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Valuating Practices, Principles and Products in DIY Biology: The Case of Biological Ink and Vegan Cheese

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Abstract
In this article, we study do-it-yourself (DIY) biology, by looking in particular at the different forms of valuation within the DIY biology movement. Building upon recent work in economic sociology and the study of valuation, we take as case studies different projects developed by DIY biologists. Our approach is attentive to the moments when these projects are valued, i.e. during competitions, investment pitches, and crowdfunding campaigns. The projects analyzed involve both market valuations (with investments, products and potential markets) and non-market valuations (be they social, ethical or cultural). Our key argument is that value is produced through distributed and heterogeneous processes: products, practices, principles and places are valued at the same time. We show that there is not only a valuation of technical and production aspects (well highlighted in the key literature on valuation), but also a valuation of social links and of specific forms of organization. Both are inseparable - it is neither the object nor the context in themselves that are valued, but the "good-within-the-context-of-its-making": the production of vegan cheese or biological ink *and* the places and communities of DIY biology or future markets are valued. The valuation practices we examine aim at producing an *interest* in a threefold sense: a general interest (a public good), an interest for the public (its curiosity), and a monetary interest (by making people financially participate).

Keywords: DIY biology: biological ink; vegan cheese: moments of valuation: non-market valuation

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Introduction

The mid-2000s saw the emergence of a movement known as do-it-yourself biology (DIYbio) that aims to make the practice of biology accessible to non-professionals. Motivating many practitioners is the idea that R&D in the biological sciences and biotechnology should not be the exclusive province of those who work in academic or corporate labs, but should be opened up to members of a broader public. Participants put this idea into practice by pursuing projects as varied as DNA barcoding, the fabrication of laboratory equipment, the organization of educational workshops, seminars and classes, the creation of artwork out of biological materials, and the production of food products such as yogurt or beer using fermentation techniques in home and community laboratories.

DIYbio aims to be open to all, and involves participants from a range of ages and social and professional backgrounds. Nevertheless, some demographics are better represented than others: a study by Grushkin et al. (2013) found that three-quarters of participants have a university education, about two-thirds are between 25 and 45 years old, and three-quarters are male. Half of the respondents in Grushkin et al.'s study work in a community lab while 27 percent work in their homes. (These figures might have changed over the past six years; but there has been no other comparable study done since 2013.)

Academic articles on DIYbio have analyzed the risks that it engenders (Schmidt 2008; Bennett et al. 2009; Gorman 2011), its political and social features (Kelty 2010; Kera 2012; Delfanti 2013), and its material aspects (Delgado 2013; Meyer 2013). Less attention, however, has been paid to the economic and commercial dimension of DIYbio. One of the few authors who addresses the topic, Alessandro Delfanti (2012: 174), affirms that DIYbio is "strictly related to entrepreneurship, academic capitalism, and neoliberalism" and that the movement is in the process of exploring new markets based on open source business models.[1] The fact that DIYbio has given rise to startups such as Pearl Biotech and Amplino shows that it is not outside the logic of the market (Meyer 2013). According to Philippe Brunet, "the structural limit of the DIYbio movement is an unconscious acceptance of remaining within the logic of value"[2] (Brunet 2014: upd).

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[1] On the open source biology movement more generally, and its different kinds of 'non-market valuations' (although this term is not used) see Hope (2008).

[2] Authors' translation

If ties between DIYbio and the market have been acknowledged, the manner in which DIYbio projects are valued and presented to different audiences in a market context or to attract funding has not been analyzed. The goal of this paper is to contribute to the academic analysis of DIYbio by exploring the heterogeneity and distribution of its valuations. We will, in particular, pay attention to the sites and events at which the values of DIY biology are being rendered explicit.

To this end, we mobilize recent work in economic sociology on valuation. Vatin points out that "economic value can no longer be solved by the market alone"[3] (2009: 21). It is therefore necessary to account for the social and material relations and institutions that make this value possible. Any act of valuation is at the same time an economic and technical act, and a moral act, because it also responds to problems of an ethical order and of the "general interest" (Vatin 2009). In other words, economic, technical, political, and moral properties are all inscribed together in a good (Callon 2009: 19). For Stark (2011: 7–8) the notion of *worth*, with its double connotation of economic good and moral good, offers the advantage of moving beyond two dichotomies: between economic value and social values, and between economy and social relations. He suggests that, methodologically speaking, the analysis of valuation practices requires a shift from institutional analysis to situational analysis (Stark 2011: 32). Value creation is not only achieved within the market, but also upstream of the market, through the measurement, evaluation, circumvention and reformulation of goods and services (Vatin 2009: 31). Recent work in valuation demonstrates the coexistence and continuity between market valuations and non-market valuations in cases such as biodiversity conservation (Fredriksen 2017). As an extension of these analyses, Callon proposes the concept of "valuation" to refer to the "narratives, mechanisms, devices, tools that constitute value and, at the same time, enable its measurement" (2009: 252), while adding that this assessment is both qualitative and quantitative.

Valuation is an activity that is produced in particular moments and places: we can thus speak of "moments of valuation" (Antal et al. 2015) and "valuation sites." An evaluation site, be it a court, a professional meeting place, or a laboratory, is spatially delimited. It is also delimited temporally: by duration of the test, or experiment, for example (Hutter and Stark 2015: 4). Muniesa and Helgesson (2013) argue that valuation sometimes involves "public witnessing" in which valuation is performed, watched, or put on display, thus drawing attention to the role that audiences may play.

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[3] Authors' translation.

Paying attention to translations of value across time and space has led scholars to more precise theorizations of the workings of contemporary capitalism (Ritzer and Jurgenson 2010; Kinsley 2012; Tsing 2015). These analyses have shown how economic value can originate in spaces that are far from the factory: spaces that may not be primarily conceived in economic terms. In a sense, they are analyses of valuation "at the margins," where Mennicken and Sjörgen write that power and politics become particularly visible (2015: 4).

The internet, for example, has contributed to new forms of valuation, changing processes of production and consumption. In the digital realm, users often produce content for free (and often expect to access content and services without paying). The "prosumer" – a hybrid of consumer and producer – who makes contributions of monetary value without seeing any financial reward undoubtedly finds other kinds of value in the activity: for example, maintaining relationships while adding content and divulging valuable personal information to Facebook; producing YouTube videos as a hobby; or developing open source code in order to network and build a reputation among other software developers (Ritzer and Jurgenson 2010).

While some scholars have characterized some of these non-monetary exchanges as potential harbingers of a new kind of capitalism or even a wholly new mode of production (Ritzer and Jurgenson 2010; Kinsley 2012), others have described them as a continuation of capitalism's ability to devise new means of extracting value: in this case, deriving surplus value from cultural consumption and leisure activities. From the latter perspective, the provision of free labor in digital realms or open source is akin to the free labor of social reproduction, usually performed by women, that has always sustained capitalism. Others have described it as in line with trends that move labor out of the factory and into the rest of society (Terranova 2000). In this analysis, the "gift economy" of open source is not at odds with but fully a part of the workings of contemporary capitalism.

Such phenomena are not exclusive to the digital realm. For example, in a study of mushroom foragers in the Pacific Northwest, anthropologist Anna Tsing concludes, "Amassing wealth is possible without rationalizing labor and raw materials. Instead it requires acts of translation across varied social and political spaces" (2015: 62). For the foragers who camp out in the woods during mushroom season, the mushrooms have a value as "tokens of freedom." Yet they gain additional, monetary value as they pass through a series of different hands and into different domains, eventually entering back into a gift economy after importation to Japan, where they are generally purchased to share or give away in a social ritual meant to strengthen interpersonal bonds. Tsing coins the term "pericapitalism" to signify the liminal position of the mushroom foragers: although they are not

outside capitalism, neither are they completely controlled by any of the actors that later derive surplus profit from their activities.

For our analysis, three elements are important to keep in mind. First, even if the equipment and technical processes developed by DIY biologists are generally not or, at least, not yet commercial goods, some are already being valued. Second, we are interested in *non-market valuations*, as well as those that take place in an explicitly economic or technical context, and in how economic and non-economic forms of valuation are interconnected. How and where does this valuation, whether ethical, political, cultural, or social, take place?[4] We term these practices "socio-political valuation" to focus on the narrative and argumentative way in which the value of DIYbio products is highlighted. Finally, we demonstrate how different forms of valuation are rendered explicit through public presentations and demonstrations. We thus follow this public performance at specific "moments of valuation" (Hutter and Stark 2015: 3) such as competitions, investment pitches, conferences, and crowdfunding campaigns.

Methodologically, we focus on the trajectories of two projects over the course of several years with particular attention to how they are valued during specific events. In each case, we attended meetings and public events, conducted interviews with project participants, and analyzed project publications and presentations as well as media coverage to discern the kinds of valuation at play during different moments. In the first case study, *Grow Your Own Ink,* we follow the project from its origins in a DIYbio lab to its commercialization as a startup company. In the second case study, *Real Vegan Cheese,* we draw on participant observation over the course of approximately 18 months, beginning in the spring of 2014, to explore valuation in a project that has not yet been commercialized at the time of this writing, although the possibility is under discussion. As a participant–observer, one of us attended biweekly meetings, helped with administrative aspects of the project, and participated in one of the moments of valuation which is reflexively analyzed below (see also Wilbanks 2017). These two case studies demonstrate the heterogeneity of valuation over the course of two DIYbio projects that were deemed valuable within and beyond the DIYbio community.

DIYbio: History and overview

In order to better understand valuation practices in DIYbio, we begin with the history and activities of this movement. DIYbio's origin is closely related to the field of synthetic biology, a postgenomic discipline that aims to apply engineering principles to biology in a

[4] Callon (2009) suggests that market valuation is only one form of valuation, but he does not elaborate this point.

more systematic way in order to decrease the cost and technical knowledge necessary to carry out genetic engineering projects. In 2000, in what may be considered synthetic biology's first grant application (although the term synthetic biology was not yet in use), Robert Carlson, Roger Brent, and Drew Endy submitted a grant application to he US Defense Advanced Research Projects Agency (DARPA) for the development of "open source biology," and predicted that developments in biotechnology could soon enable people to practice genetic engineering in their garages or kitchens. The year 2008 marks an important milestone, as it is this year that diybio.org, the first association dedicated to DIYbio, was created in Boston and the media began to take an interest in it.

The first laboratories associated with DIYbio, including Genspace in New York, La Paillasse in Paris, and BiologiGaragen in Copenhagen, were created in 2010 and 2011, and there are currently about 100 around the world. While most of these laboratories are in Europe and the United States, some are in Asia and South America. The emergence of DIYbio has attracted the interest of various actors and institutions: exhibitions, news articles, books for the general public (Wohlsen 2011); a documentary film (Die Gen-Köche, 2012, by Schlicher and Karberg); and a documentary web series (DIYSect) were devoted to it. The movement also has its own newsletter (BioCoder) and its national associations, such as diybio.be in Belgium.

How to explain the emergence of this form of biology and its increasing popularity since the 2000s? In part, DIYbio has been made possible by technical and sociocultural trends in biotechnology: in particular, the decreasing cost of DNA sequencing and synthesis and the development of synthetic biology. Since it was first organized in 2004, the iGEM (International Genetically Engineered Machine) competition has not only served as a site of disciplinary formation for synthetic biology, but has also been used as a meeting point for future DIY biologists. DIYbio is also linked to hacking and making, and the rise of hackerspaces. The mid-2000s saw a flourishing of interest in DIY more broadly, with the launch of *Make* magazine in 2005 and the first Maker Faire in 2006, both of which helped to make biology a "personal technology" (Tocchetti 2012). There is a triple proximity between hacking and DIYbio: a technical and spatial proximity (the tools and physical spaces of hackerspaces and DIYbio laboratories are often shared); semantics (through terms such as "biohacker" or "biohackerspace"); and ethics (i.e. the goals of promoting access, sharing, collaboration) (Meyer 2014).

Contextualizing these developments within trends at a still more abstract and broader scale, some authors have noted that the ethics of self-reliance and self-improvement that underlie hacking and making are compatible with broader neoliberal tendencies. The last several decades have witnessed the development of an increasingly flexible

labor market that values entrepreneurship and requires continuous reskilling by employees (Brown al. 2004; Gill and Pratt 2008). DIYbio also emerges as public funding for universities is in decline, and academic science is increasingly competitive (as more PhDs compete for relatively fewer academic positions) and aimed towards the commercialization of knowledge (Slaughter and Rhoades 2004; Lave et al. 2010). DIYbio often presents a rhetorical counterpoint to this trend, with calls for open science, experimentation, playful creation, and curiosity unconstrained by utilitarian and economic considerations. However, as we will see, it is not completely outside the logic of economics, and in fact in some cases is held up as a more innovative and thus ultimately more lucrative means of doing biotechnology.

The projects and activities that take place under the general term of DIYbio are diverse, but we can discern four major families of activities. First, a number of projects are dedicated to the development of low-cost technical equipment, including PCR machines, microscopes, centrifuges, and electrophoresis gels. Second are environmental or health projects. By building biosensors to detect the presence of melamine in milk, spectrometers to detect the presence of toxic substances, Geiger counters for measuring radioactivity, or tests to detect genetic diseases, DIY biologists have carried out low-cost research on environmental pollutants and health issues.

Third, many projects fall into the category of "bio-art." Examples include the production of "yeastograms" (a process for growing and visualizing yeast on Petri dishes) at Pavillion 35 in Vienna, the Do-it-together Bio project (discussions and events linking biology to art) at the Waag Society in Amsterdam, art projects within the Hackteria network, and the project Open Source Gendercodes by artist Ryan Hammond.[5] Fourth, education is a major focus of DIY biology activity. Madlab in Manchester and Genspace in New York, for example, often host activities meant for the general public (workshops, introductory courses, conferences, etc.). While the forms of this public participation are varied, DIY biology clearly sees itself as a movement capable of engendering a more active and engaged public.

Apart from these four main categories of activities – technical, environmental, and health, artistic, and educational – there has also been a certain professionalization and entrepreneurial transformation in the DIYbio movement. In the context of economic pressures discussed above, the DIYbio lab can be a place where people learn new skills: to take a common example, someone who works in information

[5] This project aims to develop open source protocols for making tobacco plants that can produce human hormones, imagining that transgender men and women might one day have "companion plants" that make the hormones that facilitate transition.

technology can acquire knowledge and practical skills in biotechnology. In this way, DIYbio is connected to the labor market even as it defines itself in distinction from the workplace.

The biohackerspace is also a place to network, since many members work in science and technology for their day jobs. The professional value of being a part of community of lab projects is shown by the fact that members proudly display their community lab affiliations on their professional LinkedIn profiles. In an article, Gewin (2013: 509, 510) affirms that "the option of launching an individual research operation is gaining traction" and that the "hackubator" form allows a fusion of "the independence and affordability of hacker spaces with the entrepreneurial bent of biotech business incubators."

To further illustrate this diversity of activities and vocations – and to show how such diversity is present both across and within laboratories – we focus on two DIYbio labs: La Paillasse in Paris and Counter Culture Labs (CCL) in Oakland, California.

DIYbio projects at La Paillasse have included the DNA barcoding project that aims to determine the genetic signature of plants, animals, or bacteria; the BlueNote project, an open source transilluminator for visualizing the DNA present in an electrophoresis gel; the production of biological ink; the manufacture of biological reactors for micro-organism cultures (destined to detoxify polluting waste for example); and the Epidemium program on cancer data. There is therefore a great diversity of goals and objectives. While some projects are addressed to health and food needs, others have rather technical goals, and still others address environmental issues. Many of these projects have received external funding or are in the process of being turned into startups. The bioreactor project, for example, received a grant of €6,500 from the SpaceGambit Foundation and is being "promoted in the form of a startup." The Epidemium program is the result of a partnership between La Paillasse and the Roche pharmaceutical company. Finally, as we will see, the Grow Your Own Ink project gave birth to a startup that aims to produce biodegradable biological ink on a large scale.

To finance these different activities, La Paillasse has mobilized various resources: donations of equipment from public institutions or private companies; one-off partnerships for certain projects; financial aid from Paris City Hall; a crowdfunding campaign through the KissKissBankBank platform (€22,000 in 2014); and individual donations.

On its end, CCL has also organized a variety of activities since its creation: hosting school-aged children for class visits; organizing social events, conferences, and educational workshops (on topics such as the Ebola virus or the intestinal microbiome); developing activities such as soil sampling or culturing starter for bread baking, and teaching more

extended courses.[6] Major projects include Fermentation Station, which produces fermented food products; the Bioprinter Project, which hacked an inkjet printer to deposit rows of cells instead of ink; the Open Insulin project, which aims to address the high cost of insulin and the lack of a generic option on the market and its high price by creating an open source method to produce insulin in yeast; and the Real Vegan Cheese project (discussed below). CCL is funded by a monthly membership fee of US$80, which allows access to the full laboratory. A US$20 membership option for "Biosafety Level 0" is offered to those who wish to work only on food projects, and a scholarship application process is provided for those who have difficulty affording membership fees. Finally, CCL raised US$37,000 on the Kickstarter crowdfunding website in 2015, and has also benefitted from sourcing used laboratory equipment from the plethora of academic and commercial labs in the Bay Area.

In Section 2, we analyze two of these projects in more detail. We believe that this type of project-based analysis has several advantages. First, projects are empirically rich sites that allow us to better understand the way in which scientific practices are articulated with broader aims. Second, this approach helps to shed light on how DIYbio activities are valued, whether this valuation is commercial or socio-political, or results from a combination of both. Finally, it avoids a too general, abstract, and homogeneous characterization of DIYbio in favor of richer description, situated discourse, and analyzing practices "in action."

Market valuations and socio-political valuations

Our first case study is the project Grow Your Own Ink developed at la Paillasse. The idea of this project, which materialized in 2012, emerged out of discussions between biologist Thomas Landrain and designer Marie-Sarah Adenis. Their aim was to create pigments that are "more easily recyclable, less polluting and [that] therefore constitute an interesting alternative in the field of colors" (project description). To this end, a species of natural bacteria was selected to produce pigments. Grow Your Own Ink has been, since the beginnings of la Paillasse, one of its "showcase" projects. One of the authors of this paper has encountered it on many occasions (presentations, interviews, maker faires, etc.) at which the project has been mobilized both as an example of a DIY biology project and as an illustration of working across disciplines, such as biology and design.

The convivial, collaborative, and "democratic" facets of the project have usually been highlighted. The project has also been presented as

[6] e.g. "So you want to be a biohacker?" which teaches the main laboratory techniques needed to know how to create one's own synthetic biology project.

being culturally significant, as writing is "what defines human culture" (Landrain 2014). In a presentation at a TEDx conference in June 2013, Thomas Landrain explained:

> What I hold in my hands is a Petri dish. And in this Petri dish there are bacteria that can potentially write the future of printing. [...] Ladies and Gentlemen, this is the first biological ink of bacterial origin. It's non-toxic and you can make it yourself, it's that easy. All this ... [applause] Thank you. All this is being made in a biohackerspace. It probably would have never come to fruition in a classical academic laboratory.

This excerpt is interesting for several reasons. First, the ecological and social dimensions of the project are both valued. Second, a clear distinction is made between a DIY biology laboratory and a conventional laboratory. And third, the project is staged both materially (the speaker presents the project and a Petri dish on a stage, in front of an audience that listens and applauds) and discursively (the innovation is explicitly announced and celebrated).

Grow Your Own Ink has also given rise to educational activities. Several workshops have been organized for children and adults, for instance at the Science Gallery in Dublin as part of the exhibition titled Grow Your Own – Life after Nature (2013–14), at the Capitaine Futur festival (2014) held at the Gaîté Lyrique, and at the Monde Festival (2015). During these workshops, the project was enacted in a specific form: it was not only displayed and celebrated, but participants were taught how to use it. In other words, beyond the argumentation that ink can be made yourself, the workshops delivered instructions for *how* to do so, with all the needed gestures, skills, and material practices.

Grow Your Own Ink has not, however, remained a community project. It has led to the creation in 2015 of a startup called Pili (by Landrain, Adenis, and two other persons). A collaboration with the company Bic (known primarily for the manufacture of pens) was established. During summer 2015, Pili carried out tests in Cork, Ireland, in a bioincubator called IndieBio. Scientific equipment and funds were made available to the members of the project for three months. Landrain states that in the course of working in the bioincubator they "met inspiring mentors and had the occasion to share our work with numerous potential investors" (cited in Garvey 2015).

During the final IndieBio EU Summer Party & Demo Dinner, held in August 2015, Pili was one of nine projects to present its after investment pitch to potential investors. Landrain explained that "at Pili, we want to use microbes to […] replace the petrochemical industry" and announced that a "proof of concept" had been obtained by printing a page with organic ink: "Pili has succeeded in printing with a standard Epson ink-jet printer, the first page using ink that was

grown by bacteria. This is amazing [applause]." While the scientific, ecological, and economic merits of the project were presented during the 8-minute presentation, several elements were, however, not presented: do-it-yourself biology, la Paillasse, and values such as sharing or openness. The presentation followed a specific format, a pitch, that is, a way of presenting and "selling" one's arguments and products typical within business circles. Pili's pitch was not only concerned with communicating *about* its potential, it was actively seeking to enroll actors and funds for fabricating ink *with* new business partners. "If we want Pili with its dyes to be able to distribute them around the world and really propose an alternative to the petrochemical industry, we need large distributors, large actors." The grammar used to present and advertise Pili tapped into a variety of registers to argue for novelty ("first"), feasibility ("succeeded"), and spectacle ("amazing," "magnificent," "exciting.")

The marketing and commercialization of the project is now a key element. The project is targeting a specific market (ink and biological pigments), while, at the same time, aiming to demarcate itself from the existing market, whose problematic nature is underlined ("toxic," "polluting," and "non-recyclable" colors). However, this marketing also means that the project has moved away from community values and do-it-yourself practices. In an article published in the newspaper *Le Monde*, one of the founding members explains: "If we want to have an ecological impact that is global, systemic, we must go further than our sympathetic protocols of home production, and produce in large quantities. [...] Not everyone wants to produce his/her jam at home" (Landrain, quoted in Legros 2015). In 2016, Pili left la Paillasse and joined Toulouse White Biotech, a "preindustrial demonstrator" dedicated to biotechnology. With this move, the Pili team has also increased in size: it now counts thirteen members of staff, including a "chief executive officer," a "creative director," a "chief scientific director," and people with various kinds of expertise in engineering and chemistry. In a 2017 promotional video, the scientific quality of the project is underlined: "state-of-the-art technologies in molecular biology" and "scientific ecosystems of excellence" are mentioned, and scientists are shown working in professional laboratories. While Pili has grown and professionalized, some former activities, such as public workshops, are no longer organized. As with other projects that started off as do-it-yourself projects, there has been a transformation of a collaborative and open project into a more commercial and closed venture (Meyer 2015).

Throughout its history, the Grow Your Own Ink project and what was to become Pili have thus been the object of different forms of valuation. All in all, the project has been presented by highlighting a range of values: ecological, economic, democratic, social, cultural,

educational, and innovative. The fact that the project has led to the creation of a startup, that it has been presented to investors, and that products are eventually to be launched: all these elements reveal an increasing market valuation. During the project's first years of existence, socio-political and market valuations did not seem to necessarily contradict each other. Different ways of communicating and highlighting the collective and commercial merits of biodegradable ink seemed to be able to coexist relatively "peacefully." But with its transformation into a startup, some forms of valuation of the project became more prominent at the expense of others.

Throughout its history, the project has seen relatively different moments of valuation. In a first type of moment – of which the presentation at the 2013 TEDx conference is an example – the project was not only valued in itself, but also for the organizational and (non)institutional contexts that made it possible. Biodegradable ink was celebrated as well as the alleged fact that it would not have materialized outside a DIY biology laboratory. There was a double valuation at work: the valuation of a project and the valuation of the place, community, and philosophy of DIY biology. Both were presented as being closely entangled – it was neither the object nor the context in themselves that were valued, but the "good-within-the-context-of-its-making." In subsequent moments of valuation – the 2015 investment pitch being an example here – the project was valued differently: the organizational and institutional context of its origins was no longer highlighted. Biodegradable ink was still celebrated as such, but not by being connected to an alternative space anymore, but to an entrepreneurial space, a space seen as an obligatory passage point for realizing its full potential. Yet, in this second moment of valuation there was also a double valuation at work: the valuation of the biological and technical qualities of the project and the valuation of its marketability, scalability, and future. Again, both were portrayed as being closely entangled – what was valued was the "good-within-the-(future)-context-of-its-making-and-marketing."

Our second case study, Real Vegan Cheese (RVC), is a synthetic biology project undertaken by two community labs in the San Francisco Bay Area: CCL in Oakland, and BioCurious in Sunnyvale, California (see Wilbanks 2017). The goal of RVC – which continues as of this writing – is to genetically engineer yeast to produce milk proteins, in order to create a synthetic cheese with the physical and phenomenological properties of the original. The project was motivated by environmental concerns about the unsustainability of animal agriculture, and ethical concerns about the treatment of animals. It was also motivated by the desire to find a suitable project to take to the iGEM competition that has played a key role in establishing synthetic biology as an academic field as well as a target of corporate research and investment. Work on the project started in

spring of 2014 and accelerated in the months leading up to the iGEM Jamboree in October 2014.

The project's first clear moment of valuation was the fundraising campaign that the team conducted shortly after initiating the project. Using the crowdfunding platform Indiegogo, the team surpassed their original goal of US$15,000 to raise US$37,000. A key element in this fundraising success was the team's ability to garner significant media attention: over 100 news articles covered the project. This feat was no accident, but the result of coordinated effort: team members spent significant amounts of time on marketing and media strategy, drawing on the expertise of different team members and their networks. For example, the partner of one team member designed a professional logo for the project, and a member of the adjoined hackerspace with experience in public relations for nonprofits helped to write a press release and the project description for the website.

To organize the media strategy, the team compiled a spreadsheet with contact information of journalists who had covered similar topics, and worked together to email each of them individually. Twitter and Facebook accounts were set up to attract further attention to the campaign and publicize each article as it came out, and a Reddit AMA ("ask me anything") was organized. RVC participants spent time meeting with reporters for interviews and photo shoots, designing T-shirts, stickers, and custom-made jewelry as rewards for the project's financial backers, and stuffing envelopes with said perks. This concerted attention to fundraising and publicity, which cumulatively took up at least as much if not more time as experimental work during the first year of the project, allowed the project to exceed its funding goals, converting page views and retweets – the currency of the "attention economy" (Crogan and Kinsley 2012) – into monetary value.

In presenting the project to the general public through the website, online platforms, and media interviews, project members foregrounded the project's ethical motivations. These moral dimensions had two aspects: first relating to RVC as a future food product, and second, relating to the process of conducting the project in an open and participatory manner. With regard to the goal of producing cow-free cheese, for example, the Indiegogo page stressed the environmental and animal welfare benefits:

> We believe that using animals as large-scale food production machines is ethically and environmentally irresponsible. We believe that our process is more ethically responsible and environmentally sustainable than the status quo. We believe that all humans, vegans included, should have access to delicious and healthy cheese!

With regard to the process, or the "good-within-the-context-of-its-making," as in the Grow Your Own Ink project, the idea of practicing open science in a collaborative and welcoming community was valued perhaps as much as the goal of achieving RVC as a product. The website states: "All information is published under free-culture licenses (e.g. Creative Commons). Any and all patentable material is put in the public domain; and all research is published via our wiki and mailing list as it is generated."

The commitment to particular kinds of practices extended beyond issues of intellectual property. The project was also "open" in the sense that meetings were publicized on social media platforms such as Meetup and open to the public. The organization of the project was deliberately non-hierarchical, with decisions made using consensus-based methods. During the first year and a half of the project, rather than prioritizing fast results and assigning lab work to those who were already skilled in the requisite techniques, the group encouraged newcomers to gain new skills through experiential learning.

Because of this commitment to open science and education, the team chose not to pursue the startup path during the first eighteen months of the project, instead filing for status as a non-profit corporation. While it was sometimes mentioned that RVC might partner with a local manufacturer down the line to produce a product, plans for this stage of the project were left vague. Other members imagined that individuals might opt out of an unjust and damaging food production system by home-brewing their own cheese in the future. Although the team's work style and internal conversations suggested that the goal of actualizing an edible product and the goal of practicing open science in a community lab setting were of equal importance, news articles and the team's own marketing materials (such as the Indiegogo page) tended to foreground the benefits of RVC as a future product, valuing product over process.

New values came to the fore during the project's second major moment of valuation: the iGEM competition. RVC's participation in iGEM showed the value that the project had as a proof of concept for DIYbio as a whole. One reason that CCL and BioCurious decided to organize an iGEM team was that many members desired to show that community labs could produce scientific work matching the standards of academic labs; 2014 marked iGEM's tenth anniversary and the first year that community labs were allowed to enter. Success at iGEM was understood to support the scientific validity of DIYbio's practices. This perspective was not universally shared, however; other members valued the position of the biohackerspace as being outside of the institutions of "Big Science," suggesting that iGEM did not share the values of the biohacking community. One team member argued that rather than submitting to the judging criteria of the synthetic biology

establishment,[7] biohackers should organize their own iGEM-like gathering with their own judging criteria – and without iGEM's participation costs, which ran to thousands of dollars per team.

Despite the ambivalence of some members about iGEM, the team attended the competition, and did well by its standards: the project won a gold medal (available to any team that scores highly enough on the judging criteria) as well as the award for "Best in Track." One of the authors of this article (Wilbanks) attended the competition as a participant observer, and was one of four team members to present the project in front of a panel of judges and audience members. Participating in the iGEM presentation was an active form of participant observation that can be particularly informative when analyzed reflexively to account for the positionality of the researcher, which inescapably comes into play in moments of collaboration and negotiation. For example, other team members requested that Wilbanks's presentation address public perceptions of synthetic biology and genetically-modified organisms because they felt that the project could improve public opinion in this area. In her presentation, Wilbanks addressed public perceptions by referring to research in the social studies of science suggesting that the context in which a technology is developed matters (Marris 2001). However, her presentation also changed the framing of the subject, a choice that reflected her own interpretation and desires for the project. Reflecting the team's ambitions to change the context of biotechnology by conducting broadly inclusive and community-driven research and development, she concluded that instead of changing *perceptions* of synthetic biology, the project aimed to change synthetic biology itself through wider participation.

The way in which this intervention was received is informative, for the judges quickly returned to the narrative of improving public opinion in their evaluation of the project. The team's highest scores were in the category of "Presentation," with second highest marks in "Policy and Practices," because of the "profound impact" that the judges thought the project could have on public perceptions of synthetic biology. One judge commented, "This project is really capturing people's imagination and changing the way people think about our field. I wish you great success!" Another wrote, "This project was exemplary for the blend of public outreach as embodied in the Indiegogo and the AMA … I think you should have pursued the policy and practices special award in connection with your work on

[7] Although some biohackers considered iGEM to be the "establishment," as synthetic biology has grown to encompass a diverse array of academic and industrial enterprises, iGEM exerts comparatively less influence over the field. For example, while iGEM continues to promote an open source ethos, many synthetic biology companies have pursued more restrictive intellectual property protections.

consumer sentiments in context of a fairly significant crowd funding campaign." For the members of the synthetic biology community who served as iGEM judges, the project was valued for its capacity to improve perceptions of the field and ultimately stimulate consumer demand.

The team's success at iGEM highlighted the ambiguous position of the project with respect to "Big Bio": on the one hand, as a non-profit organization dedicated to pursuing "open science in the public benefit," the team imagined itself as the "anti-Monsanto." Yet, by promoting public acceptance of GMOs and synthetic biology, RVC is doing work that Monsanto and other agribusinesses could get behind. This point was further highlighted when representatives of two major multinational companies that own household brands of cereal and other processed foods expressed interest in meeting to learn more about the project, and the team was happy to set up a meeting. One of these company representatives with experience in microbiology spent several hours learning about the fundamentals of the project, and also connected with team members to dairy scientists whose expertise might be useful.

As the project entered its second year, discussions about commercialization increased, bringing to the fore tensions between the value of RVC as product versus process. A participant who came to the project through involvement in vegan activism argued that her goal was to "get the product to market," so she was in favor of commercialization. Another member replied that she joined "for the open science part" and discussions of markets and startup companies made her "uncomfortable." Team members discussed trademarking RVC's logo and licensing its brand to a startup formed by some project members. One member argued that the team should take advantage of the project's "fantastic reputation" within the venture capitalist and entrepreneurial community to move forward with commercialization. These conversations suggest that although a product was still not yet imminent, much of the project's commercial value lay in these less tangible assets – making it similar to other biotechnology firms in which assets and organizations may be more significant than commodities in processes of valuation (Birch 2017).

During its first few years, the RVC project moved between the logic of the market and of a gift economy, driven by donations of time and money and the goal of contributing knowledge to a commons that would positively impact the world. While media attention and IndieGogo played a major role in constituting the project's value, the iGEM competition was the most important "valuation site" for the project with respect to synthetic biology. The judgment criteria, which are known in advance by the teams, framed the project in a certain way by highlighting its symbolic aspects (its mediagenic qualities) rather than its technical accomplishments. It can be assumed that it is

precisely this focus that has attracted the interest of companies and biotechnology investors. However, many participants instead see and value the project as part of a wider cultural movement of shaping alternative and open infrastructure: of "doing" biotechnology differently.

Conclusion

This article has focused upon the efforts and moments dedicated to the valuation of DIY biology. The support and legitimacy of DIY biology is constructed via crowdfunding campaigns, via presentations and pitches, via demonstrations and workshops, and via media communication.[8] This legitimacy is built in front of – and also by – an audience. To conclude, let us focus on three points.

First, we have seen that value is produced in various ways. The projects discussed involved both market valuations (with investments, products, and potential markets) and non-market valuations. The latter are deployed on several levels (social, ethical, and cultural). It is important to stress that valuation is produced through distributed and heterogeneous processes: products, practices, principles, and places are valued, each interacting dynamically with the others. We see here an essential characteristic of these forms of valuation: it is not only a valuation of technical and production aspects (well highlighted in the work of Vatin and Stark), but also a valuation of social links and of specific forms of organization and/or marketization.

In addition to the diversity and distribution of valuation, a second point to emphasize is the relationship to the economy and the market. While DIY biology may be seen as an example of "public understanding of science" and/or "public engagement with science," the relationships with the public cannot be summed up via these terms. DIY biology involves donations, votes, private funding, and crowdfunding, as much as education. What is also actively being sought is a *public convincing of science,* that is, a legitimization and persuasion of – and via – the public. This public is not only considered as a group of actors that should learn about, or start to practice, science. The public is also seen as a consumer that, through its commitment, makes public DIY biology interesting. To put it another way, valuation is supposed to produce an *interest* in a threefold sense: a general interest (a public good), an interest for the public (its curiosity), and a monetary interest (by making people financially participate). It is during moments and trials of valuation that this link

[8] If this trait distinguishes DIYbio from academic biology, one might still speculate whether these new sources and forms of funding and medializations are not equally likely to develop within the academic world (see Rödder 2009).

between public good, public interest, and financial interest is particularly visible.

Following authors such as Tsing and Callon, following the translation of value across different places – and across time – is essential to understanding the relation of these projects to the market. DIY biology laboratories can be conceived as "peri-capitalist" spaces in which capitalist forms of value and non-capitalist forms of value develop at the same time (Tsing 2015). While in these spaces value is often produced in a non-standardized way, it can nevertheless be integrated into capitalist projects by various kinds of translation. Hence the interest of economic sociology in examining these translations: for example, the translation of public/media interest into economic interest, the translation of ethical and social capital into entrepreneurial capital, and the translation (and physical move) of a project from an alternative, peri-capitalist space into a capitalist space. Our analysis suggests that through processes of translation, a valuation in one domain (such as a good reputation as a non-profit dedicated to education and open science) can increase the project's value in another domain (such as the for-profit world of biotechnology investment). However, these translations are not always smooth and may also involve contestation and conflict. At other times, translation may mean transforming and distancing the project from an earlier context of valuation (as in the case of Pili).

Third, we hope to have demonstrated that it is fruitful to attend to different moments of valuation across a project's history and trajectory. While at one moment of valuation, specific contextual and historic elements might be foregrounded, they might be absent at another moment. While at one moment of valuation it is the situatedness and the origin story of a project that counts, at another moment it is the future market and the upscaling of a product that is envisioned. Thus, rather than saying that a project is commercialized, we have been attentive to the ways in which a project is presented and valued "in-the-context-of-its-making" in order to be – and before being – commercialized (or not). The entanglement between a project and its various moments of valuation is important to problematize. The specific formats of the moments of valuation discussed in this article (competitions, investment pitches, crowdfunding campaigns) do pre-exist, of course, the two projects we have analyzed. Yet, while a certain perimeter and frame was predefined, it is important to stress that valuation is made *along the way*. The results and outcomes of moments of valuation (notes, successes, failures, funding, etc.) cannot be known in advance. A moment of valuation is a trial of valuation: an event where the value of a project is proposed, negotiated, and put to the test, in which its value – and, potentially, its future existence – is on trial.

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