Frequently Asked Questions

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1. About cultured meat

What is cultured meat?
Cultured meat (also known as “cultivated meat”, “cell-based meat”, “clean meat” or “slaughter-free meat”) is the same thing as regular meat, but just produced differently.

Meat is made of muscle and fat tissue, which we normally get by slaughtering animals. But, instead of slaughtering an animal, we can also grow this same tissue directly from animal cells – and this is what cultured meat is.

Cultured meat isn’t a plant-based substitute (such as the Impossible Burger or the Beyond Burger). Rather, it’s real meat that under a microscope is indistinguishable from meat that comes from a slaughtered cow, pig or chicken.

What does it taste like?
Like meat! We are aiming for our meat to be molecularly the same as regular meat, which means it will taste the same.

How is it made?
The first step is to take some cells from an animal, such as a cow if we’re making beef. This is done by a veterinarian, who uses a small biopsy to take a tiny sample of cells (no harm is caused to the animal).

The cells that are extracted are stem cells. These are “undifferentiated” cells that have the capacity to multiply, and to turn into another type of cell, such as a muscle or fat cell.

The stem cells are fed nutrients and growth factors (naturally-occurring proteins that promote cell growth). This causes them to proliferate, until we get trillions of cells. This growth takes place in a vessel called a “bioreactor”, which looks similar to the tanks that beer is fermented in.

Once we have lots of undifferentiated cells, the next step is for them to become muscle or fat cells. In order to trigger this transformation, we stop feeding the cells the growth factors, and this causes them to start differentiating naturally.

At this stage, we still have lots of loose cells. But meat is made of muscle tissue – that is, lots of muscle cells that are organised into a structure (a muscle fibre). So the next step is for the cells to form into tissues.

To make muscle tissue, we put the muscle cells onto a gel scaffold and, with this structural support, the muscle cells start to naturally contract, put on bulk, and form into muscle fibres.

When we layer all the muscle fibres together (about 20,000 fibres for one hamburger patty) and add
the fat we have meat!

The meat can then be processed using standard food technologies. For example, we could put the meat through a grinder to make ground beef.

Because it is real meat, it has the same properties we’re used to from conventional meat. For example, it “bleeds” like conventional meat, and sizzles and browns when you cook it.

Is it natural?
There is an initial reaction by many people that “lab-grown” meat is unnatural, and that’s completely understandable. But the fundamental process of the cells growing is actually the same natural process, it just happens outside the animal’s body.

Furthermore, it’s easy to see that conventional meat itself is not really natural anymore. The farm animals we eat today have been selectively bred to have very different characteristics from their wild ancestors. Furthermore, most meat comes from industrial farms, where animals are kept in very unnatural conditions. Moreover, they are fed concentrates, antibiotics and, in some cases, artificial growth-promoting hormones. In contrast, we do not need to use antibiotics or artificial growth hormones to make cultured meat.

Is it safe to eat?
Yes, it is. Cultured meat will be rigorously tested by the regulatory authorities, and it will only be allowed onto the market if the regulators are convinced it is absolutely safe.

In fact, it’s possible that cultured meat will actually be more safe than conventional meat because it will be made in a cleaner environment. Slaughterhouses are not sterile and it’s common, for example, for faeces to come into contact with the meat. In contrast, cultured meat will be produced in a sterile environment, which reduces the risk of contamination by bacteria.

Is it genetically modified?
No, Mosa Meat does not do any genetic modification (GM). As the cells we use are doing what they would do inside the animal’s body, there is no need to modify them. Furthermore, GM foods are banned in much of Europe, where Mosa Meat is based.

Can you make different types of meat?
Yes, we can theoretically make cultured meat from any animal that has stem cells that can turn into muscle and fat cells. As far as we know, that is the case for all the animals we commonly eat, including cows, pigs, chickens and fish.

Could you make a steak?
Our first products will be ground meat products, which account for approximately 50% of the total meat market. Producing a larger and more complex structure (such as a steak) presents a larger scientific challenge so will take longer, but we believe we can do it in the future.
How did the idea of cultured meat come about?
The idea is actually quite old. In 1931, Winston Churchill authored an article where he imagined the world “Fifty Years Hence”. He wrote of the future that: “We shall escape the absurdity of growing a whole chicken in order to eat the breast or wing, by growing these parts separately under a suitable medium”.

Several decades later, a Dutch entrepreneur called Willem van Eelen, who held the first patent for the production of cultured meat, began to enthusiastically campaign for the advancement of this technology. He motivated scientists from Dutch universities, including our CSO Prof Mark Post, as well as representatives from a meat processing company (Stegeman, represented by Mosa Meat’s Peter Verstrate) to develop a program and obtain funding from the Dutch government.

The so-called “InVitroMeat Project” was started in 2004. During the project, Mark and Peter became so enthusiastic about the idea that they decided to raise the money to create the world’s first cultured hamburger.

Google co-founder Sergey Brin made a major donation to fund the project, and a team of scientists in Maastricht spent months creating the hamburger. It was unveiled in 2013 at a press conference in London, an event that helped trigger the emergence of the growing cultured meat industry.
2. About Mosa Meat

Who are we?
We are a start-up company formed in 2016 in Maastricht, the Netherlands. Our team created the world’s first ever cultured meat hamburger. Our science is led by Prof Mark Post, the “founding father of cultured meat”. Our mission is to commercialise cultured meat and make it a hugely popular product so that we can all continue to eat the real meat we enjoy, but without the very harmful effects of livestock meat production. There are currently over 30 of us, mostly scientists and engineers, led by our CEO Maarten Bosch. We are all incredibly passionate about trying to have an enormous positive impact on the environment, animals, food security and human health.

What distinguishes Mosa Meat?
Our team was the first to unveil cultured meat, and our Chief Scientific Officer, Prof Mark Post, is considered the leading scientist globally on this topic. We pride ourselves on the strength of our scientific team.

In terms of our products, Mosa Meat is defined by our emphasis on high quality. We are committed to making products that contain the same mature tissues as livestock meat so that they have the same taste and texture. We don’t use genetic modification or add plant-based fillers - it’s real meat!

What have you been working on since the first hamburger launch in 2013?
The purpose of the hamburger we unveiled in 2013 was to show that the science is actually possible. But the product wasn’t perfect, and it was also prohibitively expensive to produce.

So, since 2013 we’ve been working hard on R&D with two focuses. Firstly, we’ve been improving the product. For example, the 2013 burger didn’t contain any fat (which is important for taste and texture), so we’ve been working on adding this.

Secondly, we’ve been working on how to scale up from lab-scale to an industrial-scale process that can ultimately produce hamburgers at competitive prices (and without using any animal-derived components in the production process, except the initial cells).

In parallel, we’ve been growing the company from just the two founders to a world-class team of over 30 scientists, engineers and business developers.

What’s next for Mosa Meat?
Looking forward, we’re excited to be entering a new phase of preparation for the introduction of commercial products, and gearing up to sell them across the globe.

In the next few years we will be focused on obtaining regulatory approval for the sale of cultured meat, actually scaling up production (including the construction of a pilot factory), and introducing our first products to market.
**What will your first product be?**
We are focussing first on beef products because cows have such an outsized negative impact on the environment. Cows are highly inefficient – they convert only 15% of edible food crop into meat we can eat (pigs are twice as efficient and chickens are four times as efficient). This means that cows use the most resources, generate the most greenhouse gas emissions, and have the most deleterious impact on the planet.

**When will it be available to buy?**
We are aiming for a first market introduction in the next few years. It is very difficult to commit to a particular timeframe because there are still some scientific unknowns and factors outside our control (such as the regulatory process). The first introduction will likely be small-scale. Several years beyond that, we aim to be widely available in supermarkets and restaurants.

**How much will it cost?**
Ultimately, cultured meat should be less expensive than conventional meat because its production is more efficient. But, as with most new technologies, the first products will be sold on a small scale at a high price. As we scale up, the price will come down, and we aim to ultimately be competitive with meat products currently in supermarkets.

**How much does it cost right now?**
For the past few years, our focus has been on improving the product and developing a scalable production process (as opposed to working on bringing down the price). We’ve reduced the cost of some parts of the process (for eg, by reducing manual labour through automation, and eliminating costly components of the medium). But the process remains expensive, and will only really come down in price when we scale up significantly.
3. About the societal benefits

What are the benefits of cultured meat?
Cultured meat has the potential to have enormous positive impacts on food security, the environment, animal welfare and human health.

The Food and Agriculture Organisation of the United Nations (FAO) estimates that the demand for meat is going to increase by 70% by 2050. Current production methods alone will not be able to satisfy this demand. If we want there to be enough meat for everyone in the future, we need another way of producing it.

Furthermore, livestock meat production contributes significantly to global warming through unchecked releases of methane, a greenhouse gas 20-30 times more potent than carbon dioxide as a heat-trapping gas. It has been projected that cultured meat could generate significantly lower greenhouse gas emissions (perhaps as much as 96% less emissions), helping us avoid the disastrous consequences of climate change.[1]

Beyond climate change, livestock production has a number of other serious effects on the environment. For example, raising livestock (and growing crops to feed them) uses large amounts of land, leading to mass deforestation. For instance, large parts of the Amazon rainforest have already been cleared for cattle. This in turn leads to drastic loss of biodiversity. Each day we lose upwards of 80,000 acres of tropical rainforest, and with it about 135 plant, animal and insect species. That’s 50,000 species going extinct every year. It is expected that cultured meat production would use 99% less land,[2] which would mean that land could even potentially be reforested.

Of course, cultured meat could also have an enormous impact in reducing the suffering of the billions of animals reared for food production each year, the majority in industrial farms where they experience inhumane conditions.

And, importantly, it could also be very beneficial for our own health. As it is produced in a sterile environment, we expect that cultured meat will be less prone to bacterial contamination, which currently causes millions of incidences of foodborne illness every year.

There is also the very important public health issue of antibiotic-resistant superbugs. The heavy use of antibiotics (including the huge quantity given to farm animals) means that bacteria are increasingly resistant to the drugs we have to treat them. The World Health Organization describes superbugs as one of the greatest threats to the human species. Because cultured meat will be produced in a sterile environment, it will be possible to reduce or eliminate the use of antibiotics in meat production, which could help significantly in controlling the spread of superbugs.

How much land will the production of cultured meat use compared to traditional meat production?
According to a life cycle analysis published in Environmental Science and Technology, cultured meat production will use an estimated 99% less land, [3] reducing the impetus for further deforestation.
and mass loss of wildlife. The land that is used today for raising livestock could be “given back”, allowing nature to regain its balance.

**How much water will the production of cultured meat use compared to traditional meat production?**
It has been estimated that cultured meat production will use between 82% to 96% less water than conventional meat production, depending on the product compared.[4]

**What is the real carbon footprint compared to traditional meat production?**
Various studies have made preliminary estimates of greenhouse gas (GHG) emissions from cultured versus livestock meat production.
While uncertainty is currently high, several academic studies have projected that cultured meat production (especially beef) will produce substantially less GHG emissions than conventional meat [5] [6] [7].

Of course, the actual carbon footprint will depend on what the production process ultimately looks like at large scale. But these early studies indicate the large potential for cultured meat to help us mitigate climate change. It is actually one of the main reasons many of us are doing this work!

**Is it better to develop plant-based substitutes?**
Our objective is to eliminate the harmful effects of livestock farming. One solution is switching to plant-based diets, and it is exciting to see the growing popularity of plant-based foods.

However, we are concerned that many people will not want to become vegetarian or vegan. Therefore, we think we need to look at every possible avenue of replacing livestock farming for all consumers, including cultured meat.

**Does cultured meat involve cruelty to animals?**
Improving animal welfare for billions of farm animals is one of the main reasons we started Mosa Meat, and our meat does not involve any cruelty to animals.

We do have to take a cell sample from a donor animal using a biopsy, but this is done under anaesthesia by a veterinarian and does not cause damage to the animal.

Furthermore, one cell sample can create up to 10,000kg of cultured meat, so we don’t have to take biopsies very often. And we do not need many cows – theoretically we would only need 150 cows to satisfy the world’s meat demand. By contrast, the worldwide herd is currently 1.5 billion cows.

Importantly, drastically reducing the number of farm animals in husbandry will make it possible to treat those animals humanely, and provide them with comfortable living conditions.
4. About the market

How big is the meat market?
Globally, over 300 million tonnes of meat is produced for consumption each year at a value of nearly one trillion US dollars.

Furthermore, the UN Food & Agriculture Organisation estimates that meat consumption will be 70% higher than the current level by 2050. In line with this, the World Health Organisation projects meat demand will double in the next 40 years.

This soaring demand is driven by global population growth, as well as a growing middle class in the developing world.

Can cultured meat disrupt the entire meat market?
We think that in time cultured meat can replace all conventional meat. The first cultured meat products are likely to be ground products, which make up approximately 50% of the global meat market, and other cuts of meat will follow. Given its production is more efficient, we expect cultured meat to eventually be as affordable as livestock meat.

How many cultured meat companies are there?
The field is growing quickly and many new start-ups are emerging. As of 2019, we are aware of around 30 cultured meat companies (working on beef, fish, chicken and pork), based mostly in the US, Europe and Israel.

Do you see plant-based products like the Impossible Burger as competitors?
We see new high-tech plant-based products like the Impossible Burger as complementary to cultured meat. We are excited about the prospect for people to replace some of their meat diet with sustainable plant-based substitutes, but we also think that some people will continue to want to eat meat. Therefore, we think there will be enormous demand for cultured meat products.

Will consumers accept cultured meat?
A number of surveys have been conducted in various European countries and in the US with a range of results (indicating as few as 20% or as many as 90% of consumers will try cultured meat). Even 20% of the public is an enormous market of first adopters. We are confident that when the product is of high quality and is competitively priced the benefits will appeal widely to consumers.

Will cultured meat be acceptable to vegetarians or vegans?
This perhaps depends on how one defines “vegetarian” and “vegan”. If it is taken simply to mean not eating meat (or meat and dairy) then the answer is “no” – after all, cultured meat is meat.

However, many people who are vegetarian or vegan do not object to meat in and of itself, but rather the ethical problems associated with its production. As cultured meat does not require the inhumane treatment or slaughter of any animals, nor does it have the same environmental impacts as livestock meat, it may be acceptable to many vegetarians and vegans.
Our real goal, however, is to provide sustainable and animal-friendly meat for the majority who currently eat meat, as this will have the greatest effect in reducing greenhouse gas emissions, environmental damage and animal suffering.

How has the meat industry reacted to cultured meat?
The meat industry recognises that livestock farming will not be able to fully satisfy soaring global meat demand, and meat companies are looking to diversify the range of proteins that they produce. Mosa Meat and other cultured meat companies have received investments from some of the world’s largest meat companies. We aim to work with meat companies to bring cultured meat to the market as widely and as soon as possible.

Will cultured meat put farmers out of a job?
If it is widely adopted, cultured meat will change the way that meat production is organised, and make some farming jobs obsolete. This won’t happen instantly, so there will be time to transition.

Fortunately, those working in livestock industries may be well positioned to take advantage of new market opportunities from cultured meat. For example, farmers already producing feed for animals may have an advantage in transitioning to producing feed for cells, which will be a large new market.
5. About the science

What are the biggest scientific challenges to creating commercial products?
In the past few years we’ve worked hard on improving our product, and removing all animal components used in the production process (such as Fetal Bovine Serum).

The next big scientific and engineering challenge is creating a scalable production system. We are now working on designing this and implementing it in our first pilot factory.

Do you still use fetal bovine serum (FBS) in the medium?
No, we do not use Fetal Bovine Serum in the cell culture medium.

For us, it was very important to eliminate FBS from the production process. Obtaining FBS from unborn calves is incompatible with our animal welfare beliefs. Furthermore, given the point of cultured meat is to reduce the herd of cows worldwide, it would be inherently unsustainable for our production process to rely on a product derived from the foetuses of slaughtered cows. We have a “Medium Optimisation” team who have worked hard the past year and successfully removed the Fetal Bovine Serum from our medium.

How long does it take to make a hamburger?
It takes about 10 weeks to make a hamburger. But this doesn’t mean we can’t produce at industrial scale in the future. Because cell growth is exponential, it takes 10 weeks to produce one quarter pound hamburger, but only about 12 weeks to produce 100,000 hamburgers. In comparison, it takes about 18 months to raise a cow for slaughter, from which you would get less than 1500 quarter pounders.

What volume of beef can you produce from a cell sample?
That depends on the level of scaling of production in future. Theoretically, from one sample of less than one gram of muscle we can produce 10,000 kilograms of beef, reaching a multiplication factor of 10 million. If this is translated into a reduction of cows, we would need only 150 cows to meet the entire world’s meat demand (the planet now hosts roughly 1.5 billion cows).

How do you physically scale up production?
Cell culture, in particular of mammalian cells that need to grow while being attached to a surface, is typically done in a lab in Petri dishes or culture flasks. These have an unfavourable surface-to-volume ratio and cannot easily be scaled up.

Therefore, at scale we culture cells on microcarriers (small spheres the cells can grow on) that are suspended in a large vessel (i.e. a bioreactor). The bioreactor contains culture medium, a nutrient broth which “feeds” the cells so they can proliferate. The contents of the bioreactor are constantly stirred to ensure all the cells get access to the oxygen and nutrients they need to survive.
Since one starts with a small amount of cells, the culture begins in a flask and moves up from there to a small bioreactor, and then to a larger bioreactor, and then a larger bioreactor again.

**Do you use antibiotics?**
As the production process is completely sterile, we expect to be able to eliminate or significantly reduce the use of antibiotics and antifungal drugs.

**Will cultured meat age the same way as livestock meat?**
Ageing of meat depends on “auto-digestion” and microbial contamination.

Auto-digestion is the decay/tenderisation of meat by enzymes that are present in the tissue. They will be present in cultured meat, similarly to livestock meat.

However, as cultured meat is produced in a sterile environment, there will not be microbial contamination as there is with livestock meat.

Therefore, it is likely that cultured meat will last for longer. This could mean that there will be less food wastage (as the meat will not go “off” as quickly).

**Could you make cultured meat at home?**
Theoretically it would be possible to have meat production in your own home, just as some people have vegetable gardens.

However, it probably isn’t a very realistic scenario. Producing meat on a tiny scale would take about 10 weeks, so it would perhaps only appeal to the most patient of chefs!

On a slightly bigger scale, however, we can imagine communities sharing a local production system. We could have community farms in the middle of the city with a couple of animals that are cared for by the locals together. Every now and then, they would take some stem cells from the animals (using a biopsy under anaesthesia), which would be used to farm meat for the community in a small building nearby.

This could potentially be very advantageous for communities that don’t have ready access to meat. We can even imagine having self-supporting “meat factories” carried around in vans that could deliver meat to areas that are completely cut off, such as refugee camps and disaster zones.

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