

Do-it-yourself biology

Do-it-yourself biology (**DIY biology**, **DIY bio**) is a biotechnological social movement in which individuals, communities, and small organizations study biology and life science using the same methods as traditional research institutions. DIY biology is primarily undertaken by individuals with limited research training from academia or corporations, who then mentor and oversee other DIY biologists with little or no formal training. This may be done as a hobby, as a not-for-profit endeavor for community learning and open-science innovation, or for profit, to start a business.

Other terms are also associated with the do-it-yourself biology community. The terms **biohacking** and **wetware hacking** emphasize the connection to hacker culture and the hacker ethic.^[1] The term hacker is used in the original sense of finding new and clever ways to do things. The term biohacking is also used by the grinder body modification community, which is considered related but distinct from the do-it-yourself biology movement.^[2] The term **biopunk** emphasizes the techno-progressive, political, and artistic elements of the movement.

History

The term "biohacking" as well as the concept of do-it-yourself biology has been known as early as 1988.^{[3][4][5]}

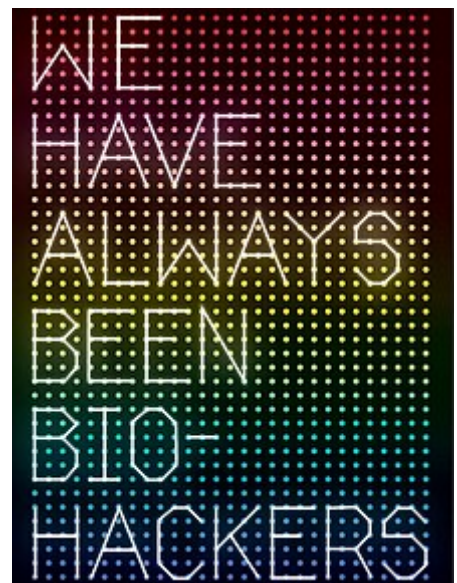
Biohacking entered the San Francisco programmer and maker communities as early as 2005, through simple demonstrations of basic experiments. As DIYbio experiments became the focus of SuperHappyDevHouse hackers, the hobby gained additional momentum.

In 2005 Rob Carlson wrote in an article in *Wired*: "The era of garage biology is upon us. Want to participate? Take a moment to buy yourself a lab on eBay."^[6] He then set up a garage lab the same year, working on a project he had previously worked at the Molecular Sciences Institute in Berkeley, California.^[7]

In 2008, the DIYbio organization was founded by Jason Bobe and Mackenzie Cowell and its first meeting held.^[8]

In 2010, Genspace opened the first community biology lab,^[9] Ten months later it was followed by BioCurious,^[10] and Victoria Makerspace. Many other labs and organizations followed, including but not limited to Counter Culture Labs in Oakland, CA, Baltimore Underground Science Space in Baltimore, MD, TheLab in Los Angeles, CA and Denver Biolabs in Denver, CO.

It has been estimated that in 2014 there have been 50 DIY biology labs around the world.^[11]:119



WHABBH poster designed by the
Center for Genomic Gastronomy
(2010)

In 2016, the first conference to focus specifically on biohacking was announced to take place in September in Oakland, CA.^[12]

Aspects

The DIYbio movement seeks to revise the notion that one must be an academic with an advanced degree to make any significant contribution to the biology community. It allows large numbers of small organizations and individuals to participate in research and development, with spreading knowledge a higher priority than turning profits.^[13] In recent years, there are various DIY ways to live healthy and many of them also focuses on different simple ways to biohack mind,^[14] body, metabolism^{[15][16][17]} and sleep.^[18]

The motivations for DIY biology include (but aren't limited to) lowered costs, entertainment, medicine, biohacking, life extension, and education. Recent work combining open-source hardware of microcontrollers like the Arduino and RepRap 3-D printers, very low-cost scientific instruments have been developed.^[19]

Community laboratory space

Many organizations maintain a laboratory akin to a wet-lab makerspace, providing equipment and supplies for members. Many organizations also run classes and provide training. For a fee (usually between \$50 and \$100), members can join some spaces and do experiments on their own.^{[20][21][22]}

Open source equipment

The DIY biology movement attempts to make available the tools and resources necessary for anyone, including non-professionals, to conduct biological engineering. One of the first pieces of open source laboratory equipment developed was the Dremelfuge by Irish biohacker Cathal Garvey, which uses a 3D printed tube holder attached to a Dremel rotary tool to spin tubes at high speeds, replacing often expensive centrifuges.^[23] Many other devices like PCR machines have been recreated extensively.^{[24][25][26]} In recent times, more complex devices have been created such as the OpenDrop digital microfluidics platform^[27] and the DIY NanoDrop^[28] both developed by GaudiLabs. Opentrons makes open-source, affordable lab robots, and got its start as a DIY biology collaboration at Genspace.^[29] Incuvers makes telemetric chambers for cellular research that are affordable and allow for complete customizability of their environments. OpenCell, a London based biotech lab provider hosts regular biohackathons to help encourage more opensource development.^[30]

Advocacy

Most advocacy in biohacking is about the safety, accessibility and future legality of experimentation. Todd Kuiken of the Woodrow Wilson Center proposes that through safety and self-governance, DIY biologists won't be in need of regulation.^[31] Josiah Zayner has proposed that safety is inherent in biohacking and that accessibility should be the foremost concern as there is large underrepresentation of social and ethnic minorities in biohacking.^[32]

Research topics

Many biohacking projects revolve around the modification of life and molecular and genetic engineering.^[33]

Bioinformatics

Bioinformatics is another popular target for do-it-yourself biology research. As in other fields, many programming languages can be used in DIY biology, but most of the languages that are used are those with large bioinformatics libraries.

Examples include BioPerl or BioPython, which use the languages Perl and Python, respectively.

Genetic engineering

Genetic Engineers are a subculture of biohackers as one of the most accessible forms of biohacking is through engineering microorganisms or plants. Experiments can range from using plasmids to fluorescent bacteria, controlling gene expression using light in bacteria,^[34] even using CRISPR to engineer the genome of bacteria or yeast.^[35]

Medicine

Restricted access to medical care and medicine has pushed biohackers to start experimenting in medically related fields. The Open Insulin project aims to make the recombinant protein insulin more accessible by creating an open source protocol for expression and purification.^[36] Other experiments that have involved medical treatments include a whole body microbiome transplant^[37] and the creation of open source artificial pancreases^[38] for diabetics, such as OpenAPS, Loop^[39] and AndroidAPS.^[40]

Implants

Grinders are a subculture of biohackers that focus on implanting technology^[41] or introducing chemicals^[42] into the body to enhance or change their bodies' functionality.

Some biohackers can now sense which direction they face using a magnetic implant that vibrates against the skin.^[43]

Art

In 2000, controversial and self-described "transgenic artist" Eduardo Kac appropriated standard laboratory work by biotechnology and genetics researchers in order to both utilize and critique such scientific techniques. In the only putative work of transgenic art by Kac, the artist claimed to have collaborated with a French laboratory (belonging to the Institut National de la Recherche Agronomique) to procure a green-fluorescent rabbit: a rabbit implanted with a green fluorescent protein gene from a type of jellyfish [*Aequorea victoria*] in order for the rabbit to fluoresce green under ultraviolet light. The claimed work came to be known as the "GFP bunny", and which Kac called *Alba*. This claim by Kac has been disputed by the scientists at the lab who noted that they had performed exactly the same experiment (i.e., the insertion of the jellyfish GFP protein-coding gene) on numerous other animals (cats, dogs, etc.) previously and did not create *Alba* (known to the researchers only as "Rabbit Number 5256") under the direction of Kac. The laboratory consequently kept possession of the transgenic rabbit which it had created and funded and the

"transgenic art" was never exhibited at the Digital Avignon festival [2000] as intended. Kac—claiming that his rabbit was the first GFP bunny created in the name of Art—used this dispute to popularize the issue as one of disguised censorship by launching a "Free Alba" campaign. A doctored photo of the artist holding a day-glow-green tinted rabbit appears on his website.^[44] The members of the Critical Art Ensemble have written books and staged multimedia performance interventions around this issue, including *The Flesh Machine* (focusing on in vitro fertilisation, surveillance of the body, and liberal eugenics) and *Cult of the New Eve* (In order to analyze how, in their words, "Science is the institution of authority regarding the production of knowledge, and tends to replace this particular social function of conventional Christianity in the west").^[45]

Heather Dewey-Hagborg is an information artist and biohacker who uses genomic DNA left behind by people as a starting point for creating lifelike, computer-generated, 3-D portraits.^{[46][47]}

Criticism and concerns

Biohacking experiences many of the same criticisms as synthetic biology and genetic engineering already receive, plus other concerns relating to the distributed and non-institutional nature of the work, involving potential hazards with lack of oversight by professionals or governments. Concerns about biohackers creating pathogens in unmonitored garage laboratories led the Federal Bureau of Investigation (FBI) to begin sending its representatives to DIYbio conferences in 2009.^[7] The arrest and prosecution of some members for their work with harmless microbes, such as artist Steve Kurtz, has been denounced as political repression by critics who argue the U.S. government has used post-9/11 anti-terrorism powers to intimidate artists and others who use their art to criticize society.^[48]

Existing regulations are not specific to this field, so that the possibility of pathogenic organisms being created and released unintentionally or intentionally by biohackers has become a matter of concern, for example, in the spirit of the re-creation of the 1917 flu virus by Armed Forces Institute of Pathology researchers in 2005.^[49] In the US the FBI Weapons of Mass Destruction Directorate has worked with the American Association for the Advancement of Science's National Science Advisory Board for Biosecurity to convene a series of meetings to discuss biosecurity, which have included discussions of amateur biologists and ways to manage the risks to society it poses.^{[50][51]:8.16} At the National Institutes of Health, National Science Advisory Board for Biosecurity^[52] leads efforts to educate the public on "dual use research of concern", for example with websites like "Science Safety Security".^[53] In 2011, DIYbio organized conferences to attempt to create codes of ethics for biohackers.^[54]

A 2007 ETC Group report warns that the danger of this development is not just bioterror, but "bio-error".^[55]

While detractors argue that do-it-yourself biologists need some sort of supervision, enthusiasts argue that uniform supervision is impossible and the best way to prevent accidents or malevolence is to encourage a culture of transparency, where, in essence, do-it-yourself biologists would be peer reviewed by other biohackers.^[56] DIYbio argues that fear of potential hazards should be met with increased research and education rather than closing the door on the profound positive impacts that distributed biological technology will have on human health, the environment, and the standard of living around the world.^[57] Due to the lack of precedent regarding such a business model, the DIYbio founders see this as an opportunity to be innovators in regulatory and safety policy.^[8]

Groups and organizations

- Baltimore Underground Science Space (BUGSS), in Baltimore, Maryland

- Biocurious, in Sunnyvale, California
- Boston Open Science Laboratory (BOSLab), in Cambridge, Massachusetts
- Counter Culture Labs, in Oakland, California
- Four Thieves Vinegar Collective
- Genspace, in Brooklyn, New York
- the Open Insulin Project, an international collaboration
- Victoria Makerspace, in Victoria, British Columbia
- DIYbio, an online network

See also

- Amateur chemistry
- Open science
- Body hacking

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