



# Natural, Artificial, Ethical? How Synthetic Biology Is Overturning Old Categories

Virginia Postrel

Visiting Fellow, Smith Institute for  
Political Economy and Philosophy,  
Chapman University

**Draped over a neat mound of rice, the slice of raw salmon glistens. I follow sushi chef Jun Sog's directions and eat the nigiri in a single large bite. The salmon's flavor is delicate, not fishy, the texture silky against the grains of the rice. Then the hidden wasabi kicks in, a sharp contrast to the mild fish. I relish the punch while stifling a cough.**

**B**efore taking this job, Chef Jun spent three years preparing 14-course offerings at a Michelin-starred San Francisco restaurant. Sophisticated diners paid a couple hundred dollars each for a chef's choice meal, or omakase, whose inventive dishes featured fish flown in from Tokyo's Toyosu Market.

The nigiri and salmon rolls he's making today are just as special, but their extraordinary character is harder to discern. The only hint is the shape of the salmon from which Chef Jun slices his elegant portions. It's a fat rectangular block with rounded edges, like a Milky Way bar. Fish markets don't sell salmon that looks like that.

We are at Wildtype, a San Francisco startup that grows sushi-grade salmon from cells. The product I'm sampling descends from cells taken from a small fish more than three years ago. "We haven't had the need to go back to the animal since that time," says co-founder Aryé Elfenbein, a cardiologist who earned a Ph.D. by researching how blood vessels form.

Wildtype scientists coaxed the original fish cells into becoming what are known as induced pluripotent stem cells. Like early embryonic cells, these stem cells can grow into any type of tissue, depending on the cues they get from the environment. Using the right nutrient mix and a mesh-like scaffold, Wildtype gets them to become muscle, including the connective tissue that forms salmon's



distinctive white lines. The resulting salmon has no bones, no skin, no blood and guts—no waste. “We only create what we eat,” says Elfenbein.

He grew up in Australia and says his aha moment came on a trip home during his medical residency. He was distressed to see former rainforests converted to raising cattle. “That made me wonder,” he recalls, “Could we eat meat and not eat animals? Can we grow the same thing, just outside of the animal?”

Founded in 2016, Wildtype is one of a host of new companies turning to cutting-edge biological techniques, known collectively as synthetic biology (or synbio), in search of more environmentally friendly, less ethically fraught materials. Some offer alternatives to existing products, such as the popular vegan burgers Impossible Meat introduced in 2016. They get their beefy flavor from heme, the iron-rich molecule in blood. Others, like Wildtype’s salmon or Huue’s indigo dye, provide duplicates of existing substances, created in new ways.

**Above:** Wildtype co-founders on Puget Sound.

Image: ©Wildtype

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Synthetic biology is a process, not a product. Unlike corn genetically modified to grow faster or repel insects, the DNA tweaks don’t show up in the final product. Impossible Meat gets its heme by giving yeast a soybean gene that makes it produce a heme-rich molecule. It grows the yeast in fermentation vats and separates out the heme.

“What we’re talking about here is a revolution fundamentally changing the way that materials are made,” says Michelle Zhu, the chief executive and co-founder of Huue. She envisions a “future where we eliminate reliance on petroleum and fossil fuels and polluting production processes, instead being able to work in harmony with nature to create nontoxic colors, and other kinds of nontoxic materials.”

Synbio executives talk like nature lovers and environmental activists. “We are a company that makes meat from plants to turn back the clock on climate change and restore biodiversity,” says Jessica Appलगren, vice president of marketing at

Impossible Foods. Dan Widmaier, the co-founder and chief executive of Bolt Threads, says, “We see the world as a four-billion-year-running experiment of inventing materials that are perfectly sustainable and circular.” Bolt’s products include a silk protein to replace silicone elastomers in cosmetics and a leather alternative made from mycelium, the tissue forming the roots of mushrooms.

Someday soon, goes the new biological vision, we’ll wear jeans dyed with indigo made using bacteria and walk on flooring formed from mycelium. We’ll dine on cruelty-free beef grown from cow cells and eat ice cream whose flavors and milk proteins were excreted by microorganisms. Corn farmers will replace synthetic fertilizers with soil microbes engineered to convert nitrogen from the air. Instead of animal hides, leather will come from cell cultures—animal cells for traditionalists, mycelium for vegans. Chemical companies will abandon petroleum feedstocks for corn syrup and customized enzymes.

And that’s just the beginning. Who knows what unknown flavors, fibers, or construction materials the new biology might yield? Given a few decades, its enthusiasts imagine, substances grown with biology will be as much a part of our everyday lives as petroleum-derived products are now. Pastureland will return to forest, wild salmon will again swarm the streams, and carbon emissions will fall. The world will enjoy ecologically benign abundance.

“We have spent the last century looking at what can we do with chemistry. And at this point, we’re kind of tapped out in what we can do with chemistry,” says Ena Cratsenburg, the chief business officer at Ginkgo Bioworks Inc., an industry pioneer. People still want the chemical products that improve human life, but without the environmental costs. “We think there’s a better way to do it,” she says. “Biology is a better way.”

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Since the first Earth Day in 1970, businesses large and small have grown from the conviction that “natural” foods, fibers, cosmetics, and other products are better for people and the planet. It’s an attitude that harkens back to the 18th- and 19th-century Romantics, who rejected industrialism in favor of sublime landscapes and rural nostalgia: What’s given is good; what’s made is suspicious, especially if it’s mass-produced or of recent origin. The natural is safe and pure, authentic and virtuous. The artificial is tainted and deceptive, a dangerous fake.

That view is still culturally potent, with its own intellectual ecosystem of publications and advocacy groups. They want nothing to do with the new biology, however fired with environmental zeal its advocates may be. “Cell-cultured meats are imitation foods synthesized from animal cells, not meat or poultry that consumers know,” says Jaydee Hanson, the policy director for the Center for Food Safety. The activist group is lobbying the U.S. government to require that lab-grown meat carry off-putting labels like “synthetic protein product made from beef cells.”

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**Above:** A cross section showing mycelium, the underground root-like system of fungi.

**Left:** Mylo, a material that looks and feels like animal leather, made from mycelium.

Images: © Bolt Threads



“If you are eating ‘animal-free’ dairy or meat products that taste nearly identical to a traditional animal product, you should be asking plenty of questions,” warns organic-food guru Max Goldberg in an essay. “And more often than not, what you will discover is that these foods are anything but ‘natural.’”

He has a point. Ginkgo’s Cratsenburg, who has been in the industry since 2006, defines synthetic biology as “a form of science that takes the engineering principles that one would apply to other engineering disciplines and applies them to biology.” Engineering identifies regularities, establishes repeatable processes, and makes outcomes predictable. Nature, by contrast, is out of control and indifferent to human purposes. Engineering bends nature to human ends. It is a science of the artificial.

Take Brave Robot ice cream from Perfect Day, founded in 2014 by two self-described “struggling new vegans.” Goldberg uses a photo of its booth at a natural foods trade show to illustrate his anti-synbio article. He sees the booth as a misleading abomination. The ice cream is an animal-free dairy product—something that does not exist in nature (Neither, of course, does ice cream itself.) Brave Robot genetically tweaks microflora so they turn out whey protein. It’s the same substance in cow’s milk but without milk’s other ingredients, such as lactose or animal fats. For its ice cream or cream cheese, Perfect Day adds in plant oils. Voilà: animal-free dairy.

Reviewers and my own taste tests confirm that Brave Robot’s ice cream is indistinguishable from the traditional sort. The Perfect Day customer, says company spokeswoman Anne Gerow, is “anyone who loves to eat but really cares. They care about animal cruelty or they care about the future of our planet.” If artificial methods make their goals easier and more delightful to achieve, so much the better. The new biology enables ethical living without sacrifice. Bring on the animal-free mint chocolate chip!

“**This is the cleanest salmon you will ever have in your life,” boasts Wildtype co-founder Aryé Elfenbein. It contains nothing but fish: no parasites, no mercury, no microplastics. Wildtype knows everything about the salmon because it grew the tissue in a vat**”

Purists aren’t convinced. One advocate of “clean eating” relentlessly posts links to Goldberg’s warning on the reviews on Brave Robot’s Facebook page. To her, clean eating means eschewing artificial ingredients. Animal-free dairy products are clearly taboo. Like the ancient prohibitions of kashrut, this concept of “clean” draws tribal boundaries, affirms identity, and makes food meaningful. The impurities it shuns are as much spiritual as physical. But while this notion of cleanliness is powerful to adherents, its appeal is limited.

The new biologists counter with their own purity claims. “This is the cleanest salmon you will ever have in your life,” boasts Elfenbein. It contains nothing but fish: no parasites, no mercury, no microplastics. Wildtype can tell the exact amount of omega-3 fatty acids in each portion.

Elfenbein bristles when reminded that the salmon’s purity comes from its artificial nature. He’d rather talk about transparency, a word with nicer connotations, and envisions detailed labels listing everything from the salmon’s carbon footprint to the day it was made. But Wildtype knows everything about the salmon because it grew the tissue in a vat. And it’s the precisely controlled environment of the cell culture that ensures that the raw salmon is free of dangerous worms. (Wild or farmed sushi-grade fish must be frozen to kill parasites.) Nature isn’t clean.

The new biology faces a more suspicious market than the postwar America that embraced the gospel of miracle fabrics, wonder drugs, and convenience foods. That naive message produced a backlash. Our era is more like the economically and technologically tumultuous 19th century. Progress comes with obvious disruptions, giving rise to muckrakers and intellectuals eager to demonstrate its dark side. ➔

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In a more affluent world where tolerance for risks has fallen, the predictability of artifice can deliver a sense of security, just as it did around the turn of the 20th century. Americans then began to enjoy “artificial ice.” Instead of blocks cut from frozen lakes and shipped to cities or southern climes, people began to buy ice made from distilled water in factories using ammonia-based refrigeration. At first more expensive than natural ice, factory-made ice nonetheless found a market among customers anxious about impure food and water-borne disease. Both were serious problems in burgeoning industrial cities.

“The demand for artificial ice has been increased by all citizens who are careful to look after the wholesomeness of their food and the general health of their homes,” reported the Fort Wayne, Indiana, newspaper in 1900, noting that “butchers who want no impurities in their ice chests are making a great demand for artificial ice” and “a dutiful mother will have nothing but pure ice for her children.”

People didn’t buy artificial ice because they were wowed by the technology, although it did get some gee-whiz press. They bought it because they wanted to be good mothers and dependable butchers. They wanted to live in big cities without eating rotten food. They wanted to go ice skating, eat ice cream, and enjoy cold beer. Artificial ice made everyday life better. And its story made sense. People understood that ice was frozen water and that pure water made pure ice. They didn’t have to understand the stuff about condensing ammonia.

Image: ©Wildtype



Wildtype hires sushi chefs so its fish makes sense. While it waits for regulatory approval, the company invites guests to see and taste the product the way they would in a restaurant. The familiar ritual sparks curiosity rather than fear. How long does it take to grow, people want to know, and where do the white stripes come from? Could you make the flavor more intense? Once the product is on the market, Wildtype hopes restaurants can tell its story. Most people don’t, after all, make their own sushi.

Over time, growing meat or silk or leather in a vat could make the “natural” alternatives seem aesthetically and morally repugnant. Eating pond ice sounds repulsive nowadays. Who knows what might be in it? And, as uncomfortable as the thought may be, economics and technology can transform ethical expectations and practices. Infanticide dwindled in Europe as condoms spread and living standards rose. The lower the cost of virtue, the more willing people are to embrace it. Most contemporary diners don’t want to give up meat but also don’t want to see exactly where it comes from. By offering kinder alternatives that don’t sacrifice taste or tradition, synthetic biology can change mores.

Ideals and stories also matter. By making muscle power less essential, steam engines probably helped along the abolition of slavery. But novels, slave narratives, and Christian lessons of common humanity were essential. For a half century we’ve been telling ourselves a story about technology as a fall from grace, about artifice as the source of human suffering and environmental ruin—even as we consumed more and more of its products. The idealistic scientists and entrepreneurs building the new biology tell a different story, a story of life and renewal. If we cherish nature, they suggest, we’ll embrace artifice. In this story, synthetic biology offers a kinder, safer, more planet-friendly way forward. ■



## About

**Virginia Postrel** (vp@vpostrel.com) is a visiting fellow at the Smith Institute for Political Economy and Philosophy at Chapman University in California and the author most recently of *The Fabric of Civilization: How Textiles Made the World* (Basic Books). She is a contributing editor for WorksInProgress.co and publishes a newsletter at vpostrel.substack.com.