

Original Article

Fringe biotechnology

Nora S. Vaage

Centre for the Study of the Sciences and the Humanities (SVT), University of Bergen, Allégaten 34, Pb 7805, 5020 Bergen, Norway.

E-mail: nora.vaage@svt.uib.no

Abstract Recent amateur and alternative uses of wet laboratory biology techniques have been called by many names. However, none of the terms currently in use include institutional, entrepreneurial and amateur engagements in biotechnology with non-scientific aims. In this article, the author introduces the more comprehensive concept of *fringe biotechnology*. While 'DIYbio' has in recent years become a term that covers a wide range of hobbyist approaches to biotechnology, it still excludes several other alternative biotech practices, such as amateur and artistic activities in institutional labs and educational facilities. This seems to imply a continued fundamental divide between the *inside* of academic and corporate science, and the *outside*, comprising public, social and cultural uses of the technologies. The author suggests that the term 'fringe biotechnology' opens up for studying biotech activities across the inside–outside divide, and presents a range of examples of fringe biotechnology. *BioSocieties* (2017) **12**, 109–131. doi:10.1057/s41292-016-0033-0;

Published online 30 November 2016

Keywords: fringe biotechnology; DIYbio; bioart; biohacking; public engagement; citizen science

The online version of this article is available Open Access

Introduction

In the past two decades, amateur and alternative uses of wet laboratory biology techniques have received increasing attention from scholars, media and policymakers. These material engagements with wet biotechnology form a complex network of interactions with the biotechnosciences. The heterogeneity of do-it-yourself (DIY) approaches, both in terms of practices and terminology, is often acknowledged in the social science literature (see Delgado, 2013; Grushkin *et al.*, 2013; Kelty, 2010), but this heterogeneity has not been systematically studied. In this article, I propose that the range of existing interactions with the biotechnosciences justify the introduction of the more comprehensive concept of *fringe biotechnology*, which includes not only amateur, but also alternative institutional approaches to the use of a range of wet laboratory biology techniques. This sociocultural sphere comprises art and design approaches, which are often involved in DIYbio settings.

The research question that has motivated the introduction of the neologism of fringe biotechnology is: How can one conceptualise the ways in which DIYbio and bioart are

interlinked and yet significantly different practices? The article will develop the concept of ‘fringe biotechnology’ as a response to this question. Expanding on this spatial metaphor, I suggest that a kind of boundary-work (Gieryn, 1983) is at play in these fringe endeavours, and that they may form heterotopias (Foucault, 1986) in which biotechnologies are mirrored.

The research question grew out of observations made during a case study at the SymbioticA Centre for Excellence in Biological Arts, Perth, in February–May 2013. Sources of evidence for the case study ranged from participant observation and semi-structured interviews to archival studies. Both the activities at the Centre and responses to my interview questions, in particular “Do you think the art projects you have contributed to could be defined as something other than art?” informed my subsequent research into how the bioart field is interlinked with DIYbio practices. This supplementary empirical research involved participant observation in a number of contexts, including events at the community laboratory Genspace, Brooklyn, October 2013; London Biohackspace, January 2014; Science Gallery Dublin, January 2014; the Waag Society in Amsterdam, September 2014 and March 2015, the Article biennials 2012 and 2015, Stavanger; the Píksel festivals 2014 and 2015, Bergen and numerous conversations with practitioners during the period of 2012–2015. In addition, my analysis is based on a literature review of relevant social science and humanities literature on DIYbio, bioart and citizen science involving biotechnology elements.

After elaborating the theoretical framework of ‘fringe biotechnology’, I go on to discuss what it means to work ‘on the fringes’ of biotechnology. I then present four spaces in which fringe biotech, in its different manifestations, is practiced: Genspace, the Waag Society, London Biohackspace and SymbioticA.¹ Next, I discuss how issues of biosecurity and ethics are treated differently in discussions of art than they are in other fringe biotech contexts, departing from the legal case of Steve Kurtz, before arguing that fringe biotechnologists, although using similar methods and having relevant commonalities, still have a range of disparate aims. Finally, I discuss how those aims in various ways are reflected in the heterotopias of fringe biotechnology spaces.

What Is Fringe Biotechnology?

In discussions about cultural and social engagements with biotechnology, one comes across terms such as ‘biohacking’ (Boustead, 2008), ‘hobbyist biotech’ (Jeremijenko and Bunting, 1998), ‘garage biology’ (Carlson, 2005), ‘kitchen biology’ (Wolinsky, 2009), ‘citizen science’ (Irwin, 1995, see also Bonney *et al*, 2009), ‘peer production’ (Benkler, 2002), ‘bioart’ (Kac, 2004),² and ‘biopunk’ (Patterson, 2010),³ among many others. The various descriptors

1 While the other three are chosen for being among the most established and recognised spaces within this sphere, London Biohackspace is a more recent addition, and thus shows an earlier stage of development as well as a somewhat different approach.

2 The term ‘bioart’ was coined by artist Eduardo Kac in 1997, in connection to his performance piece *Time Capsule*.

3 Biopunk is described as “the culture of biohacking”, meaning the books, art and other cultural, non-wet aspects of biohacking – but the term “biopunk” is also sometimes used about biohackers in general (see Patterson, 2010; Wohlsen, 2011). Taylor (2000) described biopunk as an exaggeration of social instabilities “into an alarming maelstrom of biological uncertainty: exaggerated clarity becomes exaggerated anxiety”.

applied, although some are used interchangeably, each have embedded layers of connotations that are *not* interchangeable.⁴

So what, when so many terms are already in circulation, justifies the addition of another one to the abundance? Importantly, none of the terms currently in use cover *institutional, entrepreneurial and amateur engagements in biotechnology with non-scientific aims*. While ‘DIYbio’, as it has been used since the founding of the website DIYbio.org in 2008, covers a wide range of approaches, it still excludes several other alternative biotech practices, such as amateur and artistic activities in institutional labs and educational facilities. This seems to imply a continued fundamental divide between the *inside* of academic and corporate science, and the *outside*, comprising public, social and cultural uses of the technologies.

In the following, I argue that the category of ‘fringe biotechnology’ is better suited to encompass the heterogeneous, multifaceted array of societal and cultural approaches to biotechnology. Biotechnology, in this context, is understood in its widest sense, as referring to all human manipulation of biological processes, for instance in agriculture, zymotechnology (fermentation, as in beer brewing and industrial fermentation), as well as contemporary developments such as genetic engineering and in vitro fertilisation (see e.g. Bud, 1993). In this sense of the word, biotechnology refers to a range of practices that have been institutionalised, but that – particularly with the last few years’ decreased costs and ‘de-skilling’ of biotech through the creation of standardised parts, kits, and other simplifying tools – allows multiple actors to exist at its fringes. What fringe biotechnologists practice is not the life sciences or medicine, nor even, necessarily, engineering. Rather, they engage in a heterogeneous range of practices using the methods and concepts of biotech for various purposes.

By encompassing not just citizen science but also art and design approaches, the category of ‘fringe biotechnology’ reaffirms a real-life connection between these practices while still recognising their differences. The practices have at least three important factors in common: (1) they bring biotechnology into the public eye, (2) their use of biotechnological methods for purposes other than the scientific, by actors that do not necessarily have the same formal training, makes them subject to ethical scrutiny and (3) they relate topically to the *issues* of biotechnology, from patenting rights to pertinent applications for the technologies (see e.g. Landrain *et al*, 2013; Mitchell, 2010; Wohlsen, 2011).

In proposing this term, I am not suggesting that it replace the existing terminology; rather, that it may offer a fruitful addition. In some ways, as has been discussed by other scholars (e.g. Delfanti, 2013; Meyer, 2014) biohacking may have more in common with computer hacking than with art or the science communication practiced in museums and science centres. However, I argue that differences among biohackers may be as great as between a single biohackers and bioartist, and also that consideration of how different cultural and societal approaches work on the fringes of biotechnologies is important in part *because* of these differences. Their shared use of the methods of biotechnology would, in itself, provide valid reason for consideration, if they didn’t also intermingle and meld over into each other to the extent that they do.

4 For instance, while ‘garage biology’ connotes not only to the IT hacker tradition of tinkering in garages, but also to masculine endeavours such as fixing cars, ‘kitchen biology’ speaks more of activities of cooking and being inside the home, what has until recently been considered within the sphere of the feminine (Jen, 2015).

In asserting their right to use these technologies, fringe biotechnologists are entering into what has conventionally been the territory of academic and corporate scientists (Delfanti, 2013; Kac, 2004; Özög, 2012). This coincides with a strong surge in other kinds of citizen science and DIY. Nowotny *et al*'s (2001) idea of 'Mode-2 knowledge' (while not explicitly engaging with DIY) suggests that in our current knowledge society, an increasing number of social and cultural actors are now engaged in knowledge production.

Thomas Gieryn (1999, p. 15) has observed that the "spaces in and around the edges of science are perpetually contested terrain". Since the scientific revolution, science has been at least partially defined by what it is not: demarcating science by separating other activities out as 'non-science' and 'pseudo-science' (e.g. Popper, 1980 [1959]). Gieryn's work (1983, 1999) builds upon an existing analytical tradition in the philosophy of science, in which Karl Popper (1980) and Merton (1973[1942]) and Thomas Kuhn (1962) made important contributions. Gieryn proposed the term 'boundary-work' (1983) as being "strategic practical action" (1999, p. 23) to decide what counts as science, and what does not. While most fringe biotech would be defined outside of 'science', as they are merely using the *technologies* in question, some will also be presented as being 'inside'. Wienroth and Rodrigues (2015, p. 6) have proposed that, due to the competitive nature of contemporary technoscience, "citizen scientists find themselves enrolled in the boundary work of academic scientists".

Spatial metaphors are common in discussions of academic disciplines (see e.g. Mead, 1969), and indeed "pervade much of our thinking" (Zerubavel, 1993, p. 16). They have also been used about DIYbio (Delfanti, 2013), as well as about bioart (Mitchell, 2010). 'Fringe biotechnology', too, is a spatial metaphor. It encompasses any activity at the outskirts of academic and corporate biotech, from start-ups to artworks. Dictionary definitions of 'fringe' include "the outer, marginal, or extreme part of an area, group, or sphere of activity" (Oxford English Dictionary, 2015). It can also mean "an area of activity that is related to but not part of whatever is central or most widely accepted: a group of people with extreme views or unpopular opinions" (Merriam-Webster, 2015). Since some fringe biotechnologists are explicitly opposed to the precautionary principle (see e.g. Patterson, 2010 – although other practitioners disagree with this view, see e.g. Gessert, 2010), and because biosecurity and biosafety are continuous concerns in discussions about the unregulated actors within this sphere, it does seem right that the disruptive potential in the term 'fringe' is acknowledged; however, it should not be afforded too much weight in the backdrop for fringe biotech. "Fringe" is also the name of numerous arts events around the world, notably the Edinburgh Festival Fringe, the largest arts festival in the world. Within this resonance box, 'fringe' connotes to something that is fresh, innovative and out of the mainstream. A multitude of different approaches and interests are at play within this sphere. Practitioners seeking to change the world, spread enthusiasm for the sciences, critique them or make money may coexist, sometimes within the same lab (personal conversations with Oron Catts, 2013, and Martin Malthe Borch and Emil Polny, 2013; see e.g. Wohlsen, 2011).

Different interests stand against each other in a number of ways in the field of biotechnology, creating tension between open-source advocates and the proponents of ownership (see e.g. Delfanti, 2013); researchers' need for cheap and available equipment and corporations' drive to make a profit through patented essentials; stakeholders' wish to advance the technology and worries about biosecurity risks (Schmidt, 2008) – to mention just a few. In diverse ways, fringe biotechnologists engage with the issues at hand in the field,

both through materialising possibilities and through discussing them with a wider public (Hauser, 2006; Meyer, 2014).

Fringe biotechnology, positioned in the outskirts of institutional biotech, can be seen as a set of heterotopias, “other spaces”, in Michel Foucault’s (1986) sense. As expressed by Robert Topinka (2010, p. 65), “heterotopias reorder, and reordering is fundamental to both knowledge and power”. Foucault sees heterotopias as “counter-sites”, spaces that function as a sort of mirror for other aspects of reality. Museums, cemeteries, gardens and festivals are among his listed heterotopias. Although not one of his more well-developed concepts, and described as expressing a range of sometimes contradictory properties, the figure of the heterotopia may help us in visualising the role of fringe biotechnologies: as something *other*, important for their property of shining light on the more central activities of biotechnology and how they might impact our societies, and also profoundly important in and of themselves, as practices with their own internal logics, aims and valuations.

Interestingly, considering the deliberate outside status of many (but far from all) fringe biotech actors (see e.g. CAE, 2006; Kelty, 2010; Patterson, 2010), there is also a strong focus among these actors on the ‘blurring of boundaries’. Some actors wear ‘multiple hats’, defining themselves, in different contexts, as researchers, hackers or artists (Tremmel, 2014; interviews with Guy Ben-Ary and Ionat Zurr, SymbioticA, 2013). Many fringe biotechnologists are explicitly concerned with *surpassing* and *going beyond* boundaries (see e.g. Kac, 2004; Kelty, 2010; Patterson, 2010). In proposing this new term, I am inadvertently drawing up new lines, setting the boundaries differently; I, too, am performing a form of boundary-work, if you will. However, the term ‘fringe’ implies precisely not a firm, distinct boundary or border, but a more blurry, uneven expanse of space.

In the following, art will be a main focus, for two reasons: First, as an art historian turned interdisciplinary scholar, I find it striking how, although a significant portion of the regular users of community biolabs such as Genspace and La Paillasse⁵ are artists, scholarly discussions of DIYbio have increasingly mentioned art *in passing* as being an important part of this phenomenon,⁶ without giving it more in-depth treatment (see e.g. Delgado, 2013; Seyfried, Pei and Schmidt, 2014). The practitioners themselves do acknowledge its central place in the movement, as shown in Figure 1, the sphere of DIYbio as envisioned by Huib de Vriend and Pieter van Boheemen of the Waag Society.

Second, art approaches tend to be more ambiguous and/or critical in their stance towards biotechnology than community biology, and as such offer an important counterpoint to the dominant discourse (research interviews with Oron Catts, Ionat Zurr and Benjamin Forster, 2013; see also e.g. Oźóg, 2012; Wohlsen, 2011).

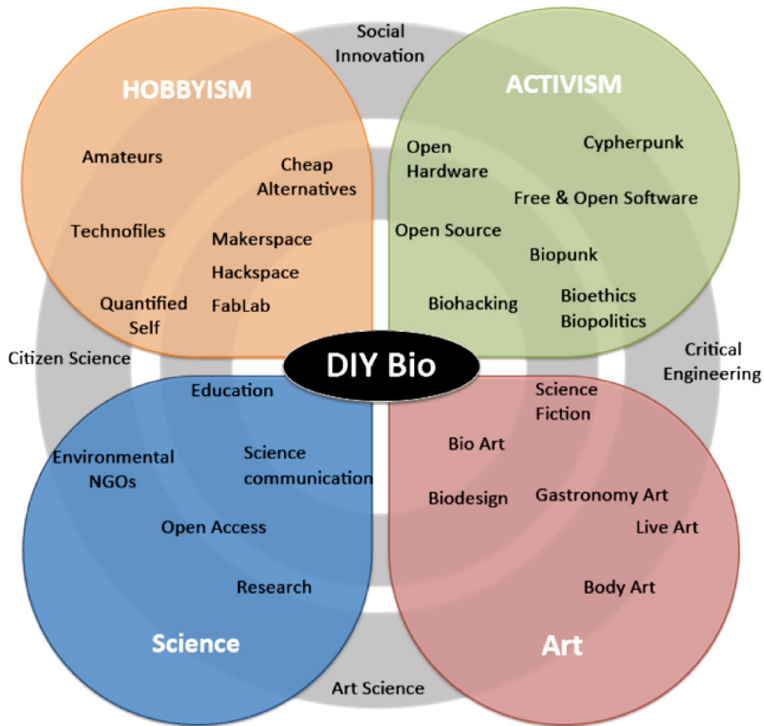
Just as most accounts of DIYbio mention art practices only briefly, the numerous scholars writing about bioart have not discussed it in relation to other cultural engagements with wet biology (with the sometime exception of design), but rather focused on the material process of creating the artworks (Reichle, 2009), their ethical issues (Levy, 2006), their status as living, material objects (Bakke, 2008; Hauser, 2006) and how the potentialities of the

5 La Paillasse started out as a Paris-based biohackspace, and now also has independent labs in Saône and Manila (La Paillasse, 2015).

6 Despite early interventions such as Jeremijenko and Bunting’s *Biotech Hobbyist Magazine* and artists’ DIY workshops, referred to later in this article, art was not commonly mentioned in the earliest DIYbio accounts (e.g. Carlson, 2001, 2005; Wolinsky, 2009).



What is going on in the lab?



Adopted from De Vriend & Van Boheemen (2014)

Figure 1: Model of the DIYbio landscape according to H. De Vriend and P. Van Boheemen. Reproduced with permission from Van Boheemen.

biotechnology in question might be explored through the artwork (Andrews, 2007; Anker and Nelkin, 2004). Artists active in this field see themselves first and foremost as working with art, and often work with multiple media, also outside of the biotechnological range. A common historical reference in bioart accounts is Marcel Duchamp, who appropriated artefacts from other realms and made them art (Byerley and Chong, 2015; Gessert, 2010; Mitchell, 2010). Many hackers who started from different backgrounds, however, have also developed artworks within the context of DIYbio (e.g. Pieter van Boheemen from the Waag Society in Amsterdam, Martin Malthe Borch from Biologigaragen in Copenhagen and Rüdiger Trojok, who is currently setting up a DIYbio lab in Berlin, all have biology and/or engineering backgrounds, but have created and exhibited artworks).

Some of these practitioners have taken to identifying themselves as ‘makers’, largely brought about through their participation in “Maker Faires” (Tocchetti, 2012; Toombs, Bardzell and Bardzell, 2014). Maker culture is described as technology-based DIY culture, and encourages innovative use of technologies and new inventions. However, fringe biotech only partially overlaps with maker culture, which is typically quite techno-optimist (Jen, 2015). Makers also seek to develop products that might eventually have high-market value. While this is true of some fringe biotechnologists, others take a more critical stance to the

Fringe biotechnology

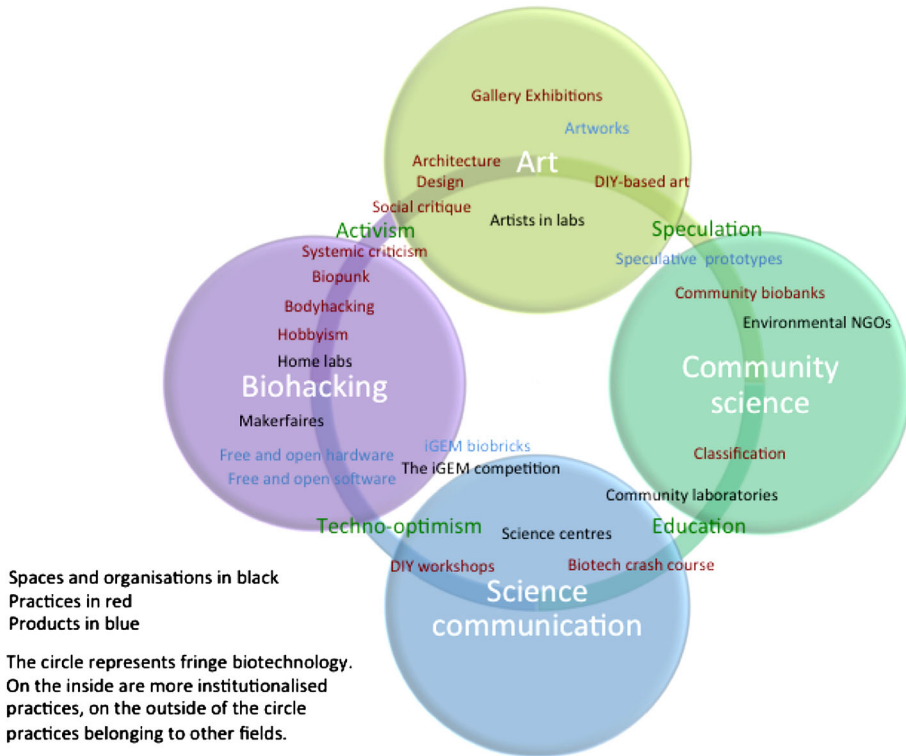


Figure 2: Fringe biotechnology mapped. (Colour figure online).

technologies themselves (e.g. CAE, 2006; Catts and Zurr, 2014), or to the systems in which they operate (e.g. Trojok, 2014), and some are professionals in their own fields, using the technologies for different purposes.

Inspired by De Vriend and Van Boheemen’s model, but considering a wider set of spaces and practices, I have developed a diagram to continue the process of making sense of these complex interactions. Figure 2 maps abstracted spaces, organisations, practices and products of fringe biotechnology onto a ‘fringe periphery’, placing some few practices on the inside of the circle as being more institutionalised. This is not by any means an exact placement of the various entities; if anything, it seeks to underline how fluent are the boundaries between these practices. Fringe biotech is by nature heterogeneous and, in many cases, transient. Showing how they populate a shared space, as well as acknowledging what these approaches have in common, opens up for arranging and discussing these practices in new ways.

Work on the Fringes

Science never exists in a vacuum, and continually draws the attention of ‘outsiders’ and ‘publics’ seeking to interpret scientific technologies within societal contexts (Nowotny, Scott



and Gibbons, 2001; Wilson, Hawkins and Sim, 2014). Some scientific disciplines, such as astronomy and archaeology, had numerous amateurs contributing to the knowledge pool throughout the heyday of disciplinary science. In the wider field of biology, including anatomy, ornithology and botany, there are many cases of lay engagements having brought the field forward, a famous example being the monk Gregor Mendel's experiments with pea plants leading to his uncovering of mechanisms of heredity in the mid-1800s (Drouin, 1995). However, in other fields, including microbiology, expensive equipment and time-consuming procedures, in addition to a high level of expertise required, prevented amateurs from more than superficial involvement.

Towards the end of the last millennium, some scientists suggested that biology in the 21st century would be the most important of the sciences, biotech products impacting and potentially transforming our society, and that citizens therefore should take a more active part in it (e.g. Carlson, 2001; Dyson, 2007). Artists had already begun to involve themselves in wet laboratory activities, two decades before the advent of the contemporary biohacker movement. In order to gain access to the knowledge and expensive materials of scientific facilities, they sought entrance into state-of-the-art laboratories as residents and visiting researchers.⁷ Since the early 1980s, Joe Davis has been active in MIT and (later) Harvard's biology laboratories, producing artworks such as *Microvenus* (1986–2000, in collaboration with Dana Boyd and Jon Beckwith). Here the Germanic rune for Mother Earth, which is also the visual symbol of the female external genitals, was inserted (after the graphic symbol designed with binary code had been 'translated' into genetic code) into the plasmids of *E. coli* bacteria, in what was possibly the first case of recombinant DNA technology being used for art (Reichle, 2009, and personal conversation with Joe Davis, 2013).⁸ The project explored the idea that DNA can be a stable storage unit for information, and that bacteria may travel through space and serve as transmitters of messages to extra-terrestrial intelligence. In the 1990s, more and more artists started using a variety of biotechnological methods to create artworks.

The possibility for engagements with biotechnology outside of such laboratory residencies had been seen at least as early as 1988 (Schrage, 1988). In 2001, Rob Carlson predicted that "[i]n 2050, following the fine tradition of hacking automobiles and computers, garage biology hacking will be well under way"; by 2005 he had already revised this timeline considerably, and wrote a "recipe" in *Wired Magazine* for how one could start right then, setting up a lab of one's own in the garage, at the cost of about 1000 \$.

With the resources and knowledge gained through contact with scientific environments, a number of artists, from SymbioticA's Oron Catts and Ionat Zurr to Reiner Maria Matysik, had since the early 2000s organised biotechnology workshops for non-biologists, mainly artists and art students.⁹ In 1998, artists Natalie Jeremijenko and Heath Bunting started the online *Biotech Hobbyist Magazine* for biotech beginners and enthusiasts. As the 2000s

7 Wohlsen (2011, p. 201) suggests that reasons why artists were the first to engage materially with biotechnology may be "because they already saw themselves as outsiders, and because what they make has no obligation to be useful".

8 Davis is currently a member of George Church's synthetic biology lab at Harvard, and they are working to create a "tree of knowledge" by inserting the genetic translation of all written content in Wikipedia into an ancient apple strain. Davis, 2013–2016, personal conversations.

9 Catts and Cass (2008, p. 143) listed participants in the SymbioticA Biotech Art Workshops as having been "artists, theorists, philosophers, writers, ethicists, architects, designers, curators, and engineers".

progressed, other actors started similar initiatives, without an artistic angle. From the mid-2000s, the biohacker phenomenon started to gain momentum, propelled, among other things, by the International Genetically Engineered Machine competition (iGEM) in synthetic biology, and the 2008 founding of the DIYbio.org website by two graduates of iGEM, Mackenzie Cowell and Jason Bobe (Eggleston, 2014; Landrain *et al*, 2013).

Within the next few years, DIYbio developed into an international network of amateur biotechnologists, including many groups who defined themselves as biohackers (e.g. BioCurious, Biologigaragen, La Paillasse), and some with a focus on the arts (e.g. BioArt Laboratories, Hackteria, The Waag Society). Today, DIYbio.org provides chat forums, a library of DIY laboratory hardware, a blog, and the possibility to “ask a biosafety expert” (DIYbio, 2015).¹⁰ The DIYbio network provides a loosely knit sense of community, but the groups affiliated with the network have quite diverse approaches. Even within individual groups, DIYbio practitioners engage with biotechnology at quite different levels, and some also interact with institutions (according to a study by Grushkin *et al*, 2013: 20, “some 28 per cent of DIYers already do some or all of their work in an academic, corporate, or government” laboratory).¹¹

Biotechnology is closely linked to information technologies, and although it is still more complicated and expensive to do biology outside of the institutions than it is to do DIY computer work, in the last ten years affordability, standardisation of procedures and availability of knowledge and materials have enabled an increasing number of actors to do material work using biotechnology, without the requirements of formal academic or corporate affiliations (see e.g. Delfanti, 2013; Meyer, 2014). DIYbio practitioners have made significant contributions to S&T through the development of cheaper tools, as Landrain *et al* (2013) exemplified in a table showing DIY alternatives to 22 key laboratory tools and consumables (in the case of the DIY device Amplino, reducing the cost of quantitative PCR diagnostics from 10000\$ to 200\$, thus facilitating diagnosis of malaria in the field).¹² Cheaper equipment might make all the difference in countries where “neglected diseases” such as malaria are wreaking havoc (Wohlsen, 2011). As Catts and Cass (2008, p. 150) have pointed out, one of the reasons “for the inhibiting costs of scientific equipment is their need to be as precise as possible. This is not always the need of artists or hobbyists”, who therefore have an interest in developing simpler, less expensive tools suitable for use in makeshift labs or in the field.

10 In this article, I distinguish between ‘DIYbio’, referring to this organisation, and ‘DIY bio’/‘DIY biology’, meaning the broader phenomenon of hobbyist biotechnology, including groups and individuals not affiliated with the DIYbio website.

11 It should be noted that some DIYbio members refused to answer Grushkin *et al*’s survey as a matter of principle, since the Woodrow Wilson International Center for Scholars, the funder of the survey, had collaborated with the FBI in organising events discussing biosecurity issues (Kera, 2014).

12 A Polymerase Chain Reaction (PCR) machine is a thermal cycler (a device that alternately heats and cools the sample) which produces multiple copies of a particular segment of DNA. After this process of amplification, the presence of relevant DNA can be detected using gel electrophoresis. Quantitative PCR, often called real-time PCR, combines the thermal cycler with fluorescence detection, thus enabling DNA amplification and detection in one step.



Spaces for Fringe Biotech

As pointed out by many scholars in the last few years, the community spirit is important in DIY endeavours (Grushkin *et al*, 2013; Seyfried *et al*, 2014). A characterising feature of DIYbio is the widely shared opinion that more hands and more brains working together can do more by joining forces than the same hands and brains could achieve by themselves.

In the 2000s, quite a few DIYbio practitioners worked from home, in kitchens, garages or bedrooms (see e.g. Carlson, 2001, 2005; Wolinsky, 2009). But since the start-up of Genspace, New York City's Community Biolab, in 2010, community laboratories appearing in numerous locations have provided new spaces for fringe biotechnologists. In the 2013 survey by Grushkin *et al*, 92 per cent of the respondents reported that they work in group spaces (just over 16 per cent reported that they also worked at home). Since the tools needed even for simple biotech experiments can still be quite expensive, it makes sense to pool one's resources.

Fringe biotechnology is rhizomic in the online distribution of advice, discussion boards, and available protocols across geographical borders. Concurrently, however, specific groups and spaces for fringe biotech tend to be very much local in their grounded presence within a community, and also urban in their location: almost all community labs, science and art centres and other fringe biotech spaces are located in medium-to-large cities (see e.g. Landrain *et al*, 2013; there are of course exceptions, such as Cultivamos Cultura in countryside Portugal).

Genspace

Opened as a Biosafety Level One (BSL-1) laboratory,¹³ the first with such classification outside of institutions and industry, Genspace in Brooklyn quickly established itself as one of the most successful spaces on the DIY scene (Ireland, 2014; Wohlsen, 2011). The community lab hosts an eclectic range of activities, from iGEM teams to workshops by established artists such as Oron Catts. Director Ellen Jorgensen estimates that about a third of the people that make use of its lab for a small monthly fee are artists, about a third are IT programmers and the last third are "just curious" (Ireland, 2014). One of the founders of the community lab, artist Nurit Bar-Shai, describes the community lab as "a diverse community that explores cross-disciplinary visions through its art-science programs" (2014).

Heather Dewey-Hagborg is one of the artists who has made use of Genspace's facilities. The series *Stranger Visions* features realistically rendered sculptural portraits based on DNA she obtained from loose hair, cigarette butts and used chewing gum. After using forensic DNA phenotyping technology at Genspace, the artist used custom software to visualise what one can assume about the DNA owner's appearance, and created her sculptures based on that. Dewey-Hagborg seeks to raise awareness about genetic privacy and the possible

13 In the USA and EU, Biosafety Levels specify the amount of biocontainment routines and equipment required in the lab in order to deal with different orders of biohazardous materials. BSLs run from 1 to 4. 1 is the lowest level, and is used "for work involving well-characterised agents not known to consistently cause disease in immunocompetent adult humans, and present minimal potential hazard to laboratory personnel and the environment" (CDC, 2016). This means that BSL-1 labs do not allow work with transgenic or pathogenic organisms.

implications of current technologies, through showing that a single, abandoned strand of hair can provide strangers with access to one's genetic information. She has stated that “[a]rt at the intersection of science has a liminal status, and therefore a critical potential”.¹⁴ The combination of critical potential and an open-ended material object that does not tell the viewer what to think recurs in bioart approaches.

Taking advantage of the large number of volunteer hands that are attracted by and help build a community-oriented attitude in their lab, the people at Genspace wish to supplement institutional science by doing projects that require time and manual labour, but not high levels of skill. Their *Barcoding Alaska* project seeks to taxonomically classify a large number of arctic plants using DNA barcoding, a simple protocol that any layperson can do given the ‘recipe’. In this way, they are contributing to the knowledge pool (spoken introduction by Ellen Jorgensen, Open DNA Barcoding Night, Genspace, 2013). This approach puts a strong emphasis on science communication, spreading enthusiasm for the science, and connotes to the numerous hobbies focused on collecting and categorising, such as stamps or herbariums. It can be considered part of a bigger movement towards crowd participation, crowdsourcing and peer production in citizen science utilised in a number of other projects worldwide (Bonney *et al*, 2009).¹⁵ Such interests exist side by side with the more individualist aims of artists and entrepreneurs (Bar-Shai, 2014, writes that she finds in Genspace a place to “explore failure and doubt, and bring the same freedom, curiosity and experimental practices that I have in my art studio into the biology lab”, and a semi-regular at the Genspace community nights, a software engineer who stated that he comes to Genspace mostly for the community spirit, nonetheless expressed his goal of professionally transitioning into bioengineering). In addition to the open nights, Genspace also offers courses in biotechnology and synthetic biology, currently at the cost of \$300 for four three-hour sessions (Genspace, 2016).

Genspace's website (2016) features the catchphrase “Remember when science was fun? At Genspace it still is”. This discourse asserts that they are practicing both science communication and, in fact, science, and also suggests that they see institutional science as *less* fun – compared, perhaps, to the joyful appreciation of making sense of the world often seen in children and youths. As such, they facilitate entry into their lab for audience groups who would not feel comfortable entering a scientific facility, but may still find it rewarding to engage directly with ‘tinkering’ in the laboratory or at the big communal table placed outside the Genspace Biosafety Level 1 lab.

14 H. Dewey-Hagborg, Public talk at Litteraturhuset, Bergen, Dec 17, 2013, and personal conversation with the author.

15 The idea of citizen science connotes quite strongly to a public individual that is active and politically engaged, aware of the rights citizenship bestows. However, the term ‘citizen science’ as coined by Rick Bonney (see Bonney *et al*, 2009) in the 1990s refers more to public outreach projects coordinated by scientists, than to peer-to-peer approaches such as those most often seen in fringe biotechnology. Irwin (1995) coined the term at about the same time in the UK, referring to the necessity of opening up scientific processes to public participation. This appears to be closer to the sense in which laypeople use the term today.



The Waag Society

The Waag Society in Amsterdam, one of the most established institutes at the cross-section between art, science and technology, has an active Open Wetlab Community. Although more institutionalised than most DIY laboratories, and participating in (and getting funding from) multiple EC projects, the Waag Society's Open Wetlab shares the ideals of open-source, democratisation of knowledge and hands-on engagement for the public. In 2015, they launched what they call "the first BioHack Academy in the world", with a more in-depth course (10 classes over 2.5 months) in working with biomaterials using self-built, open-source hardware (Waag Society, 2015, and personal conversation with Pieter van Boheemen, 2014).

Their website states that the Open Wetlab seeks "to involve the industry, artists and designers, but also the political forces and the public, hands-on in the shaping of biotechnology, as well as in what biotechnology creates". The same statement also professes that the Waag Society "promotes the production of bio-art because we believe that bio-art is visionary and can be guiding for new prototypes and applications. Thus, we investigate to what extent and how art and science can work together and in what way art can influence a scientific agenda" (Waag Society, 2015). Lucas Evers, head of the Open Wetlab, is an artist. Since the Wetlab's opening in 2012 they have, among other events, hosted a DIY series of public events called *Do It Together*, where DIY biologists, scientists and artists present frameworks for public engagements, from human blood cell tournaments (artist Kathy High) to future food (Centre for Genomic Gastronomy). The boundaries between art and design are also currently quite permeable: designer Agatha Haines is an artist in residence at the Open Wetlab for the year of 2016.

In both Genspace and the Waag Open Wetlab, as in most community labs with organised programs, experienced DIYers, sometimes employees, oversee the activities and teach newcomers the basic skills needed. Most active DIY biologists do have some background in biotech, although an undergraduate degree in biology is more common than a PhD (see the survey by Grushkin *et al*, 2013). Despite the process of 'de-skilling' and lowered costs of practicing biotechnology in the last few years, the 'democratisation' of science does meet this obstacle: While it is the matter of a few minutes to teach someone to use a pipette or seed agar plates, the knowledge of why we should do it, what is possible and what is safe, is not so easily acquired. Therefore, the current proceedings often take the form of one or more knowledgeable leaders of the experiment, directing the others at each stage (personal conversations with Pieter van Boheemen, 2014, and Martin Malthe Borch and Rüdiger Trojok, 2014). This is in conflict with the explicit intentions of many fringe biotechnologists, who state that they seek to dismantle hierarchies and open up science to those who are currently outsiders (see e.g. Delfanti, 2013; Meyer, 2014).

London Biohackspace

DIY also encourages individuals to solve puzzles for themselves. The tension between individual and collective forces in DIYbio is recognisable from what Gabriella Coleman (2013) described in her study on ICT hackers. The "hacker ethos" and its ideals of problem

solving, tinkering and freedom (Kostakis *et al*, 2015; Levy, 2001) ring true for a number of fringe biotechnologists. London Biohackspace is one of several community labs that grew out of existing hackspaces,¹⁶ and are located next to or within them (another example is Biologigaragen, situated within Labitat in Copenhagen). This also facilitates that some existing members of hackspaces join biohackspaces, bringing with them an interest in ICTs and electronics. When I visited London Biohackspace, in a room in the basement of the London Hackspace, in January 2014, its members consisted of a small group of active participants who sought to increase their knowledge of biology and develop their laboratory facilities. At that point, they had not done much “actual lab work” (personal conversation with Simon, 2014), apart from participating in the iGEM competition along with University College London. Their lab is not yet BSL certified, and they do not offer courses, rather aim at learning together through reading and doing. So far, they focused on building equipment such as a shaker platform, gel electrophoresis box and microscopes from scratch, and more recently the Juicyprint, a bioprinter that should run on fruit juice and print bacterial cellulose shapes (LBH, 2016).

This focus on hardware and software before wetware (biological materials) is common especially in the biohackspaces. While most actors and scholars use ‘DIYbio’ and ‘biohacking’ synonymously (Meyer, 2014; Seyfried *et al*, 2014), some see relevant differences. In a practitioners’ discussion forum, one actor (defining himself as a biopunk, which he described as a hacker culture) found the difference between DIYbio and biohacking to be that DIYers think it important to build stuff themselves, whereas to biopunks, “this adds no extra value” – they will use whatever is most efficient (Splicer, 2010).¹⁷ However, a comment to this statement by another biohacker, Cathal Garvey, contradicted Splicer’s representation of the situation: “in my experience, there are many people in the DIYbio community who are ‘in it for the wetware’, rather than obsessively making their own equipment and sequencing things using only their own tools” (*ibid.*), highlighting the intricate web of terminology, interactions and self-conceptions among fringe biotechnologists.

SymbioticA

As mentioned, far from all bioart is DIY. A range of artists work within institutions, be they dedicated to art or science or something in between. The SymbioticA Centre, founded in 2000 at the University of Western Australia (UWA), is the first artistic centre in the world to be based within a biology department. In 2008, it also became a Centre for Excellence in Biological Arts. SymbioticA offers residencies, BSc, MSc and PhD programs, and a range of activities including open seminars and exhibitions. The Director of SymbioticA, Oron Catts, observed in a recent interview that their more than 70 residents have included “techno-utopians, we had very critical artists, theoreticians, geographers and philosophers and designers and architects and artists... performance artists, media artists, formalist artists who wanted to use it as a formalist material” (Reeve, Catts and Zurr, 2016).

16 As with DIYbio, there are a number of terms in use covering similar initiatives, such as makerspaces, fablabs, telehouses and medialabs (Maxigas, 2012). The Americans say ‘hackerspaces’ rather than ‘hackspaces’.

17 Splicer’s statement implicitly subscribes to Meredith Patterson’s “Biopunk Manifesto” (2010).



The Centre consists of a small office space and a PC1 laboratory, which is mostly used as a storage space for a large number of artworks, leftover components of residents' projects and a number of odd objects. The staff and residents more often make use of the PC2 and PC3 laboratories in the School of Anatomy, Physiology and Human Biology, to which the Centre belongs.¹⁸ In order to use these labs, they have to go through inductions, follow lab procedures and get approval from the UWA ethics committees for their projects.

Oron Catts established the Tissue Culture and Art Project with his partner Ionat Zurr in 1996. Ozóg (2012, p. 44) names “promoting a ‘Do It Yourself’ approach that is unprejudiced and founded on sound knowledge” as an important aspect of Zurr and Catts’ activities. In *The DIY De-Victimizers* (2006), the artists developed a kit, called *DIY DVK m1*, which would allow people to “bring back” individual cell lines of dead meat in order to, as they ironically put it, “allay some of the guilt people feel when they consume parts of dead animals” (Catts and Zurr, 2013, p. 110). The artists explicitly sought an absurd approach in their performative installation, to bring through their critique of the hypocrisies of human interactions with other living beings.

Although they value the democratisation of science, Catts and Zurr (see e.g. 2014) in their articles criticise the standardisation of biocomponents, which makes routine out of the manipulation of life. De-skilling is important for letting amateur beginners into biotechnology. However, Catts and Zurr see the ways in which it is being done as a worrisome development.¹⁹ This illustrates an important point of contention among these practitioners: the opinions as to what level of manipulation of living matter is desirable or acceptable, and how we should relate to and discuss the current state of biotechnology (Ginsberg *et al*, 2014, p. xiv). This mode of engaging with biotech and its societal aspects is not, *per se*, *science*. Ionat Zurr, in a 2013 research interview, has stated that “I’m not even trying to be the scientist or the engineer, I have my other skills”. She considers her role to be supplementary to science in a different sense, through critical inquiry into the rhetoric and conditions of scientific work and the place of its products in society.

Catts has stressed that the SymbioticA approach, and the outcomes they are interested in, are “very, very different” from those of the DIY and biohacker communities, although some of the rhetoric and ideas are similar to their own. He says that he is

now making a point of distancing myself to some extent and what we do at SymbioticA from those amateur bio-hacking communities, because I think that the problem is now that there seems to be an attempt to cluster all of those approaches as one way of doing things [...] I like some of the stuff they are doing with the biohacking and amateur biologists, but I’m not really finding too many connections in regard to the way they do it, and the reasons they are doing it, and the outcomes they are interested in (Catts, 2013, research interview with the author).

Catts delineates the artistic approach as something essentially different from the DIY communities. Similarly, Kera (2014), biohacker and researcher at the National University of

18 The PC (Physical Containment) levels in the Australia/New Zealand Standard correspond to the BS levels of the EU and US systems.

19 Also, when using kits, laypeople without prior knowledge of wet biology might be able to go through the steps of a protocol, in the same way as they are capable of following a recipe, but they will not necessarily understand the process as they are doing it.

Singapore, has argued that while “most bioart projects place biotechnologies in the context of art institutions and galleries, DIYbio and biohacking activities grow and spread through the emergent culture of hackerspaces, makerspaces and citizen science laboratories”. The products of these actors’ activities are notably different: while artists seek to create artworks – as Kera points out with the aim of exhibiting them (although such artworks are often shown in Science Centres and other untraditional venues for art, not just in art galleries) – biohackers seek other outcomes such as producing new knowledge or developing new equipment. However, these boundaries are very blurry, since several biohackers without artistic backgrounds have produced artworks, considering this form a good communication venue (for instance, Martin Malthe Borch and Cristina Muñoz from Biologigaragen created the *Urine Journey*, described as “an interactive art-science installation” in which energy is produced from urine, a process displayed at art fairs in a “urinal”, see Borch and Muñoz, 2014), and SymbioticA has since the early 2000s hosted workshops in which they teach DIY alternatives to expensive gear and materials, with a twist. Like the workshops hosted at sister Centre Biofilia in Helsinki, the focus is also on “broader philosophical and ethical explorations into the extent of human intervention with other living things” (Taipale, 2014).²⁰

As a fringe biotechnology space, SymbioticA differs from the open community labs in two important ways: (1) Its labs are not open to the public. SymbioticA, set within the UWA, operates on an ordinary university model of application and acceptance for residencies and educational programs (they do host weekly seminars that are free and open to the public). (2) It is not cheap. Upon acceptance, the prospective resident must commit to pay bench fees for the use of UWA’s professional laboratory equipment and consumables. Due to the grant system, both artists and academics have the opportunity to apply for funding for such residencies; however, this is far from the inclusive system of most DIYbio labs.

These spaces, we see, to varying extents accommodate a range of different practices. Differences in motivations, interests and aims between actors are real and prominent: not only between DIYbio and institutional bioart, and between diverse geographical local situations, but also between different actors within a single laboratory space. The distinctions between artistic, educational and entrepreneurial activities, and the range from techno-optimist to techno-critical and sociocritical approaches, appear more important than the division between DIY and institutional practices – but the issue of funding is notable as perpetuating this division (Delfanti, 2013; Mitchell, 2010).

Comparative consideration of these approaches can showcase the differences. But fringe biotechnologists, as mentioned, have some important factors in common: they bring biotechnologies into the public gaze, opening them up to scrutiny and facilitating discussion. Also, their alternative utilisation of the technologies makes them subject to questions regarding ethics, responsibility and biosafety. Hackers, artists and scholars alike often refer to the Kurtz case as exemplary of the negative turn these questions can take.

20 In the manuals SymbioticA use for their workshops, there is very little, apart from the title of the courses, to indicate that this has anything to do with art. It constitutes a basic crash course in history and practice of modern biotech, some basic cell biology. However, throughout the workshop week, they intensively discuss questions of ethics and philosophy, such as “what should be our relationship with other living beings”, and “should we let a worm live?”.



Biosecurity and Ethics in Fringe Biotechnologies

The Kurtz case

In 2004, artist Steve Kurtz of the Critical Art Ensemble (CAE) and his academic collaborator Robert Ferrell were arrested by the FBI on suspicion of bioterrorist intentions. Kurtz had been cultivating bacterial cultures in his home for an artwork. Ferrell, a geneticist, had ordered the bacterial samples (*Serratia marcescens* and *Bacillus atrophaeus*) from the American-Type Culture Collection. The artwork, called *Marching Plague*, was to simulate anthrax and plague attacks (Annas, 2008; CAE, 2006).²¹ The subsequent court case received large amounts of media attention, partly because of the unfortunate timing of Kurtz's arrest: the petri dishes were discovered by local police who came to his home along with paramedics on the day his wife, Hope, had died. A number of artists, celebrities and members of the public spoke up on Kurtz's behalf, sending letters of protest to the government and even organising demonstrations.

The bioterrorism claims against both Kurtz and Ferrell were dropped when the New York Department of Health had ascertained that the bacteria were harmless, and that Hope Kurtz had died of natural causes. However, they were still charged with mail fraud. In 2008, the indictment was dismissed by the federal court as being "insufficient in its face" (see e.g. Mitchell, 2010). George Annas (2008, p. 105) strongly claims that "[b]ioart is not bioterrorism, but the two are related politically", meaning that the activist nature of the Critical Art Ensemble's work was also intended as strikes against the system – but in constructive ways that were, contrary to bioterrorism, *non-violent*. The Kurtz case is routinely mentioned by DIYers when discussing attitudes from the public, government and academics as to the possibilities of bioterror from citizen scientists (e.g. Ellen Jorgensen, statement at Open DNA Barcoding Night, 2013; Martin Malthe Borch, statement at S.Net conference in Karlsruhe, 2014), again indicating the perceived similarities between different fringe approaches to biotechnology.

Biosafety concerns and their discontents

In the wake of the Kurtz case, the FBI changed their approach to fringe biotechnologists, preferring to interact with DIYbio actors in conferences and workshops, ideally to recruit them as 'canaries' who can warn the authorities if suspicious actors (read: potential bioterrorists) appear on the scene (see e.g. Kera, 2014; Wohlsen, 2011). Morgan Meyer (2014) has remarked that the anxiety that biohackers might become bioterrorists "is mostly voiced in the US". Reflections on biosafety and biosecurity issues are ubiquitous in scholarly treatments of DIYbio (see e.g. Eggleson, 2014; Schmidt, 2008). Perhaps partly due to this, DIYbio practitioners display a sense of *ennui* in the face of such discussions (Marc Dusseiller, workshop at Píksel festival, Bergen, 2014; panel debate featuring the author and Gjino Šutić, Píksel DIY Alife seminar, Bergen, 2015). This, in turn, can invoke further concerns from ethically minded scholars (see e.g. Vaage *et al.*, 2015). The DIYbio network

²¹ Kurtz's home also contained a lab developed for the "Free Range Grain" project, in which CAE tested food objects to see if they were genetically modified (CAE, 2006).

has sought to counteract such developments through arguing against the bioterrorist potential of DIY biologists (Grushkin *et al*, 2013), agreeing upon draft codes of ethics for the American and European groups (see Eggleston, 2014) and establishing the “ask a biosafety expert” portal on DIYbio.org (2015).

Other ethical questions

While discussions of DIYbio and ethics have largely centred on biosafety concerns, within bioart, multiple other ethical questions have been posed. Biosecurity, outside of discussion of the Kurtz case, has received relatively little attention. The use of biological materials for art, and especially the creation or manipulation of organisms for art, on the other hand, has received extensive and concerned treatment (see e.g. Gigliotti, 2006; Levy, 2006). This points to one of the most prominent differences between bioart and biohacking: since art is considered primarily non-utilitarian, considerations of the use of living organisms *for art* receive more sustained attention (Vaage, 2016; Wohlsen, 2011). These ethical issues are not to the same extent raised concerning biohacking or science communication, which appear to be considered largely within the scientific rationale of utility (Landrain *et al*, 2013).

The specificity of art reception goes across the DIY-institutional divide, meaning that artistic work in community spaces is subject to the same ethical discussion as art developed in high-tech laboratories such as SymbioticA. A more comprehensive ethics for fringe biotechnology would take into consideration how questions posed about bioart, and within institutional bioethics, may fruitfully be applied to other alternative biotech practices.

Common Ground, Disparate Aims

To different extents, hackers, artists, designers and citizen scientists working with biology can all be said to display what the Greeks called *metis*, a form of cunning, clever knowledge, a practical intelligence that also has an element of the trickster, a wily adaptability that stood, in the Greek intellectual world, as a predecessor and displaced counterpoint to the type of intelligence displayed by the philosophers. The person who possesses *metis* is flexible enough “to bend in every conceivable way”, and is thus able to “devise the *straightest* way to achieve his end” (Detienne and Vernant, 1991, p. 6, original emphasis). Combining the properties of *homo faber* and *homo ludens*, fringe biotechnologists all exhibit a will and ability to use technologies to their own ends; but those ends are variable.

Fringe biotechnologists make use of a variety of technologies and methods. A number of fringe actors utilise the oldest forms of biotechnology, in experimental ways: At Biologigaragen they use different kinds of bacteria to ferment yoghurt, porridge, and drinks, make their own miso paste and more. Christina Agapakis and Sissel Tolaas, as part of the project Synthetic Aesthetics, took an artistic approach to cheese-making, using microbes from individual people’s bodies: an armpit blue cheese or a moustache white.²² Agapakis, on her website, points to the fact that many stinky cheeses are hosts to bacteria

²² The cheeses were exhibited under the title *Selfmade* at the Grow Your Own exhibition at the Science Gallery Dublin, 2013–2014.



closely related to the bacteria that give human armpits and feet their distinctive smells, and asks: “Can knowledge and tolerance of bacterial cultures in our food improve tolerance of the bacteria on our bodies?” (2015). Other practitioners focus more on technical experiments, such as DNA barcoding (Genspace, La Paillasse), bioluminescence (BioCurious, Biolab Prague) and bioprinting (BioCurious, London Biohackspace, Waag Society). Yet, others work primarily on bioelectronics (Hackteria, DIYbio Singapore).

Although differing in their motivations, approaches and products, fringe biotechnologists have in common a close connection to the free and open-source ethos (see e.g. Delfanti, 2013; Levy, 2006). Although this is, in a sense, a liberalist attitude, most practitioners also share a sceptical attitude towards neoliberal capitalism and corporate and institutionalised power (Catts and Cass, 2008; Delfanti, 2013). On the other hand, a number of actors, especially in the US, have entrepreneurial aspirations, launching start-up ventures for their newly developed biotech software or hardware (Landrain *et al*, 2013). Start-up companies have been founded for the Open PCR, the Dremelfuge²³ and the Genelaser open-source projects (Landrain *et al*, 2013; Meyer, 2015). The teams behind Open PCR, Amplino and LavaAmp have been racing each other to develop the best, cheapest PCR machine. In this sense, the innovation spirit of these particular fringe actors is linked to a market logic (see e.g. Jen, 2015; Meyer, 2015).

Curiosity and creativity

Fringe biotechnologists generally value creative thinking and action, curiosity and problem solving (see e.g. Malina, 2011; Seyfried *et al*, 2014). This, however, does not necessarily mean the same to all. Ingenuity in taking equipment made for other purposes, such as power drills, pressure cookers and hotplates, and converting them into cheap replacements for expensive lab equipment, is highly valued by biohackers (Meyer, 2015). In some cases, the procedures developed are merely a nod in the direction of the institutionalised version, for instance when using a blowtorch to circulate air, a weak echo of the sterile conditions of a laminar flow cabinet (tissue culture hood). In the case of art, creativity plays an even more fundamental role. Research for art is curiosity-based, to an extent that many scientists would envy. Oron Catts (personal conversation, 2013) has repeatedly stated that any residency at SymbioticA in which the artist leaves having developed only the same ideas as (s)he had coming in, would be a failure. A similar open-endedness can be found in community labs, as well.

Fun, play and making a difference

A sense of fun is important in fringe biotechnology. Beatriz da Costa, an artist who sometimes worked with Critical Art Ensemble, suggested that the “appearance of biotech science kits in toy stores” showed the pleasure of playing with biotech (2008, p. 384). This, according to her, demonstrated how “the act of making, building and simultaneously learning seems to be an appealing and desirable way of spending spare time for those who

23 The Dremelfuge is described on the website of its maker, Irish biohacker Cathal Garvey (2015), as “the world’s cheapest super-centrifuge”.

can afford doing so” (ibid.). She posited that artists share this pleasure and desire to make things, but that art, in addition, needs to be “saying something” (ibid.). While the emphasis of some DIYbio projects is, as da Costa suggested, on “fun and play” (2008, p. 376) – recall Genspace’s assertion that science is *still fun* at their community lab – that is far from all it *can be*. Fun is an important aspect in science communication activities, but DIYbio communities also seek to *make a difference* through increasing science literacy, contributing to the knowledge pool, and supplementing institutional science activities. Delfanti (2013, p. 126) posits that “DIYbio’s success seems to be rooted in its symbolic power”, and its “radical requests for openness and inclusion and [...] rejection of institutional prerogatives and constraints” (2013, p. 127). Some biohackers, like some artists, seek to critique the current institutions, sometimes suggesting that they might be fundamentally changed or even replaced by active citizens doing science for themselves (Trojok, 2014) – a strongly political motivation. However, as observed by Frow (2014, p. 183), “it’s not clear that the culture of ‘hacking’ and ‘play’ so valued in the push to make synthetic biology a ‘citizen science’ is a framing that fits seamlessly with the drive for accountability emphasised in accounts of democratisation more concerned with governance”. There is a tension between the rhetoric of fun and play – especially combined with the sometimes-subversive connotations of ‘hacking’ – and the idea of the democratisation of science contributing positively to the world.

Fringe Biotech: What Boundaries?

As we have seen, the methods used are not what set the different practices on the fringes of biotechnology apart. Artists will say that their biotechnology projects are art, whereas hackers will call them hacks and citizen scientists may call them science. More importantly, however, the categories employed express ideas about what a project aims to do, and guide how it is received. While actors within fringe biotechnology often operate across boundaries, engaging in multiple projects and endeavours, there nevertheless appears to be a sort of boundary-work at play here, as citizen groups and actors from other fields outside of institutional science seek to “assert their right” to use biotechnologies in ways that were previously reserved for science and industry only. Other modes of knowledge than those approved within traditional research institutions are increasingly seen as valid and worth promoting.²⁴

In my assessment, these endeavours play different parts in the current topography of the boundary-work of science. In various ways, through using scientific methods in diverse contexts, they serve to shape, affirm or move the boundaries of what is considered science, and who is allowed to practice it. This fringe biotech boundary-work is far from systematic, and is rather a by-product of attitudes within some of the involved groups. The importance of DIYbio in shifting the current ideas of who is entitled to conduct research in the life sciences, and how such research should be done, has been noted by scholars. Art and design, as part of this movement, can play a similar role, but works such as Dewey-Hagborg’s *Stranger Visions* can also reflect differently upon the cultural potential of biotechnology in society.

The spaces of fringe biotechnology, in various ways, function as heterotopias, reordering the social space at the outskirts of biotechnology and shifting ideas of what belongs on the

²⁴ Other examples of this tendency are post-normal science (Funtowicz and Ravetz, 1993) and recent work in the sociology of scientific knowledge (e.g. Collins and Evans, 2002).

inside and the outside of the domains of biotechnoscience. As Eugene Thacker (2004, p. 80) has observed, “In the back-and-forth exchanges between what counts as science and what doesn’t, there are myriad hybrids formed, processes enacted, and people and artifacts enlisted in the production of scientific knowledge”. The community labs that define themselves as practicing *science*, supplementing the work of institutional and corporate science and disseminating and communicating science more broadly, are demarcating themselves from those biohackers, artists and designers who merely use scientific *methods and techniques* for different purposes. The *DIY De-Victimizers*, *Urine Journey* and other artworks, like *Stranger Visions*, are also received differently from biohackers’ innovative products due to their status as art, and reach a different audience (see e.g. Hauser, 2006; Mitchell, 2010; Wohlsen, 2011).

Fringe biotechnology encompasses a wider array of projects, approaches and events than the ones I have shown in these pages.²⁵ Rather than presenting a typology of the range of approaches encompassed by fringe biotechnology, I have focussed on presenting an open framework, within which further work may place a number of projects. Importantly, the term embraces the commonalities between art, design, hacker and science communication approaches to biotechnology. It also gives room, through the very acknowledgement of relevant similarities and interactions, for analysing at what points these approaches differ, and how the heterogeneities *within* the categories may be as marked as the heterogeneities separating them as different practices.

About the Author

Nora S. Vaage is an art historian and interdisciplinary researcher at the Centre for the Study of the Sciences and the Humanities, University of Bergen, and an RRI (responsible research and innovation) coordinator at the Centre for Digital Life Norway.

References

- Agapakis, C. (2015) *Selfmade*, <http://agapakis.com/cheese.html>, accessed 20 October 2015.
- Andrews, L.B. (2007) Art as a public policy medium. In: E. Kac (ed.) *Signs of Life Bio Art and Beyond*. Cambridge: The MIT Press, pp. 125–149.
- Anker, S. and Nelkin, D. (2004) *The Molecular Gaze. Art in the Genetic Age*. New York: Cold Spring Harbor Laboratory Press.
- Annas, G.J. (2008) Bioterror and ‘bioart’—A Plague o’ both your houses. In: A. Miah (ed.) *Human Futures: Art in an Age of Uncertainty*. Liverpool: Liverpool University Press and FACT, pp. 100–111.
- Bakke, M. (2008) Zoe-philic desires: Wet media art and beyond. *Parallax* 14: 21–34.
- Bar-Shai, N. (2014) Art & science at Genspace, Brooklyn’s community biotech lab. In: A. Bureaud and R. F. Malina (eds.) *Meta-Life: Biotechnologies, Synthetic Biology, ALife and the Arts*. Cambridge, MA: The MIT Press (ebook, unpaginated), <https://read.amazon.com/?asin=B00LI69BQO>.

²⁵ The term could fruitfully be applied, for instance, to interactive science centres, outreach projects and other science communication ventures with public engagement elements. Science museums, galleries, university satellites and other institutional efforts to have people practice biotechnology all exist on the fringes of institutional and corporate biotechnology. They are also venues that combine multiple spheres of cognition, utilising the creative potential of both artistic, scientific and various technological approaches.

- Benkler, Y. (2002) Coase's penguin, or, Linux and the nature of the firm. *The Yale Law Journal* 112(3): 369–446.
- Bonney, R., Cooper, C.B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K.V. and Shirk, J. (2009) Citizen Science: a developing tool for expanding science knowledge and scientific literacy. *BioScience* 59(11): 977–984.
- Borch, M.B. and Muñoz, C. (2014) *Urine Journey*, <http://urinejourney.com/wp-content/uploads/2014/09/Urine-Journey-FlyerA6.pdf>, accessed 23 August 2016.
- Boustead, G. (2008) The Biohacking Hobbyist. *Seed Magazine*, December 2008, http://seedmagazine.com/content/article/the_biohacking_hobbyist/, accessed 14 August 2015.
- Bud, R. (1993) *The Uses of Life. A History of Biotechnology*. Cambridge and Melbourne: Cambridge University Press.
- Byerley, A. and Chong, D. (2015) Biotech aesthetics: Exploring the practice of bio art. *Culture and Organization* 31(3): 197–216. Doi:10.1080/14759551.2013.836194.
- Carlson, R. (2001) Open-source biology and its impact on industry. *IEEE Spectrum*, May 2001: 15–17.
- Carlson, R. (2005) Splice it yourself. *Wired*, <http://archive.wired.com/wired/archive/13.05/view.html?pg=2>, accessed 15 September 2014.
- Catts, O. and Cass, G. (2008) Labs shut open: A biotech hands-on workshop for artists. In: B. da Costa and K. Philip (eds.) *Tactical Biopolitics: Art, Activism, and Technoscience*. Cambridge: The MIT Press, pp. 143–156.
- Catts, O. and Zurr, I. (2013) Disembodied livestock: The promise of a semi-living utopia. *Parallax* 19(1): 101–113. doi:10.1080/13534645.2013.752062.
- Catts, O. and Zurr, I. (2014) Countering the engineering mindset: The conflict of art and synthetic biology. In: A.D. Ginsberg et al (eds.) *Synthetic Aesthetics. Investigating Synthetic Biology's Designs on Nature*. Cambridge and London: The MIT Press, pp. 27–37.
- Centers for Disease Control and Prevention (CDC, 2016) *Laboratory Biosafety Level Criteria*, http://www.cdc.gov/biosafety/publications/bmbl5/BMML5_sect_IV.pdf, accessed 21 February 2016.
- Coleman, G.E. (2013) *Coding Freedom: The Ethics and Aesthetics of Hacking*. Princeton: Princeton University Press.
- Collins, H.M. and Evans, R. (2002) The third wave of science studies: Studies of expertise and experience. *Social Studies of Science* 32(2): 235–296.
- Critical Art Ensemble (CAE, 2006) *Marching Plague: Germ Warfare and Global Public Health*. Brooklyn: Autonomedia.
- da Costa, B. (2008) Reaching the limit: When art becomes science. In: B. da Costa and K. Philip (eds.) *Tactical Biopolitics. Art, Activism, and Technoscience*. Cambridge and London: The MIT Press, pp. 365–385.
- Delfanti, A. (2013) *Biobackers. The Politics of Open Science*. London: Pluto Press.
- Delgado, A. (2013) DIYbio: Making things and making futures. *Futures* 48 (Special Issue: *Synthetic Biology: Making Plug and Play Futures*): 65–73.
- Detienne, M. and Vernant, J.-P. (1991 [1974]) *Cunning Intelligence in Greek Culture and Society* (J. Lloyd, Trans.) Chicago and London: The University of Chicago Press.
- DIYbio (2015) *An Institution for the Do-It-Yourself Biologist*, <http://diybio.org>, accessed 05 February 2016.
- Drouin, J.-M. (1995) Mendel in the garden. In: M. Serres (ed.) *A History of Scientific Thought*. Oxford, MA: Blackwell, pp. 506–525.
- Dyson, F. (2007) Our biotech future. *The New York Review of Books* 54: 12, <http://www.nybooks.com/articles/archives/2007/jul/19/our-biotech-future/>, accessed 10 July 2015.
- Eggleson, K. (2014) transatlantic divergences in citizen science ethics—Comparative analysis of the DIYbio code of ethics drafts of 2011. *Nanoethics* 8(2): 187–192.
- Foucault, M. (1986) Of other spaces: utopias and heterotopias. *Diacritics* 16: 22–27.
- Frow, E.K. (2014) In images we trust? Representation and objectivity in the digital age. In: C. Coopmans, J. Vertesi, M. Lynch, & S. Woolgar (eds.) *Representation in Scientific Practice Revisited*. Hong Kong: The MIT Press, pp. 249–267.
- Funtowicz, S.O. and Ravetz, J.R. (1993) Science for the post-normal age. *Futures* 25(7): 739–755.
- Garvey, C. (2015) Dremelfuge. *Indie Biotech*, http://www.indiebiotech.com/?page_id=16, accessed 04 February 2016.
- Genspace (2016) *Website, New York City's Community Lab*, <http://www.genspace.org>, accessed 07 February 2016.
- Gessert, G. (2010) *Green light: Toward an art of evolution*. Cambridge: The MIT Press.
- Gieryn, T.F. (1983) Boundary-work and the demarcation of science from non-science: Strains and interests in professional ideologies of scientists. *American Sociological Review* 48(6): 781–795.
- Gieryn, T.F. (1999) *Cultural Boundaries of Science: Credibility on the Line*. Chicago: The University of Chicago Press.



- Gigliotti, C. (2006) Leonardo's choice: The ethics of artists working with genetic technologies. *AI&Soc* 20: 22–34.
- Ginsberg, A.D., Calvert, J., Schyfter, P., Elfick, A., and Endy, D. (2014) Introduction. In: A.D. Ginsberg *et al* (eds.) *Synthetic Aesthetics*. Berkeley: University of California Press, pp. ix–xxii.
- Grushkin, D, Kuiken, T. and Millet, P. (2013) Seven myths & realities about do-it-yourself biology. *Symbio* 5. Wilson Center & Synthetic Biology Project, <http://bit.ly/1G40Obw>.
- Hauser, J. (2006) Biotechnology as mediality: Strategies of organic media art. *Performance Research* 11(4): 129–136. doi:10.1080/13528160701363663.
- Ireland, T. (2014) Do it yourself. *Society of Biology* 61(3): 12–15.
- Irwin, A. (1995) *Citizen science. A study of people, expertise and sustainable development*. Abingdon: Routledge.
- Jen, C. (2015) Do-it-yourself biology, garage biology, and kitchen science: A feminist analysis of bio-making narratives. In: M. Wienroth and E. Rodrigues (eds.) *Knowing New Biotechnologies: Social Aspects of Technological Convergence*. London and New York: Routledge, pp. 125–141.
- Jeremijenko, N. and Bunting, H. (1998) *Biotech Hobbyist Magazine*, http://www.nyu.edu/projects/xdesign/biotechhobbyist/bio_about.html, accessed 11 August 2015.
- Kac, E. (2004) *Telepresence & Bio Art. Networking Humans, Rabbits, & Robots*. Michigan: The University of Michigan Press.
- Kelty, C.M. (2010) Outlaw, hackers, victorian amateurs: Diagnosing public participation in the life sciences today. *Journal of Science Communication* 9(1): C0.
- Kera, D. (2014) Do-It-Yourself Biology (DIYbio): Return of the Folly of Empiricism and Living Instruments. In: A. Bureaud and R.F. Malina (eds.) *Meta-Life*. Cambridge, MA: The MIT Press, <https://read.amazon.com/?asin=B00LI69BQO>.
- Kostakis, V., Niaros, V. and Giotitsas, C. (2015) Production and governance in hackerspaces: A manifestation of commons-based peer production in the physical realm? *International Journal of Cultural Studies* 18(5): 555–573.
- Kuhn, T. (1962) *The Structure of Scientific Revolutions*. Chicago and London: University of Chicago Press.
- Landrain, T., Meyer, M., Perez, A.M. and Sussan, R. (2013) Do-it-yourself biology: Challenges and promises for an open science and technology movement. *Systems and Synthetic Biology* 7: 115–126.
- La Paillasse (2015) *La Paillasse*, <http://lapaillasse.org>, accessed 02 February 2016.
- Levy, E.K. (2006) Art enters the biotechnology debate: questions of ethics. In: E.A. King and G. Levin (eds.) *Ethics and the Visual Arts*. New York: Allworth press, pp. 199–216.
- Levy, S. (2001 [1984]) *Hackers: Heroes of the Computer Revolution*. New York: Penguin Books.
- London Biohackspace (LBH, 2016) *JuicyPrint*, <https://biohackspace.org/projects/juicyprint/>, accessed 04 February 2016.
- Malina, R.F. (2011) Alt. Art-sci: We need new ways of linking arts and sciences. *LEONARDO* 44(1): 2.
- Maxigas (2012) Hacklabs and hackerspaces—Tracing two genealogies. *Journal of Peer Production* (2): 1–10, <http://peerproduction.net/issues/issue-2/peer-reviewed-papers/>.
- Mead, M. (1969) Crossing boundaries in social science communications. *Social Science Information* 8(1): 7–15. doi:10.1177/053901846900800101.
- Merriam-Webster (2015) *Fringe*, <http://www.merriam-webster.com/dictionary/fringe>, accessed 20 July 2015.
- Merton, R.K. (1973 [1942]) The normative structure of science. In: R.K. Merton and N.W. Storer (eds.) *The Sociology of Science: Theoretical and Empirical Investigations*. Chicago: University of Chicago Press, pp. 267–278.
- Meyer, M. (2014) Hacking life? The politics and poetics of DIY biology. In: A. Bureaud and R.F. Malina (eds.) *Meta-Life*. London: MIT Press, <https://read.amazon.com/?asin=B00LI69BQO>.
- Meyer, M. (2015) Knowing new biotechnologies: Social aspects of technological convergence. In: M. Wienroth and E. Rodrigues (eds.) *Knowing New Biotechnologies*. London: Routledge, pp. 142–157.
- Mitchell, R. (2010) *Bioart and the Vitality of Media*. Seattle: University of Washington Press.
- Nowotny, H., Scott, P. and Gibbons, M. (2001) *Re-Thinking Science. Knowledge and the Public in an Age of Uncertainty*. Cambridge: Polity Press.
- Oxford English Dictionary (2015) *Fringe*, <http://www.oxforddictionaries.com/definition/english/fringe>, accessed 20 July 2015.
- Ozóg, M. (2012) The art of critical engagement. Remarks on the work of the tissue culture & art project. In: R.W. Kluszczyński (ed.) *Crude Life: The Tissue Culture and Art Project. Oron Catts & Ionat Zurr*. Gdansk: LAZNIA Centre for Contemporary Art, pp. 34–51.
- Patterson, M.L. (2010) *Biopunk Manifesto*, <http://maradydd.livejournal.com/496085.html>, accessed 10 August 2015.

- Popper, K.R. (1980 [1959]) *The Logic of Scientific Discovery*. London: Hutchinson.
- Reeve, O., Catts, O. and Zurr, I. (2016) Oron Catts and Ionat Zurr: Working with life. *RCA Blog*, 25 January 2016, <http://www.rca.ac.uk/news-and-events/rca-blog/oron-catts-and-ionat-zurr-working-life/>, accessed 31 January 2016.
- Reichle, I. (2009) *Art in the Age of Technoscience. Genetic Engineering, Robotics, and Artificial Life in Contemporary Art*. Wien and New York: Springer.
- Schmidt, M. (2008) Diffusion of synthetic biology: A challenge to biosafety. *Systems and Synthetic Biology* 2(1–2): 1–6.
- Schrage, M. (1988) Playing god in your basement. *The Washington Post*, January 31, 1988.
- Seyfried, G., Pei, L. and Schmidt, M. (2014) European do-it-yourself (DIY) biology: Beyond the hope, hype and horror. *BioEssays* 36(6): 548–551.
- Splicer (2010) *On the Difference Between Biopunk and DIYbio*. <http://www.biopunk.org/on-the-difference-between-biopunk-and-diybio-t420.html>, accessed 10 July 2015.
- Taipale, U. (2014) SymbioticA/Biofilia Biotech Art Workshop. *Workshop with Oron Catts and Marika Hellman*, 28 January–1 February 2013, <http://biofilia.aalto.fi/en/studies/workshops/#symbiologica>, accessed 10 April 2015.
- Taylor, P. (2000) Fleshing Out the Maelstrom: Biopunk and the Violence of Information. *M/C: A Journal of Media and Culture* 3(3), <http://www.api-network.com/mc/0006/speed.php>.
- Thacker, E. (2004) *Biomedica*. Minneapolis: University of Minnesota Press.
- Tocchetti, S. (2012) DIYbiologists as ‘makers’ of personal biologies: how MAKE Magazine and Maker Faires contribute in constituting biology as a personal technology. *Journal of Peer Production* (2), <http://peerproduction.net/issues/issue-2/peer-reviewed-papers/diybiologists-as-makers/>.
- Toombs, A., Bardzell, S. and Bardzell, J. (2014) Becoming makers: Hackerspace member habits, values, and identities. *Journal of Peer Production* (5): 1–8, <http://bit.ly/1q7TIZT>.
- Topinka, R. (2010) Foucault, Borges, heterotopia: producing knowledge in other spaces. *Foucault Studies* 9: 54–70.
- Tremmel, G. (2014) The intertwined strands of biology, computer science and art. Conference paper, SLSA2014: *Life, in Theory*. Turin, 05 June 14.
- Trojok, R. (2014) *Bio-Commons Whitepaper*, http://bioartsociety.fi/Bio-Commons_Whitepaper.pdf, accessed 15 April 2015.
- Vaage, N.S., Trojok, R., Bosch, M.M. and Delgado, A. (2015) Biohacking meets philosophy, sociology and ethics: Notes on the S.NET 2014 meeting in Karlsruhe. In: D.M. Bowman *et al* (eds.) *Practices of Innovation and Responsibility: Insights from Methods, Governance and Action*. Berlin: AKA Verlag, pp. 211–226.
- Vaage, N.S. (2016) What ethics for bioart? *Nanoethics* 10(1): 87–104.
- Waag Society (2015) *Open Wetlab*, <http://waag.org/en/lab/open-wetlab>, accessed 05 February 2016.
- Wienroth, M. and Rodrigues, E. (2015) An introduction to social convergences. In: M. Wienroth and E. Rodrigues (eds.) *Knowing New Biotechnologies*, New York: Routledge, pp. 3–11.
- Wilson, B., Hawkins, B. and Sim, S. (2014) Editors’ introduction. In: B. Wilson, B. Hawkins, and S. Sim (eds.) *Art, Science, and Cultural Understanding*. Champaign: Common Ground Publishing (ebook, unpaginated), <http://www.amazon.com/Science-Cultural-Understanding-Brett-Wilson/dp/1612294863>, accessed 06 February 2016.
- Wohlsen, M. (2011) *Biopunk. Solving Biotech’s Biggest Problems in Kitchens and Garages*. London and New York: Current.
- Wolinsky, H. (2009) Kitchen biology. The rise of do-it-yourself biology democratizes science, but is it dangerous to public health and the environment? *EMBO Reports*, 10(7): 683–685.
- Zerubavel, E. (1993) *The Fine Line: Making Distinctions in Everyday Life*. Chicago and London: The University of Chicago Press.



This work is licensed under a Creative Commons Attribution 3.0 Unported License. The images or other third party material in this article are included in the article’s Creative Commons license, unless indicated otherwise in the credit line; if the material is not included under the Creative Commons license, users will need to obtain permission from the license holder to reproduce the material. To view a copy of this license, visit <http://creativecommons.org/licenses/by/3.0/>