-based chicken nugget could provide the genuine taste of chicken as well as improving juiciness and meatiness.

Looking at it this way, plant-based and cultivated products are not mutually exclusive categories but actually form a highly promising complementary strategy – together, they have the potential to accelerate market entry by combining two different approaches in order to arrive at a perfect result, rather than perfecting just one approach completely.

Diversifying food supply and expanding consumer choice

From protein-rich plants to plant-based alternatives to cellular-agriculture products, there are many ways to meet the increasing demand for tasty, healthy, sustainable, and ethical food. Cellular agriculture can help to diversify our food supply and expand consumer choice: it provides foods that people know and like, and it increases variety even further through the possibility of combining plant-based and cultivated ingredients (such as a pea burger that contains cultivated fat). Broadening the solution portfolio, cellular agriculture can be respectful of people's diverse physiological and cultural needs.



Protein rich plants



Plant-based alternatives



Cellular agriculture products

8. Are cultivated products vegan?

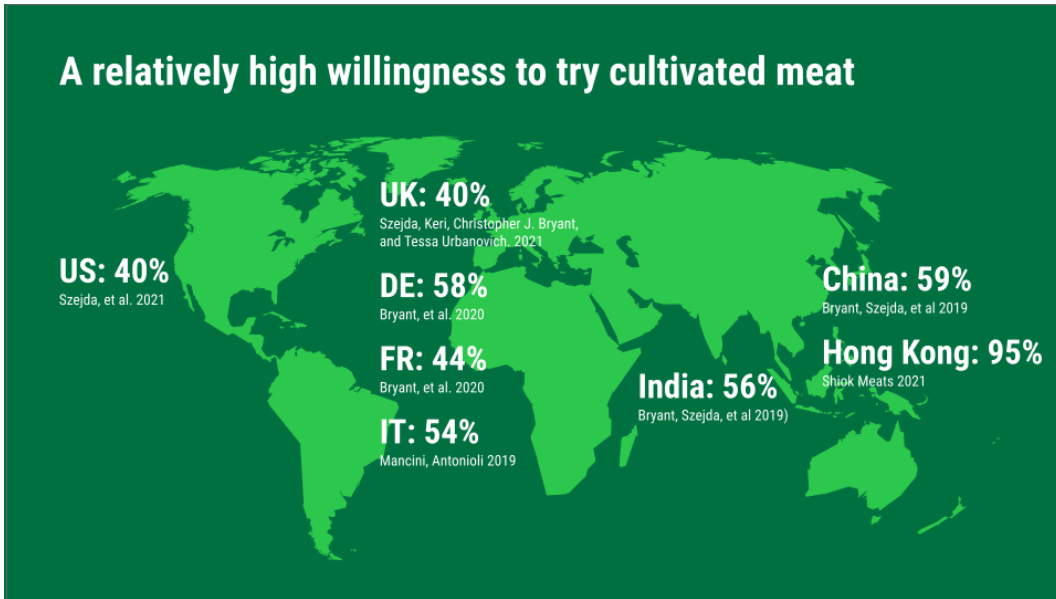
In the strict sense of the word, these products are not vegan since the initial cells that form the basis of cultivated products are of animal origin. However, it is quite obvious that cultivated meat, eggs, and dairy avoid all the negative effects that veganism also aims to avoid. And, of course, cultivated eggs and dairy would still be vegetarian. It is important to note that cultivated products are not aimed specifically at vegans or vegetarians, but at flexitarians and other consumers who find it particularly challenging to shift away from animal products.

9. Will consumers accept cultivated products?

Consumer acceptance of cellular-agriculture products will be crucial for the success of the field. Current research suggests varying levels of acceptance of cultivated meat across the world, with many factors coming into play.

Surveys show that familiarity is an important driver of purchase and acceptance for novel food products. The more that people know about cultivated meat, the more they are willing to try it and buy it. Consumer acceptance studies also show that the health, taste, environmental, and animal-welfare benefits of cultivated meat are strong factors in the acceptance and adoption of cultivated meat.²⁰ Here, personal benefits (e.g. health, with a reduction in antibiotics and the chances of pathogen contamination) outweigh societal benefits (environment and animal welfare).²¹

When it comes to consumer acceptance of dairy products made via precision fermentation, studies show that in Brazil, Germany, India, the UK, and the US, 79% of respondents stated that they are willing to try cheese made via precision fermentation, while 71% indicated a willingness to buy these products.²²



10. Will cultivated products be affordable?

Bringing production costs down is one of the key challenges currently facing cellular agriculture. The early stages of most new technologies tend to be expensive – the first cultivated burger, produced by Mark Post in 2013, cost €250,000 to produce. In 2021, the company Believer Meats (formerly Future Meat Technologies) announced that it has reduced the production price to \$4 for 110 grams of its cultivated chicken breast.²³ According to the consulting firm McKinsey & Company, cultivated-meat companies have been able to reduce the production costs of cultivated meat by 99 percent in less than a decade.²⁴

Prices are expected to continue decreasing since production will continue to scale up and materials costs will continue to decrease. In the long run, cellular-agriculture producers aim to make their products affordable for everybody. According to the Dutch consultancy CE Delft, cultivated meat could be cost competitive with some forms of conventional meat within a decade. Cellular agriculture also offers the potential to make luxury products such as foie gras and caviar more accessible for a larger part of the population.

11. Are cultivated products natural?

Humans have been producing cultivated foods for thousands of years, including cheese, beers, and numerous traditional foods. Cellular-agriculture products would just be as natural as these products. Conventionally produced meat, eggs, and dairy, on the other hand, are quite unnatural.

Today, 90% of farmed animals worldwide come from factory farms²⁵ – with various problematic implications, from breeding to raising to slaughter. The animals that people eat today are the result of genetic selection in order to grow faster and bigger. Chickens, for instance, grow twice as fast as they did just 30 years ago, reaching their slaughter weight in around 40 days, which results in serious health problems.²⁶

Today, most animals are raised in unnatural numbers and unnatural environments without access to sunlight or fresh air. Additionally, they have to undergo unnatural procedures such as dehorning and debeaking, and are fed unnatural foods. In order to prevent diseases resulting from these unnatural living conditions – and to increase profitability – farmed animals are treated with various substances such as antibiotics. Finally, they are transported and killed under circumstances that are difficult to consider natural. Cellular agriculture avoids all of these problems while providing animal-based food products.

Socio-economic implications

12. What are the economic benefits of cellular agriculture?

While it's too early to estimate the precise economic impact of cellular agriculture, studies have shown that cellular agriculture has the potential to become a real lever for economic growth. According to Boston Consulting Group, cultivated meat is estimated to capture a 6% share of the global market for alternative-protein by 2035.²⁷ In the UK, a study by Oxford Economics has predicted that the cultivated-meat industry could add over £2 billion to the economy and create 16,500 jobs by 2030.²⁸ A report funded by the UK Foreign Office found that public investment in diversifying our protein supply, including cellular agriculture, could add \$1 trillion to the global economy and create 10 million jobs.²⁹

Whether cellular agriculture becomes a real lever for economic growth will largely depend on governments. By funding open-access research and infrastructure development, investing in education and skills, and fostering multi-stakeholder dialogue, governments can maximise the economic opportunities of cellular agriculture.

Israel and Singapore emerging as true food innovation hubs

Singapore and Israel are prime examples of nations investing in cellular agriculture, and thus creating favourable environments for the field to develop. In April 2022, the Israel Innovation Authority invested \$18 million in a cultivated-meat research consortium that aims to reduce the manufacturing costs associated with cultivated-meat production while investigating scaling opportunities.³⁰ Israel is also the first country in the world in which both a prime minister and a president have sampled cultivated meat.³¹ In September 2022, the Israeli government declared food tech – “with an emphasis on alternative proteins” – to be one of its five national R&D priorities.³²

Singapore's investments in cellular agriculture have similarly positioned the country as a true food innovation hub. As of April 2023, Singapore remains the only country in the world to have approved the commercialisation and consumption of cultivated meat. In December 2020, Singapore greenlit Eat Just's cultivated chicken, which is now available in some Singapore restaurants.³³ And, at the COP27 summit in 2022, Singapore's pavilion served samples of cultivated meat from GOOD Meat.³⁴ The favourable environment around cellular agriculture development in Singapore is attracting companies and talents to the country. For example, in 2022, the Dutch company Mosa Meat signed a partnership to produce cultivated beef in Singapore,³⁵ while Meatable has partnered with a plant-based company to establish the Future of Meat Innovation Centre in Singapore.³⁶

13. What are the benefits of cellular agriculture for farmers?

Farmers are an integral part of our food system, and it is imperative to assess how they can embrace the rapidly developing cultivated-meat sector and reap the benefits. This is why ProVeg is part of a research project funded by the UK Government that looks at the potential impact of cultivated meat on farmers in the UK.³⁷

Cellular agriculture offers animal farmers an opportunity to identify new areas of focus and remodel their businesses. For instance, they might consider cultivating crops for the expanding plant-based food sector or provide raw materials for cellular agriculture. They could also decide to become producers in the cultivated-meat, -eggs, and -dairy industries – some farmers have already expressed interest, including Illtud Dunsford, who founded his own cultivated-meat startup in the UK.³⁸

Given the highly unsustainable system of current industrial animal agriculture, which swallows billions in subsidies each year while yielding insufficient profits and reputational benefits for most animal farmers, cellular agriculture could potentially open up new and more lucrative business opportunities. The RESPECTfarms project, for example, aims to bring cultivated meat to farms, focusing on leveraging the existing expertise, networks, and entrepreneurial spirit of farmers towards producing cultivated meat. In January 2023, RESPECTfarms received a grant of €900,000 for an 18-month research project exploring the feasibility of producing cultivated meat on conventional farms. The grant has been awarded by the European Structural and Investment Funds in the form of the ‘Kansen voor West’ subsidy.³⁹

14. Will cellular agriculture be democratic?

As cellular agriculture gets introduced to the food system, there is the opportunity to do it in such a way that is more just and ensures that the existing problems in our current food system are not replicated.

In order to counter the potential monopolisation of cellular agriculture by big transnational food companies, there is promising research by the Japanese citizen-science community Shojinmeat, which is exploring the unique vision of “developing open-source DIY cell-cultured meat so that everyone can grow meat at home”.

Open-source science is a powerful catalyst for innovation. Making research on cellular agriculture publicly available would greatly benefit all stakeholders in the field. Openness and transparency are crucial to democratising knowledge and opening up the cellular agriculture market to producers of all shapes and sizes.

Several companies are adopting open source practices, contributing to the development of the field by publishing peer-reviewed research. Mosa Meat has published several papers, revealing fundamental advancements to cultured meat production, including animal-free media, and muscle and fat differentiation. Similarly, in December 2022, the company Believer Meats, in partnership with The Hebrew University of Jerusalem, published a study in *Nature Foods* revealing its production methods for cost-efficient, non-GMO cultivated chicken.⁴⁰

Regulation

15. How will cultivated products be regulated in Europe, the US, and Asia?

Products of cellular agriculture will have to undergo the same regulatory processes and safety tests as any novel food item before being authorised for commercial use. As of now, Singapore and the US are the only countries in the world to have approved of the consumption and commercialization of cultivated meat.

Europe

In the EU, food products which were not significantly used for human consumption prior to May 1997 are considered novel foods. The novel-food category covers four categories: new foods, food from new sources, new substances used in food, and new ways and technologies for producing food.⁴¹ Cultivated animal products fall under the category of novel foods and companies will have to follow an [application procedure for novel food authorisation](#) in which the European Food Safety Authority (EFSA) performs risk assessments on the safety of a novel food upon request by the European Commission. The goal is to ensure that novel food products are safe for consumers.

In the UK, the Food Standards Agency (FSA) deals with applications for authorisation of novel foods.

US

In the US, the FDA and USDA share the responsibility for regulating food products. The FDA oversees the safety of cell-based meat and poultry products, while the USDA oversees the labelling of these products.

In June 2023, US regulators approved the consumption and commercialisation of cultivated meat from two companies – Upside Foods and Good Meat. This represents a significant milestone for the cellular agriculture sector as a whole.⁴²

Asia

In 2020, Singapore was the first – and is still the only – country to approve the sale of cultivated meat. Japan has also been supportive of cultivated-meat startups, while South Korea has made investments in the industry. However, the regulation of these products in Asia is not yet clear, with each country taking its own approach

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