

**bsi.**

● The future  
of sustainable  
alternative  
proteins:  
Cultivated meats



By Royal Charter



# Introduction

## Contents

- 2 Introduction
- 4 What is cultivated meat?
- 7 Creating the conditions for growth
- 20 The role of standards
- 22 Summary



### **Sara Walton, Sector Lead, BSI Knowledge (Agri-Food)**

The impact of meat production and consumption on the environment is widely recognized and there has been much debate about mitigating its effects.

Whilst there are many people arguing that we should stop eating meat altogether, the growth in the global population is driving increased meat consumption. In response, there has been a huge drive by the food industry to find other protein sources such as insects and plant or fungus-based substitutes made with soy, wheat gluten or pea protein.

This drive has also led to the development of 'cultivated meat' as an alternative protein source. Cultivated meat is produced by a process using tissue engineering techniques pioneered in regenerative medicine. In 2013 this innovation led to the development of the first hamburger patty grown directly from animal cells. This was followed with the "world's first commercial sale of cell-cultured meat" in December 2020 at Singapore restaurant "1880 Singapore".

The industry is rapidly developing with new proteins being produced and new technologies for growing meat being developed. As a result the industry is attracting huge investment. Data published by the non-governmental organization Good Food Institute found that in 2021 cultivated meat companies attracted \$140 million in Europe<sup>1</sup>.

However, cultivated meat is still a long way from being commercially viable, as well as acceptable to consumers. As with many developing technologies getting from lab to market is a major challenge. In such markets, the development of standards can play a vital role in turning innovation into reality.

So, in our role as the UK's National Standards Body, we have begun a conversation with stakeholders from across the cultivated meat industry to explore how standardization can support innovation and growth in this area and explore what new and practical solutions can be put into place to help realize the commercial and environmental potential of this new and exciting industry.

**"in 2021 cultivated meat companies attracted \$140 million in Europe"**

## Our work so far

In early 2022, we hosted a roundtable in partnership with Paul Bello from Innovate UK and Cai Linton from Multus Media, inviting experts and stakeholders from across all areas of the sector to discuss the needs of the cultivated meat industry

Participants included Defra, Food Standards Agency, Cabinet Office, Innovate UK, Multus Media, Biotechnology and Biological Sciences Research Council, IBioIC, Fera Science, National Farmers Union, Institute for Food Safety and Technology, Agriculture and Horticulture Development Board (AHDB), University College London, Bath University, Animal Alternative Technologies, Cellular Agriculture UK, Cellular Agriculture Ltd, Aberystwyth University: Future Food Centre, CPI, Higher Steaks, Roslin Technologies, CellulaRevolution, 3D Biotissues, Ivy Farm, Unicorn Biotechnologies and Hoxton Farms.

With the emergence of cultivated meat as a new protein source, and its potential to grow as one alternative option to traditionally produced meat, a key focus of the roundtable was to identify the structural support required to help the industry to grow, scale-up and gain buy-in and credibility with regulators, policy makers, investors, and consumers.

The core themes that came out of the roundtable included creating a sustainable production process that is relative to the scale of the product, not just in terms of production, safety, storage, management and logistics, but also a sustainable price point for consumers to create a commodity product. The market is currently based on a pharmaceutical production method which makes its price point and capital investment points unsustainable, meaning it will be hard to compete in the wider meat market.

Other challenges that were brought up included the difficulty of collecting cells ethically - something that we know businesses are working on, as well as ensuring high nutritional quality by adding supplements, while also avoiding the product falling into the highly processed category.

The safety element and consumer perception were also considered with labelling and traceability as crucial aspects. Implementing standards was named as a key way of providing comfort and security for consumers and supporting effective regulatory systems, as well as opening avenues for productive scale-up and trade with other countries.

With the industry working together collaboratively on decisions as a central point, we take the findings from the roundtable to the next stage through this in-depth report. Discover in more detail the key challenges each stakeholder group is facing, suggestions for how we can overcome these together, as well as the opportunities and various types of support that will be needed to help the industry grow and thrive.



# ● What is cultivated meat?



**Cultivated meat involves taking actual animal cell types to create and grow a genuine meat product, with the process involving using the same cell types in a similar structure as animal tissues. It's a term that is referred to in various guises, including cultured meat, lab-grown meat and cellular agriculture, among many others.**

**There are three key steps involved in the process of cultivating meat:**

**01**

The cells must be gathered from the animal by a biopsy, and this doesn't kill the animal, but tissue samples can be taken from an animal that has just been killed and would go to waste.

**02**

The different cell types, such as muscle, fat and connected tissue, must be isolated. Some companies are working with stem cells, while others are working with more mature cells.

**03**

These cells are then grown outside of the animal by feeding it all the right nutrients, such as sugars, fats, amino acids, minerals and salt, as well as the right signalling cell-to-cell stimulus to tell them to grow in the right way. It works in a similar process to insulin in a human body where it tells cells to take up all the sugars in the blood. The right combination of those nutrients is key for growing different cells effectively. To scale this process up, bioreactors are used, which work very similarly to the way that different pharmaceutical drugs are produced today using standard technology.



Coping with the increasing demands and pressure on our food system and ensuring food security, addressing environmental and health concerns, and providing an alternative for consumers are three of the key arguments for why we need the cultivated meat industry.

There are varying statistics out there estimating the potential size and predicted growth of the cultivated meat market in the next few years. One source suggests it will be worth more than \$319.8 million in the next six years<sup>2</sup>, experiencing a market growth rate of 10.2%, whilst another claims it is currently valued at \$1.64 million and will reach \$2788.1 million by 2030, a compound annual growth rate of 95.8%<sup>3</sup>.

While much of the industry is still being worked out given its early stages, these differing statistics do show the huge potential of the sector in the near future if its challenges can be overcome and standards set.

Since the first cultivated meat product was created in 2013 by scientist, Mark Post, at a cost of \$325,000, the sector has reached many milestones and now has around 110 companies working to produce cultivated meat products.

In 2016, the US' Upside Foods (formerly known as Memphis Meats) produced cultivated beef meatballs for \$40,000 per kilogramme and cultivated poultry for \$20,000 per kilogramme. A year later, Finless Foods, a cultivated fish brand, produced the world's first cell-cultured seafood product, produced at a cost of \$19,000 per pound of fish. Just three months later, the company succeeded in reducing production costs by 50%.

In late 2020 SuperMeat, in Israel, opened its first test kitchen for its cultured chicken burgers and the food technology company, Eat Just, in the US., became the world's first company to receive regulatory approval for delivering its cultivated meat to the Singapore market and soon after became the first company to commercially sell this product to a restaurant.

More recent developments have seen Future Meat Technologies, also based in Israel, successfully decrease its manufacturing costs for cultivating chicken by creating a hybrid product of plant proteins and cultivated meat. The company also opened the first of its kind industrial cultivated meat facility, with capacity to produce around 500 kilogrammes of cultivated meat each day.

Not just becoming the first company to get regulatory approval and commercially sell its product, in 2021, Eat Just also achieved the record as the first company to sell cultivated meat products to consumers via home delivery.

Shiok Meats, a Singapore-based cultivated seafood company, is working to reduce production costs by building a cultivated meat production facility using funding it received in July 2021.

It's currently estimated that the production cost of cultivated meat can be anywhere between \$116-\$22,423 per kilogramme, but in the future, this could reduce to something in the region of \$5.66-\$17 per kilogramme by the year 2030<sup>4</sup>.

“Coping with the increasing demands and pressure on our food system and ensuring food security, addressing environmental and health concerns, and providing an alternative for consumers are three of the key arguments for why we need the cultivated meat industry.”

● Creating the conditions for growth





**Cai Linton** is the Co-founder and CEO of Multus, which seeks to innovate through supplying environmentally sustainable and ethically sourced growth media to the cultivated meat industry.

With a background in bio-engineering, Cai launched Multus with his co-founders, Kevin Pan and Reka Tron, as part of a mission to bring together the disciplines of engineering, biology and data science to create solutions to society's biggest problems. Identifying the need to address price and scale in the cultivated meat industry, Multus is dedicated to using its capabilities and technologies to accelerate the industry forwards.

"The cultivated meat industry is all about giving choice and optionality, allowing people to eat the meat they know and love today, without the environmental impact. The target is to make cultivated meat that tastes as good, or even better, and the costs are just as good, or even cheaper versus conventional meat, and is produced in a far more efficient way.

Livestock notoriously takes up a lot of land, water, energy and antibiotics and are efficient in converting calories from their feed into meat. When you're growing a cow in a field, you have to grow the whole cow. Cows are essentially being used as a factory for meat production but that is not their natural purpose. Whereas with cultivated meat, companies are growing the meat tissues that we want to consume and we provide the cells with the exact nutrients and environment that they need to grow. In fact, land-usage, water-usage and GHG emissions are estimated to be around 90+% less than cattle farming, and while there may be energy required in running a production plant, that energy can be sourced in renewable ways.

There is also no need to use antibiotics as cultivated meat is grown in a very clean environment. 50% of all antibiotics are used in animal livestock rearing and this is becoming a huge problem due to antibiotic resistance. Having a production process that doesn't involve antibiotics or microplastic contamination is ultimately good for the end consumer.

"Having a production process that doesn't involve antibiotics or microplastic contamination is ultimately good for the end consumer."

Cultivated meat can also further broaden the options for consumers by combining different tissues together in different ratios, whether you want something that's very healthy, very tasty or using different species, so extending the definition of meat.

Cows aren't going to become obsolete. People will still want to eat conventional meat, and it will take a long time for the market to shift towards something like cultivated meat, but as long as people have those options, then hopefully we'll be in a position of producing something that's just as preferred by the market. Plus, over time, the bulk of what is currently factory-farmed meat will become cultivated meat and there will still be a large market for more locally produced and high-standard meat products.



The benefits to the end consumer include health benefits, either by eliminating contaminants, like antibiotics or microplastics, or just by designing the product itself to be healthier or tastier. As part of novel food requirements, when bringing a new food product to market, it must be nutritionally equivalent or better. The industry is still very much in the research and development stage, so a lot of this is still evolving, but it's likely cultivated meat can be supplemented, just like we do with our cereals, so nutritionally it should be the same or better than conventional meat, but it also means the negatives can be removed.

There are still plenty of questions to be answered to bridge the gaps in the industry and support the growth of the cultivated meat market. What is really going to stop cultivated meat from becoming a mass market product is how quickly the industry can scale to produce a product that's as convenient, cost-effective, and tasty as what they consume today.

There's also an infrastructure challenge. There needs to be new supply chains that are set up and scaled relating to the inputs in growth media, particularly for a manufacturing process that fits in between the pharmaceutical and food industry. It's a big challenge, but it's something the whole industry is working towards.

Standards will play an important role as they create trust. When there are standards that everybody adheres to and set by a recognized body, the public trust that and recognize it's been through a rigorous approval or certification process. Standards are also important for the industry to understand the boundaries they'll be operating in, so resources aren't spent in trying to do something that won't be approved. It means we can start sharing technologies more effectively so that we can get safer products to consumers sooner.

In terms of the structural support needed, clarity is useful. Current food regulation in the UK and Europe is such that everything must already be set up before it is presented to regulators for approval, whereas it would be beneficial to have the regulator's input at the early stages to ensure the system is fit for purpose.



A professional body for the cultivated meat industry is absolutely necessary and should be part of our national strategy for mitigating the effects of climate change, handling supply chain disruptions and food security. The Alternative Protein Association was recently set up to bring together stakeholders,

including the cultivated meat industry. The UK is a leader in the bio-economy, so any changes to policy and standards will support talent, investment and a regulatory process that is world-leading and help the UK to be at the forefront of the alternative proteins industry."



**Calum Murray** is Head of Agriculture and Food at Innovate UK, with a focus on supporting business-led innovation to make things happen that wouldn't otherwise be possible without the benefit of public investment.

"In the UK, we have an agricultural production system that occupies about 70% of UK landmass, and about 70% of that agricultural land is in grassland, upland and hill-type environments. If you want to harvest food for human consumption from a grassland-based environment, then we require ruminant livestock as they are the only ones that convert grass into the meat and dairy products we consume.

There is however, a clear challenge that's been levelled at the agriculture industry in relation to its carbon footprint and the greenhouse gas emissions that derive from livestock production systems. This suggests there is a market for alternative protein products that mitigate this, and that there is potentially a way for concerned consumers to find a way of consuming meat without the associated emissions.

"There is a clear challenge that's been levelled at the agriculture industry in relation to its carbon footprint and the greenhouse gas emissions that derive from livestock production systems."



While the cultivated meat market may reduce emissions from livestock in the field, there will still be a great deal of energy required to deliver the products in volume. It is because of this aspect that I think that, for now, the cultivated meat market will change the wider meat market very subtly in terms of its current environmental credentials. But, it could add an alternative product line to those who want to continue

to eat meat, but without the associated concerns of the slaughter process in livestock systems. In the longer term, if the economic and environmental considerations become compelling then it could also allow for some land to be released for other forms of carbon capture and storage.

Price parity is clearly a significant challenge in the current climate. With new technologies and associated innovation, the scale up of production will inevitably lead to the potential for price reductions and for new meat products to become a more affordable product. But, how fast that happens, particularly with the current energy price spikes, is a question I can't answer.

It is also clear that the physical infrastructure and capital cost of investment in the sector to drive significant production volumes will be substantial. The question is how that can be accommodated in existing brownfield sites, bearing in mind the considerable planning constraints that may be associated.

The other challenges are consumer acceptability. Tackling the perception of cultivated meat will need to be tackled extremely carefully and sensitively if we are to avoid a consumer backlash. The ethics need to be properly presented, alongside the environmental credentials and the benefits to the individual.

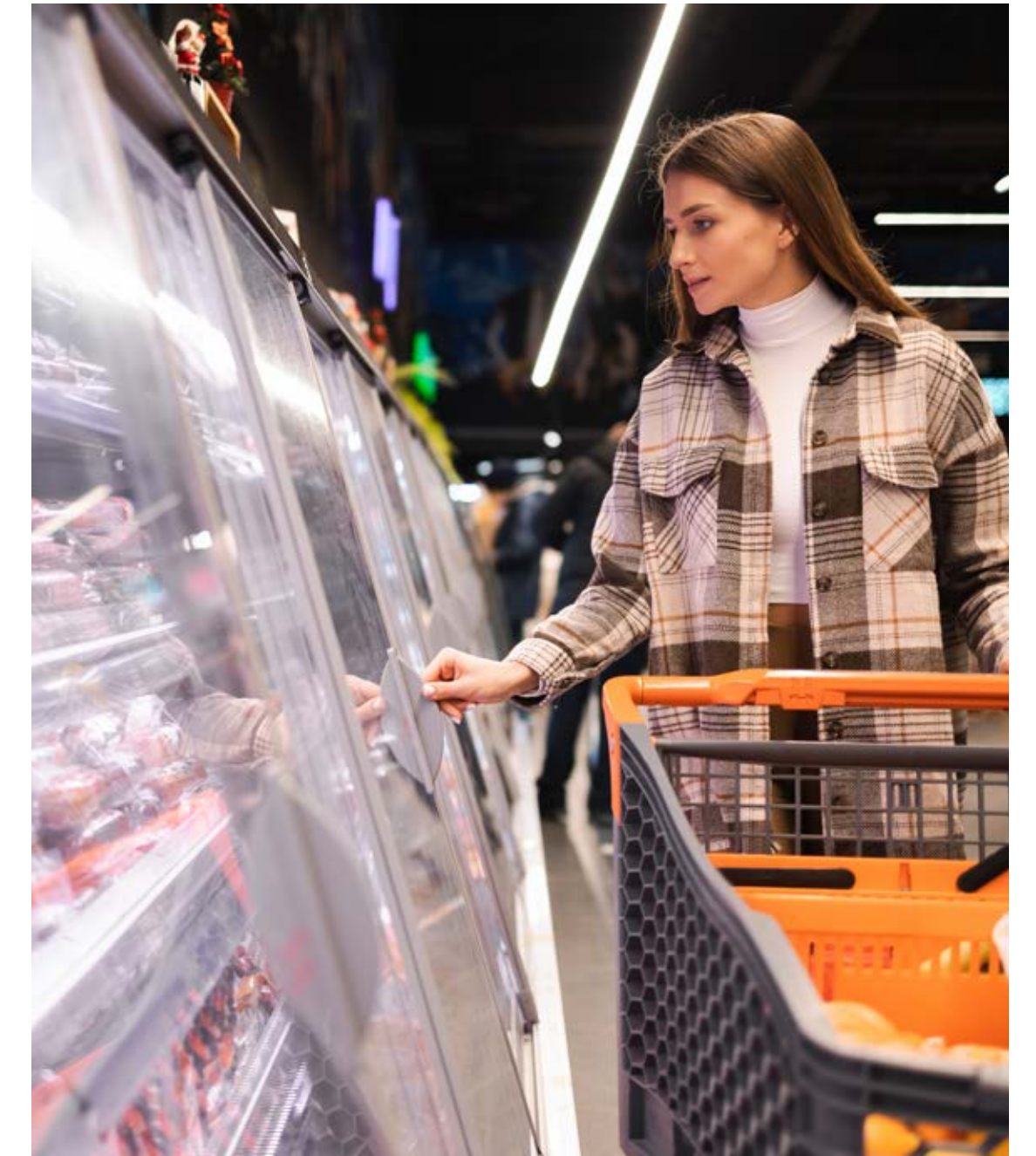
The language and marketing will need to be addressed as I'm not sure people necessarily fully understand what cultured, lab-based or cultivated meat means. The sector simply must ensure it has learnt from the mistakes of the past, as they pertain to the introduction of new technologies if it is to be successful.

Standards will also be crucial if consumers are going to have confidence in the cultivated meat market. The confidence that society has in any product is critical in terms of safety and production techniques, ethics, standards of hygiene and cleanliness, environmental claims, nutritional values, labelling, and those processes are key. We must ensure consumers know exactly how it's handled, reported, labelled, distributed and produced and that they are fully aware of what it is they're buying.

People buy into things, not just because of marketing pressure, but because of the confidence they have in the product and the benefits that they perceive to themselves. If the price point, taste, flavour and texture are all signed with the environmental credentials, then no doubt the market and consumers will have their say.

Regulation proportionately, where standards are tailored based on factors such as business size, isn't the right approach for this industry. There should be robust regulatory standards (and consensus standards) which apply to everyone involved in the sector, regardless of size or status. I would suggest that the regulatory environment must also be sensitively delivered by the key players, such as Defra, The Food Standards Agency, and other ethics councils to facilitate the development of technology that allows the UK to remain competitive. This implies that we must avoid becoming hamstrung by an overly burdensome regulatory framework BUT, the framework must be robust to scrutiny so that the producers are ultimately accountable for the quality and standards of their products.

At Innovate UK, we are exploring a number of responsive programmes that, if funded, would be and are open to proposals from any sector, including the cultivated meat market. We are currently looking at the whole question of novel proteins and how we try and tackle the development of these solutions, including unlocking funding that would specifically support novel production systems and protein development."





**Paul Bello** is the Innovation Lead at Innovate UK and looks after the industrial biotechnology portfolio and national contact point for bioeconomy as part of Horizon Europe, the EU's key funding programme for research and innovation within AgriFood.

“Cultivated meat will have its place in the future of the conventional meat market, but it is unlikely it will displace actual meat from livestock. While we can address the obstacles of regulations, standards and policy, there will still be the techno-economic bundles, such as price points, the evolution of the technology and unlocking funding to address how the industry tackles the technology aspect, to make scaling up more robust and to achieve a reasonable price point.

The plant sector also has a huge head start and now has incredible traction and momentum, to the point that we now see substantial plant-based meat alternatives on supermarket shelves, let alone restaurants and ‘fast foods’. This means there will be quite a bit of catching up for the cultivated meat sector. Similarly, outside competitors, such as those located in North America, Israel and Singapore, have been throwing big money into the industry. A recent news article highlighted the sheer scale of bioreactors that are being built in the next two to three years in North America to bring cultivated meats to market. The key question this raises is what the UK's response is to this? What is the opportunity for our UK stakeholders, how do we play this out until we have a technological advantage and will this leverage policy from the UK government?



The process of cultivating meat involves taking biopsy samples from live animals and working with the stem cell that resides within. Then, the initial cultures and inoculums build the master cell banks which will then be used to throw into the vats (or bioreactors) to grow up to scale and specialize to whatever the end cell type will be, for example, a muscle cell.

I don't think that cultivated meat as an ultra processed food will be any different with respect to supplementations that are required on a nutritional, taste or texture basis. If it's not to a suitable level compared to the normal meat equivalent (let alone processed meats), the industry will opt for supplementations. There's also the taste aspect. It's not just the meat cells that give it its texture, taste and nutritional aspects. It's something that is already happening in the plants protein sector where they use different types of plants to add to the taste, but they still have to do some supplementation for salt or an equivalent fat. However, the possibility here is that by adding in supplements it may detract from the product in the consumer's eyes.

I think there's a misconception that a myriad of tests, either at the beginning or the end of the cultivation process will be needed to make it acceptable to the end user and certified by regulatory bodies. I think those that were setting the bar high came from a stem cell or therapeutic background and so the rigorous tests that are required for cellular therapeutics wouldn't need to all be adopted for cultivated meat products.

Even though it's early days, it is seen as a credible intervention with respect to reducing our carbon footprint. Many consumers will be aware of the impact livestock farming has on the environment, from the methane released by cows, the high intensity of raising poultry, the amount of land and water used, it all carries an onerous carbon footprint. The standards that are brought in mustn't be too high, and certainly, not too low. You've got to strike the balance. Set good practice and outline what the expectations are and try to meet them so that the standards naturally come from there.

If the climate change and carbon footprint credentials can be demonstrated, then that is a huge tick for the consumer. But, it will also need to go one step further. It must be palatable to the eye, have an equivalent taste and texture, 'use by date' and have similarities in the way it is cooked because a consumer will be expecting it to be a near equivalent if they're going to displace conventional meats.

Hopefully, now that industry and stakeholders across the board have been engaged, standards can be brought forward and reduce the potential for any barriers for access, not only for the local market of the UK, but international markets as well. That's all part of the commercialization and success of the industry. It's all about opening up an entirely new industry, technology and market, which will bring plenty of benefits, as well as welcoming new skill sets, new employment and allowing other opportunities to arise."

"The standards that are brought in mustn't be too high, and certainly, not too low. You've got to strike the balance."



**Clare Trippett** is a Chief Technologist at CPI, an innovation catalyst, bringing research and advanced technology to the commercial market. With a background in bioprocessing, biotechnology and biopharmaceuticals, Clare is responsible for technical and strategic oversight for a few key areas within the company. She has been closely involved with the firm's work on cultivated meat for more than five years.

"Cultivated meat won't completely displace or replace conventional meat, but will end up co-existing with it, giving consumers more options. If we can get this technology to scale to produce enough cultivated meat, and it's accepted by consumers, which will be the big challenge, it will help to take the pressure off the intensive production of conventional meats, allowing farmers to focus on managing smaller overheads.

As cultivated meat is still at such an early stage, how we scale up production is still a gap that needs to be bridged. The sector is developing really quickly but has still got a long way to go to overcome challenges such as manufacturing development and scale up, bringing down production costs, growth media optimization and bioreactor design. Suitable bioreactors need to be developed that are optimal for cultivated meat production, and not just using those which have been developed for other markets.



Cell culture media is currently one of the major costs of scaling up cultivated meat production. Bringing down media costs will be critical to the success of cultivated meat – they need to be brought down from the pharma grade level to food grade. At the moment, much of the growth media used to support the growth of animal cells contains something called fetal bovine serum, which

is extracted from the fetuses of cows. This is clearly not aligned with the ethics of cultivated meat, isn't sustainable and is really expensive. There's a real need to develop growth media that can be used for culturing animal cells that doesn't contain this fetal bovine serum, but still does a good job with supporting cell growth.

Another one of the major challenges will be around making sure the manufacturing process is clean and sustainable. We can't replace one problem with another, and there will already be a lot of scrutiny on the industry. If we're developing what we see as a process with a lower environmental footprint, then aspects such as the manufacturing process have to be sustainable and clean using renewable energy where possible.

There's also the cost aspect of cultivated meat too. It's still extremely expensive and when we manage to scale this up, how can we get the price parity to conventional meat?

However, there are plenty of benefits to cultivated meat too. There are the human health benefits as we can potentially tailor the nutrition of the meat, greater food security, reducing the use of antibiotics in the food system, the opportunity to eat meat from different species, and the potential for farmers to grow meat where raising livestock would be difficult, which would provide options for countries where it might be difficult. It's because of all of these benefits that it's such a vital technology area that needs to be developed.

There's also the potential for enormous environmental benefits. Some of the impacts from conventional animal agriculture are said to be responsible for 14-18% of all global greenhouse gas emissions, which is phenomenally high. We focus so much on transport, but we don't give the same focus to emissions from animal agriculture. There's the land and water use also coming from animal agriculture, but also the knock-on effects, like the soya to feed the animals and the transport associated with this. Part of the problem with conventional meat is that animals are a really inefficient way of producing food for us to eat. It takes something like a chicken, which is quite well optimized, to eat 9 calories to produce one calorie of food, versus a cow, where it takes 20 calories to produce one calorie.

While it's very early days in the industry and we don't have a lot of cultivated meat products to analyse the nutrition, this is likely to evolve, and in principle, there's the potential for a lot of beneficial nutritional aspects. This could include increased omega 3, decreased saturated fats and fine-tuning digestibility.

I think for consumers to accept cultivated meat the regulatory aspects are key. There needs to be transparency about where the cells come from, making sure the public is informed, educated and understand the process properly and the benefits it can bring and why it's a much better way of producing meat. The name is also going to be important. Lab-grown meat or cultured meat doesn't sound appealing. If we don't get the name and terminology right, it might deter consumers. I don't think we know yet what it's going to end up being called.

It will be absolutely critical to have standards in place so that consumers can be confident in the safety and origin, so they know how it's been produced, that it's been produced in a reliable way with an environmentally and animal-friendly process. For businesses, especially manufacturing, standards will help with consistency across the industry, which will also help build trust with consumers. It's also important that companies are able to engage early with regulators of what the manufacturing process should look like and any considerations that need to be built in right at the start."

"Some of the impacts from conventional animal agriculture are said to be responsible for 14-18% of all global greenhouse gas emissions."



**Jonathan Rand** is part of the biotechnology business unit at CPI. A key market area for CPI is food, feed and nutraceuticals, which is why the business is so interested in the cultivated meat sector.

“In the short and medium term, I think cultivated meat will have a very limited impact on the conventional meat market. Currently, there’s just one product, which is in Singapore and it’s very expensive. The challenges in commercializing a product present opportunities for organizations like us, but it will be a challenge to meet the scale that’s required. Unless there’s a significant consumer change in the demand for meat on a global scale, which is unlikely given the increase in meat consumption year on year, in the longer-term, cultivated meat will continue to coexist with current meat production.

The regulatory side is going to be difficult and there are going to be lots of issues in terms of understanding where there needs to be more or less scrutiny. The challenge for regulators will be to understand the ingredients as some of these will be sourced from GMO microorganisms. It’s key they have the right technical panels who understand the differences, which I think is something the Food Standards Agency is trying to address.



The cells themselves may not need as much scrutiny as other aspects of the processes such as the scaffolding or the growth medium constituents, for example. There needs to be an understanding where the risks really lie in the products and the processes of cultivating meat. It does present an enormous challenge, especially with bioreactor design and scale-up, as cultivated meat cell lines are harder to keep contaminant free than the traditional microbial fermentation processes that are producing biomass, and there are also viruses to consider. However, one of the advantages of this type of product over

traditional meat could be the removal of antibiotics from the production process.

If we can reduce the amount of farmland used for animal agriculture, that will have a massive impact on the wider environment. 77% of farmland is utilized by either providing the feed for the animals or grazing the animals, which puts incredible pressure on our food system. Similarly, chickens in the UK are largely fed on soya which is often imported from South America. It’s that carbon footprint which feels ridiculous but is the reality of our global food system.



“When companies are making strides in sustainability and ethics, there must be a labelling system that fairly reflects this.”

There are plenty of technologies being developed to help the cultivated meat process. These include 3D printing to print cells into the final meat-like product, but it is very early days and hard to say how much of these technologies will be the reality when cultivated meat actually becomes a commercial product.

Another question is whether these companies choose to end up with a pure meat cell line of beef, chicken or pork, or produce a new cell line or products which are combinations of meat. Australian company VOW is sourcing its cells from deceased animals and their cell lines tend to be from exotic animals or game animals, and so they're looking at combining these cells into a product which creates a new improved taste. Also, we may end up with hybrid products where the meat component forms an ingredient in a plant-based burger, so you're creating a reduced-meat product, but it still has that meaty taste.

To help consumers fully embrace the sector, the educative element will be really important, as well as clear and transparent standardized labelling. The increased consumer acceptance of alternative dairy products and vegan meats that are derived from a lab-based process and produced by a fermentation route may provide this first step in educating consumers that they're actually already eating similar kinds of products. It would be just a little bit more of a push to encourage acceptance of a product that's derived from a cultivator or bioreactor.

Standards will play a key role in terms of the food sector as a whole. Things like provenance and traceability are important, and there are a whole lot of different ingredients that go into these processes, so there needs to be an understanding that these are all safe. When companies are making strides in sustainability and ethics, there must be a labelling system that fairly reflects this, perhaps not just within the cultivated meat sector, but extending into the regular meat sector too.

In terms of support from regulators, they must understand that the businesses in the field will often originate from a very scientific background and are only now moving towards becoming food producers. These are two very different environments in the way you have to think about regulation, and this sector is a very novel thing. These aren't food producers by trade, and there needs to be some acceptance of this, as well as people with the expertise to translate and guide them in the right direction. Maybe this leadership could be provided by one of the existing organizations, such as The Alternative Proteins Association, Cultivate or the Good Food Institute; key experts in supporting the growth and adoption of this sector.

Even in overcoming these challenges, it's not going to be a quick process to get the product to market. It could take a cultivated meat product around three years to get through the novel food application process. The Food Standards Agency is talking about a 'stop-the-clock' process, where time will be paused until companies answer questions they have. However, once a few companies have gone through this process, and the questions have already been answered, I imagine it will become a much quicker and smoother process, and more like 18 months in the future.”



**Glyn Stacey** is the Chief Executive of SCCBio Ltd, experts in cell culture technologies, but also provides advisory services to government agencies and institutions in countries including Korea, Japan, China and India. The majority of his work revolves around stem cell banking, including donor issues, donor consent, ethics, production of cell lines, banking of cells, QC characterization, cell development and the early stages of manufacture. Before this, Glyn worked as a microbiologist, before moving into cancer research, and then biotechnology animal cell technology.

“It’s clear that there’s a strong push towards cultivated meats. The big question at the moment is achieving the right levels of reproducibility and costs. From my involvement with The European Centre for Validation of Alternative Methods, they have done quite a lot of work on the replacement of animal serum in cell culture and found the inefficiency of it. Several cows, dams and calves were required to actually make one beef burger in the original animal cell culture system which made it a non-starter, not economic or efficient at all. However, serum-free systems are much more effective now and are almost pretty much routine. Culture media must be entirely serum free to be transferable to non-animal-based systems and validated to assure manufacturers can achieve the cost efficiencies that are claimed.

Some of the more successful companies are claiming they can combine different cell types, and it’s obviously not just about making muscle cells. In the past, I’ve used low shear stress culture systems and rotating wall vessel systems, the same type of equipment that NASA uses to culture animal cells, but you need the whole range of cell types to give the precise texture and flavour of real meat.



Scale-up and stability have always been an issue in terms of getting the cells in the state that they can actually be used, which has been a struggle for the cell therapy area too. Common solutions include moving towards a suspension culture system to give you a different cell type, but that can affect the functionality of the cell and disrupt the cytoskeleton. On the case of pluripotent stem cell lines, the scaling up to give sufficient cell numbers can be done as a first manufacturing step and then the cells are differentiated to make the cell types needed. How this is done will vary from company to company, although it won't differ too much from a stem cell perspective, just in terms of the development of the different cell types to make the final product.

From a nutritional perspective, the cell culture media may also need to be adapted to get the right composition of the product. It's possible there may still be deficiencies with the nutritional value of the final product, but that's something food manufacturers will be able to handle to recombine with supplements so that the final product contains the essential nutrients needed. However, I think the manufacturers should try to avoid cultivated meat becoming an ultra-processed food and keep it as simple as possible.

There are some challenges, in particular around safety. The cell culture process gives an opportunity for contaminants to expand and thus, microbiological control is essential, including aseptic bioprocessing and testing of raw materials and possibly the product. However, there is a danger that companies might try to take regulation from a different area like medicines and apply them directly to cultivated meat. There needs to be a balance of scientific critical thinking, but without the overload of testing and control. The risk-benefit balance for vaccine manufacturing, for example, is quite different and certain elements would not be necessary or even desirable. There should be an assessment of what the safety and quality issues are for the cell culture process and what that brings to food manufacturing that is different to traditional meat production. The process of developing the cell culture is complex involving numerous reagents and cell manipulation procedures that could introduce the risk.

There is a danger in rushing directly to development of standards. It will be important to establish useful standards in time, but immediate requirements are careful scientific consideration to drive science-based risk assessment and ensure appropriate use of national guidance and professional consensus on the relevant issues. However, any standards brought in should be set with full engagement of the industry. It's crucial that there's coordination between the academic and commercial organizations, so the scientists with the knowledge of how things work in the cell culture and cell engineering, are coordinated with the companies in terms of the challenges and standards that are really needed.

The vocabulary used is also a concern. The use of the term 'lab-grown', for some people, instantly raises concerns that it's just full of chemicals and things that scientists dream up and don't test properly. We saw it with Covid-19. But cultivated meat isn't going to be manufactured in a lab. It's going to be a proper commercial manufacturing facility that's much the same in looks as any other meat production factory.

“Scale-up and stability have always been an issue in terms of getting the cells in the state that they can actually be used.”

If the industry can overcome all these challenges, then its benefits can be enjoyed, such as the ecological, global warming and the Three Rs aspects (reduction, replacement and refinement). If you look at the size of the meat-free section in supermarkets, it's expanding and people will go for it, not because it's necessarily better for them food content wise, but it's the feel-good factor regarding the environment. Some of the products taste as good as ultra-processed natural meat, so why not go for a plant-based or animal cell culture-based meat?”

# ● The role of standards



**Standards define best practice in many different areas. They're put together by groups of experts and come in several varieties, from a set of definitions to a series of strict rules.**

A standard is a collective work. Representatives of organizations having an interest and expertise in the subject matter are brought together by BSI, to form a technical committee to draw up the standard, with our staff facilitating their development and review.

Standards are not the same thing as government regulations, but they can be used in support of legislation, to aid compliance.

Businesses looking to commercialise emerging technologies are part of a developing business 'ecosystem', and the stronger they can exploit the networks within the ecosystem, the faster the market for their products will grow. However, these complex ecosystems can give rise to obstacles that get in the way of successful innovation.

Standards are key to removing these obstacles as they help an emerging technology ecosystem rally round the issues to promote successful commercialization of new products. They can lay down the 'rules of the game' for markets looking to develop and adopt emerging technologies: for example they can help define interoperability so that one product or service can work with another made by a different organization, or they can put down rules which reassure consumers

about safety and reliability, particularly for technologies which are perceived to be risky.

Standards can also streamline the development of new technologies and related products, though processes and systems which are known to work. By doing this, standards can reduce the time taken to commercialize new technologies and accelerate the speed at which innovations become more than mere ideas.



# Summary

---

The contributors to this white paper have eloquently highlighted the huge opportunities that cultivated meat offers, as well as the challenges that need to be overcome to commercialise the technology.



**Sara Walton. Sector Lead, BSI Knowledge (Agri-Food)**

“All agree that cultivated meat will complement, rather than replace traditional meat and that this will deliver numerous health and environmental benefits if the huge financial and technical challenges can be overcome. Equally they are unanimous about the essential role that legislation and standards can play in helping shape a bright future for the industry. Vitally, with their knowledge of current state of the art in science, processes and activities, they are also able to reassure consumers that cultivated meat can be ethically produced and safe to eat.

Communication will be vital to instil consumer confidence. Lessons can be learned from the pharma and cosmetics industries where numerous products are developed under highly controlled and regulated laboratory conditions. This very process is what gives people confidence that the products are safe to use. Similar rigorous standards and regulations will be vital in creating trust in cultivated meat. And a key aspect of communication is reaching agreement around the language and terminology that is being used by the key stakeholders. It is not only an integral part of providing reassurance to consumers, but it is also where successful innovative and emerging industries often begin their journey in standardization.

Regulators can't develop rules unless they have a picture of where the industry is going and companies will struggle to attract investment without certainty that the future of the industry will be supported with the appropriate frameworks, comprised of both regulation and consensus-based expert standards, as designed by industry, research and other key stakeholders.

At BSI we can help with development of standards that will enable innovation and future industry scale-up, help disseminate knowledge about the process, reassure investors, and support and complement regulatory pathways.

The commercialization of disruptive technologies is often challenging. Their pioneers are often faced with great uncertainty around the nature of future business models and value chains. But there are good examples such as electric vehicle technology or the development of graphene nanotech, where standards have helped create the 'scaffolding' that supports the economic endeavour of these innovations.

BSI offers an open invitation to any person or organization involved in any aspects of the development of cultivated meat who would like to join our coalition of expert stakeholders and help in the ongoing work to realize the potential of this emerging technology.”

Please get in touch with [sara.walton@bsigroup.com](mailto:sara.walton@bsigroup.com) to discuss active support for the ongoing exploration of standardization required in this area.

**bsi.**



Read more about our  
services and products  
on our website  
[bsigroup.com](https://bsigroup.com)