Monitor

Biohackers of the world, unite

Following the example of maker communities worldwide, hobbyists keen on biology have started to get together

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Timekeeper

IT LOOKS like an experimental cooking class as participants taste a green powder, pull faces and then mix it into a concoction of fruit and milk. But the event organised by Open Wetlab in Amsterdam has a more serious goal than to come up with new recipes for smoothies: finding ways to make spirulina—an algae which is full of proteins and vitamins, but tastes disgusting—more palatable.

Welcome to the world of biohacking. In its original sense, hacking involves taking things apart and putting them back together again in new ways. Such tinkerers helped to create the “maker movement”, which has grown into a worldwide community of people constructing things ranging from 3D-printed jewellery to robots. Biohackers have also started to organise themselves, under the umbrella of a movement called DIYbio.

Nearly 50 cities, mostly in America and Europe, are now home to groups of biohackers or amateur laboratories where they can meet and experiment. Besides Open Wetlab, these include Biocurious in Sunnyvale, California, Genspace in New York and La Paillasse in Paris. The number of biohackers around the world is anybody’s guess, but the movement’s main online-mailing list boasts nearly 4,000 members and is growing rapidly.

What drives the movement is the belief that “biology is technology” (to quote the title of a book by Rob Carlson, a DIYbio pioneer): that DNA is a form of software that can be manipulated to design biological processes and devices. But some people worry that amateur laboratories could create killer bugs or provide training for bio terrorists. For the

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moment, at least, such fears seem premature. The amateur labs are not yet very sophisticated, according to a recent survey of 359 members of the DIYbio movement by the Woodrow Wilson International Centre for Scholars, a think-tank. Most activities involve extracting DNA, for instance from strawberries. Only 13% of the biohackers have synthesised a gene and just 3% have genetically engineered a mammalian cell. Since biohackers often have a PhD, they probably did this in a professional lab.

Art and science

Not all the groups are focused on synthetic biology. In Europe, amateur biologists often work with artists and designers, says Markus Schmidt, co-author of a paper on European DIYbio. A recent fair called "Synthetic Aesthetics" at the Victoria and Albert Museum in London included projects that use bacteria to colour tapestries, grow bags and encode music in DNA.

"Our goal is not only to advance biology, but democratise it," explains Ellen Jorgensen, president of Genspace. Founded in 2010, the community laboratory in Brooklyn is the model for the two dozen others that have since opened around the world. Genspace hosts all sorts of events, including "biohacker boot camps", as well as projects such as "barcoding" in Alaska, an attempt to catalogue plants.

Technological movements often arise when a critical mass of enthusiasts get greater access to information and find tools that are both cheap and widely available. A similar thing is happening in medical technology, where there is a flourish of innovative startups making new devices (see article).

Many of the first makers were software developers wanting to reconnect with the real world by building physical things. Enough people are now interested in biology and have knowledge to hack DNA, says Mr Carlson. DIYbio also has roots in iGEM, a successful annual synthetic-biology competition for undergraduates.

As in the case of the maker movement, websites such as YouTube and Instructables allow tinkerers to share ideas. Similarly, access to information about biotechnology has become much easier, says Mr Carlson. The *Journal of Visualised Experiments*, a peer-reviewed online-video publication, is one source.

The necessary laboratory equipment is no longer beyond the budget of hobbyists. Many devices are now for sale on eBay and more specialised online marketplaces, not least because the recession has forced a number of commercial laboratories to close. Such equipment can also be built more cheaply by using off-the-shelf parts and open-source software.

My own PCR machine

If 3D printers are the tool of choice for makers, PCR machines are *de rigueur* in amateur labs. Using a biochemical technology called polymerase chain reaction (hence PCR), the machines are used to identify a specific segment of DNA and make multiple copies of it. "You can now build these in a garage," says Josh Perfetto, who is one of the founders of OpenPCR, a group which has developed a simple PCR machine that costs only $600.

DIYbio also benefits from the organisational infrastructure of the maker movement. Many laboratories start in hackerspaces, which serve as clubhouses for makers. Amsterdam's Open Wetlab, for instance, is part of the Waag Society, an organisation which also runs a shop for makers. Moreover, many tinkerers have started dabbling in biology.

All this raises the question of how big DIYbio will become. The maker movement now counts tens of thousands of members and hundreds of startups. Its boosters say DIYbio

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could repeat the trick. It has already spawned its first firms. OpenPCR has now become a startup business and is working on an improved PCR machine. Amplino, a Dutch startup, has built a low-cost device capable of detecting malaria, which it hopes will be used in developing countries.

Other firms are working on products that could make life much easier for biohackers. Autodesk, a big software company, has a scheme under way code-named “Project Cyborg” which is developing design tools for DNA. Opus Labworks, a startup, aims to build a fluid-handling robot starting at $2,000. Even more ambitious, Cambrian Genomics is building a “3D printer for living things”—a device that can cheaply synthesise DNA.

But there are barriers that will limit DIYbio’s growth. Building a biological device is a lot more complicated than putting together a robot or designing a new circuit board. And whereas regulators have largely ignored the maker movement, they are a lot more interested in the work of amateur laboratories.

If European biohackers are less focused on synthetic biology, it is partly because they need to ask for permission. Genetics laboratories require a licence and only a few are even trying to get one. In America biohackers used to risk getting arrested, but in recent years the FBI has opted for a more enlightened approach: local special agents talk to community labs; the agency organises an annual DIYbio conference; it is even a sponsor of iGEM. “The people who practise DIYbio are best placed to know what is going on,” says Edward You, who pioneered the FBI’s effort. He also thinks that the agency and the DIYbio movement have a “shared responsibility to protect science”. In other words, if things go wrong there will be tighter regulations—making life more difficult for both law enforcement and biohackers.

Most DIYbio leaders welcome all this (although some joke that DIYbio would not be where it is today without the FBI’s support). “What you don’t want to do is surprise law enforcement and regulators with new technologies,” says Jason Bobe, co-founder of DIYbio.org, a charity that supports the movement, who also works with George Church, a pioneer of genetics (see article). For now it seems to be able to regulate itself. DIYbio.org has hired safety experts for members to consult. And leaders of the movement on both sides of the Atlantic have developed a code of ethics which frowns on releasing genetically modified organisms into the environment. When one group wanted to launch a crowdfunding project to develop a glowing plant and send contributors the seeds, their laboratory showed them the door. (The project nonetheless went ahead and will be the first biology startup to join Y Combinator, Silicon Valley’s leading “accelerator”, which provides capital and advice to new ventures.)

As DIYbio grows calls for tighter regulations will get louder. Yet clamping down would be counter-productive, argues Mr Carlson. Such rules would be hard to enforce and drive biohackers underground. It would hamper startups and limit innovation. Much better, says Mr Carlson, for governments to support community labs where everbody—biohackers, startups and anyone who is interested—can experiment openly and safely.

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