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Meat Planet

CALIFORNIA STUDIES IN FOOD AND CULTURE

Darra Goldstein, Editor

Meat Planet

ARTIFICIAL FLESH AND THE FUTURE OF FOOD

Benjamin Aldes Wurgaft

UNIVERSITY OF CALIFORNIA PRESS

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For Shannon

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ONE

Cyberspace/Meatspace

I wake up to a weird future. It is 4:30 A.M. in Los Angeles on August 5, 2013. I'm about to watch the food of tomorrow appear at just past noon in London, my bleary eyes and smudged computer screen a double set of windows into space and time. I set my browser to www.culturedbeef.net. The future will arrive in the form of laboratory-grown meat made of bovine muscle cells that proliferated in a bioreactor. Or at least that's how the press event I'm awake to watch has been billed. Each announcement has been filled with promise: meat will never be the same, nor will we.[1] A basic fact about humans is that one of our food sources has, for longer than we've been *Homo sapiens,* come from the bodies of dead animals. That might soon change, as technological progress moves us further along a track that leads from hunting to farming to the laboratory. Such transitions are serious business, but if we're perched on one of history's great pivot points, it's good to keep our sense of humor—there is something inherently silly about the idea of an international media event staged around a hamburger, one of the world's most recognizable, mundane, and American foods. At the world's fairs and expositions of a previous era, grand events that one critic called "sites of pilgrimage to the commodity fetish," novel foods were displayed to crowds of visitors inside glass pavilions.[2] I'm getting ready to watch the early twenty-first-century equivalent, coffee mug clutched tight.

Journalists have described the hamburger in question as a "frankenburger," "test-tube burger," or piece of "vat meat." It was produced not by killing and butchering a cow, but through the expensive and laborious use of a well-established laboratory technique known as tissue or cell culture, first accomplished by the American embryologist Ross Harrison in 1907.[3] After decades of use in scientific and medical research, tissue culture has only

recently been used to produce what is sometimes called, with technical accuracy but zero gastronomic zest, "in vitro meat." One of the many promises attached to this new meat is that it could offer an alternative to industrial animal agriculture, perhaps completely replacing its environmentally damaging and cruel practices with pacific ones. This meat's utter weirdness cannot be overstated. Meat that never had parents. Meat that never died (in the sense that a whole animal dies) and, in the eyes of some critics who define their meat narrowly, never properly lived. Meat that could utterly transform the way we think of animals, the way we relate to farmland, the way we use water, the way we think about population and our fragile ecosystem's carrying capacity of both human and nonhuman animal bodies. A new kind of flesh for a planet of omnivorous hominids who eat more meat with each passing generation. As my Los Angeles neighborhood stirs in the early morning, cyberspace becomes meatspace.

Clickbait stubs have swarmed through the Internet in recent weeks, drawing bits of human attention (perhaps the Internet's real currency—I'm spending some now) by announcing the burger's shocking price tag: over $300,000. Rumor has it that a single wealthy benefactor in the United States has funded the Dutch laboratory that grew the cells and shaped them into muscle and then meat. Mark Post, the medical doctor and professor of physiology who created the burger, is the man of the hour, but media professionals coordinated this event, paid by Post's benefactor. Cultured meat is a technology still in development, despite the very established nature of tissue culture techniques; this is one of the reasons it costs so much to produce a small piece of meat. In the local language we might use to describe this technology, it is "emerging"—a metaphor regularly used to mark the phase when novel types of computers, energy generators, or medical technologies are devised or discovered, built or grown, eventually tested and licensed, promoted in the media and (with painful slowness, from the perspectives of their designers and investors) become available to consumers. "Cultured meat" is a term that is just starting to surface as of 2013, and Post's use of the term at this event may be an effort to replace the clinical-sounding "in vitro meat."[4]

The "emergence" metaphor casts the future as a kind of mist out of which concrete things materialize. I think of the signs by which we track emerging technologies: patents, investments, research grants, conferences, exploratory launches of products in specific markets, splashy front-page profiles of entrepreneurs in technology magazines. Before my own meat brain is properly awake it occurs to me that the emergence metaphor performs a curious

sleight of hand by hiding human agency. It implies that a new technology comes toward us of its own accord, rather than being ushered into being by many hands, each pair with its own agenda. And for a given technology to emerge, there must be a public for it to emerge into. Someone must be watching, and they'll have their own ideas about the future. I've been trained by utopian science fiction to expect certain things from a future of spaceships, and dystopian science fiction has taught me what to expect from a future Earth devastated by climate change, but do I know what to expect from a future of vat-grown meat? I train my eyes on my monitor.

For a subjectively long stretch of time, "feed will start soon" is all my browser shows, but then the event begins with a promotional film. A gentle guitar chord strums in the background and the camera shows gulls diving down over waves. A house is perched over the ocean. We see a bucolic human coastal settlement, the architecture noticeably North American or European. We're in the immediately recognizable aesthetic mode of a nature documentary or a science program aimed at young viewers. The camera pans out over the ocean, showing a lighthouse. Over this a voice states, "Sometimes a new technology comes along, and it has the capability to transform the way we view our world." Post's secret backer is revealed. A quick cut to a headshot of the speaker shows Sergey Brin, cofounder of the major Internet search and product company Google, and thus someone with a unique perspective on the way technology changes worldviews. But why is a Silicon Valley billionaire, someone who made his fortune from a search engine that has become so ubiquitous that "to google" is practically standard English, getting interested in the future of food? A simple lexical shift will reveal one answer to this question; cultured meat may someday be food, but right now it is part of what investors in Silicon Valley, Brin's domain, often call "the food space," an area of enterprise and investment that links food production and supply, environmental sustainability, human health, and the welfare of nonhuman animals. The food space is one in which venture capitalists have been very visibly active in recent years. But the word "space" has narrower and more specific historical connotations, conveying not mere dimensionality but also an intimation of the frontier. Frontiers are places different human populations have gone, over the centuries, in order to extract resources.[5] Some have argued that without frontiers capitalism itself could not function, for capitalists need fresh natural resources and new opportunities for the profitable investment of capital.[6] From the standpoint of shareholders, Google doesn't produce value by providing free search functionality to billions of people around the world. It

produces value by establishing a new frontier: extracting the resource of our search data (and many other kinds of data too), which it then puts to undisclosed but immensely profitable use—and it also sells advertising space, a chance to catch human attention that was originally directed elsewhere.[7] Meat is already in our money in many parts of the world, through a trace quantity of tallow in the lining that coats our banknotes. You might say that commodity meat and money are already "spaces" for one another, reciprocally linked through use and investment.[8] This is how cows become capital—they are counted head (*caput* in Latin; thus "capital") by head.

Brin continues speaking, and the scene dissolves from the birds and the waves to a close-up of his youthful face with a fringe of salt-and-pepper stubble, framed by the device known as Google Glass. This is a headset designed in California and built by the Chinese company Foxconn, with a tiny computer screen the wearer can look into, gazing at the Internet while they appear to be gazing at those around them. Itself an emerging technology, Glass was released to the public in February 2013, but it is rare to see anyone walking around wearing the very expensive Glass (the name reminds me of glass pavilions from world's fairs) except in such tech-centric places as Palo Alto, California, or the blocks surrounding the Massachusetts Institute of Technology. Brin's decision to wear Glass in the film underscores his role as a very wealthy ambassador from the future. Brin speaks of his efforts to find technologies "on the cusp of viability," capable of being "really transformative for the world" (more promises, I note, and his phrasing reminds me that cultured meat may soon be an investment opportunity), and then the scene changes again.

A new talking head appears. It belongs to the senior biological anthropologist Richard Wrangham, who sits in his Harvard office, book spines visible on shelves behind him. He's apparently here to explain the transformative potential of which Brin spoke. "The story of human evolution," Wrangham says, ". . . is intimately tied to meat." He proceeds to tell a common and widely shared story about the importance of meat in our species' natural history, a version of which is included in his 2009 book *Catching Fire: How Cooking Made Us Human*.[9] There Wrangham argued that our evolution into modern humanity was made possible by cooking, and especially by cooking tubers and meat, abundant sources of calories that facilitated the development of several features of our contemporary morphology and sociability: small mouths, large brains (the brain is a calorie hog), a facility for cooperation, and a distinctive social structure based on reproductive relationships between males and females. Wrangham's is a radicalized version of

other tales about humans and their evolutionary relationship with meat and other foods. His book has been subject to discussion and debate among biologists and anthropologists in a way that the film I'm watching can't possibly track.[10] The tactical reasons for bringing Wrangham into the picture are clear. If Brin speaks for the promise of new technology, Wrangham speaks for evolutionary antiquity and the authority of science.

Whether one agrees with Wrangham or not, it's impossible to miss the way the film matches a story about our hominid past with a story about the future of meat. Why suture together the deep time of species identity and the shallow time of our imminent dietary choices and food-provisioning strategies? Is evolutionary antiquity supposed to ground and legitimate hypermodernity? Am I to think that the past justifies the future? The next sequence jars me out of such reflections, as we cut from Wrangham to a piece of meat being cooked over a campfire in the darkness. The meat is on a stick held by a long-haired human, naked save for a loincloth, features obscured by darkness and the glare of the fire. Then a quick cut to African tribesmen, carrying spears and running barefoot. Wrangham goes on: "Hunters and gatherers all over the world are very sad if, for a few days at a time, the hunters come back empty-handed. The camp becomes quiet. The dancing stops." Wrangham's voice grows more animated and he raises his fists: "And then someone catches some meat! They bring the prey into the camp"—the camera jump-cuts to a new, distinctly modern scene, in which an adult white male opens the lid of an outdoor grill—"or nowadays, into someone's back garden barbecue." The two registers, the stereotypical African-primitive and the white and modern, are suddenly fused to a specific purpose, as if to explain and justify Western and modern behaviors by reference to "primitive" ones. The move is familiar, and offensive though probably innocently intended. It's the sort of fusion that took place in the after-school science programs I watched as a child, or in some older nature documentaries; it comes as a considerable surprise to see such recourse to the notion of the primitive many decades later. It is the visual equivalent of what anthropologists have criticized as an unthinking sociobiological turn.[11] As the film continues, Caucasian children stare at modern meat in the form of hamburgers. Wrangham says, "Everyone gets excited to come and share. . . . It is ritually cut." A knife-wielding white male in a baseball cap divvies up a steak. "We are a species designed to love meat."

The symbolic assignment of modernity to Western white males, and of an ancestral past to black Africans, is surprising in a promotional film released to an international media audience in 2013. Yet Wrangham's claims hold a

different kind of surprise. In less than a minute of exposition, Wrangham (as presented by the film's director and editor) has achieved a magnificent elision of meaning, moving from the idea that cooked animal flesh played a crucial role in producing human physiological and social modernity to suggesting that our taste for meat is original, innate, that it is natural for us to desire it. According to this logic, vegetarianism represents a break from our "design." But this logic is a tangle. The idea of a natural taste for meat is not uncontested, and this contest may in turn be the iceberg-tip of a deeper scientific debate regarding the status of humans in the food chain and our relationship with other forms of animal life. Technology is implicated in the practice of hunting animals, and thus our relationship with meat is linked to our status as tool-making and tool-using creatures. This latter point is not lost on cultured meat's advocates. Some of them argue that laboratory-grown meat may be a logical extension of our gradually changing and inherently technological relationship first with subsistence itself and then with industrial food production. "Designed to love meat" is a slogan that invokes hominin evolution as a license to pursue the love of meat in whatever modern way technology enables.

The film won't wait for me to summon footnotes to mind, of course.[12] It moves on to a conveyor belt carrying pink hamburger patties directly into the camera lens. We've dropped the question of human appetites and picked up the crucial question of scale, announced with this look into the guts of our industrial meat production system. A new expert, the environmentalist Ken Cook, says, "Feeding the world is a complex problem. I think people don't yet realize what impact meat consumption has on the planet." With a quick cut to cows in a field, Cook and Brin alternate to provide a few bullet-point problems associated with industrial-scale animal agriculture, the problems that cultured meat's pioneers hope to remedy. For example, 70 percent of antibiotics used in the United States go into livestock bodies, not human ones, and those antibiotics are required partly because of the cramped conditions in which livestock are raised and kept before the slaughter.[13] Another important reason for the use of subtherapeutic doses of antibiotics is that it enhances the rate at which animals put on weight, bringing them to slaughter faster. "When you see how these cows are treated . . . that's certainly not something I am comfortable with," says Brin, reminding me of the obvious problem of animal ethics, but the other side of such intensive antibiotic use is that it has been known to breed antibiotic resistance in the pathogens that circulate among livestock. This makes concentrated animal feeding operations (CAFOs) breeding grounds for viral agents dangerous both to livestock

and to humans. Stories about the hazards of CAFOs and slaughterhouses have become commonplace. From a dystopian perspective the "future of meat" isn't lab-grown meat, it's a global pandemic originating in abused and crowded animal bodies.[14] Cook reminds us of the health risks associated with simply eating a lot of meat; high levels of carnivory are associated with a 20 percent greater-than-normal chance of developing illnesses such as heart disease or cancer. However, as I will come to learn, more supporters of cultured meat are motivated by the next issues he raises: the environmental cost of meat production, which is thought to yield about 14–18 percent of industrial society's greenhouse gas emissions annually, and which uses an enormous amount of water and land. These resources could feed more mouths if they were devoted to fruits, grains, and vegetables instead. In 2011 a graduate student at Oxford conducted a theoretical life-cycle assessment of cultured hamburger, comparing it to the conventional kind. While the assessment favorably compared the lower environmental costs of cultured meat production to those of conventional meat, it was also declared full of holes by critics and was eventually revised.[15]

More images of farmland, then a runner passes in front of the camera while Cook describes the healthier diet of the potential future. Then we cut quickly to the crowded streets of Amsterdam's central neighborhoods, with their canals and bridges, and Cook gets to the heart of the issue, our growing global population. He expresses an idea that I will hear often as I make my way through the cultured meat movement, namely that meat consumption is rising faster than population growth alone explains. Some expect global carnivory to increase by 50 percent by 2050. I blink, noticing a prediction being taken for granted as if it tracked a natural law. "We're in for a terrible reckoning," Cook says as the camera cuts to a field, dust rising in the wind. This is grim, but predictions for an increasingly carnivorous humanity have substantial precedent. Meat consumption doubled worldwide between 1960 and the 2010s, and it increased even more, and faster, in later-modernizing countries like China. Wrangham's voice returns, reminding us of the pressing problem of climate change, which promises to collide with population growth, shifting resource distribution in ways that will promote conflict. "In a modern world, where we have Paleolithic minds [I choke on this a little] and contemporary weapons, that's really dangerous." Wrangham has returned to his strange fusion of the modern and the prehistoric, invoking Paleolithic minds (he probably means brains that became effectively modern in the Paleolithic—that is, prior to the technological and agricultural

revolutions of the Neolithic) as if cultural change and modern civilization matter little when it comes to the basics of human behavior, as if the mind is not much more than the meat brain with its meat instincts. But the film has also smuggled a prediction inside a prediction: if we don't develop technologies to thwart resource scarcity before widespread crisis hits, we'll be savages playing with nukes.[16]

Implicit in Wrangham's image is yet another intriguing but questionable idea, one that I will encounter repeatedly in the course of my travels within the cultured meat movement. This is the idea that the modern human condition is constituted by a disharmony between our biology and our technology, a lack of synchronicity between our bodies and their myriad artificial extensions. Everything about modern meat returns us to this notion of disharmony. We maintain a polluting, dangerous meat production system, a form of artificial infrastructure that allows an unprecedentedly large human population to consume an unprecedentedly large amount of animal flesh per capita per annum. This is not identical to the idea of a "machine in the garden," a technological presence that disrupts both the natural world and a sense of human connection to nature.[17] It is, instead, the desire to rediscover our biological condition from within the "second nature" that we have built around our bodies, and with which our bodies constantly interact, and to ask how that condition might be better served. The idea seems to be that our problems would be solved if we had better prostheses.

Once the viewer has been thoroughly exposed to the links between meat, population growth, climate change, and our dangerous future, Brin reappears to suggest that we might "do something new." A grassy hillside dissolves, and in its place we see a lattice of white lines over red, like a bird's-eye view of an organic city planned as a grid. This is in fact a close-up of animal muscle. Post's voice rises above it: "By our technology we are actually producing meat. It's just not in a cow." Post identifies himself as a physician experienced in vascular biology, with the goal of creating tissues for human transplants, especially blood vessels for heart patients. Referring to the fact that stem cells—unspecialized cells that can replenish themselves via cell division and, either in bodies or in experimental media, become cell types that fulfill specific functions—have been seen as promising for the production of human parts intended for transplantation, he says that "stem cell techniques are very useful for growing beef." My monitor has grown dark, but a cluster of red cells glows in its center, a model that will illustrate Post's process. "We take a few cells from a cow, muscle-specific stem cells that can only become muscle." A single

cell divides, an animated exemplar that resembles a celestial body floating in the void. Post continues: "There's very little that we need to do to make these cells do the right thing." He describes the way muscle cells proliferate and divide, creating functional structures almost all by themselves. Via technology, we simply provide anchor points and future muscle fibers will form. "A few cells that we take from this cow can turn into ten tons of meat."

Post's remark reminds me of the 1952 science fiction novel *The Space Merchants,* by Fredrik Pohl and Cyril M. Kornbluth, in which an entire factory of workers is fed by a giant, quivering, gray hemisphere of chicken flesh called "Chicken Little," whose creaturely status is uncertain; she lives on algae and occupies a nest in the basement.[18] Post's statement also recalls the scientific and medical discourse that has emerged, in the last two decades, around the stem cell, that enigmatic but ever-present object of hope, about which news items appear each week.[19] Post's "ten tons of meat" is just one of the miracles stem cells are expected to perform. Others range from regrowing broken teeth to reducing the physiological age of human tissue. In the world of cardiology, Post's world, stem cells are expected to yield therapies that add years to patients' lives, therapies that would also (needless to say) represent a source of immense wealth for the medical industry: here stem cells offer both economic and biographical potential.[20] Running through all of this are the complex dynamics of promising; like some other observers of biotechnological hopes, I am reminded of Friedrich Nietzsche's observation that humans are defined by their status as creatures who make promises. Nietzsche's specific claim was that, in this regard, humans are a "paradoxical task Nature has put to itself."[21]

Gentle music strikes up. The sun rises red in a red sky above red hills. This could be a science fiction film, or California reddened by airborne particulate matter (I will later learn that the Department of Expansion, the documentary film company that produced this film, is based in Los Angeles). We hear Brin's voice again: "Some people think that this is science fiction, that it's not real, it's somewhere out there. . . . I actually think that's a good thing. If what you're doing is not seen by some people as science fiction, it's probably not transformative enough." A quick cut: a man's hands (white ones; I realize I've become race-conscious because of the earlier juxtapositions of Africans and Europeans) drop some hamburger meat from wax paper onto a wooden surface, where they mold it into a patty. Brin: "We're trying to create the first cultured meat hamburger. From there I'm optimistic that we can really scale." To pause on that crucial word "scale," here used as a verb, the price tag of the

first cultured beef burger reflects ample research-and-design time, the salaries of technicians, plus expensive laboratory supplies, and it benefited from no economies of scale—it is massively higher than the potential (that word again) cost of the burger at scale. Such talk of potential brings us back around to the ultimate target of the cultured beef project, the future. Post again:

> Twenty years from now, if you entered the supermarket, you would have a choice between two products that are . . . identical. One is made in an animal. It now has this label on it [stating] that animals have suffered or have been killed for this product. And it has an "ecotax" because it's bad for the environment. And it's exactly the same as an alternative product that is being made in a lab, it tastes the same, it has the same quality, it is the same price or even cheaper, so what are you going to choose?[22]

As he speaks, we see images of children and their parents happily munching on hamburgers. "From an ethical point of view, it has only benefits."

As Post continues, our scene shifts from the burger-munchers to an arboreal display that could only be Northern Californian. We look up at soaring redwood trees from their bases, viewing an environmental treasure whose preservation is one of the "ethical benefits" of which Post speaks. Water drips and minnows swim, as Cook describes growing consumer interest in new systems of food production that may not damage the environment. Then we return to Wrangham, who speaks of meat's benefits as he did before, but with a difference: "Now, by some horrendous irony, it's become part of a system that threatens our species. We have to do something about it." The image of Wrangham in his office fades to a white screen on which the words "Be Part of the Solution" appear in black letters.

Environmental crisis. The unstoppable power of human appetites. Flesh, both the flesh we eat and the press of human bodies in our crowded cities. And against the onward rush of the disasters of climate change and population growth, another trend line, a more hopeful one accelerating upward, labeled "technological progress." The six-minute film is almost too much to take in, a kind of signifying fire hose, but it lays out many of the puzzles that will preoccupy me for the next few years as I quest after the meanings of laboratory-grown meat. This isn't a mere product demo that I'm squinting at over the Internet, it's an effort to position cultured meat as a new food technology that can resolve a problem whose scale is civilizational, so large that any effort to calculate it requires the tools of social and environmental science. Spaceship Earth's problems can be seen from orbit.

And while the film did not say so explicitly, it seems clear that the core problem's name is not exactly meat itself, however much conventional meat production is an important immediate target of criticism. Just where the problem lies, however, is ambiguous, and the film raises questions about our civilization that are too large to easily grasp but that demand more than mere hand waving. While much of the film locates the problem in that strange quantum called modernity, Wrangham's contributions are more troubling, inviting us to view human appetites as fundamentally at odds with our species' survival. Meat makes and unmakes us, according to the narrative toward which Wrangham gestures. Or is it sheer civilizational scale that makes and unmakes us? Is it technology? And what would it mean for modernity if technology can save the same natural world that it imperils, or more cynically, what does it mean that some people have become convinced that one technology can undo the problems created by another? And how would those sentences read differently if the word "technology" were replaced by the word "capitalism"? What if the solution lies not in producing more, but in needing less, and in the more just distribution of what we already produce?

And, if the future is coming in the form of tissue-cultured animal muscle to be consumed as meat, what does it mean to wait for it? The promotional film is true to the style of thinking that accompanies cultured meat in its early, "emerging" years. This style is hopeful, worried, sincere, and immensely ambitious, responding to a grandiosely scaled map of the world's problems that its proponents have themselves drawn up, a map that usually leaves out the basically political character of those problems, just as the metaphor of emergence slides past the tangle of political and financial interests out of which new technologies actually emerge.

Now my screen shows the interior of a television studio, full of journalists. There is a modern kitchen counter and a small stovetop. A host welcomes Post to the stage, which is set up as if for an anonymous cooking show. They chat briefly, and then it's time to unveil the burger itself. Post lifts the lid off of the tray and reveals the burger, which looks very pink; it's been colored with beet juice and saffron, without which it might be a muted white-gray. Insofar as visual inspection can reveal texture, it appears to be very different from conventional meat, and we are told that it has been thickened with bread crumbs. A chef named Richard McGeown and two other guests then join Post onstage. One is Josh Schonwald, an American food writer with a book on "the future of food" to his credit, and the other the Austrian nutrition scientist Hanni Rützler.[23] The chef receives the burger at the stovetop

and uses just a little vegetable oil and butter to cook it, as the camera moves between close-ups of the stovetop (it must be a little nerve-racking to cook such an expensive piece of meat) and the expectant faces of members of the audience. The burger does indeed start to brown in the same way that conventional meat does when the Maillard reaction begins.[24]

Later I'll learn more about why Post, an amiable, tall Dutchman who speaks the excellent English of an educated European who has lived in the United States and travels often, chose London: every major media outfit has a London bureau or roving journalist, and Greenwich Mean Time still enjoys a certain global centrality. I'll also learn that Post's team would have had more trouble getting its hamburger past the U.S. border than past the British one, a surprising detail because the British are understandably—given prior outbreaks of bovine spongiform encephalopathy ("mad cow disease") among British cows—touchy about meat. The lab-grown hamburger isn't just a new form of meat; it is also a border-crossing alien, albeit a legal one. I wonder what all this means for the eventual regulation of cultured meat as a food product.

While the burger cooks, Post shows us a second film, an animation illustrating the process by which he and his team produced their burger. A tiny biopsy of muscle tissue was taken from a cow, which was barely grazed by the experience, and returned to grazing. After skeletal muscle stem cells were isolated they were encouraged to proliferate in a growth medium. As the cells grew they were encouraged to form chains, strands that would later be turned into the muscle tissue of hamburger meat; those strands were "exercised"—in other words, encouraged to expand and contract as skeletal muscle does in vivo. I know enough about tissue culture to suspect that the process was somewhat more complex than this. It certainly was time consuming, since it took several months for Post's lab to grow enough material to produce their burger.

McGeown finishes cooking the burger, which he describes as having a "very pleasant aroma." He turns it out onto a plate along with a tomato slice, lettuce, and a bun, although he doesn't assemble the burger to be held and munched. It sits in the center of the plate, naked, as if contesting the historical role the bun played in defining the qualities of a hamburger sandwich. Each of the two "taster experts," Schonwald and Rützler, cuts into the meat with a knife and fork and samples some that way. Both report that it definitely does not taste like conventional meat, but Schonwald attests that it reminds him of the "mouthfeel" or "bite" of meat. Post takes a bite himself.

Cultured meat apparently eats like real meat, even if it doesn't taste exactly like it. Throughout this entire process, the studio audience of journalists has

been visible, and now they're stirring, impatient to ask questions. Post is ready to field them, and the first two are critical. The first: Will consumers *want* to eat meat made under laboratory-like conditions? Post acknowledges that there's a powerful initial "yuck factor" that we need to bear in mind, a potential resistance to meat that wasn't grown in animals. I'll encounter this during my research in the form of a hard psychic line drawn between the kitchen and the laboratory, as if much of our food hasn't already passed through institutional kitchen-laboratories shaped by science.[25] The second question from the audience is about whether a new source of a large volume of meat would encourage people to eat more meat than a healthy diet suggests. Post nods, understandingly, and says that he himself is a "flexitarian" and would happily see us all eating less meat. However, he goes on, the hard truth is that meat consumption will only continue worldwide; the "meat question" will not be resolved by mass vegetarianism or flexitarianism. And Post continues to respond, in the same open spirit, to a long series of questions, many of which target apparent weaknesses or flaws in his plans. Post acknowledges that his techniques are at an early stage of development, currently too inefficient, scarcely near the point of "scaling up." Furthermore, a replacement for the current growth medium must be found. That medium includes fetal bovine serum, making the whole process emphatically nonvegetarian, and moreover, antibiotics have been added to the cell culture to prevent a damaging infection. One solution to the problem of overreliance on antibiotics, Post says, would be to use robotic and thus totally sterile production facilities.

To an additional question about the burger's taste, Post responds that his team has not yet mimicked the taste and mouthfeel of animal-grown muscle tissue. One reason for this is that they have not yet learned to generate the fat cells such tissue would contain. Not only does fat contribute to flavor in many ways, it also adds much to our sense of meat's tenderness.[26] The popularity of lean cuts of meat among health-conscious eaters should not obscure the central role played by fat, even small amounts thereof, in creating the taste of meat. As he addresses question after question, Post remains optimistic and upbeat. Asked whether cultured meat would start rolling off assembly lines in a week, and onto the shelves of Sainsbury's (a British supermarket chain), he laughs appreciatively, as he does at questions like "How much will it cost?" Today's demonstration was strictly a proof of concept, and Post limits himself to the conservative prediction that cultured meat may not be available for another ten to twenty years. I pay careful attention to this. Such

predictions have appeared in the media with striking frequency as part of the media swarm around this event, and one journalist even takes the time to assemble them, creating a chart entitled "When Will We Eat Hamburgers Grown in Test-Tubes?"[27] I am not the only watcher conscious of the way cultured meat is bound up with a culture of prediction, and of the relationship between the long timeline for perfecting Post's technology and the possible funding streams that might support it. Isha Datar, who heads an organization called New Harvest, founded in 2004 to promote research into laboratory-grown meat (Post's lab is not the origin of this technology; he is just the latest and best-funded entrant into the field), brings up an interesting point about how such work gets support. At the moment, the money for vat meat research is principally philanthropic, because the venture capitalists who support companies need to see returns in far shorter increments of time than twenty or ten years. I expect this to change as cultured meat develops an aura of viability through demonstrations like this one.

A Brazilian journalist, in a jocular tone, voices his doubts about whether you could produce a good barbecue using laboratory-grown meat. Post agrees that to truly replicate meat is a huge challenge. Tastes are complex. There are some four hundred peptides and aromatics in meat, and no food scientist can tell us exactly how the composition of meat yields specific tastes. For a moment I think that the question-and-answer session will end on this relatively gentle and optimistic note—a scientist working to complete a very difficult but not impossible task, with the fruits of this labor helping to resolve civilization-scale challenges. Instead the last word comes from an audience member who expresses her irritation at Post's failure to bring enough to share with the whole audience. This too is greeted with laughter from the room, and the event ends. Watching through my Internet browser, I find that I cannot blame her for wanting a bite. After all, in the twenty-first century we are bombarded with images and words designed to summon the future. Rare is the chance to engage with the future through the intimate senses of taste, smell, and touch.

In the years of this book's research, from 2013 to 2018, I went out to find the lineaments of my larger society in the concepts of its speculative biotechnology.[28] Cultured meat was not just an emerging food technology. It was an emerging conversation, a climate of opinion condensed into a physical object—in fact, into a very small physical object, because between 2013 and 2018, no cultured meat was being produced beyond the level of small tests such as Post's burger. The charismatic pull of that conversation has been enor-

mous, though, and for good reason. It is a conversation about what our world might become. It has linked human actors ranging from vegan activists in Brooklyn to designers in Amsterdam, venture capitalists in San Francisco, and biohackers in Tokyo, not to mention laboratory scientists from a wide range of disciplines and a handful of social scientists, journalists, writers, and professional futurists (or "futures workers," as these consultants are often known). Everyone brings their own desires to the subject; there are, of course, entrepreneurs who desire wealth and fame as well as those for whom entrepreneurship is a means to an end. There are activists who hope to set food animals free, and others who want food security for a growing population, or to mitigate climate change, and there are scientists pouncing on a technical challenge. Meat's meanings are multiple, and this holds true for the lab-grown kind, too. There are also gadflys who believe, despite Post's burger, that cultured meat can never work, that Post and his colleagues will never find a way to scale up to industrial production, leaving cultured meat nothing more than a novelty of its time, the biotechnology equivalent of a giant elk whose antlers are outsized for its survival.[29]

This book tells the story of what I found, and what I did not find, in the course of my time in the small, strange world of cultured meat, during what seemed to be the early years of an emerging technology. I expected to spend time in laboratories, observing scientists and learning how they encouraged cells to proliferate, and exploring their expectations for the future of cultured meat. This did happen in some measure, but for the most part I found myself with very little laboratory science to observe and a great many public conversations about cultured meat to participate in and sort through. During my five years of research, the world of cultured meat changed dramatically, fed by venture capital, media interest (an inevitable pun: cells feed on growth media while an embryonic industry sometimes thrives on attention from the media), and the growth of more than one nonprofit organization devoted to promoting cultured meat and other technological alternatives to animal agriculture. At the very beginning of my research, there was only Post's burger and an expansive, and perhaps unanswerable, set of questions about what would happen next. In other words, we were in the territory of professional futurists who speculate about where new technologies might lead us, and accordingly I spent time with futurists in the consulting firms and nonprofit organizations that are their workshops. Anthropological fieldworkers have traditionally learned local languages after reaching their field sites, out of necessity. I busied myself by reading the small scientific literature on

cultured meat, and by speaking with entrepreneurs and investors to learn the idioms in which both science and investment articulate their goals. As of 2013, the most commonly asked question was "When?" or "How soon?" and the answer given by most researchers and observers of the field was "About ten years"—ten years until a marketable cultured meat product could reach consumers, perhaps beginning the process by which cultured meat would undermine conventional animal agriculture.

I quickly learned that Post's hamburger had emerged out of a small world of cultured meat researchers who preceded him. Around the turn of the millennium, a grant from NASA had funded a team at Truro College in New York, led by Morris Benjaminson, that attempted to turn goldfish cells into a compact and self-replenishing food source for long space flights. Meanwhile the artists Oron Catts and Ionat Zurr were using fetal sheep cells to create "living sculptures" from a lab at Harvard Medical School. Post himself was originally part of a consortium of Dutch researchers operating with a substantial grant from the government, won through the persistence of a Dutch businessman named Willem van Eelen. In other words, the potential for tissue culture to produce cells for nonmedical applications was apparent to a range of actors with different purposes. During the first decade of the twenty-first century, all this work unfolded in relative quiet. People for the Ethical Treatment of Animals (PETA), seeking to catalyze research, announced a contest in 2008: the first laboratory that could produce a chicken nugget made via cell culture would win a million U.S. dollars. No one collected, but PETA did make the papers.

What quickly coalesced in 2014 and 2015, perhaps catalyzed by Post's burger demonstration, was a climate of eager conversation about cultured meat and the future of food in which elites from developed nations, most especially the United States, the Netherlands, and Britain, discussed the possibility of feeding the world through a new subsistence strategy. This strategy would be in keeping with these elites' ideological preferences, organized (as in Post's demonstration) around environmental protection, sustainable protein production, animal welfare, and human health. A group of actors from biomedical research, venture capital, the nonprofit world, and other fields unselfconsciously played a role that other elites have played over the past two centuries of European and North American history. They cast themselves as food planners for the globe, and arbiters of proper dietary practice for both the well fed and the poorly nourished.[30] This role playing, which arguably goes back to Thomas Robert Malthus's *Essay on the Principle of*

Population (1798) and whose original political context was British colonial expansion, retains its political character, even when this is not explicitly acknowledged. The preference for solving problems using technology is very often a political preference even when it appears to ignore politics.

The developments that actors like Post ponder and debate are very real, and they include agricultural land becoming unusable (or even flooded) due to climate change, the effects of rising global temperatures on the bodies of farm animals, and the possibility that rising middle classes will consume more and more meat. But their proposed responses reflect specific beliefs (Western ones) about what constitutes a desirable human diet, and beliefs about the right relationship between human eaters and the ecosystems from which their food comes (industrial ones). I was in the world of cultured meat as a kind of anthropological fieldworker, but I was also led into the deeper histories of the debates I witnessed, and this book is as much a work of history as it is an ethnography (to use that strange term, which literally means "the writing down of a people"). "Soylent Green is people" runs the tagline from a classic dystopian film about the future of food, in which green wafers are made to feed a population that has grown beyond the limits of sustainability much as Malthus once warned it would, and those wafers are made from reclaimed corpses. Cultured meat, conversely, is not people, but it rests on a series of claims about the human condition, both in its physical aspect and in the sense of what we consider a good life. That banal phrase, "a good life," becomes more meaningful when shifted into the idiom of philosophy. What is a good life, one in keeping with our ethical beliefs about purpose, dignity, and posterity?

When my research ended in 2018, much had changed. Post was still one of the leading figures in the field, but in a new role as one of the founders of a company, Mosa Meats, to which the 2013 hamburger demonstration would subsequently be attributed. Hampton Creek, a company previously known for vegan mayonnaise, suddenly revealed that they had been working on cultured meat and promised to put some on customers' plates (it was not clear which customers, where, or what the meat would be like) by the end of 2018 (by which time Hampton Creek would take the new name "Just"). Memphis Meats, which despite its name is based in the Bay Area, had unveiled samples of chicken strips and pork meatballs, two types of meat that, like hamburger or sausage, are less dependent on texture than steak would be. There are other players in the "space" too, making their own promises. What 2018 and 2013 shared was a focus on the question of "when," but the existence of specific

players making ambitious promissory statements changed the dynamic considerably, as did the inevitable black boxing of research. It was possible for a visiting scholar to get inside a start-up's in vitro meat lab in 2013 or 2014 or even 2015, but this had become very difficult by 2018. This meant that even as the companies seemed to make progress, the ability of social scientists and journalists to confirm that progress diminished. My research began in one kind of fog bank and concluded in another. Tracking emerging forms of biotechnology can make you cynical, but part of what is at stake here is our capacity for sincerity in the face of grand challenges. Sincerity is complicated when one does not know whom to trust or believe.

At one point during my fieldwork within the cultured meat movement, "the post-animal bioeconomy" became a buzz-phrase of sorts, used to describe a range of techniques, often involving tissue culture, for developing products humans have traditionally obtained from nonhuman animals. Such a phrase bespeaks a lot of ambition to say the least. It would take an effort far beyond that of a few coordinated start-up companies, consultants, and promoters to make our "bioeconomy" truly "post-animal." The post-animal bioeconomy, even if it is still a matter of the imagination, is intertwined with another kind, a "promissory moral economy." In these intertwined economies we invest hope, energy, and attention in novel technologies that are moral in a double sense: not only would these technologies have desirable moral outcomes (particularly from animal protection perspectives), but they function as ways to express moral feelings even before the desired technology emerges. To support cultured meat is, for many, to condemn CAFOs and perhaps all animal agriculture. Such expressions bring activists together and justify the use of the term "movement" for the effort to bring cultured meat to pass. We watchers, especially those of us with our feet planted in history or anthropology, are often suspicious of promises coming from the world of technology. Indeed, an "ethic of suspicion," as the historian and anthropologist of genetics Mike Fortun has called it, has become central to the way we watch.[31] It is a curious thing to meet a moral economy with an ethic of suspicion, but such encounters are common as world-saving claims are made on behalf of emerging technologies that arrive with business interests attached.

Cultured meat was a glittering object in the media during my years of research, but a holographic one, without solidity. News articles vastly outnumbered researchers and laboratories. To the best of my knowledge, then and now, very little cultured meat has been produced, and nothing beyond the scale of Post's 2013 hamburger. But the relative absence of much cultured

meat in those years is precisely the point. Cultured meat was, and remains as of this writing, a technology that has not fully emerged, and thus remains largely an abstraction. If this book reads like a series of detours—"Where's the meat?" the reader may ask, and it's a reasonable question—it is because my research often took the form of detours and delays. This was frustrating at first but later became interesting, because what I found "on the way" to cultured meat was a set of questions whose intrinsic intellectual worth is great. Unexpected detours, one might say, are the opposite of predicted routes, and thus the opposite of a certain style of futurism too, the kind that asserts the knowability of a particular future, often a future presumed to follow from the development of a particular kind of technology. Detours turn a planned journey into a series of surprises, perhaps pleasant, perhaps regrettable. For me, the detour starts out as an irritation or a disappointment. Then it becomes a method. This book's arrangement of chapters is the result of that method. They move between past and contemporary frames of reference, between concerns that are anthropological and historical and philosophical. They contain very few hard-and-fast answers to concrete questions such as "Will cultured meat succeed?" and "When is cultured meat likely to arrive?" and "What does it taste like?" This is not only because those questions are, as of this writing, without final answers, but also because I contend that they ultimately matter less than the questions this book does ask, the essential one being "What makes cultured meat imaginable?"

This book is not an attempt at prediction but rather a study of cultured meat as a special case of speculation on the future of food, and as a lens through which to view the predictions we make about how technology changes the world. Almost all of those predictions, whether made by professionals in consulting firms or think tanks, by scientists and entrepreneurs with a personal investment in the work, or by members of the general public, have been influenced, at least to some degree, by science fiction, that ubiquitous form of lay futurism. As of this writing, cultured meat is still an unwieldy bricolage of communications, a holograph projected from no point in particular.[32] It is often described as a sign of the gradual triumph of science and progress over civilization's ills, but it is more like an engineering project at whose center passions and interests churn. These range from a heartfelt desire to eliminate animal suffering to sheer cupidity.

Still waking up to a weird future in 2013, I have no idea about this yet. The hamburger demonstration ends and I close my computer, crossing from cyberspace back to meatspace.