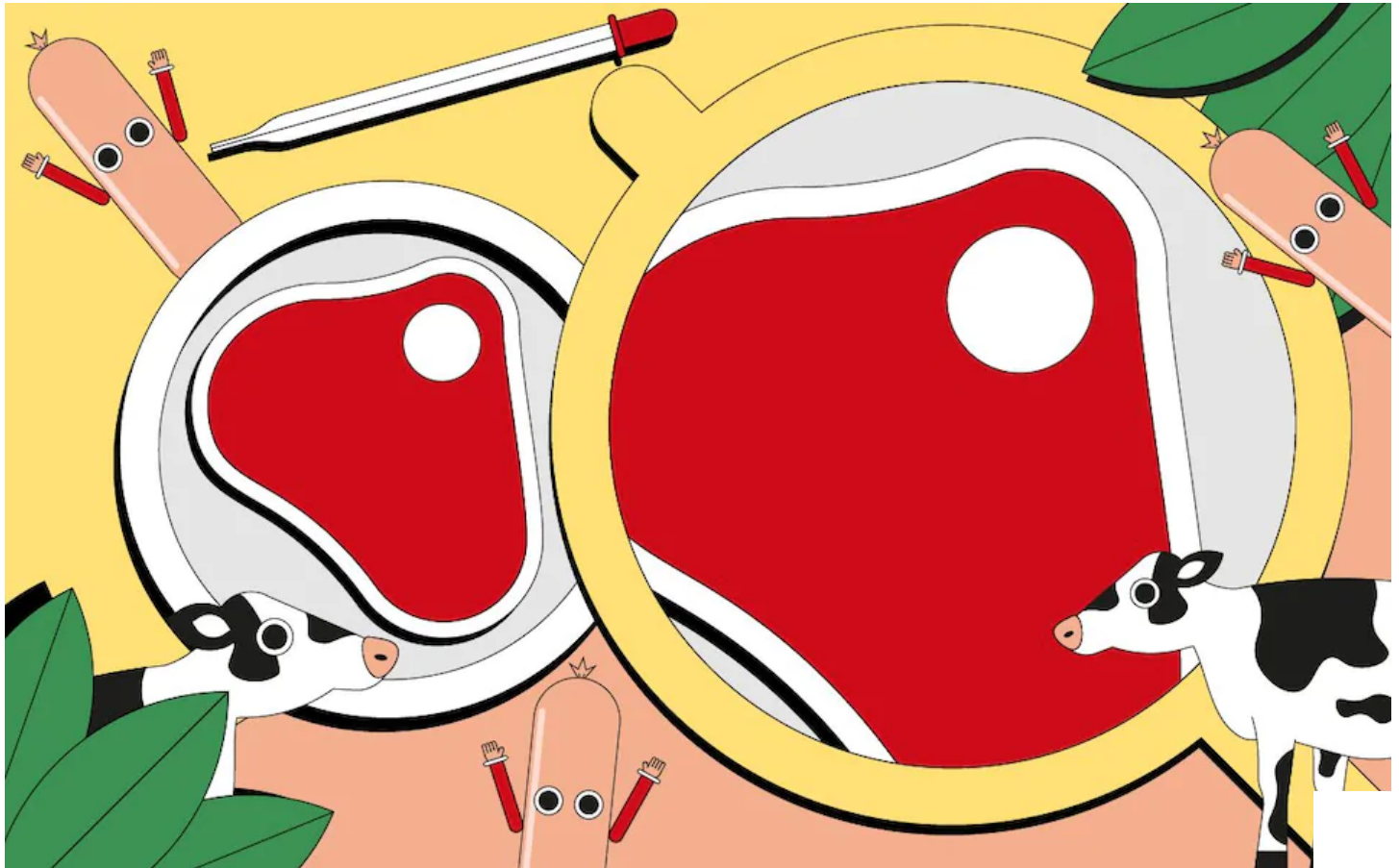


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The future of meat: plant-based, lab-grown and goodbye to the abattoir

Will changing habits and production methods mean the end for traditional meat-eating?

By Harry de Quetteville

16 July 2020 • 8:00am

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This is the sixth instalment of [The Future Of... a new weekly longread series](#) which seeks to examine in depth what the next 5-10 years holds in a variety of different areas.

Estimated read time: 18 minutes

“Sage and Marjoram Sausages”, the packaging proudly declared, beneath a picture of crispy-skinned bangers on a bed of lightly sauteed onions. My mouth started watering. Quarter of an hour later, an almost familiar aroma filling the kitchen, I pulled the baking tray from the oven.

There they lay. True, they were not glistening with molten fat in that familiar, tempting way. They did not quite manage to be crispy on the outside, tender within. But when I popped that first slice into my mouth, I was surprised. These [meat-free](#) sausages were surprisingly meaty.

Yet no animal was harmed, as the old cinematic phrase goes, in the making of this sausage. The stunt doubles were wheat and soya protein, stepping in to save the pig’s bacon. And it wasn’t bad. With a bit of ketchup, there were moments I forgot I wasn’t chewing the real thing. All apart from that skin, a somehow papery casing which never approximated the true experience. As I cleared away, my little taste test had demonstrated both the improvement of plant-based meat - and how hard it is to fool the senses.

Yet the latter is precisely what an entire breed of new producers are trying to do - make or emulate meat in a new way that looks, smells, and tastes as good as the animal flesh we are used to.

If they succeed, the norms of global food supply, of raising billions of animals for slaughter, could become a thing of the past. Industrial abattoirs might disappear, and meat as we know it become a rare luxury, a treat to splash out on, like a great bottle of wine. “A different type of product, a more expensive product and more high quality product,” as Prof Sir Charles Godfray, director of the Future of Food Programme at Oxford University’s Martin School puts it.

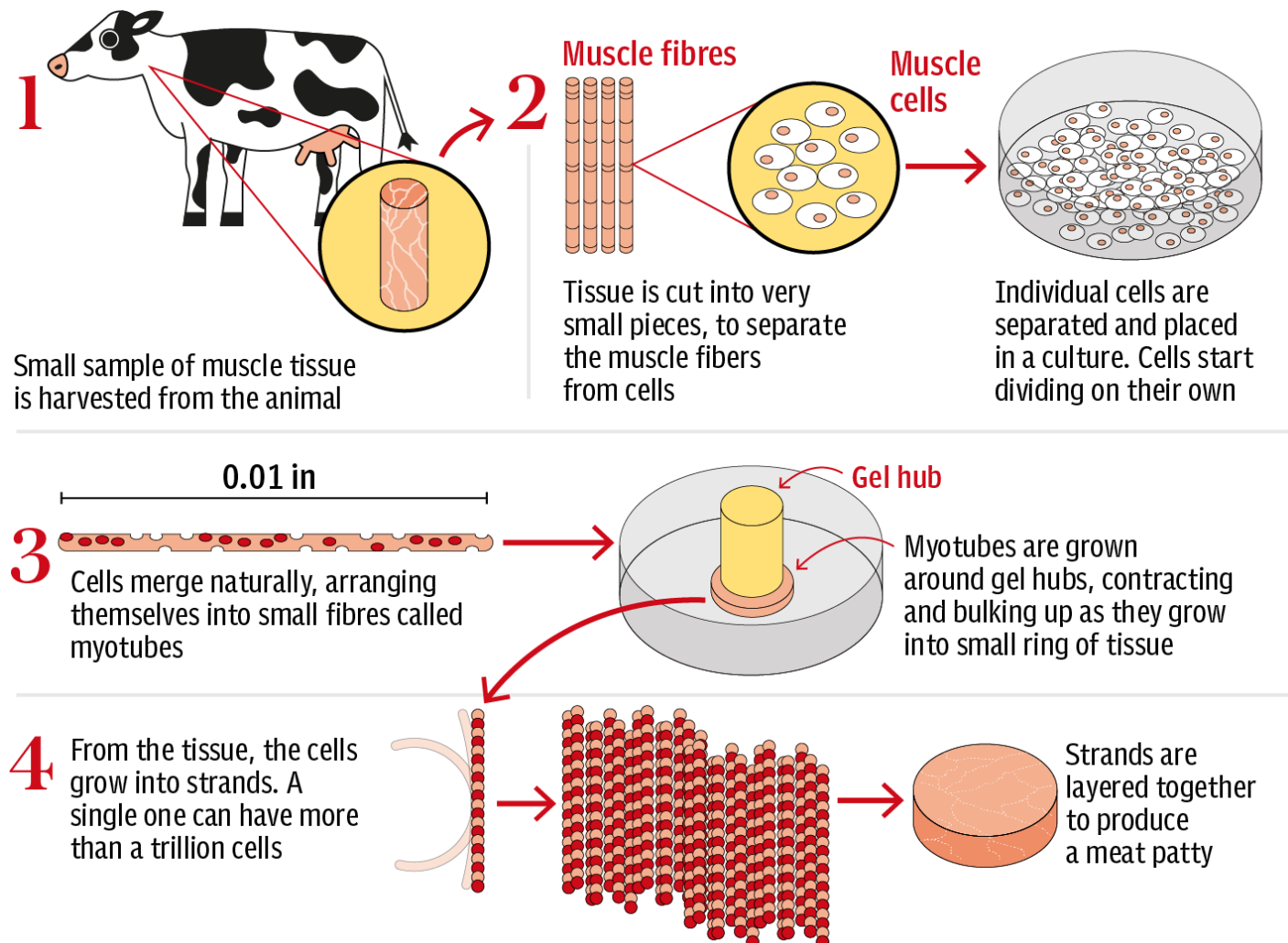
It’s a vastly complex business. We all know how texture alone (“mouth-feel” in the new-meat jargon) can arouse passions on the plate - just ask those who love, or hate, baked beans.

Some companies, like VBites, which turns out everything from meat-free nuggets to roasts (to my test sausages) from its factory in Corby, are using plant-based substitutes. Others want us to switch to insect protein. And then there is the “clean meat” brigade - the

companies which grow actual pork or beef or fish muscle cells - but in labs rather than in the traditional way, on the flanks of an animal.

How is cultured meat made?

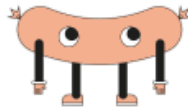
The science behind producing cultured meat is relatively straightforward - the major technical challenges are about scaling up while keeping costs down



Each technique faces challenges in technology and taste and in overcoming scepticism from consumers who are rarely more demanding than about products they cook and put in their mouths. The shadow of GM foods - many of which have been passed as safe, yet continue to be resisted by consumers - looms large in the industry.

Even so, a vast global race is on to find a new way of satisfying our ever-growing appetite for meat. It is a race that, analysts say, will create not just huge financial winners and losers (a new book on the subject is entitled “Billion Dollar Burger”).

It will also determine the fate of those animals we rear in industrial quantities to slaughter, and have a significant impact on our species as well.



There are tentative signs that change is already under way. Witness the rise in “flexitarianism” among consumers aware that traditional meat not only has an ethical, animal welfare dimension, but a significant environmental impact too.

According to research by Mintel, 48 per cent of British consumers see reducing consumption of animal products as a way to lessen human impact on the environment. They are also turning away from meat to save money and because they think it’s healthier to do so. The effects are palpable: almost a quarter of all UK food products launched in 2019 were labelled as [vegan](#).

The number of those around the world reducing their meat consumption, however, is dwarfed by the total increasing theirs. Today, approximately 320 million tonnes of meat is consumed, up from 268m tonnes a decade ago. And the Food and Agriculture Organisation of the United Nations (FAO) estimates that the demand for meat is going to increase by 45pc again by 2050, to 464m tonnes. Global per capita consumption has risen from 23kg in 1969 to 32kg in 2019. Moreover, the world’s population is not only increasing, but becoming richer, fuelling an ever-increasing demand for meat which, it has become clear in recent years, farming-as-usual will struggle sustainably to answer.

But it has above all been this year, 2020, that the price of our taste for flesh has been laid bare - by a global pandemic which, like the near-catastrophes of Sars and Mers before it, seems to have crossed the species barrier at a food market where human and animal exist cheek-by-jowl.

Can Silicon Valley fake a full cooked breakfast?



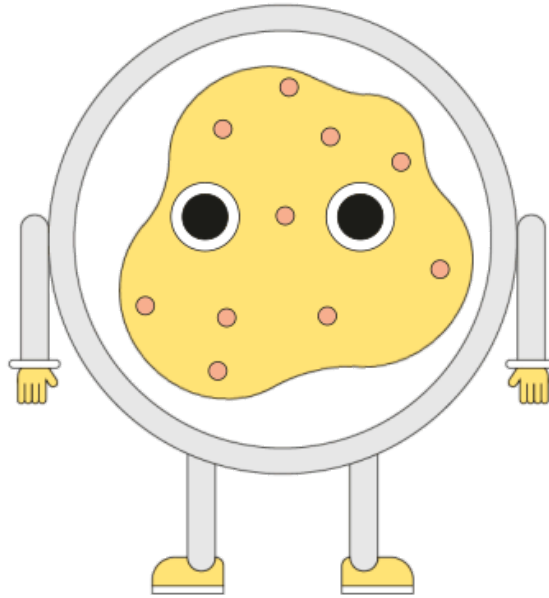
That is not all. In the months since, efforts to corral Covid-19 have repeatedly been upset by outbreaks in meat processing plants. One of the biggest occurred in South Dakota at a plant which shares its name with the famous meat market in London: Smithfield. On a normal day it is one of America's biggest, slicing and dicing almost 20,000 pig ("hog" in US terminology) carcasses.

But towards the end of March it became notorious instead as a fever factory, when hundreds of its 3,700 workers fell sick. More than 600 cases were eventually linked to the factory, an outbreak which has been echoed again and again on crowded, noisy, physically demanding meat-packing lines around the world, including several in Britain. Such has been the impact of Covid-19 that by the end of April John Tyson, chairman of Tyson Foods, America's biggest meat company, remarked: "The food supply chain is breaking."

Our passion for meat - the way we rear it (both intensive and extensive), transport it, sell it, butcher it - has long been considered a vector for disease. As Valentina Rizzi, at the European Food Safety Authority, put it May: "The majority of emerging new infections in humans in the last 10 years really come from animals or food of animal origin."

But this year our appetite has helped transmit a disease that has shattered economies around the world and cost more than half a million lives.

No wonder there's a growing band of entrepreneurs who argue that if we want to keep on eating meat, from fish to foie gras, we have to find another way of producing it.



Meat is not only delicious, it is an excellent source of protein and dietary essentials like zinc, iron and vitamin B12. Above all, however, it provides an abundance of energy - energy to fuel our large, power-hungry brains. Our small-brained, nut, fruit and plant-eating ancestors devoted resources instead to a large gut and long digestion. But meat provided a shortcut to that lengthy process, allowing the gut to shrink and the brain to grow. Is it too much to say eating meat made mankind the uniquely capable species we are today?

Of course, eating meat has its downsides too. Consumption of processed meat has been linked to colorectal cancer, with the World Health Organization's International Agency for Research on Cancer estimating that 34,000 deaths per year worldwide are attributable to diets high in processed meat.

And calorie for calorie, [meat production, the world's most important source of methane, creates more emissions](#) than plant-based foods. A third of all the freshwater we use for agriculture (itself the most thirsty business on the planet) is used for livestock; indeed 46 per cent of the world's harvest is used for livestock feed, more than the 37 per cent we eat ourselves.

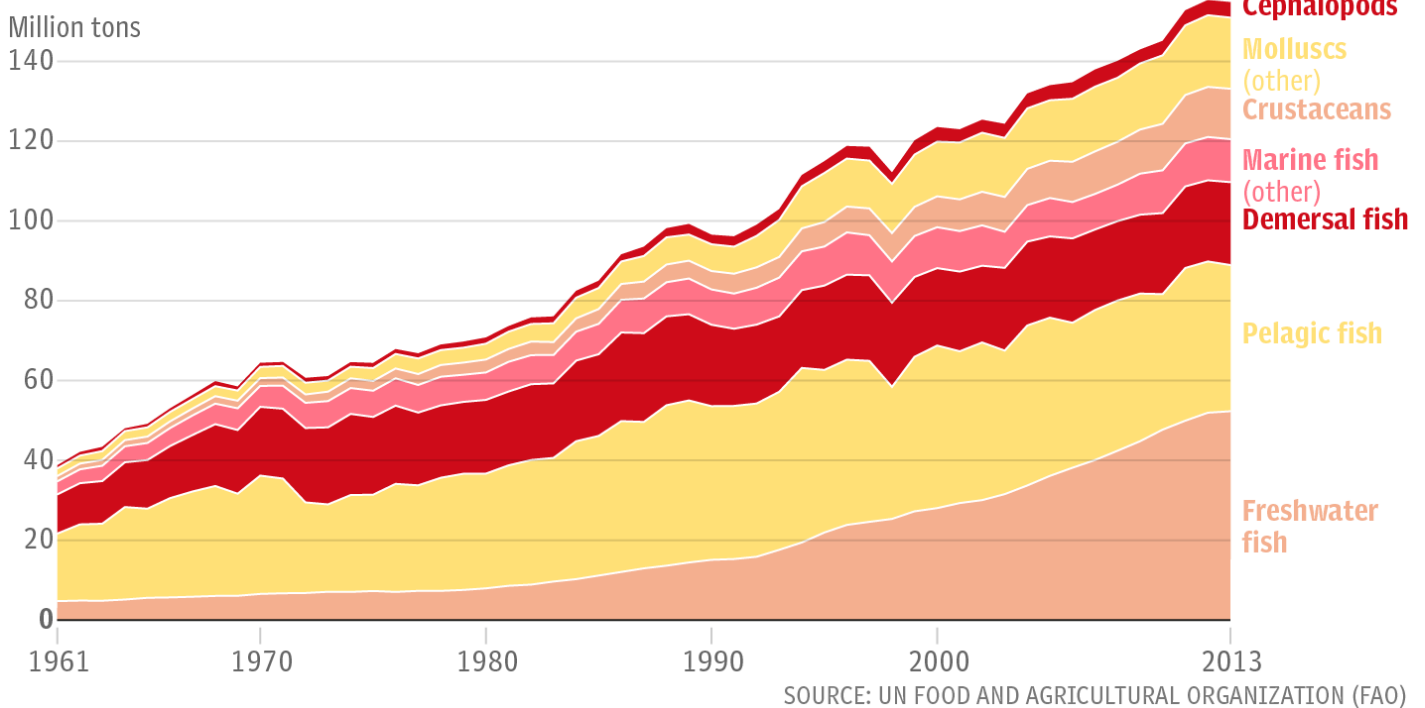
Meanwhile the use of antibiotics as animal medicines and growth promoters helps bugs develop resistance to the vital drugs, ushering ever closer the human health nightmare in which antibiotics no longer tame routine infections. And who among us has not seen tear-

jerking footage of [rainforest ripped down](#) to create grazing land, or converted to arable to produce grain or soy feed for livestock? According to the FAO, between 2015 and 2020, the rate of deforestation was estimated at 10 million hectares per year, with “agricultural expansion... the main driver”.

The consequences for biodiversity are significant. “The biggest transformational change,” to redress the damage notes the FAO, “is the way in which we produce and consume food.”

This story is not just limited to land. In the seas too, demand has increased, with production of fish and seafood almost quadrupling from 43m tonnes to 154m tonnes in the 50 years to 2013. With that rising demand, the percentage of fish stocks that are overexploited has risen from 10 per cent in 1974 to 33 per cent in 2015. Even the dramatic rise in fish farming - which overtook wild catch by tonnage in 2012 - has failed to stem the damage.

World seafood and fish production



The rise in global demand is driven, says Carrie Chan, founder of Avant Meats, by Asian consumers. “China alone consumes more than 35 per cent of global seafood and fish,” she says from Hong Kong, where Avant is based. “Asia accounts for about 66 per cent.”

That demand is why Avant, which is among China’s first lab-grown meat companies, has chosen to focus on producing not pork or beef, but fish.

The very phrase “lab-grown” has, inevitably, attracted the term “Frankenmeat”. But this is not about making the dead live. Rather it is about the altogether more prosaic process of

That expense is actually an advantage for Avant, because the company's main problem, like that of all cultured-meat manufacturers, is relative cost. When Post and Verstrate unveiled that first burger back in 2013, it cost \$325,000 (£258,000). Manufacturing improvements have driven such figures down since then, but still, not so far that cultured meat is anything like competitive on price. "It can cost \$2-3,000 [£1,600-2,400] per kg," says Chan. Just Inc's cultured chicken nuggets cost 50 bucks a piece.

Avant's second product is grouper, "which is very popular in this part of the world," she says. "Very firm, textured white flesh." It is this which highlights the other significant difficulty for cultured meat - turning an amorphous mass of meat cells from the bioreactor into something that resembles a steak, or a fish filet.

It is a fiddly process that usually requires a "scaffold" to shape the tissue cells. The problem is then removing that scaffold without destroying the product. At the moment, Avant can produce homogeneous textured meat, a bit like calamari. Its first filet prototype, says Chan, is coming at the end of this year. Price parity, she hopes, a year after that.

Tomorrow and tomorrow and tomorrow. This is a business, it can sometimes seem, where revolutionary product launches are forever just around the corner. "I invested in Memphis Meats about six years ago and the plan was to launch in five years," says Niccolo Manzoni, managing Partner of Five Seasons Venture Capitalists. "And of course they're probably still five years away."

But Manzoni, who has been investing in food tech since 2014, is not worried. "It's easy to get it wrong by a decade, this kind of technology, simply because it's really game changing." It's not just pioneering a manufacturing process at scale to bring down costs and get the right texture that needs to be mastered, he suggests; an entirely new regulatory system needs to be put in place. Then there's the final, and most important hurdle: us, out there in the shops and supermarkets. "Most importantly you have to convince consumers that it is alright to buy and eat something that comes from a petri dish as opposed to an animal."

Yet there is no reason, say its advocates, why meat from cattle raised in intensive barns should be seen as "natural" and lab-grown meat "unnatural". It is all farming, says, Iñigo Charola, CEO of BioTech Foods in Spain, which produces cultured pork.

"Mankind has been doing agriculture for thousands of years, and this is what we are doing here. We are doing cellular agriculture, no more and no less. The process is as natural as any other we use nowadays - how we produce beer or cheese or many other things that

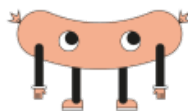
multiplying tiny samples of meat cells until there are enough of them to eat. If anything it is antiseptic, not creepy. There are no animals with electrodes attached. Indeed, animals are barely involved at all. That's the whole point.

At Avant, as at all cultured-meat companies, the basic concept is simple: a sample of cells is taken from a live animal (a process which doesn't harm bigger animals but does kill fish). This sample is nurtured with growth serum until great quantities of meat cells are eventually produced in large drums called "bioreactors".

How world's first test-tube burger was grown



In theory, says Becky Calder-Flynn, of Mosa Meat, which cultivates beef, "one cell sample can create up to 10,000kg of cultured meat". Mosa, whose founders Mark Post and Peter Verstrate famously unveiled the first cultured beef burger in 2013, estimates that such ratios means "we would only need 150 cows to satisfy the world's current meat demand".



Back in Hong Kong, Avant has two pilot products. One is Yellow Croaker, a fish which, to the untutored eye, looks entirely unremarkable. To the aficionado, however, croaker is a delicacy, renowned for its swim bladder, or maw, which is turned into soup so prized that the maw can cost hundreds of dollars a kilo.

we grow from raw materials. Here, instead of using an animal to grow a cut or joint that we need, we are just saying let's do it more efficiently. And the end result is the same, you will have your burger or your sausage.



Meat can now originate from labs like these instead of the farm | CREDIT: BIOTECH FOODS

"You're not going to change the way you enjoy food, but we're going to change the technology to allow us to feed the whole planet, a planet that is changing really dramatically and that needs to go for technologies that are more sustainable."

It would not be all upside. In the UK alone, more than 300,000 people work in the livestock industry. "Even in middle and high income countries, a vast number of people do owe their livelihoods to rearing meat," says Charles Godfray.

"We can see that tension within this country. We need a narrative so that those people who would feel threatened by simplistic arguments about 'we must eat less meat', can maintain viable livelihoods. And there are ways one could do that - one could find different uses for that land, or think of meat as a more expensive, more high quality product." In the UK, he says, a narrative is already emerging, from both consumers and producers, of "less and better".

That all sounds very well and good but, as Michael Dent, author of a recent [report on the industry](#) for analysts IDTechEx points out, no producer should bet on shoppers paying

more, just because a product has green credentials. “Consumers,” he says, “are notoriously sceptical when it comes to paying extra for things that are sustainable... and they are also notoriously sceptical about biotechnology”.

The risk is that such scepticism turns to disgust. And there, apparently simple matters like how “clean” meats should be labelled take on huge significance, he says: “If governments decide you have to call your product ‘animal derived laboratory cultured cell protein’ then that’s a big deal.”

First impressions will matter, and shoppers have long memories. The industry remains scarred by the launches of plant-based meat substitutes from decades gone by. “They were awful,” says Dent. “And the butt of jokes for a while.”

Since then, however, manufacturers have got better at replicating the taste and texture of the original. Trial and error have allowed them to get ever closer to the grail of the perfect “mouth-feel”. It has not always been easy. Beyond Meat’s burger, for example, uses beetroot juice to replicate that yummy dribble down the chin moment of biting into a traditional beef patty that “bleeds”.

As Uma Valeti, CEO of Memphis Meats, cautioned his fellow entrepreneurs at a conference last year, a rushed launch, a botched product, a safety scare, could set the entire field back by decades. No wonder, then, that at Five Seasons, Manzoni insists that the companies he backs produce food that competes on taste and price above all. “That is one of the mantras we have here.” New meats can’t just be greener than traditional meats. If they are to succeed, they must be tastier, and cheaper too.



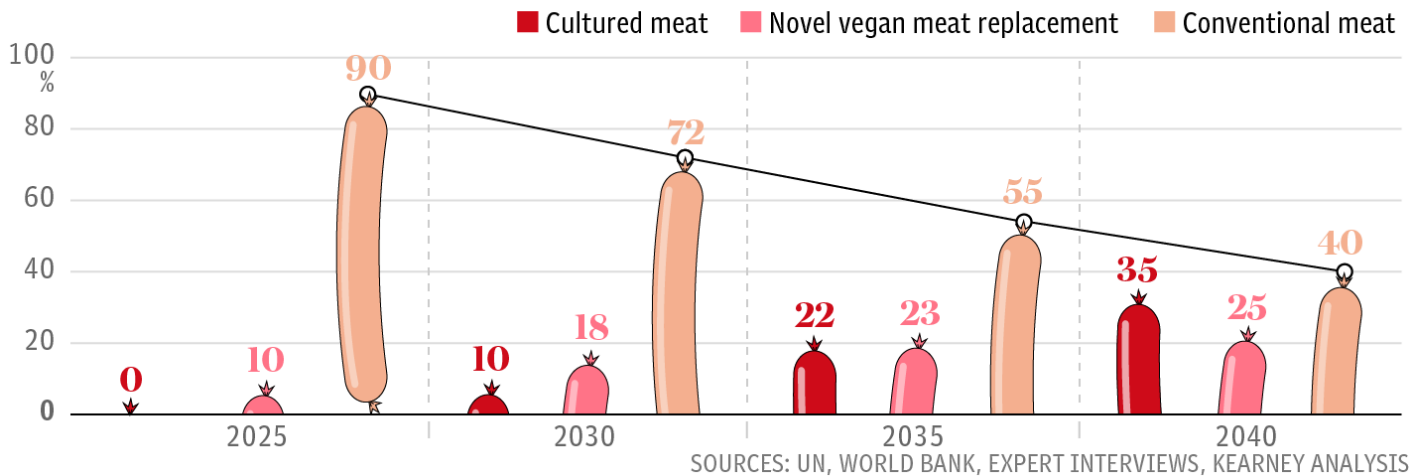
Impossible Foods' Impossible burger, another which mimics the colour of a beef patty | CREDIT: IMPOSSIBLE FOODS

Establishing consumer trust, then is first of a series of steps to market dominance. Many in the industry describe the same unfolding sequence they hope to see: the launch of niche, premium products in restaurants and supermarkets in the next few years; early adopters becoming word-of-mouth advocates while regulatory and manufacturing process are streamlined; greater confidence leading to greater funding, the entry of major industrial players lowering costs still further; until the magic moment comes when plant-based and cultured meat both tastes as good as, and is cheaper than, traditional meat.

It is a virtuous cycle. One in which plant-based products erupt from their less than 1 per cent meat market share of today, and cultured meats, the first of which are due for launch in 2022, do the same, jointly contributing to a tipping point at which traditional farming - from birthing pens to abattoirs - become a thing of the past.

Global meat consumption

By 2040 conventional meat supply will drop by more than 33%



It is not impossible. A report last year suggested the tipping point - when cultured and plant-based meats overtake conventional meat supply - will have arrived by 2040.

Already, the flourishing number of companies involved, and the sums being invested in them, suggests that such products are moving from a fringe to a mainstream tech sector. By the end of 2019, there were 55 cultured-meat startups around the world. Last year the “Impossible” Whopper was debuted at Burger King restaurants across America, which testified to the mainstream acceptance of plant-based products, as did the launch of plant burgers by JBS, the world’s largest meat producer, and Nestle. Tyson, whose CEO suggested Covid was shattering the traditional food supply chain, itself launched a line of plant-animal blended products and meatless nuggets, and made several investments in new food startups.

The industry, then, has come a long way since the plant-based horrors of the 1980s, and since 2000, when the two earliest projects to grow meat in a lab - one funded by Nasa - got under way and produced preliminary samples that were, according to one research paper “inspected, smelt and described as ‘acceptable as food’”.

But of course, innumerable missteps - scandals, health hazards, or sheer technical difficulties - could intervene to interrupt the rise of these new meats. Among the many voices - in academia, analytics, investment or the industry itself - that I spoke to for this article, opinion differed about when the breakthrough would come for cultured meat.

Most suggested a five to 10 year horizon for products appearing on the market and gaining acceptance. Most also cautioned against the promises in the next couple of years. But all were confident that the displacement of traditional meat and the farming processes behind it was a matter of when, not if. I tended to conclude my interviews by asking if, as a

45 year-old, I should be lucky enough to live another 45 years, would abattoirs still be standard at my death? All agreed they would have largely or completely disappeared.

That would represent an astonishing transformation, a transformation which some liken to the car taking over from the horse. At the car's debut, the two technologies delivered roughly the same. But the horse was at the upper limit of what it could do. The car was only beginning its journey of improvement. With more investment, infrastructure, acceptance, might new meats too be at the beginning of their journey, so that a man of my age might look back at the end of his life, and consider how extraordinary it was that at its outset, the globe sustained a vast population of livestock - 1.4 billion cows, 1 billion pigs, 20 billion poultry, and 1.9 billion sheep, lamb, and goats at last count - which were raised purely for slaughter?

If that comes to pass, 2020 may come to be seen as a tipping point all of its own - a point where the risk of transmission of deadly, novel diseases from animal to man became abundantly, tragically clear; and where the appeal of meats grown in sterile laboratories, where traceability at every stage of the process can be guaranteed, began to take off.

"Today, people understand animal-human contamination much better," says Inigo Charola. "Before it was a horror movie, some kind of science fiction. Now it is real."

The Future Of longread series is taking next week off, but will return on Thursday 30 July, check back on our site at 8am BST then for the next chapter.

The previous four instalments covered [the future of the Great British country pub](#), [the future of Portsmouth FC](#), [the future of female friendship](#), and [the future of the fried chicken shop](#).

Would you have any qualms about eating lab-grown meat? Are you eating more vegetarian or vegan foods than before? What's your favourite meat-centric dish? Let us know in the comments below, and look out for Harry de Quetteville, who will be visiting at 12pm BST on Thursday 16 July.

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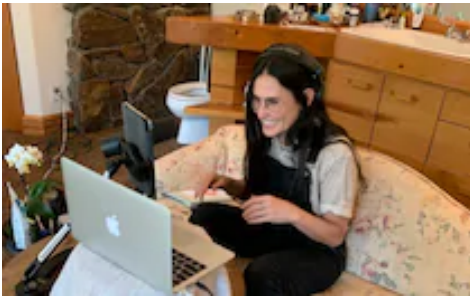
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