



The Race to Make Cell-Grown

Meats

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ON AUGUST 5, 2013, CHEF RICHARD McGeown was in London, preparing to film a cooking segment on British television. McGeown was searing a burger, something he'd done countless times before. But this time, an estimated billion people would be watching or reading about what was about to transpire. Because the round, pink mass McGeown was cooking was a \$325,000 burger made from stem cells cultivated in a lab by scientists in the Netherlands.

"It's close to meat," said Hanni Rützler, a food trend researcher who tried the so-called in-vitro patty. But, she noted, it lacked fat and juiciness. Perfection wasn't the goal for Mark Post, the lead scientist behind the burger. "This is just to show we can do it."

Futurists have imagined growing meat from cells for decades. In an essay containing his predictions for a world fifty years beyond its 1931 publication date (republished in the March 1932 issue of *Popular Mechanics*), Winston Churchill described a future where we "escape the absurdity of growing a whole chicken" in favor of a lab-grown breast or wing.

We're still probably a decade away from lab-grown hot wings, but cultured chicken nuggets and burgers might be available in the next two years, says Kate Krueger, PhD, a cell biologist and the director of research for New Harvest, an organization that funds cultured meat research. Initially, those products will probably appear in restaurants, but eventually they'll hit grocery stores.

Still, chasing cultured meat is "a bet," concedes Josh Tetrick. The 39-year-old is the CEO and co-founder of Just, an eight-year-old San Francisco

company that makes a plant-based mayonnaise and an egg scramble made from mung beans. Now, Tetrick is hell-bent on proving that cultured proteins alone, not plant-based substitutes, have the unique ability to completely replace conventionally farmed meat in our diet.

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The cells that comprise a cultured steak are nearly identical to those in the meat from a butchered cow. Both are made of animal tissue, with very few differences. In other words, as Tetrick says, cultured meat is real meat.

PAOLA BIGNONE, PH.D., SENIOR research scientist on Just's Cellular Agriculture team, peers into a microscope under a fume hood in one of the company's cultured meat labs. The lab looks like any other research facility, lots of white and stainless steel. But what happens in this lab is anything but ordinary. The team keeps mum on many of the particulars of the growing process, especially the nutrient cocktail that is fed to the cells, because the cost and efficacy of that cocktail are what will undoubtedly determine which of the 20-plus companies that are working on cultured meat will win the race to market.

The process of making cultured meat is actually much closer to the process of growing organs for transplant than it is to raising and slaughtering conventionally farmed animals.

Bignone starts with a very small cluster of cells: All that's needed is a push pin-sized tissue biopsy usually taken from the muscle tissue of a live chicken. Though that first burger cooked in London came from cells from a dead cow, these days the source livestock are all very much alive. "We don't need to sacrifice the animal," says Vitor Espírito Santo, PhD, the Director of Cellular Agriculture for Just, who leads the company's cultured meat team. "The tissue samples can be taken out in a way that's fairly painless" using local anesthesia, says New Harvest's Krueger. "They don't feel anything and they're happily back

out in the field that very day." And you can grow quite a bit of meat from just a few cells, says Santo.

The first part of the culturing process is isolation: separating the satellite cells—adult muscle stem cells that can divide to create more muscle cells—from the rest of the tissue. To coax these cells out, Bignone places the biopsied tissue in a container with a proprietary mix of salt, sugar, and proteins. The container is put into an incubator the size of a mini-fridge that mimics the temperature and movements of a growing animal's body.

The next step in the process is growth. Santo says the scientists feed the cells much like a farmer would feed an animal. But instead of dump-





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ing grass or grain into a food trough, labs techs bathe the cells in a liquid solution that contains proteins, sugars, vitamins, "a cocktail of different nutrients that are also available in the animal's body," says Santo.

Cultured meat researchers initially fed all cells fetal bovine serum, a thick, nutrient-packed fluid made from tissue extracted from a slaughtered calf. But in addition to being expensive, the serum poses an obvious conflict for an industry that's positioned itself as an alternative to conventional animal farming. That's why all of Just's cultured meats are serum-free.

Santo points to several clear lab flasks about the size of a half-gallon of milk. Each is partially filled with

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the initial red liquid "food." As the cells grow and proliferate, the team changes the recipe of the liquid nutrients to boost growth. These starter cells continue to grow in a petri dish until they differentiate into a more mature, fibrous muscle tissue.

Scientists can cultivate the differentiated cells into the exact texture and structure they want in their meat, either using one of the small bioreactors they have in-house or using one of the larger ones they have at their off-site facilities. During this stage they

ALSO ON THE MENU OF THE FUTURE

INSECTS

Most common types for human consumption are the Acheta and the banded cricket, says Jarrod Goldin, president of Canada-based insect farm Entomo Farms. Packed with a nutty, earthy flavor, crickets are rich in protein, prebiotic fibers, and antioxidants.

ALGAE

Triton Algae Innovations's proprietary strain of algae boasts flavor-mimicking properties—think savory flavors of meaty foods and salty notes of umami. "It runs about 45 to 50 percent protein, has a complete amino acid profile, and is rich in vitamin A and iron," says David Schroeder, director of corporate and regulatory affairs.

ANIMAL-FREE EGG WHITES

Clara Foods converts sugar into proteins, which are then encoded with 3D-printed genes that code for the same proteins found in an egg, explains CEO Arturo Elizondo. One strain produces a baking albumen; another generates a soluble mix for drinks.

3D FOOD PRINTING

With the aid of a precision tech system, preloaded shape libraries, and customizable print nozzles, 3D printer Foodini prints with fresh ingredients. "[These printers] don't require arable land, fixated CO₂ or regular feed, and require far less water," says food designer Chloé Rutzerveld. —Leah Campano

can also add more fat or other ingredients to boost flavor. The duration of the process varies, too—up to eight weeks or more, depending on the protein.

Just receives cells from some of the most prized animal farms in the world, including a Wagyu beef operation called Toriyama Farms located in Gunma, Japan. Tetrick talks about the beef in glowing terms: "It has the best umami [flavor], the best texture, the best color." The Wagyu is the flashiest protein in Just's wheelhouse, but the company's fastest-growing cells come from a chicken, which is why the company's first cultured meat product will be chicken nuggets, not a Wagyu burger. Santo says the first nugget will probably be sold at one or two high-end restaurants in Asia, possibly as early as this year, as the company has been in discussions with government regulators in countries there for several years.

Once Just gets better at making cultured meat on the cheap, however, Tetrick says you can expect to see more of these once-exclusive proteins. "I think the future of cultured meat is premium meat like Wagyu and bluefin tuna," he says, because in the world of cultured meat, those few initial cells aren't the main cost, the growth factors are. "It's actually not any more expensive to take a cell and then scale that cell up from the world's most expensive cow than the world's cheapest," he explains.

BEING ABLE TO EAT WAGYU ON A ground chuck budget isn't the only upside to cultured meats. Getting Americans to eat less conventionally farmed meat, especially beef, is also an environmental win, says Caroline Grunewald, a food and agriculture analyst at the Breakthrough Institute. Raising beef and other ruminant meats like lamb produces much higher greenhouse gas emissions than other proteins like beans and nuts, and these emissions are major contributors to climate change. Researchers compared how much GHG emissions conventional beef production currently produces with how much cultured meat is expected

to produce at the same scale, and found that cultured meat production would likely result in lower emissions.

Cultured meat doesn't require antibiotics beyond the initial tissue isolation to keep an animal healthy, either, which means it could help drastically reduce the spread of antibiotic-resistant bacteria associated with conventional chicken and pork production. And with no animal waste, there's much less risk of an outbreak from pathogens like *E. coli* (assuming the company's production facilities can match the pristine conditions of a laboratory).

It will also likely take less land to produce cell-based meat. That's important because certain types of land, like forest, serve as "carbon sinks," which means they keep carbon trapped in the vegetation and the soil rather than releasing it into the atmosphere where it amplifies greenhouse

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heating. When you clear forest to produce something like beef, or grain used to feed beef, you release more carbon, explains Tim Searchinger, a research scholar at Princeton University and a Senior Fellow at the World Resources Institute, an organization that researches environmental issues like sustainable food production.

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more efficient, cultured meat proponents say the industry has an even greater potential to lower its greenhouse gas emissions and be better for the planet.

CHEF JOSH HYMAN WAITS FOR A small pot of oil to heat up in the test kitchen before dropping in a single frozen cultured chicken nugget. It looks like any other nugget purchased in the freezer aisle of a grocery store: a clump of ground chicken that is breaded,

flash-fried, and frozen. As we chat, Hyman reflects on one of Just's earliest tests.

The scientists had rushed upstairs from the lab with about a teaspoon-sized clump of cells that looked like ground chicken and asked him to cook it. When Hyman pan-fried that first bit of chicken, it was tasty. Tender. Their next step was a comparison test: "We made two veggie burgers," he says. "We added cultured chicken to one and we left the other one alone." As the burgers cooked, something happened in the room, according to Hyman, who sniffs at the air to demonstrate. Colleagues rushed over to ask if they were cooking meat, which proved they'd nailed the aroma. As the burgers cooked,

▼ The lab growing process could bring down the cost of exclusive proteins like bluefin tuna.

"you could see that Maillard reaction," says Hyman, referring to the browning





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chemical reaction that happens to meat and other foods. The taste difference between the two was “night and day,” says Hyman. The chicken-veggie blended burger was so much more juicy and delicious, like a real chicken burger. “That was kind of the click, when we understood what we were working with,” he says.

“This is close to the final formulation,” Hyman tells me as he lifts the crispy nugget up out of the oil with a wire skimmer and drops it onto my plate to cool. “But...we’re still tweaking here and there.” I slice the nugget in two; it’s white on the inside, sort of

crumbly, almost like a chicken burger. The breading. The nugget tastes perfectly sea better than a food nugget.

Lou Cooper, CEO of Bluebird, a company that has raised over \$100 million in 2019, says Tetrack. He says the industry is still in its infancy, and meat business processing is still in its infancy. He recognizes

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crumbly, almost like a small, white chicken burger. I take a bite: first, crisp breading. Then, sinking deeper into it, the nugget tastes like a light pillow of perfectly seasoned ground chicken, far better than a hockey puck-hard fast-food nugget.

Lou Cooperhouse, President and CEO of BlueNalu, a cultured fish company that reportedly raised \$4.5 million in 2018, isn't a disruptor like Tetrick. He's a self-described food industry guy who came to the cultured meat business with decades of food processing experience, which means he recognizes one of the major hurdles

...faced by lab-grown meat: scalability. But if the industry can solve that problem, Cooperhouse

thinks cultured meat is the perfect solution for the entirely unpredictable world of fish supply. Each season, the supply surges or falls at the whim of the planet. Something like increasing ocean temperatures or plastics in the ocean can do significant damage to a wild fishery, leaving fewer fish to sell to restaurants or markets. You remove all of that risk by culturing fish rather than catching it in the wild, says Cooperhouse.

Cultured meat is still pretty expensive—the current cost of a single nugget made by Just is about \$50—because the growth factors scientists feed the cells are both difficult and expensive to make, says New Harvest's Krueger. Just and BlueNalu are figuring out how to bring these costs down while making plans to build their factories, which Cooperhouse describes as something like "a microbrewery meets a traditional food processing facility." "The production systems that we use at scale look more like fermenters," explains Just's Santo, "because we actually use similar processes to make beer, wine, or cheese. The only difference," adds Santo, "is that the starting material is the animal cells"—and instead of fermenting the cells, they're growing them in bioreactors.

Companies also have to negotiate with government regulators to make sure they can actually sell their products. Santo says the company hopes to be able to share some news on that front "soon," but for now they're happy with the FDA and USDA announcement of a regulatory framework for cultured meat in March.

Even if companies can work out scale, cost, and regulatory kinks, they still have to convince consumers that cultured meats are worth eating. Alex Trembath, Breakthrough's Deputy Director, has written about the backlash to what he likes to call "fake meat." There's trepidation—and even a bit of revulsion—to meat grown in a lab. Trembath gets it: When he

made meatballs out of "meat" from Impossible, he was "sort of grossed out" by how gross and strange it felt in his hands, even though he's "perfectly fine handling ground-up cow carcasses," Trembath says the feeling is "very uncanny valley," a theory that describes the sense of revulsion inspired by robots that look almost exactly like humans but, at the same time, just a little bit different.

A person's comfort level with this stuff may depend on how they encounter it—a 2019 study found that individuals felt more negatively about cultured meat and less likely to consume it when framed and depicted in images as something high tech, rather than being characterized as "same as meat" or for "societal benefits"—and what companies end up calling it. Cultured meat has already gone by a number of different names, including clean meat, in vitro meat, lab meat, and vat meat, none of which sound very appetizing. The industry faces an uphill battle at the moment—"No, no, don't call it lab meat," Cooperhouse protests—but most consumers don't know what "cultured meat" is, at least not yet.

Tetrick knows it will probably take a long time to escape our aversions. But if Just can bring down the price of a cultured Wagyu beef patty, he thinks more chefs will be willing to serve it on their menus. And if the meat is cheap enough and the chef tries it, Tetrick starts to like his odds. "It's just better tasting. It's more umami. It's deeper. It's richer," he predicts, and then the kicker: "I think my customers would like it better."

As BlueNalu's Cooperhouse reminds me, much of the food we eat has been optimized by scientists, for better or for worse, whether it's grapes grown to taste like cotton candy or beef from cattle bred to be more docile for ease of slaughtering. If people can accept that and enjoy the pleasurable umami of a cultivated Toriyama Wagyu burger, Tetrick hopes they'll begin to ask another question: "Why do we also have this other thing [this conventional meat] on the menu?" And at that point, Tetrick will have won his bet. **PH**