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## Rise of the garage genome hackers

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KATHERINE AULL's laboratory in Cambridge, Massachusetts, lacks a few mod cons. "Down here I have a thermocycler I bought on eBay for 59 bucks," she says, pulling out a large, box-shaped device she uses to copy short strands of DNA. "The rest is just home brew," she adds, pointing to a centrifuge made out of a power drill and plastic food container, and a styrofoam incubator warmed with a heating pad normally used in terrariums.

In fact, Aull's lab is a closet less than 1 square metre in size in the shared apartment she lives in. Yet amid the piles of clothes she recently concocted vials of an entirely new genetically modified organism.



(Image: Mackenzie Cowell)

Aull, who works as a synthetic biologist for a biotech company by day, created her home lab after hearing about a [contest on the science fiction website io9.com](#) for "mad scientists with homebrew closet labs, grassroots geneticists, and garage genome hackers".

After two months of tinkering, she engineered a microbe that she says is capable of performing simple logic operations, which could be the forerunner to basic biological computers. "Biology is wet, squishy and imprecise. It drives engineers insane," Aull says. "This would allow us to take the noise out of biology."

One amateur biologist engineered a microbe she says is capable of simple logic operations

Despite her success, Aull was edged out of first place in the competition by Vijaykumar Meli, a graduate student at the [National Centre for Plant Genome Research](#) in New Delhi, India, who designed bacteria that could help rice plants process nitrogen more efficiently, reducing fertiliser use.

The competition is part of a do-it-yourself movement that hopes to spark a revolution in biotechnology. It is based on the emerging field of synthetic biology, which uses genes and other cell components as the building blocks for new organisms or devices. The movement is trying to open up this field to anyone with a passion for tweaking DNA in their spare time - from biologists to software engineers to people who just like it as a hobby. The hope is that encouraging a wider mix of people to take part could lead to advances that would not happen otherwise, just as tinkering by the Homebrew Computer Club hackers of the 1970s spawned the first personal computers.

"Biology is becoming less of a science and more of a technology," says Mackenzie Cowell, co-founder of the group [DIYbio](#), which aims to be an "Institution for the Amateur", providing scientists with resources akin to those found in academia or industry. "There will be more opportunity for people who didn't spend up to seven years getting a PhD in the field," he says.

Meredith Patterson, a software engineer in San Francisco, is one such amateur. She is engineering fluorescent yoghurt by zapping bacteria with a \$40 ultrasonic jewellery cleaner she set up in her kitchen. The sound waves create pores in the bacteria's cell walls which stay open for long enough for Patterson to insert genes that code for green fluorescent proteins she bought from a biological supply company.

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You might say that making glow-in-the-dark yoghurt is an end in itself, but Patterson has a serious goal in mind: to engineer bacteria that light up in the presence of melamine, the industrial chemical recently found in infant formula in China, which injured hundreds of children and killed at least six. At present, the principal test for the toxin is chromatography, an expensive laboratory procedure. "Here is a problem that was difficult to solve by conventional means," Patterson says. "People should have an inexpensive and portable test to make sure their food is safe, but no lab was working on this, so I said let's do it ourselves."

Patterson took up DIY biology as a hobby after doing some bioinformatics work for a biotech company. "Biology is an interesting puzzle. I learned the informatics tools to solve those puzzles, now I'm interested in taking that to the next level and producing novel organisms to solve problems," she says.

It's not hard to get in on the act either. Patterson uses resources such as [openwetware.org](http://openwetware.org) for research, and found the best growth medium for yoghurt bacteria in a 1950s edition of a dairy science journal. "Knowing how to do research helps, but the barrier for entry is pretty low," she says.

DIYbio, which so far has around 20 active participants, held its first meeting in Cambridge, MA, in May 2008. Amateurs were invited to extract DNA for analysis from apples, oatmeal and their own saliva, and learned how to make gel boxes and dyes - essential tools for genetic fingerprinting.

Is it a good idea, though, to encourage "freelance" researchers to experiment with DNA, however well-intentioned they may be? Not everyone thinks so. Inexperienced hackers could pose a significant public health threat, warns Richard Ebricht, a biochemist at Rutgers University in Piscataway, New Jersey. "Without any oversight from an institution, colleagues or peers, the probability that a cataclysmic entity might be constructed by someone unaware of known cautions is significant," he says.

The greatest potential danger, he says, is that someone might [intentionally synthesise or recreate deadly pathogens like the 1918 flu strain](#), which killed an estimated 40 million people worldwide. "That is on the edge of being within the technical capabilities of someone working outside the laboratory environment."

In response to such fears and in anticipation of calls for the group to be shut down, DIYbio has begun policing itself. Cowell says there is now "a self-imposed moratorium on 'wetwork'", or all synthetic biology experiments, until researchers can show that what they are doing is safe. For the moment, the group is focusing on DNA fingerprinting projects, with the analysis carried out by commercial labs, rather than manipulating genetic information themselves.

The first such project is BioWeatherMap, a plot of the different microbes, or "bioweather", to be found on street crossing buttons. Over the next few months DIYbio hopes to mobilise amateur scientists in Boston, San Francisco, Seattle and other cities to send in swab samples from their nearest street corner. A commercial lab will then sequence the microbes they find and DIYbio will post the results online with the help of mapping software such as Google Maps.

"I think this is a perfect opportunity for high-school biology classes to get exposed to genomics, sequencing and microbiology," says DIYbio co-founder Jason Bobe, who expects to find hundreds or even thousands of different species living on each crosswalk button.

Ultimately, Cowell hopes to set up a public lab where group members can safely conduct experiments of the kind Aull managed in her closet. In this he has the surprising support of George Church, a synthetic biology researcher at Harvard University who in 2004 published a paper claiming that the consequences of synthetic DNA misuse could be more severe than chemical and nuclear weapons. He now says: "The world has an energy crisis and a healthcare crisis that synthetic biology can help solve; we need to go out and do it and the more people working on this, the better."

Church argues that licensing and monitoring would-be DIY biologists is better than alienating them. "It's going to happen anyway; you can make it go underground or you can try to shape it," he says.

Church has agreed to act as an adviser to DIYbio, which will give the group greater academic oversight and could allow it to resume experimental work with less fear of being shut down.

As for Aull, she is coming out of the closet with plans to help DIYbio set up protocols for safe lab

practices. She says she will donate her thermocycler to the group if it is able to secure a public lab and she's also planning to carry out further work on her microbe to confirm it really is performing logic operations.

Based on her own experiences of DIY biology, including its limitations, she says warnings of the dangers are overblown. "It's like a baby that just rolled over for the first time and his aunt is crying because she doesn't have anything to wear to his wedding."

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