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DIYbio: Making things and making futures

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ABSTRACT

http://DIYbio.org (Do It Yourself Biology) is an online site and a digital brand subscribed to local groups of amateur biologists worldwide. Despite of making up a rather heterogeneous public, DIYbio groups are organized around a concern to make biology accessible, easy and enjoyable. DIYbio combines an open source ethos, with a DIY will to do things and the joy to mess with biological matter. As biohacking is about de-composing and re-composing things, DIYbio takes on a particular approach to the making of the new and to the making of futures that this paper explores. Inspired by Heidegger's notion of the thing, I suggest that differing from institutionalized forms of biology, DIYbio produces things rather than techno-objects. I go into this point by first situating DIYbio in relation to synthetic biology and other instutionalised forms of biology. To explore how DIYbio takes on a particular approach to the making of the new, I look at a number of things that DIYbio groups have projected, designed and realized. I suggest that DIYbio combines a sort of individual craftiness and self-determination to do things with a praxis in which things are always in the making, waiting for the next realization. DIYbio take on an approach to the making of things and futures that is immediate and mundane. Yet, as an emerging public, DIYbio relies on an ambiguous relation to institutionalized science, and might be turned into a transfer of materialities and temporalities from public domains to science.

> 'The thing things. Thinging gathers. Appropriating the fourfold, it gathers the fourfold's stay, its while, into something that stays for a while into this thing, that thing.' (Martin Heidegger, 1971: 172)

1. DIYbio: just do it

Biologigaragen is the local DIYbio, (Do it Yourself Biology), group in Copenhagen. Occasionally, they take part in public events where they show how easy it is to 'hack' biology. One of these events was the 'Open Source Food Night' which took place in a public library of Copenhagen. To begin the session the 'Opensource Food Project' was introduced. This project is a community driven initiative that aims at calling attention to the living conditions of asylum seekers in Denmark.[1] In this project, asylum seekers learn about plant varieties that are freely available in the surroundings of the city of Copenhagen. Open access to food is promoted by sharing knowledge about local plants. As the audience was introduced to the project, big pots were boiling in the library room. To demonstrate how tasty open source food can actually be, the audience was invited to a dinner consisting of a soup made with local plants and home made bread and butter with local herbs. Afterwards, Biologigaragen showed the audience how easy it is to 'hack' a yoghurt, and hacked yoghurt was served for dessert. The DNA

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[1] http://opensourcefood.info/.

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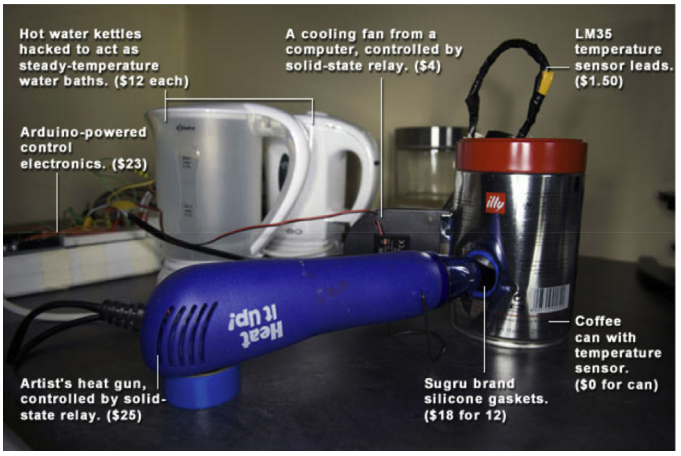

Image 1. Home made-lab, image displayed at the Open Source Food Night event.

of the yoghurt had been hacked to have a particular flavour. Together with this tasty demonstration, the audience was introduced to DIYbio as 'easy biology' that people can make in their garage or kitchen (Image 1).

As introduced by Biologigaragen at this event, and at other DIYbio sites, DIYbio is very much about making and messing with things by combining wetware, software, and hardware in a low-cost fashion. Mundane living entities, such as yoghurts; re-used kitchen 'stuff', such as toasters and coffee cans; and used lab equipment are the kind of things that can be found in a DIYbio lab. As part of the audience of the 'Open Source Food night', I was certainly impressed to witness how simple and trivial hacking a yoghurt is and how unusual it is to bring together such heterogeneous elements as kitchen stuff, forgotten plants, asylum seekers, hacked yoghurts, and DIYbio lab tools in one event. By considering this combination of easiness and the determination to re-make realities, one can see DIYbio as a particular approach to the production of *the new*; one that builds on hybridity, creativity, and the will to mess with things.

The hackings that DIYbio biologists do are often very trivial and domestic, as with Biologigaragen's hacked yoghurt. Biolumiscent gadgets that generate their energy from living organisms and open source basic lab tools are some common DIYbio things. Focusing on such triviality one can easily argue that DIYbio is not a site where important techno-scientific breakthroughs are likely to occur, and so, one could conclude DIY bio will not have a real impact for future innovation. Yet, that argument may appear less significant when acknowledging that that is precisely the point: DIYbio does not necessarily pursue the kind of science and innovation that occurs in institutional settings. Instead of producing sophisticated biological objects, DIY biologists produce rather mundane living things. DIYbio entails a different way of engaging with science and technology, and with the making of things and futures. It is biology moving out of institutions and to the realms of the public.

In a sense, DIYbio is not a very original phenomenon, neither it is an isolated one. It emerges as one of many DIY outbreaks that we see today within different sectors of the public.[2] In different technological domains such food consumption, repairing and re-using electronic waste or making digital maps by using GIS, (geographical information systems), the public is increasingly emerging in a number of DIY forms, as makers, menders, [3,4] and hackers of different kinds. Simultaneously, the words hacking and open-source are being transferred to a number of new domains to mobilize claims for access and the right to do and to change things. Whether an increasing DIY attitude of current publics echoes a situation of institutional crisis of Western societies and it reveals a generalized disbelieve in public institutions and in their capacity to make futures, is something that remains to be explored. What is nevertheless quite clear, is that DIY entails a certain civic positioning: the vision of a "self" that can make futures by doing things. DIY is praxis-oriented, and it builds on direct action [5]. Yet, interestingly, current DIY expressions combine the focus on the "self" with a vision of 'the community; encoded in the open source ethos: A community that makes *itself* through hacking practices of sharing, circulation, and the constant transformation of things [6]. Resonating with the ethos of constant transformation, Mackenzie Cowell, co-funder of http://DIYbio.org, argues that biohacking is: "Taking things apart and putting them back together in a way that makes them better" (quoted in [7]: 133).

In the following sections I explore how DIYbio relates to the making of the future(s), not only in its claims and visions, but also through the making and re-making of things. The paper assumes a particular definition of innovation as the emergence of the new: the realization of a future that lies between possibility and actualization (see [8]). My approach to DIYbio is inspired by Heidegger's (1971) notion of the *thing*. In Heidegger's account, things are temporary 'gatherings'. *Things* bring together a multiplicity of otherwise heterogeneous elements at a certain time. Being always unfinished, they bring to presence past relations, projecting them towards the future in the form of temporary actualisations. In their heterogeneous

[2] Although one can trace back the history of DIY expression to the XIX Century, it configured as a citizen movement and as an alternative business model only in recent history. Becoming popular in the 1990s, what makes DIY unique is that it has brought together citizenship, protest, and design [1–3].

and changeable appearances, things are different from the 'purified' objects of technoscience. As Bruno Latour and others have argued, science proceeds by purifying and domesticating the unruliness of things, presenting them *as if* they were stable, finished and coherent objects [9,10]. Technoscientific objects are often presented as existing out particular times and space, as being universal. What the descriptions of DIYbio things bellow suggest is that differing from such purified objects, DIYbio things are not intended to be more than just *things*, in Heidegger's sense. This entails a more situated and immediate way of producing the new, right *here* and *now*. The next section introduces DIYbio as it emerges questioning institutionalized forms of biology with its technological and bureaucratic mediations, and projecting futures that are performed by direct action and the right to do. I then introduce a number of things that DIYbio groups have projected, designed, and realized. I suggest that DIYbio combines a sort of individual craftiness and self-determination *to do* things with a praxis in which things are left open, waiting for the next realization. I argue that immediacy and constant actualization are key temporalities organizing those things. Turning to a more conceptual discussion, the last section of the paper provides furthers arguments on how, through constant actualization, an immediate action DIYbio may relate to the production of the new.

2. Biohacking: questioning presents, projecting futures

The Biopunk Manifesto, begins: 'Scientific literacy is necessary for a functioning society in the modern age. Scientific literacy is not science education. A person educated in science can understand science; a scientifically literate person can *do* science'.[3] Written by Meredith Patterson, a well-known DIYbio advocate, the Manifesto claims that the right *to do biology* is a political right. The Biopunk Manifesto breathes a certain optimist spirit of enlightenment; it carries the vision of a more democratic future where citizens have access to and can modify the biological world, without a PhD in biology.[4] In this view, scientific literacy does not necessarily require long hours of institutional education to then be certified in a number of official degrees. Rather that it can be self-achieved out of enthusiasm. Yet, nevertheless, most DIY biologists do have a degree in biology, while others are entrepreneurs and artists, and less commonly, just curious citizens. DIYbio is certainly a heterogeneous public, sometimes even presented as a 'new business model' [23]. This heterogeneity materializes in the form of a number of projects as different as glow in the dark yoghurts, bioluminescent gadgets, bio-reactors that produce energy, genetics tests, or open source lab tools. What these projects have in common is that, in one way or another, they enact creativity, curiosity, and enthusiasm. That is, bio-hackers say, what differentiates *amateur* biology from institutionalized biology.

In the following lines I will argue that DIYbio is emerging in an ambiguous move. On the one hand, depending on the infrastructures generated by institutionalized forms of biology. Simultaneously, DIYbio labs, online forums, and designs are a materialized contestation to the ways in which biology, and biological entities, are produced in academic labs and by the Big Bio business. In this sense, DIYbio emerges questioning presents and projecting futures.

Evoking the great history of computer hacking in the 1970s and 80s, some advocates of DIYbio foresee a future in which the next revolution in biology will occur out of the institutions, in the garages [24,25]. And yet, in the present, DIYbio is a rather marginal phenomenon. Launched in 2008, http://DIYbio.org is a website used by local DIYbio groups in the US and Europe. Although about 2000 members make up the DIYbio email list, few groups have indeed been able to put together a lab of their own. Wikis and online forums[5] are key sites where DIYbio occurs: open protocols, personal experiences, tips on how to make things, and information on where to buy cheap 'stuff' are shared in these forums. This is open biology happening out of the institutions. However, many of the open source tools that are available on the Internet have been produced in institutional and commercial settings.

The OpenWetWare,[6] a wiki that gives instantaneous access to protocols, the Registry of Standard Biological Parts, and a number of CAD (computer aided design) open software[7] are some of the open source tools available for DIY biologists. Yet, they are infrastructures that have been generated in synthetic biology labs rather recently. Such a synthetic biology toolkit is targeted to turn biology into an engineering discipline [26].[8] Synthetic biologists envision a 'Lego biology', in which basic blocks can be assembled in multiple combinations. To realize this vision, standard modular parts are being produced that can be combined in the making of 'living things' [27]. These parts are called Biobricks and are designed to be interchangeable and reusable. They are stored in an online and open repository, the Registry of Standard Biological parts.[9] The basic idea of the Biobricks School of synthetic biology is that biology can *be made easily* out of basic parts that can be de-composed and

[3] http://www.cyberpunked.org/bpkdir/.

[4] While DIYbio emerges as a public, governmental security agencies present it as a threat to the general public. In the media visions of an open biology co-exist with visions of terror [13–16] and mass catastrophe [2,11,12,17–19,20–22].

[5] A number of active DIYbio forums exist where people share information on how to hack biology and how to develop open source software and lab equipment cheaply. Debates on political issues such as the future of open source biology are also prominent in those forums. This paper builds for the most part on a follow up of some of those forums and the media as well as informal interviews with leading DIYbio hackers. Informal interviews and email exchange were performed with members of DIYbio groups with members of DIYbio groups in different European cities, New York and Los Angeles. My research focused on particular things projected, designed, and in most cases, developed by DIYbio.org groups.

[6] http://openwetware.org/wiki/Protocols.

[7] See for instance https://www.dna20.com/genedesigner2/.

[8] Synthetic biology is a vastly heterogeneous field. I am here referring to the bioengineering school of synthetic biology that originated around Michael Knight's biobricks minimal biological parts at MIT.

[9] http://partsregistry.org/Main_Page.

re-composed. Not unusually, young DIY biologists have a background that relates them to this kind of approach to synthetic biology.[10]

Arguably, synthetic biology is producing a kind of biology that is modular, portable, and shareable. What ultimately has made possible that kind of biology is the development of DNA industrial synthesis. The fast decrease of the price of gene sequencing and synthesis that automated technologies have made possible in the last years has been crucial in the advent of both synthetic biology and DIYbio. Obtaining a synthetized DNA sequence is now cheap and fast. It is as simple as ordering it online, waiting a few weeks, and receiving it in the mailbox. In this very material way, DIYbio is dependent on Big Bio business. But DIYbio is dependent on BigBio in at least one further way. Within the accelerated time of technological innovation, laboratory equipment quickly becomes obsolete.[11] In addition to the obsolescence that comes with the acceleration of production, DIYbio has made itself out of the recent crises of the biotech industry. As a result of such crises and accelerations, used and out-of-date equipment is today available at a low cost. DIYbio depends on the technological accelerations of Big Bio. Furthermore, it shares with synthetic biology and other new forms of open source biology the 'distributed innovation mantra' [28] that repeats that when communities freely collaborate, technological novelty is fast produced [29]. Yet, in some other ways, DIYbio designs also materialize a protest against Big Bio and academic ways of doing biology.

Due to technological acceleration, to a large extent, biological research has become a business in which there is little room for curiosity and experimentation. The 'century of the gene' [30] has resulted in biology increasingly becoming global, technologically mediated, and expensive [31]. Involved in large-scale projects, researchers often end up performing very specific and repetitive experimental tasks. In addition, they are put under pressure to produce data at a high speed: PhD theses, publications, and patents, as well as somewhat anticipated results and applications, are promised to the corresponding funding agencies. DIYbio can be understood as a reaction against a way of doing biology that is bureaucratically and technically over-mediated and in which anticipated results and repetitive routines replace individual curiosity.[12] Such over-mediation translates in the kind of biological innovation that current research on dominant fields such as genomics produce: massive amounts of genetic data to be endlessly interpreted and integrated [32] and technological innovation [33–35]. Current research in biotechnology is hence dominated by one approach to the production of the new that is expensive and remote and runs on endless and accelerated technological development. Hacked yoghurts, bio-luminescent gadgets, and other mundane and punk DIYbio things appear as a materialized response to BigBio: a way of doing biology that is both too mediated and in this sense slow and remote, and simultaneously too accelerated.

3. DIYbio-hacking and the making of new things

3.1. Biohacking: the tools

Even when some have foreseen a fast decrease of the price of lab equipment in the near future [36], access to this equipment is still presently limited, not only because of high costs, but also because most technical suppliers restrict their services to licensed labs. However, some used basic equipment can be bought on eBay and a number of other online sites.[13] One way of putting together a DIYbio lab, thus, is by buying out-of-date equipment and turning it usable again. A complementary way is to turn garage and kitchen stuff such as rice cookers, coffee cans, and kettles into lab equipment. DIYbio aligns with the Self Repair Manifesto and the claim that 'if you can't fix it, you don't own it'.[14] Yet, ownership is not restricted to the action of repairing, but it expands to re-using and transforming in a broader sense. Bio-hacking involves craftiness to tinker and to transform things, so old materials are given new shapes and uses. Emerging in a process of constant conversion, DIYbio tools are precarious without being obsolete.

In the spirit of the open hardware, a number of DIYbio open tools have been developed in DIYbio settings [20]. These open tools are recurrently mentioned in DIY magazines and websites such as *Make* and *Thingiverse*.[15] In Ireland, Cathal Garvey developed an open centrifuge that can be made *just-in-time*[16] at home by using a 3D printer. Garvey named his invention 'DremelFuge' and gave it a Creative Commons Attribution ShareAlike license.[17] On the other side of the Atlantic, Mac Cowell, co-founder of DIYbio, and his associate Josh Perfetto developed an OpenPCR which is now accessible online for $599 while the price of a conventional PCR machine oscillates between $3000 and $6000 (in this instance, 'open' is used as synonymous with 'low-cost'). Availability of low-cost and open equipment is key to the existence of DIYbio.

[10] Particularly through the iGEM (Internationally, Genetically Engineered Machines) competition, an undergrad synthetic biology competition that takes place every year at MIT.

[11] A lot of 'technological rubbish' was generated also as a result of the crisis that hit the biotechnology industry at the end of 2000s.

[12] Disillusion towards research institutions and funding agencies was explicitly expressed in my talks with DIY biologists both in Europe and in the US.

[13] http://www.equipnet.com/Processing-Equipment-Equipment 42984?gclid=CNX1tOCC1a4CFetXmAodRj8Ueg.

[14] Quoted in Biologigaragen's presentation at the "Open Source Food Night".

[15] See for instance http://www.thingiverse.com/thing:1483; http://www.thingiverse.com/thing:3632; http://blog.makezine.com/2011/07/06/dna-is-now-diy-openpcr-ships-worldwide/.

[16] I use the expression just in time (JIT) in a general sense to refer to a way of producing were production meets demand in time. Things are produced right here and now.

[17] Quoting from http://www.thingiverse.com/thing:1483; see also http://www.wired.com/magazine/tag/biohacking/.

DIYbio online forums are full of discussions on how to develop open tools such as microscope lenses and other lab equipment by re-using 'stuff'. In this account DIYbio designs emerge as non-lasting, unstable, and indeterminate. Being the object of continuous actualization, they appear as radically oriented towards the realization of a near future by transforming the present state of things. Yet, transformative and open DIYbio practices often deploy a rather localized and domestic dimension, differing from the industrial and large-scale scope of synthetic biology and other Big Bio open source endeavours. As distinct from practices of hacking in industrial settings, DIYbio hacking is often performed as an artisan activity; it is messing with DNA proteins, yeast, yoghurt, hardware, gadgets, and electronic parts. Often, this type of hacking is described in terms of tinkering: tearing things in parts and re-composing or re-using them in creative and uneven ways.[18] The vending machine described in the following section is one of these hybrid designs in which living entities, software, electronic equipment, etc... are assembled together without really following an established method, nor a strict plan. Tinkering is learning by doing. To do a good hack, in this context, there is no need to spend time in acquiring a PhD, in entering slow funding systems, in waiting for academic peer-reviewers and top journals to state what is valuable knowledge, and for an expert committee so say which research projects are worth carrying out. To the extent that no one has the monopoly to determine what a good hack is, those mediating practices that in normal science are used to identify reliable knowledge and valuable research are subverted. Even when DIYbio builds on the accumulated knowledge of biology, hacking in this context is not about facts or sophisticated data, and it is not necessarily guided by the expectation of concrete results and applications promised to a sponsoring agency. DIYbio groups convey the same message: that biohacking is informed by enthusiasm and the will to try. DIYbio is an experimental way of knowing that allows for creative ideas to emerge, or so biohackers claim (see [25]). In this light, DIYbio hackers appear as 'bricoleurs' in the sense of Lévi-Strauss: assembling heterogeneous elements together, but not necessarily following a strict plan or a method [37].[19] The notion of the bricoleur captures a sense of indeterminacy, freedom, and usability, (and reusability of things), that is encompassed in the DIYbio approach to the making of the new. Indeed it may be the interplay between indeterminacy and immediacy what makes this approach to the making of biology distinctive. To the extent that it is organized through immediate action, ('you can do things here and now'), DIYbio is strongly anchored in the present. Arguably, DIYbio hacked things materialize a transformed present while they are oriented towards the next realization: towards the making of somewhat near, but still undetermined, futures.[20]

3.2. 'Yes, in my kitchen': energy management in the household

Living bacterial factories that will produce biofuel rapidly and at a low cost are one of the main promises of synthetic biology. Big investments are being directed to promote fast innovation in this direction. Possibly inspired by these promising developments, but also differing in interesting ways, there are a number of DIYbio projects for energy production, management, and consumption. They also aim at producing energy at a low cost, (or even at a no-cost), however not necessarily in an accelerated fashion. DIYbiodesign, I will argue, has a time of its own. Bioreactors, bioluminescent lights, and alternative biofuels are some of the things that DIYbio hackers are designing, (or projecting to design). In 2011, the Barcelona-based group http://blablablab.org was awarded at the Arts Electronica Festival for producing an artefact that worked as a bioreactor. On their website, (http://haberlandt.blablablab.org/), they describe it in this way:

> Haberland is designed to sustain any suspension culture, currently consisting in spirulina algae. Biological conditions are maintained throughout the systems via a processor. Impacts are measured and sent to the processor and an output is executed generating a negative feedback that allows for constant conditions and thus for the survival and reproduction of the algae, thus turning this system into a cybernetic organism. Haberlandt produces, stores and delivers in the same place.

Basically, Haberlandt is an organic vending machine that synthetizes food by using spirulina algae. The transformation from components into food is facilitated by a combination of open software and hardware. This vending machine is a way of producing food *just-in-time* and without mediators, (i.e. packaging and transportation companies and other brokers). In this way, Haberland allows for non-mediated, and even immediate action. At the moment this DIYbio vending machine has only been developed as an object of art, but it is thought as a domestic design that will allow for a localized energy production-consumption, radically compressing time-space dimensions. Made to perform sustainability in the household, the design is oriented towards a future that lies far away, a long-term future. But, to be sure, the realization of that future depends on a mechanism for energy transformation that is localized in intermittent and repetitive presents, (activated by the user every time he starts the machine). Thus, as for the cycle of energy transformation, those long-term futures can be seen as also depending on recurring domestic action. What is interesting here is how transformation, cyclical and domestic time, and

[18] "Tinkering" has been used also in the context of synthetic biology. In a DIYbio context, the use of tinkering seem to point to unruly and punk combinations, perhaps differing from the use of the word in the context of synthetic biology.

[19] Also relevant in this account is John Law's notion of heterogeneous *engineering* defined as: "associations of unhelpful elements into self-sustaining networks that are, accordingly, able to resist dissociation"[38]: 114. In addition to heterogeneity, Strauss' notion of the *bricoleur* emphasizes lack of method and pre-defined plan.

[20] See http://www.kickstarter.com/projects/1040581998/biocurious-a-hackerspace-for-biotech-the-community.

long-term futures are inscribed in the design of the vending machine as a product of DIYbio, and how all of these temporal dimensions come together and are performed simultaneously.

Other DIYbio groups, such as BiologiGaragen in Copenhagen, are also working on developing bioreactors and systems for energy processing. This is projected as integrated design where energy production would be incorporated within the whole architecture of the house. A combination of aesthetic pleasure and energy efficiency is the aim of such integration. In this sense, sustainable long-term futures would coexist with contemplative slow presents, in a living environment that would be subject to the organic rhythms of growing and transformation. In this view, a desirable future would be one of reduced energy processing. As explained by one of the members of BiologiGaragen: in the present, energy processing introduces a number of unnecessary mediations. Every time that energy is transformed, (i.e. from gas to hot water), some energy is lost in the transformation. However, one could radically reduce the number of mediations by directly using the energy produced by living systems. Other DIYbio projects echo BiologiGaragen's view on (immediate) energy production. Playing with bioluminescent bacteria to produce light is a DIYbio favourite. It could be argued that in the context of DIYbio, innovation and creativity are performed through placing an emphasis on immediacy and domesticity. This is, action that is *just-in-time and in place* (in situ) that challenges prevailing forms of centralized energy production.

3.3. 'Yes, in my body': DIY medicine

In DIYbio online forums, a number of discussion on how to develop common drugs such as insulin (http://www.indiebiotech.com/) at a low cost point to a shared concern of health issues. As these online discussions go, synthetic biologists have been working in similarly oriented projects for the development of drugs such as artemisinin at a low cost and at an accelerated industrial pace [39]. However, DIYbio designs appear to have a time of their own as Meredith Patterson's 'glow in the dark' yoghurt suggests. Educated as a computer programmer, Meredith has partially succeeded in engineering yoghurt to turn fluorescent in the presence of a certain toxin found in baby milk in China and that was reported to cause a number of deaths. By engineering yoghurt to work as a biosensor, Meredith certainly intended to 'speed things up'.[21] But her attempt at accelerating innovation comes together with a sense of locality, as her innovation would enable people to identify the toxin quickly, easily, and at home by using something as domestic as yoghurt. This engineered yoghurt is not only an attempt at compressing time and space, but it can also be seen as conveying a certain sense of urgency and distrust in the big corporations, the sense being that if you wait for the pharmaceuticals to solve this problem, it will never happen, (or it would be too late). Hence, this 'glow in the dark' yoghurt appears as an attempt at eliminating unnecessary institutional mediations that make things slow, and to act-here-and-now. This is, again, unmediated and immediate action.

In a similar way, Katherine Aull has gained a lot of attention in the media for developing a homemade genetic test. By buying some used equipment on eBay together with some domestic 'stuff' such as a rice cooker and a whiskey tumbler to make distilled water, she made a lab in her closet (see [25]). She produced her genetic test to find out whether she was carrier of a gene that is associated with hemochromatosis. This disease causes the body to absorb too much iron, turning the blood very thick and possibly causing chronic damage in vital organs. The commercial test to find out about this disease is not easily accessible. Aull made her closet lab for about the same price that she would have paid for the commercial test [25]. She and other DIYbio people want to prove that doing biology is easy.[22] But Aull is not a novice; she has a degree in biological engineering from MIT. After graduation, she worked for a synthetic biology company, but she quit soon to dedicate her time to more curiosity and self driven research. Such a move can be interpreted as a neglection of the routines and mediated pace of Big Bio research towards the more situated and 'right now' temporalities of DIYbio. Instead of entering into a cycle of slow standardized routines, (contacting her insurance, visiting doctors, waiting for results insurance, and so on and so forth), so she decided to make her genetic test 'here and now'. Her story brings to mind and interesting distinction between chronos, (the rational time of the clock), and kairos ('the right time'). In DIYbio designing, the right time to act is now. This has important implications in terms of when one thinks that innovation, or the new, will emerge. For DIYbio things are to be acted upon, (decomposed, transformed. . .), and reality is to be constantly made. Within constant change, the realization of the future appears just around the corner. The future is near and DIYbio approaches it fast. In this sense, the future appears as an 'extended present' [40].

There are other interesting temporalities involved in the making and enactments of Aull's test. After testing her own DNA, Aull found out that she actually has a relatively high risk of developing hemochromatosis and consequently, she decided to take health measures by changing some of her habits. In this sense, her present seems to be trapped in between her genetic past and her risky future. In an interview she points out, 'This disease is completely tractable if I catch it early and now I can monitor it proactively, instead of waiting to get sick' [41]: 684. This means that there is a 'late', and more concretely that institutionalized medicine usually arrives late. But it also means that there is a kind of a before and after, a linear time to which the human body is subjected. Aull wants to have control over her future, and she wants to have it now. So a sense of personal history comes together with an aim at anticipating the future and taking action now.[1]

Aull is one of many people who have decided to take action by actively searching for her genetic information [42,43]. Much can be said about this way of taking responsibility for one's own future, which appears in many cases as standing on an ambiguity between technology empowering people and people internalizing risks and fears and governing their bodies in

[21] Quoting Meredith Patterson in an interview to the Guardian (Bloom, 2009).
[22] Quoting Meredith Patterson in an interview to the Guardian (Bloom, 2009).

accordance [44–46]. While the future of DIY medicine may actually emerge as an interplay of determining and liberating elements, in the present, DIY practices are turning the body into a test field for medical innovation; people are actively using their bodies for producing new diagnosis and for testing treatments when established medical practices provide no hope [47]. Yet, DIY medicine developments are not de-linked from institutional science; like, for instance, Jason Bobe, who is co-founder of DIYbio but is also the community director for the Personal Genome Project at Harvard Medical School. In an interview for *Nature Medicine*, Bobe, and the other co-founder of DIYbio Mac Cowell, express their conviction that DIYbio will facilitate faster innovation, as 'there would be lots of more people working in biology, which would create more opportunities for discovery' (in [28]: 231).

4. DIYbio designs: actualization, immediacy, and the production of the new

As an approach to the production of knowledge and things, DIYbio brings together a DIY attitude grounded on direct action, the ethics of open source, and the pleasure of messing with biological matter. The sections above suggest ways in which those elements come intertwined within DIYbio designs. Concretely, I point to different ways in which constant actualization and immediacy perform as key temporalities organizing DIYbio designs. This section provides a reflection on how through constant actualization and immediate action DIYbio designs might relate to the emergence of the new.

Inspired by Heidegger's notion of the thing, I suggest that through the making and remaking of things, *the new* is performed in a move from possibility to actualization. In Heidegger's account, things unravel as presence: things are actualisations of a multiplicity of past relations in the present. In this light, Aull's genetic test would not appear as a simple object but as a multiplicity of heterogeneous elements, (doctors, her father's diagnosis, insurance companies, genes, the invention of DNA sequencing, etc.). In Heidegger's account things bring past relations to presence, but they are also oriented towards the future in a very pragmatic sense: things are made to perform a certain purpose. Thus, we relate to the world through things and things enable particular ways of inhabiting the world. Furthermore, Heidegger argues, things have an intrinsic temporality that would influence the *tempo(s)* in which we relate to the world [48]. The intrinsic time of things depends on the set of relations within which things are realized: Hence a rice cooker used as a kitchen tool would enact different times than if used as a lab tool in Aull's closed-lab. Interleaved within specific temporalities, things perform times. As things, the home-made genetic test, the vending machine, the bioreactors, the centrifuge, are organized by and produce a multiplicity of co-existing temporalities.[23] The descriptions above explore those co-existences. For instance, the DIYbio vending machine allows one to synthesize algae *just in time* (right here and now). It also performs the cyclical time of energy conversions, and it is oriented towards a future that lies far way and that should be approached slowly, (long-term sustainability). Differing from this, Aull's home made genetic test is organized around different temporalities and relates to the future in terms of urgency, risk, and control. Still, both the DIY genetic test and the vending machine are made to enable immediate and unmediated action. While Aull's homemade test enables her to avoid dealing with insurances and hospital bureaucracies, home made energy management systems allow reducing the chain of intermediaries that go from energy production to consumption. Hence, even when being organized by heterogeneous temporalities, these DIYbio designs share a sense of domesticity and of doing things in situ, right here and now. Arguably, these open designs also encompass a certain air of distrust in over-mediated institutional systems that are slow and out-of-date. Furthermore, following an open source approach, they appear as being always in the making, unfinished.

The multiple temporalities that co-exist in DIYbio things meet in a combination of immediacy and constant actualization; what does this multiplicity say about the ways in which futures are made? One can easily argue that the DIY sense that things can be made 'here and now' is not necessarily oriented to the accomplishment of great technological futures, (i.e. the realization of grand narratives and promises). Rather it performs by making mundane futures in every-day practices of composing and re-composing things. In this way, DIYbio differs from how futures are projected and realized in synthetic biology and other BigBio settings. This is not to say that DIYbio does not present itself as promissory. DIYbio does entail the promise of a future in which citizens are more autonomous as they are entitled *to do* biology. Transferred to the domain of the public, the promise of biological innovation takes on the form of a political claim, rather than being mainly a technologically oriented promise. While institutionalized forms of biology aim at producing innovation in the form of outstanding techno-objects that, behaving in foreseeable ways, will lead to the realization of promising futures, DIYbio makes novelty by hacking trivial things in uneven ways.

Thus, arguably, differing from institutionalized technoscience, in DIYbio designs the 'thingness of things', as defined by Heidegger, is emphasized: things are gatherings of heterogeneous[24] elements that hold together only temporarily. Appealing to Levi-Strauss's metaphor of the bricoleur, I have argued that in composing and re-composing things DIYbio hackers do not necessarily follow a method. DIYbio things do not appear as purified [9] and coherent objects. Things appear here as *just* things: transitory associations of people, technologies and natural entities, provisional encounters of otherwise heterogeneous elements. In their punk, unruly, domestic, and unfinished character, DIYbio designs hail heterogeneity and precariousness. While BigBio research often pursues the production of sophisticated innovation that is based on timeless

[23] For further discussions on multiple and co-existing temporalities see [47,49].

[24] In a similar approach, John Law [10] has described artefacts as compositions of heterogeneous elements. To be made into objects such heterogeneity is reduced through a set of stabilizing strategies. In Latour [9], such a work of purification prevents things appearing as plural, multiple and relational [50].

facts and sound explanations, DIYbio is oriented to the production of low-cost, not necessarily coherent things. Introducing a renewed emphasis on things, DIYbio performs a different approach to the making of innovation in the biological domain.

A lot of investment in the last two decades has gone to finance high-tech BigBio projects. For the most part, those projects have produced huge amounts of data. This comes as a result of understanding and translating biology in terms of information. The human genome project produced a myriad of information, and this tendency continued with subsequent advances in genomics. A result of this is that more technology was needed to classify, integrate, and make sense of that data. Hence, this creates a dynamic in which innovation comes in the form of data which requires more innovation to be managed [51]. Thus, to a large extent, BigBio has been producing innovation of a technical and informational kind. In material terms, the most immediate results of biological research often take the shape of scientific publications. Differing from the BigBio model of research, one could think of the DIYbio approach as pointing out a way of producing novelty that is less remote and more materially oriented and immediate, although not necessarily advanced from a technical and scientific point of view.

Bio-hacking, bio-hackers argue, is about messing with biology. DIYbio designs such as the vending machine, bioreactors, and bio-gadgets, have a rather tangible and material character, they can be used and transformed *here and now* by someone else. As DIYbio designs invite to direct action, their intrinsic time is immediacy. As an approach to the production of knowledge and things, DIYbio confronts a number of mediations that are constitutive of institutional science such as established methods and techniques and peer reviewing practices. As described above, this entails a negation of, or rather a subversion of, institutionalized temporalities, at least to a certain extent. Challenging those mediations, a relocalisation of action as immediacy occurs.[25] Likewise, informed by open source ethics, DIYbio designs encourage a certain way of acting as continuous transformation and actualization. In this way, DIYbio things are always *becoming*.[26] The emphasis of things as always being in a state of *becoming* may, nevertheless, generate a sense of acceleration. Running on relentless actualization, an open source epistemology may produce a sense of approaching the future fast.[27] However, argued above, DIYbio designs combine the temporalities of hacking with the more situated temporalities of the art craft. The instantaneous time of the internet; the simultaneous time of a community that exist virtually; the long-distance times of post delivering of sequenced and synthesize genes and online ordered tools; the slow and repetitive times of the domestic; the unruly time of garage labs; the up-dating time of re-usable equipment; the imminence that comes with a DIY urgency to *just do it.* All of these multiple temporalities co-exist within a DIYbio approach to the making of the new.

As a final remark, a sceptical note can be introduced, suggesting that the open source ethos may not be totally unproblematic when it comes to thinking DIYbio as a public in relation with BigBio and governmental agencies. Particularly, when the focus of the analysis is placed on the mantra of 'distributed innovation' that informs open source and that repeats that innovation is likely to happen faster if many people contribute to a project freely and creatively. In this light, an experimental public such as DIYbio may appear as a field of opportunities for business and governments. In the descriptions of DIYbio medicine, I have pointed out an ambivalence that is intrinsic to emerging forms of open science and user-driven innovation. A DIYbio approach may enable citizens to shape new technologies, and produce a type of innovation that is immediately relevant for them [56]. Simultaneously, open science and user-driven forms of innovation can be read in terms of out-sourcing and donation [51]. Hence, DIYbio can be seen as liberating citizen science that empowers citizens by enabling them to have control over their subsistence and energy, their health, and more broadly over their futures. But within broader politics of innovation, DIYbio may also appear as a 'donation' of citizens to science: donated work-time and creative visions of the future, donated genetic pasts, risky futures and bodies to experiment with, donated domestic time. DIYbio hackers ask for the de-regulation of biological sciences and technologies, but paradoxically, within a context of de-regulated innovation policy, DIYbio might turn into a transfer of materialities and temporalities from public domains to science.

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[25] For a further description of "immediacy" as cancellation of bureaucratic and technical mediations see [52].

[26] Somewhat in a Deleuzian sense, as, the unfolding of the difference and the dissimilar during time in the form of constant actualizations [53].

[27] The notion of "extended present" was originally used by Kenneth Boulding [54]. Raising the question of how long the present might be, the notion of "extended present" is focused on the present as it emphasizes responsibility and the consequences of present actions in the future. The present extends insofar as actions in the present will have consequences, shaping futures. Helga Nowotny [55] uses the same notion later, transferring it to the field of STS (science and technology studies). In her use the concept changes slightly: Nowotnys analysis is more concerned with how far the future lies, and how fast it is approached. On this account, "extended presents" appear as futures that presented as being 'near', organize present action. In the analysis of technoscientific developments, the sociology of expectations has exploited a similar notion of "extended present" focused on how futures have effects on the present: expectations are real insofar as they shape actions in the present [47]. Within economies of expectations, technoscience is often presented as 'bringing' the future closer, and rendering it faster. One could think of the digital turn in biology and the adoption of open source approaches as radicalizing the tendency towards the production of "extended presents".

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