

May 30, 2012

# Craig Venter's Bugs Might Save the World

By WIL S. HYLTON

In the menagerie of Craig Venter's imagination, tiny bugs will save the world. They will be custom bugs, designer bugs — bugs that only Venter can create. He will mix them up in his private laboratory from bits and pieces of DNA, and then he will release them into the air and the water, into smokestacks and oil spills, hospitals and factories and your house.

Each of the bugs will have a mission. Some will be designed to devour things, like pollution. Others will generate food and fuel. There will be bugs to fight global warming, bugs to clean up toxic waste, bugs to manufacture medicine and diagnose disease, and they will all be driven to complete these tasks by the very fibers of their synthetic DNA.

Right now, Venter is thinking of a bug. He is thinking of a bug that could swim in a pond and soak up sunlight and urinate automotive fuel. He is thinking of a bug that could live in a factory and gobble exhaust and fart fresh air. He may not appear to be thinking about these things. He may not appear to be thinking at all. He may appear to be riding his German motorcycle through the California mountains, cutting the inside corners so close that his kneepads skim the pavement. This is how Venter thinks. He also enjoys thinking on the deck of his 95-foot sailboat, halfway across the Pacific Ocean in a gale, and while snorkeling naked in the Sargasso Sea surrounded by Portuguese men-of-war. When Venter was growing up in San Francisco, he would ride his bicycle to the airport and race passenger jets down the runway. As a Navy corpsman in Vietnam, he spent leisurely afternoons tootling up the coast in a dinghy, under a hail of enemy fire.

What's strange about Venter is that this works — that the clarity he finds when he is hurtling through the sea and the sky, the dreams he summons, the fantasies he concocts in his most unhinged moments of excess actually have a way of coming true. He dreamed of mapping the human genome, and he did it. He dreamed of creating a synthetic organism, and he made it. In 2003, he scrawled a line across a map of the world, hopped on his boat with a small team and sailed around the planet in search of new forms of life. By the time they returned, two years later, they had discovered more species than anyone in history.

And last fall, Venter was back in motion at the end of another journey. He was crouched atop his touring bike in the final stretch of a weeklong sprint through the American Southwest, with a handful of friends trailing behind as he whipped through the mountain foothills in a blur. In the

days to come, he would return to his office to piece together a design for the first of his custom bugs. But as he streaked back toward the lab, he made a final detour, swerving into the parking lot of a bakery to grab a slice of fresh pie. Venter hopped off his motorcycle, lifted his helmet and grinned into the California sun. “We hit 110!” he said. “Now I feel like I can go back to work.”

In This Article:

- **A Sci-Fi Fantasy Made Possible?**
- **To Seek Out New Life**
- **Yellow Algae Is Just the Beginning**
- **The Art of Creating Life**
- **Starting From Scratch**

## **A Sci-Fi Fantasy Made Possible?**

The prospect of artificial life is so outlandish that we rarely even mean the words. Most of the time we mean clever androids or computers that talk. Even the pages of science fiction typically stop short: in the popular dystopian narrative, robots are always taking over, erecting armies, firing death rays and sometimes even learning to love, but underneath their replicant skin, they tend to be made of iron ore. From the Terminator to the Matrix to the awakening of HAL, what preoccupies the modern imagination is the sentient evolution of machines, not artificial life itself.

But inside the laboratories of biotechnology, a more literal possibility is taking hold: What if machines really were alive? To some extent, this is already happening. Brewers and bakers have long relied on the diligence of yeast to make beer and bread, and in medical manufacturing, it has become routine to harness organisms like *Penicillium* to generate drugs. At DuPont, engineers are using modified *E. coli* to produce polyester for carpet, and the pharmaceutical giant Sanofi is using yeast injected with strips of synthetic DNA to manufacture medicine. But the possibility of designing a new organism, entirely from synthetic DNA, to produce whatever compounds we want, would mark a radical leap forward in biotechnology and a paradigm shift in manufacturing.

The appeal of biological machinery is manifold. For one thing, because organisms reproduce, they can generate not only their target product but also more factories to do the same. Then too, microbes use novel fuel. Chances are, unless you've slipped off the grid, virtually every machine you own, from your iPhone to your toaster oven, depends on burning fossil fuels to work. Even if you have slipped off the grid, manufacturing those devices required massive carbon emissions. This is not necessarily the case for biomachinery. A custom organism could produce the same plastic or metal as an industrial plant while feeding on the compounds in pollution or the energy of the sun.

Then there is the matter of yield. Over the last 60 years, agricultural production has boomed in large part through plant modification, chemical additives and irrigation. But as the world population continues to soar, adding nearly a billion people over the past decade, major aquifers are giving out, and agriculture may not be able to keep pace with the world's needs. If a strain of algae could secrete high yields of protein, using less land and water than traditional crops, it may represent the best hope to feed a booming planet.

Finally, the rise of biomachinery could usher in an era of spot production. "Biology is the ultimate distributed manufacturing platform," Drew Endy, an assistant professor at Stanford University, told me recently. Endy is trained as an engineer but has become a leading proponent of synthetic biology. He sketched a picture of what "distributed manufacturing" by microbes might look like: say a perfume company could design a bacterium to produce an appealing aroma; "rather than running this in a large-scale fermenter, they would upload the DNA sequences onto the future equivalent of iTunes," he said. "People all over the world could then pay a fee to download the information." Then, Endy explained, customers could simply synthesize the bugs at home and grow them on their skin. "They could transform epidermal ecosystems to have living production of scents and fragrances," he said. "Living perfume!"

Whether all this could really happen — or should — depends on whom you ask. The challenge of building a synthetic bacterium from raw DNA is as byzantine as it probably sounds. It means taking four bottles of chemicals — the adenine, thymine, cytosine and guanine that make up DNA — and linking them into a daisy chain at least half a million units long, then inserting that molecule into a host cell and hoping it will spring to life as an organism that not only grows and reproduces but also manufactures exactly what its designer intended. (A line about hubris, Icarus and Frankenstein typically follows here.) Since the late 1990s, laboratories around the world have been experimenting with synthetic biology, but many scientists believe that it will take decades to see major change. "We're still really early," Endy said. "Or to say it differently, we're still really bad."

Venter disagrees. The future, he says, may be sooner than we think. Much of the groundwork is already done. In 2003, Venter's lab used a new method to piece together a strip of DNA that was identical to a natural virus, then watched it spring to action and attack a cell. In 2008, they built a longer genome, replicating the DNA of a whole bacterium, and in 2010 they announced that they brought a bacterium with synthetic DNA to life. That organism was still mostly a copy of one in nature, but as a flourish, Venter and his team wrote their names into its DNA, along with quotes from James Joyce and J. Robert Oppenheimer and even secret messages. As the bacteria reproduced, the quotes and messages and names remained in the colony's DNA.

In theory, this leaves just one step between Venter and a custom species. If he can write something more useful than his name into the synthetic DNA of an organism, changing its genetic function in

some deliberate way, he will have crossed the threshold to designer life.

Unless he already has.

## **To Seek Out New Life**

In person, Venter is a sturdy 65-year-old with a ring of gray hair, a deep tan, perpetual stubble and crow's feet that dance around his eyes. When he caught the world's attention, in 1998, he was leading a private company, Celera Genomics, in a race against the government's Human Genome Project to complete the first map of human DNA. That race ended in June 2000, when Venter and the director of the government program, Francis S. Collins, shared a lectern at the White House to declare a tie. Neither man particularly wanted to be there, and each believed his own map was superior, but in the interest of science and at the urging of President Bill Clinton, both grudgingly relented.

In the decade since, Collins has gone on to lead the National Institutes of Health, while Venter has mostly drifted away from the capital, where his challenge to the N.I.H. did not particularly kindle friendships. Though his nonprofit organization, the J. Craig Venter Institute, maintains a base in Rockville, Md., Venter spends most of his time in California, where he grew up and is currently building a \$35 million laboratory on the campus of his alma mater, the University of California, San Diego. The building is designed to be carbon-neutral, with solar power and rainwater catchment, nestled on 1.75 acres overlooking the Pacific Ocean; less than two miles away, Venter has renovated a \$6 million home with sweeping curvilinear architecture, which is perched on a hilltop of breathtaking views.

In contrast to his lavish home and office, Venter's commercial enterprise makes a rather humdrum sight. Tucked into a suburban office park, a few miles north of his home, the headquarters of Synthetic Genomics Inc. is a leased two-story box plopped beside a highway. Yet in some ways, the building is the more exciting locus of Venter's work. Though its grounds and mission are less expansive than the institute, S.G.I. is where Venter's breakthroughs will be refined and marketed whenever they have real-world potential.

One day recently, I visited the S.G.I. building to have a look around. I found Venter in his office on the second floor, watching a video on his iPad of a race car he nearly crashed last fall at 120 miles per hour. We watched that footage for a while, then another video from a motorcycle trip, and Venter said he had recently flown a helicopter for the first time.

For a scientist, Venter spends little time in the lab, but it would be a mistake to confuse this with a

lack of focus. All critical decisions at his company and his institute ultimately ascend to Venter, who monitors the work of about 500 scientists every day, imparting various kinds of guidance and direction, even if he has to be patched in by satellite. After a few minutes in his office, we were joined by Gerardo Toledo, the company's senior director of microbial discovery. Toledo is lean and angular with hazel skin and amused eyes. In his spare time, he competes in Ironman triathlons and chases Venter on dirt bikes through the California hills. He suggested we visit the labs on the first floor, and as we descended a flight of stairs, he explained that part of the company's mission is to find, usually in nature, the genetic components that might be useful in synthetic life. For Toledo, this meant scouring the planet for intriguing microbes with uncommon genes. "The idea is to try to understand the extent of microbe diversity," he said.

Earth is a microbial planet. Micro-organisms make up about half the planet's biomass, and without them, large animals could not survive. Because they are so small, so abundant and so differentiated, they also contain most of the earth's genetic diversity. One of the most important discoveries to emerge from the human-genome projects, both at the N.I.H. and at Celera, was the revelation that humans have relatively few genes. Before the human-genome map, most scientists assumed that there were about 100,000 genes in our DNA. In fact, there are about 20,000, or fewer than those of a typical grape. That discovery was one reason that Venter began trolling the oceans in search of new forms of microbial life. Over the past nine years, he and his crew at the institute have collected water samples from thousands of locations, sending them to his lab to be screened and genetically mapped. In total, they have discovered hundreds of thousands of new species (the number is imprecise because the term "species" can be muddy) and about 60 million new genes. There were genes to help organisms survive in chemically noxious water, genes that led to the production of hydrogen and genes that trigger the manufacture of antibiotics, to name just a few. How Venter might incorporate those genes into a designer species one day remains to be seen. But as we walked down the hallways of S.G.I., Toledo explained that the company's quest to discover microbes is not limited to the oceans.

He stopped by a framed photograph of a hand filled with oily dirt. "That picture is in Malaysia," he said. "Oil palm is one of the highest oil-producing crops, but we're trying to see how that can be enhanced. First by understanding its genome and how it can be better. And second to understand what is the ecosystem of all the microbes that fit with it and help it, for example, to assimilate nutrients and prevent diseases."

We continued past a series of glassed-in labs, where scientists hunched over flasks filled with green fluid, and Toledo explained that some of the earliest organisms that S.G.I. plans to modify will be strains of algae. That's because algae, even in a natural state, offer an enticing combination of features: they photosynthesize, capturing energy from the sun; they can absorb carbon dioxide, removing a greenhouse gas from the environment; and they produce oil to store energy, which

could be cultivated into food or fuel. For decades, scientists have been tinkering with algae to make them more productive and efficient, but success has been elusive. Venter is convinced that the problem will never be solved by tinkering alone. “Algae didn’t evolve to produce tens of thousands of gallons of oil per acre,” he said. “So we have to force the evolution.” For now, S.G.I. is studying natural strains, but the goal is not to select any one of them; it’s to combine the best qualities from each. “We’re collecting all this knowledge,” Venter said, “and then we have to put it all together and design something that hasn’t existed before.”

## **Yellow Algae Is Just the Beginning**

If the promise of synthetic biology is expansive, the potential for catastrophe is plain. The greater the reach of biomachinery, the more urgent the need to understand its risks. As every hobby gardener knows, the introduction of an outside species can quickly devastate an ecosystem. From the kudzu vine to the gypsy moth to the Burmese python surge in the Everglades, we often discover the impact of a species only when it’s too late. Looking to the dawn of a biomachine age, many environmental groups worry that synthetic bugs could become the ultimate invasive species. “It’s almost inevitable that there will be some level of escape,” Helen Wallace, the executive director of the watchdog group GeneWatch, told me. “The question is: Will those organisms survive and reproduce? I don’t think anyone knows.”

The reassurance offered by Venter and other proponents may not be convincing to everyone. A synthetic bug, they say, has little chance of surviving in the competitive natural ecosystem, and anyway, it could be designed to die without chemical support. In 2010, President Obama ordered his bioethics commission to examine the implications of Venter’s work, and the commission found “limited risks.” Still, a person can be forgiven for recalling the moment in “Jurassic Park” when Dr. Ian Malcolm smirks at a team of genetic engineers and warns them, “Life finds a way.”

At the S.G.I. office, Venter suggested we step outside to visit the greenhouse, where the most promising strains of algae were already growing in open air. We met up with Jim Flatt, the chief technology officer, and followed a narrow path through woods until we emerged at a massive glass facility. We stepped into a staging area filled with hoses and flasks, beside a laboratory stacked with computers and machines. Through a wall of windows, we could see into the main room, where algae was growing in vats under bright sunlight. Each was affixed with a small plastic tube that piped in shots of carbon dioxide. “We use bottled CO<sub>2</sub>,” Flatt said, “but in an industrial facility, we would use an industrial source. That could be captured from a power plant. It could be captured from a geothermal resource. It could be captured from a cement plant. Or it could be captured from a refinery.”

As Flatt and I poked around, Venter wandered over to chat with a scientist monitoring the algae on a computer, then he stooped by a benchtop shaker with four conical flasks of algae. Three of the samples were deep green; the fourth was brilliant yellow. Venter explained that the yellow algae was the first strain engineered by S.G.I. to include a portion of synthetic DNA. In fact, the color of the algae *was* the synthetic modification. Changing the pigment of algae may seem trivial, but it represents a critical factor for commercial success. One challenge to growing algae at scale is that a successful strain, by definition, tends to reproduce quickly and turn dark green. This blocks sunlight to the algae below, and requires more-frequent care and harvest. A strain engineered to a lighter color could allow the organisms to grow more densely without obstructing essential light. The yellow algae in Venter's greenhouse was just the first to include a synthetic adjustment, but it would be followed by a series of similar changes. Even as the company modified pigment, it could also experiment with synthetic alterations to boost the production of oil and even force the algae to secrete that oil into surrounding water. "Their objective is to grow and survive," Flatt said, "not necessarily to produce things for us. So that's where the engineering comes into place. We say, 'We're going to force you to give it up.' "

We stepped into the main room of the greenhouse and walked between huge tubs filled with algae. The next step, Venter said, was to move the algae outside into large ponds. "None of this can be done at the lab scale and have any meaning," he said. "People take stuff in a little test tube and multiply it by several million or something, and claim they have these yields. But nothing works the same in a giant facility. Most things fail when you take them outside." To that end, S.G.I. had recently purchased an 81-acre parcel of land about 150 miles away, right beside the Salton Sea, where it can begin to cultivate its most successful strains. The site, he added, also sits near a geothermal power plant, which doesn't burn fossil fuels but does release carbon dioxide from underground. Venter was already in discussion with the plant's owner to divert its carbon emissions into the algae. It was possible that, within months, his algae would be turning pollution into food and oil.

We came to the last tub in the room, filled with the telltale yellow: a culture of synthetically modified organisms growing in the open air. They were the color of lemon-lime sports drink and, in the bright sunlight, had a radiant glow. It was like peering into a bathtub filled with the juice of 1,000 light sticks.

Venter gazed happily at the algae. "The photosynthetic process has been working for about three and a half billion years," he said. "This is the first major change."

## **The Art of Creating Life**

Venter's house above La Jolla is a swirl of clean, modern lines, with a sprawling kitchen at one end and hideaway nooks all around. There is a wine room that doubles as a walk-in humidior, an outdoor pool that seems to reach into the ocean and, in the garage below, an electric Tesla Roadster that pops from 0-60 in less than four seconds.

Two weeks ago, Venter met me at the door in jeans and a sweatshirt, and we sat down to chat on a brown leather sofa overlooking the Pacific. Nearby, a six-foot sculpture of a humpback whale leapt from a knotty burl of hardwood. Venter took a sip of a drink and leaned back with a sigh. "It's too bad we have to do an interview," he said.

Over the last decade, I have followed Venter's work closely, which often meant following Venter himself on strange and harrowing journeys. Through the years, I've sailed with him, flown with him, dived with him and raced across the desert on motorcycles with him, often against my better judgment and at speeds I prefer not to recall. Many of Venter's peers in science find his reckless hobbies and temperament obnoxious. No story about his work fails to mention the legion of biologists who despise him or the legendary berth of his ego. This hostility comes partly from his entrepreneurial approach to science. After he challenged the Human Genome Project in the 1990s, he was accused by the eminent James D. Watson, who was a co-discoverer of the structure of DNA in 1953, of trying to "own the human genome the way Hitler wanted to own the world." But to the colleagues who have worked with Venter for decades, his reputation as an egotist can be puzzling. At a dinner table or a cocktail party, Venter is far more likely to brag about his skill at dominoes than any professional accomplishment, and he quickly becomes awkward and irritable when a crowd of admirers surrounds him at a reception.

This is not to say that Venter is modest. He is not. But what defines him is less the show of ego than its immovable mass. When Venter tackles a scientific problem, he tends to ignore just about everyone else working on it and to dismiss whatever approach they are taking — and shoot for the fastest way to beat them to the finish line. Speed is Venter's muse and siren. The same manic energy that propels him into race cars and speedboats animates his professional life, leaving behind as many enemies as breakthroughs.

When Venter announced, in 2010, that he brought to life the first bacteria with entirely synthetic DNA, he was met with equal parts ceremony and dismissal. Many scientists hailed the achievement as a watershed moment in human history. "The ability to design and create new forms of life," the prominent physicist Freeman Dyson proclaimed, "marks a turning point in the history of our species and our planet." Yet others insisted that, because the DNA was modeled on a natural organism and was inserted into a natural cell, the claims of "synthetic life" were overblown. "He has not created life, only mimicked it," the Nobel laureate David Baltimore insisted.

When I asked the bioethicist Arthur Caplan about these extremes of adulation and indifference,



Caplan did not hesitate. Though he has criticized the Obama ethics commission for underestimating the risk of synthetic biology, he praised Venter himself as revolutionary. “He’s about three major innovations back from the Nobel Prize he should have gotten already,” Caplan said. “When you have the kinds of breakthroughs and insights that he’s had, it’s inexcusable that you wouldn’t reward that kind of work with the Nobel — and it has to be battles over personality and character, more about him than anything else.”

When I asked Venter about his reception among scientists, he was uncharacteristically nonchalant. “Some senior biologists, who in theory should know better than anybody else, keep talking about the importance of the cell,” he shrugged. “They argue: ‘Well, the cell contributed something. It can’t just be the DNA.’ That’s like saying God contributed something. The trouble for these people, it is just the DNA. You have to have the cell there to read it, but we’re 100 percent DNA software systems.” He pointed out that when his lab inserted the DNA of one organism into the cell body of another, the cell became a different organism.

Venter was quick to acknowledge that he still hadn’t created a microbe that serves an innovative purpose. “Sorry we didn’t design some new creature that never existed before as our opening gambit,” he said with a laugh. “What we published was the proof of concept. It’s like: ‘Gee, it would be really nice if the Wright brothers made a supersonic jet! Because that would have been much more useful!’ ”

This seemed like a good opportunity to ask Venter whether he had come any closer to that goal — whether, in addition to the algae modification at S.G.I., his team at the institute was working on another whole-genome assembly. Since the May 2010 announcement, Venter has been comparatively quiet, but it would be unlike him not to silence his critics. I asked him how far he had come over the last two years.

Venter was quiet for a long time. He nodded his head, as if making some calculation, then he said: “We’re doing a grand experiment. We’re trying to design the first cell from scratch.” He suggested we head into town for dinner with his two closest partners in synthetic biology, to discuss the leap they were about to take.

“It’s a little bit of a black art,” he said.

## **Starting From Scratch**

Venter’s closest collaborators in the lab are Hamilton O. Smith and Clyde A. Hutchison III, each vaunted in his own right. Smith shared a Nobel Prize in 1978 for his work on restriction enzymes,

and Hutchison's long pedigree in genetic mapping began in 1975, when he helped the pioneer Frederick Sanger sequence the first genome of a virus, for which Sanger shared his second Nobel in 1980. At 80, Smith is tall and genial, with hearing aides and a slight stoop; Hutchison is 10 years younger, with a boyish flop of hair in his eyes and an air of perpetual worry. Together they enjoy a crotchety rapport that delights Venter endlessly. "They're like the two old guys in the balcony on the Muppets," he said. "But they've both reached a point in their careers where they can afford to take risks they never would've taken 20 years ago — it's like having the oldest, smartest postdocs in the world."

As we settled around a dinner table in downtown La Jolla, a waitress delivered foie gras from the chef, setting a plate between Smith and Hutchison, who immediately lurched forward to examine it.

"What's that?" Hutchison asked.

"Goose liver," Venter said.

"Oh," Hutchison said. "I like liver."

Smith frowned. "It's glycogen," he observed.

"Yeah, glycogen," Hutchison said. "Glycogen is almost like carbohydrate."

"It is carbohydrate," Smith said.

Hutchison nodded. "You shouldn't eat a lot of liver if you're on a low-carbohydrate diet," he said.

Then they both attacked it with their forks.

Venter and Smith first met at a conference in Spain in 1993, when Smith approached Venter after a lecture. Venter was just 46, but he was already preceded by controversy. He had recently left the N.I.H. to map gene fragments in his own lab and was licensing the results to a private company, which raised alarms about privatizing life. After his lecture, Venter recalled over dinner: "Ham came up, and his first statement was, 'Where are your horns?' And I said, 'What?' He goes: 'You're supposed to be the devil. Where are your horns?'"

Smith let out a guffaw. "Well," he said, "he had inflamed a lot of the academics!"

Within months, Smith had joined Venter's nonprofit, and in 1995, they completed the first genetic sequence of a bacterium, expanding on the work at Sanger's lab two decades earlier. As a follow-up, they reached out to Hutchison, who was studying another bacterium at the University of North Carolina, and offered to map its genome for him. Two days later, Hutchison mailed a vial of DNA to

Venter and Smith. “If that was to happen now,” Smith said, “it would have been three months and a bunch of lawyers.” Hutchison shrugged. “They made me an offer I couldn’t refuse,” he said.

Venter and Smith worked quickly. Using the method they developed for the first bacterium, they completed a genetic map for Hutchison in three months. But as all three men studied the second genome, which was only a third the size of the first, they began to wonder how much smaller a genome could get. What was the fewest number of genes that could sustain a free-living organism?

“I think any good inquisitive scientists in our position would have asked those same questions,” Venter said. “But how do you get there? The limits of molecular biology don’t give you enough tools.” Working together, they began to winnow down the genome by inserting snippets of DNA that interrupt gene function, on the theory that any gene that could be disrupted without killing the cell must not be essential. In 1999, they published [a paper in the journal Science](#) describing “1,354 distinct sites of insertion that were not lethal,” and speculating that more than a quarter of the bacterium’s DNA might be superfluous. But there was still no way to be sure — no way to knock out all the nonessential genes at once and see if the organism survived. In the final sentence of their 1999 paper, they proposed a novel solution: “One way to identify a minimal gene set for self-replicating life would be to create and test a cassette-based artificial chromosome.”

Create a chromosome. This was still far beyond the reach of science, and in hindsight, marks one of the earliest references to synthetic biology as we know it today. But by the time the paper appeared, in December 1999, Venter and Smith had turned their attention to the human genome project at Celera, which would consume their attention for three years. Looking back, Venter says, “the human genome was a detour.” As soon as the Celera map was complete, they returned to the synthetic project. In 2003, they developed a new method to assemble fragments of DNA and built their first virus; when that worked, they scaled up to bacteria, ultimately writing their names and quotes in its code, but the real prize was, and remains, to build the stripped-down organism they first proposed in 1999 — a free-living bacterium with less DNA than any in nature. It would not only test their theories about essential genes but would also provide an ideal framework for future organisms. Once they had the minimal genome, they could use it as a chassis to attach other genes: maybe a component to feed on sulfur or a module to generate hydrogen or both.

“That’s why it’s so valuable,” Venter said. “If we’re going to design really complex biological machinery, it has to have these fundamentals.”

But the minimal genome may raise an even more fundamental question, one that touches on the nature of innovation itself. When we think about technological change, most of us view progress through a narrow lens: we imagine new gadgets and devices that will streamline our modern lives, bringing the most technically advanced civilization in history to new heights of technical advancement. Yet the innovations that really matter in the long term may not have much to do

with advancement at all. They may have less to do with improving our own standards of living than with extending those standards around the world. As the global population continues to rise, the greatest technological challenge we face may be to avoid leaving large tracts of the earth behind. The synthetic biology that Venter proposes, using a minimal genome as a platform to make advances in food, fuel, medicine and environmental health, could backfire into a biological calamity, but it could also offer the most transformative approach to a medley of problems with no apparent solution.

“Agriculture as we know it needs to disappear,” Venter said. “We can design better and healthier proteins than we get from nature.” By this, he didn’t mean growing apples in a Petri dish. He meant producing bulk commodities like corn, soy and wheat, that we use in processed products like tofu and cereal. “If you can produce the key ingredients with 10 or 100 times the efficiency,” he said, “that’s a better use of land and resources.”

As we enjoyed a decidedly real dinner of lobster and fresh vegetables, Venter explained that he was just days away from trying the first synthesis of a minimal genome. For two years, even as the team at S.G.I. has been working to cultivate algae, the institute has been poring over research to design a new genome. Eventually, the process grew tedious. “Up to three weeks ago,” Smith said, “we were on a very gradual course, and we were looking at a long time to get the thing completed. So Craig says, ‘Damn it, let’s make a guess, and synthesize the darn thing based on what we know, and maybe it’ll work!’ ”

Venter laughed. “I call it the Hail Mary Genome.”

Just days earlier, he said, they completed two designs — one led by the office in Maryland, the other by Hutchison’s team in California. In the days ahead, they would begin assembling both. If either worked, it would represent the smallest genetic code of any free-living creature on earth, one that would be impossible to dismiss as a copy. Even as we sat at the dinner table, it was possible that Venter, Smith and Hutchison already had it; that somewhere in their lab, they held the design for the first custom organism made from synthetic DNA.

Hutchison said he was encouraged that the two drafts overlapped. “There are about 30 genes different between the two,” he said.

Smith grinned. “I’m gonna go with Clyde’s draft,” he said.

“Well, mine is smaller,” Hutchison said. “I think maybe we’re going to pick some of the pieces from one design and some from the other.”

“We’re also trying to re-engineer the genome in a much more logical fashion,” Venter said. “We’re

doing it in the form that, if there was a God, this is how he would have done it.”

“Evolution is very messy,” Smith added.

“We’re trying to clean it up,” Venter said.

“What’s the time horizon?” I asked.

“I have some ideas that, within the year — ” Hutchison began.

Venter shook his head. “Before the end of summer,” he insisted.

Hutchison chuckled.

“It might be the end of summer,” Smith said.

“It’s going to be the first rationally designed genome,” Venter said.

“Actually, my preference would be not to do the fine needlework,” Smith said. “I would just take the very largest 30 or 40 clusters and remove those.”

“We can do that,” Hutchison said.

“Let’s do it,” Smith said. “The hell with the rest of them.”

*Wil S. Hylton is a contributing writer for the magazine. He last wrote about the state of U.S. biodefense preparations.*

*Editor: Joel Lovell*



OPEN

MORE IN MAGAZINE (

**It’s the Econo  
Market Thriv**

Read More »