Building a $325,000 Burger

By Henry Fountain

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MAASTRICHT, the Netherlands — As a gastronomic delicacy, the five-ounce hamburger that Mark Post has painstakingly created here surely will not turn any heads. But Dr. Post is hoping that it will change some minds.

The hamburger, assembled from tiny bits of beef muscle tissue grown in a laboratory and to be cooked and eaten at an event in London, perhaps in a few weeks, is meant to show the world — including potential sources of research funds — that so-called in vitro meat, or cultured meat, is a reality.

"Let's make a proof of concept, and change the discussion from 'this is never going to work' to, 'well, we actually showed that it works, but now we need to get funding and work on it,' " Dr. Post said in an interview last fall in his office at Maastricht University.

Down the hall, in a lab with incubators filled with clear plastic containers holding a pinkish liquid, a technician was tending to the delicate task of growing the tens of billions of cells needed to make the burger, starting with a particular type of cell removed from cow necks obtained at a slaughterhouse.

The idea of creating meat in a laboratory — actual animal tissue, not a substitute made from soybeans or other protein sources — has been around for decades. The arguments in favor of it are many, covering both animal welfare and environmental issues.

A 2011 study in the journal Environmental Science and Technology, for example, showed that full-scale production of cultured meat could greatly reduce water, land and energy use, and emissions of methane and other greenhouse gases, compared with conventional raising and slaughtering of cattle or other livestock. Those environmental arguments will only gain strength, advocates say, as worldwide demand for meat increases with the rise of middle-class populations in China and elsewhere.

Dr. Post, one of a handful of researchers in the field, has made strides in developing cultured meat through the use of stem cells — precursor cells that can turn into others that are specific to muscle, for example — and techniques adapted from medical research for growing tissues and organs, a field known as tissue engineering. (Indeed, Dr. Post, a physician, considers himself first and foremost a tissue engineer, and about four-fifths of his time is dedicated to studying how to build blood vessels.)

Yet growing meat in the laboratory has proved difficult and devilishly expensive. Dr. Post, who knows as much about the subject as anybody, has repeatedly postponed the hamburger cook-off, which was originally expected to take place in November.

His burger consists of about 20,000 thin strips of cultured muscle tissue. Dr. Post, who has conducted some informal taste tests, said that even without any fat, the tissue "tastes reasonably good." For the London event he plans to add only salt and pepper.

But the meat is produced with materials — including fetal calf serum, used as a medium in which to grow the cells — that eventually would have to be replaced by similar materials of non-animal origin. And the burger was created at phenomenal cost — 250,000 euros, or about $325,000, provided by a donor who so far has remained anonymous. Large-scale manufacturing of cultured meat that could sit side by side with conventional meat in a supermarket and compete with it in price is at the very least a long way off.

"This is still an early-stage technology," said Neil Stephens, a social scientist at Cardiff University in Wales who has long studied the development of what is also sometimes referred to as "shmeat." "There's still a huge number of things they need to learn."

There are also questions of safety — though Dr. Post and others say cultured meat should be as safe as, or safer than, conventional meat, and might even be made to be healthier — and of the consumer appeal of a product that may bear little resemblance to a thick, juicy steak.

“This is something very new,” Dr. Stephens said. “People need to wrestle with the idea of whether this is meat or not.”

Dr. Post is well aware of the obstacles. “I see the major hurdles, probably better than anybody else,” he said. “But you’ve got to have faith in technological advances, that they will be solved.”

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And as with any technology, costs should eventually come down. “If it can be done more efficiently, there’s no reason why it can’t be cheaper,” he said. “It has to be done using the right materials, introducing recycling into the system, controlling labor through automation.”

Cultured meat would have some inherent cost advantages over conventional meat, said Hanna Tuomisto, whose research while at the University of Oxford in England was the basis for the Environmental Science and Technology study. “It’s really about the conversion of feed to meat,” she said. “In cultured meat production it’s much more efficient; only the meat is produced, and not all the other parts.”

Gabor Forgacs, a researcher at the University of Missouri and a founder of Modern Meadow, a start-up company that wants to develop and market cultured meat, is aware of the hurdles as well. “Getting cultured meat to the supermarket is going to be difficult, and controversial,” said Dr. Forgacs, whose approach to cultured meat has some similarities to Dr. Post’s, although he has also developed 3-D bioprinting technologies that might someday be used to create thicker tissues.

Given the difficulties, Modern Meadow is first focusing on creating cultured leather. Its process does not use stem cells but rather skin fibroblasts, specialized cells that produce collagen. “There are a lot of parallels to cultured meat, except that it is a lot less controversial because you’re not going to eat it,” Dr. Forgacs said. “But if we can convince the universe that we can build leather, it will be much easier to convince the universe that we can build meat.”

In his work on cultured meat, Dr. Post uses a type of stem cell called a myosatellite cell, which the body itself uses to repair injured muscle tissue. The cells, which are found in a certain part of muscle tissue, are removed from the cow neck and put in containers with the growth medium. Through much trial and error, the researchers have learned how best to get the cells to grow and divide, doubling repeatedly over about three weeks.

“But we need billions,” said Anon van Essen, the technician in Dr. Post’s lab.

The cells are then poured onto a small dab of gel in a plastic dish. The nutrients in the growth medium are greatly reduced, essentially starving the cells, which forces them to differentiate into muscle cells. “We use the cell’s natural tendency to differentiate,” Dr. Post said. “We don’t do any magic.”

Over time the differentiated cells merge to form primitive muscle fibers, called myotubes. “And then they just start to put on protein,” Dr. Post said, and organize themselves into contractile elements. The key to this self-organization, he said, is that the cells are anchored in place (using a technique that he declined to disclose; earlier in his work he used Velcro). “We add anchor points so they can attach to something and start to develop tension,” he said. “That is by far the biggest driver of protein synthesis, and they do that by themselves.”

The result is a tiny strip of tissue, about half an inch long and only a twenty-fifth of an inch in diameter, that looks something like a short pink rice noodle, Dr. Post said.

The strips have to be thin because cells need to be close to a supply of nutrients to stay alive. One approach to making thicker tissues — to make a cultured steak rather than a hamburger, for instance — would require developing a network of channels, the equivalent of blood vessels, to carry nutrients to each cell. (A steak would also require culturing fat and incorporating it in the tissue, something Dr. Post has not had to do with his burger.)

Dr. Post said that one advantage of using myosatellite cells is that they differentiate easily. “The satellite cell is the ideal cell,” he said. “You don’t have to pull a lot of tricks to let it differentiate. I also think it’s a practical advantage of keeping a lot of the stem cell production and quality control in the animal itself.”

But others note that since there is a limit to how often myosatellite cells can reproduce, Dr. Post’s cultured meat will never be completely animal-free; he will always need a supply of muscle tissue from which to obtain new cells.

Other researchers are studying different kinds of stem cells that, unlike myosatellite cells, can reproduce indefinitely, ensuring a “livestock-autonomous” supply of cells to make cultured meat. Dutch researchers at Utrecht University are trying to isolate embryonic stem cells from pigs and cows. And Nicholas Genovese of the University of Missouri is trying to develop a type of stem cell that is “induced” from a regular adult cell. So a skin cell from a pig, perhaps, could be turned into a stem cell that could reproduce indefinitely and differentiate into muscle tissue to create cultured pork.

But Dr. Post said that efforts to use different kinds of stem cells introduced other problems. And even if his approach means the world will still need cattle, it will need far fewer of them. “If we can reduce the global herd a millionfold, then I’m happy,” he said. “I don’t need to reduce it a billionfold.”

Anyway, he said, “a lot of the technologies in the process we are currently using eventually have to be changed, if not all of them.

“That’s not the point of the proof of concept,” Dr. Post said. “The point is, we already have sufficient technology to make a product that we could call meat or cultured beef, and we can eat it and we survive.”

“I’m not by nature a very passionate guy,” he added. “But I feel strongly that this could have a major impact on society in general. And that’s a big motivator.”

What We Eat: This is the fourth in a series of articles exploring the science of food.

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