

# Controversial DNA startup wants to let customers create creatures

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In Austen Heinz's vision of the future, customers tinker with the genetic codes of plants and animals and even design new creatures on a computer. Then his startup, Cambrian Genomics, prints that DNA quickly, accurately and cheaply.

"Anyone in the world that has a few dollars can make a creature, and that changes the game," Heinz said. "And that creates a whole new world."

The 31-year-old CEO has a deadpan demeanor that can be hard to read, but he is not kidding. In a makeshift laboratory in San Francisco, his synthetic biology company uses lasers to create custom DNA for major pharmaceutical companies. Its mission, to "democratize creation" with minimal to no regulation, frightens bioethicists as deeply as it thrills Silicon Valley venture capitalists.

With the latest technology and generous funding, a growing number of startups are taking science and medicine to the edge of science fiction. In the works or on the market are color-changing flowers, cow-free milk, animal-free meat, tests that detect diseases from one drop of blood and pills that tell doctors whether you have taken your medicine.

## 'Totally new organisms'

But few founders are pushing the technical and ethical boundaries of science as far as Heinz, who told the Wall Street Journal, "I can't believe that after 10 or 20 years people will not design their children digitally." At a recent conference in Vienna, he said, "We want to make totally new organisms that have never existed."

His 11-person team has raised \$10 million from more than 120 investors, including Peter Thiel's venture firm Founders Fund. "It's a fundamentally new technology that can open up a whole new industry," said partner Scott Nolan.

Venture capitalist Timothy Draper, another investor, praises Heinz as an "exceptional leader with a unique passion for his business."

“I love Cambrian,” he wrote in an e-mail. “The company is literally printing life. Can’t wait to see all the great things that come of it.”

To be clear, Cambrian isn’t printing designer babies or dinosaurs — yet. Still, its rhetoric alarms critics. Marcy Darnovsky, executive director of the Center for Genetics and Society, a bioethics watchdog group in Berkeley, sums up Heinz’s belief that “every problem can be solved by engineering” as a kind of “techno-libertarianism.”

“We have to take seriously people like Austen Heinz who say they want to modify future generations of human beings and upgrade the human species,” she said. “I think that technical project is far more complicated than they acknowledge. Nonetheless, their story about what we should be striving for as human beings, as a society, I think is very troubling.”

### **‘Powerful technology’**

Scientists modify the DNA of living organisms for many reasons: to make plants resistant to herbicides and pests, for example, or to make research animals mimic human conditions and diseases.

Editing DNA has become significantly less costly over the last decade, and Cambrian has modified or built machines that make the process even cheaper and faster. Traditionally, Heinz said, machines create DNA strands one at a time and many of them contain errors. His method makes millions of strands at once, errors and all, to also generate a few correct ones.

“It is the most powerful technology humans have ever created,” Heinz said. “Hydrogen bombs can destroy whole planets, but this is a technology that can create planets. This is the greatest human achievement of all time — the ability to read and write life, because that’s who we are.”

DNA is made up of four chemicals represented by the letters A, C, T and G. When Cambrian receives an order for specific genes, it adds DNA chemicals millions of times onto tiny beads that are then layered onto a glass slide. A machine assigns a color to each DNA chemical. The next step is the key one: A laser programmed to analyze the color combinations ignores the erroneous strands and “prints” the correct ones by pushing them apart from the rest. The final product arrives on a small plastic plate as a powder that customers put inside the cells of an organism.

Right now, employees check each order to make sure that a customer isn’t printing, say, base pairs of Ebola. But staff won’t have time to do that if, as Heinz predicts, orders dramatically increase in the next two years. In that case, he said, Cambrian might first ship the plates to an independent facility where experts would put the DNA inside cells, film and analyze it, and make sure that it is safe before releasing it.

This facility, he envisions, could be run by another company, not necessarily the government. Because Cambrian wants to keep government interference to an absolute minimum, its CEO insists that behaving well is in the company's best interest.

"It's pretty obvious why we wouldn't want to do something bad," said Heinz on a recent afternoon in his South of Market office. "We wouldn't want the industry to be regulated. So, 'How do we democratize creation without killing everyone?' is basically the question."

The federal government already regulates forms of genetic modification. The Food and Drug Administration oversees gene therapies for humans, and another agency has indicated it will not approve proposals to change parents' sperm and eggs with the goal of passing genetic changes to their offspring. But Darnovsky, the bioethicist, said that it's less clear what rules would apply to Heinz, who isn't proposing to design modified humans himself, but to someday provide the DNA to a third-party designer.

"There does need to be a public discussion, and public policy about when and who and under what circumstances and how new life forms can be created," she said.

Heinz and other scientists have years of technical hurdles to clear before they can create living, breathing humans from a plate of printed DNA. Such an act is not possible right now. But he doesn't hide his enthusiasm about the possibility.

Is he essentially enabling eugenics? He rejects that term, which to him means government interference with reproductive rights. He insists that it differs from his approach, which he describes as allowing individuals to eliminate future suffering in a more humane way than abortion, "which is pretty barbaric." "A decent percentage of people have really nasty mutations that cause really bad, horrible things," like Down syndrome and cystic fibrosis, he said. "These are basically like hell on Earth, and I think it's smart to be able to avoid those things."

### **DNA printer**

The technology could also be used for more superficial means, like printing desired eye and hair colors, and Heinz has no problem with that. "People are already trying to make those decisions by deciding who they're going to breed with."

Then there is the potential matter of creating living things that are now the stuff of science fiction. "If you could take a chicken and make it the size of my building," Heinz mused, "you would probably learn a lot about genetics, which could be useful for human applications."

Wouldn't that be dangerous? "If the chicken's carnivorous, then yeah."

Heinz became interested in genetics as a student at Duke University in North Carolina, his home state. In 2008, he moved to South Korea for a doctoral program in electrical engineering and computer science, where he built the DNA laser printer used today. In 2011, after giving a talk about the technology at Stanford University, he dropped out of school and returned to the United States to incorporate Cambrian.

Cambrian currently prints DNA for Roche, GlaxoSmithKline and Thermo Fisher Scientific at 5 to 6 cents per DNA letter, Heinz said. Next year, the company wants to open a pilot version of the service to academics at a steep discount: \$50 for 20 distinct 500-letter strands of DNA.

To succeed, Cambrian is investing in and working with companies that share its vision. It made an early investment in Glowing Plant, which raised more than \$480,000 on Kickstarter to create genetically modified glow-in-the-dark plants. In response, the crowdfunding platform banned projects involving genetically engineered organisms. Glowing Plant plans to use Cambrian's technology as it makes more plants.

### **Improved aroma**

Cambrian will also share its technology with startups in which it holds a 10 percent equity stake. One is Petomics, which is making a probiotic for cats and dogs that makes their feces smell like bananas. Another is SweetPeach, which hopes to take samples of users' vaginal microorganisms and send back personalized probiotics to promote vaginal health. (Contrary to Heinz's description of SweetPeach at a recent conference, the products will not make vaginas smell like peaches.)

Heinz seeks to help create "thousands" more startups in this vein. On top of that, he wants to replace lost limbs, fight viruses and develop alternatives to antibiotics. Maybe someday, he said, scientists will even print DNA on Mars. "It's going to be an amazing next few hundred years."