

From open to objecting: in-situ publics in synthetic biology

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Abstract

Sciences have long enrolled specialized publics in processes of witnessing, demonstrating, and spectating . In certain respects, the presence of a public can be seen as constitutive of science. The crucial questions are: what kind of public, who belongs to it, and how does it participate or become a part of the specific science in question. This paper argues that these questions always entail site-specific answers, and attention to the specificities of how the public is addressed, how it is materialised, and the how the potential of a public to object or intervene in the science and its ramification is configured. It discusses the case of synthetic biology, a recently emerging biological engineering discipline. In this setting, multiple notions of public are mobilised. Publics are addressed outside the science, as forces of legitimation and validation. Interestingly, publics are also addressed within the science, as somehow part of the doing of the science. The crucial problem is how such 'in-situ' publics differ from the ideal of a public already inherent to the notion of scientific community. I argue that in a blending of popular media forms, borrowing of patterns of collaboration from recent network media, and reflexivity in relation to public governance of science, we can imagine the possibility of objecting minorities in science.

Introduction

'Public participation is today one of the key dynamics at the core of the co-evolutionary, co-production processes ... redefining the meaning of science and the public, knowledge and citizenship, expertise and democracy' (Bucchi, 2008, p. 467)

What would happen if a scientific enterprise took the 'key dynamic' or 'essential ingredient' of 'public participation' to the heart of its elementary processes of community building, work practice and experimentation? If the science studies view is right, any scientific or technological enterprise that does not take public participation seriously today would jeopardise a viable future for itself. However, public participation is usually understood as a component of governance, and as a matter of legitimation, not of the doing of the science. As Allen Irwin and Mike Michael write, '[t]he public has in some ways become an essential ingredient within scientific governance' (Irwin & Michael, 2003, p. 56). This is perhaps why many attempts to engineer participation, and to pre-emptively model the utterances of a public around new technologies and sciences (nanotechnology, stem cells, personalized genomics, etc.) are made.¹ However such an understanding of public participation immediately generates two problems. Firstly, what happens to the more interesting side of publics, their spontaneity, incommensurable alterity or even 'bad will' given heavily pre-emptive modelling of their participation? Secondly, and perhaps more provocatively, what would happen if a science, or proto-science, went further and sought to establish itself on the basis of this dynamic, if it made public participation a condition of its own possibility?

The case of 'synthetic biology' (henceforth, 'synbio') provides a vivid and richly entangled contemporary example of a science being made in public. Synbio appeared approximately ten years ago in 2000 (Rawls, 2000). The field has no solid definition, although many public events, publications and public statements seek to define it in terms of engineering biological constructs such as minimal cellular genomes, regulatory pathways and metabolic processes using design processes adapted from engineering disciplines such as electronics and software (Weiss, 2007; Nicholls, 2008; Mossman, 2008; S. Mueller, Coleman, & Wimmer, 2009; J.D. Keasling, 2008; Geddes, 2008; Ferber, 2004; de Lorenzo, Serrano, & VALENCIA, 2006; E. Hayden & Ledford, 2009; Benner, Hutter, & Sismour, 2003; Venter, Smith, & Hutchinson III, 2007). Synbio depends heavily on the panoply of techniques developed by molecular biology as well as the ongoing infrastructural transformations in the large-scale production of biological data in high-throughput whole genome sequencing. While bio-engineering encompasses synbio in practice, synbio displays promissory, institutional, communicational and imaginary components that other more established forms of bioengineering such as biochemical engineering, bioprocess engineering, metabolic engineering, tissue engineering and genetic engineering – all fields that have existed for decades or more – lack.

The materials I deal with in this paper include popular science TV, policy reports, scientific articles and opinion editorials, online webcasts and above all, an extensive 'open science' online wiki site, *OpenWetWare* (*OWW*, 2008). I regard all of these writings, images, messages, and announcements as components in the material transformations that tend to give rise to an 'in situ' public. The notion of an in situ public draws loosely on biological laboratory methods. There, in situ techniques (such as in situ hybridisation, in situ mutagenesis) target the phenomenon exactly where it occurs, without moving it somewhere else (for instance, to a special medium in vitro). Similarly, I am exploring whether synthetic biology could be understood as differentiating itself through an in-situ hybridisation of scientific work and public participation. An in situ public would not be external to the doing of the science and it would not make judgments for or against the science. It would be part of the making of the science at every level.

In-situ publics: recursive, material and objecting

Against the background of abroad-ranging literature that examines science and publics from the perspective of issues, controversies, engagement, understanding and participation (see (Henderson, 2007; Irwin & Michael, 2003; Hackett, Amsterdamska, Lynch, & Wajcman, 2008) for overviews), the exploration of an in situ public developed in this paper departs from three specific theoretical axes. Firstly, a public that is wholly predicated or defined in terms of pre-given categories, institutions, processes, values or norms falls short of democratic political practice. Publics and public deliberation cannot be fully grounded or located in any specific political institution. Consequently, any attempt to account for the reality, efficacy, or legitimacy of a public has to also run the risk of naming the dynamics that lend publics spontaneity and alterity. From this perspective, there is something excessive or disruptive about publics. Hence, we can understand why a body of recent work argues that publics come into being somewhat recursively and performatively. Michael Warner, for instance, attributes a reflexive reality to publics:

A public might be real and efficacious, but its reality lies in just this reflexivity by which an addressable object is conjured into being in order to enable the very discourse that gives it existence (Warner, 2002, p. 51).

In Warner's account, the somewhat recursive circularity between discourse and 'addressable object' permits a certain spontaneity and potential alterity in the emergence of publics. It would be very tendentious to say that 'synbio has a public' or that 'synbio is a public', but as we will see, certain aspects of it display characteristics of reflexivity that seek to conjure an 'addressable object.' In turn, synbio as an addressable object enables a discourse on biology, or strictly speaking 'synbio,' to take place.²

The second theoretical departure point here concerns the materiality of publics: publics inhabit niches in

specific media-economic systems. They live through practices of making, communicating, and consuming. In some respects, this would be an obvious assumption to make in any science-studies guided discussion of publics. However, I would suggest there is a significant conceptual tension here. On the one hand, much political theory (e.g. Habermas, Fraser) recognises the pervasive role of media in publics, but then seeks to locate some form of political autonomy that transcends the instrumental forces of mass media (for instance, in a 'transnational public sphere' (Nancy Fraser, 2007)). On the other hand, for science studies and feminist work on publics, material specificities and embodiment are not constraints to be escaped, but differential processes to be negotiated by publics. In a discussion of cosmopolitan publics, Pheng Cheah brings these tensions into focus by framing the conditioning of publics in terms of 'economic conditions' established by *techne*:

[that] the proper functioning of a political public sphere is always dependent on external formative conditions that put the autonomy of the political into question. Put another way, the spontaneity of *Offentlichkeit* is not quite that of the self-recursive organism. Because the economic conditions for public deliberation are established by instrumental action or *techne*, its spontaneity is itself is a product of *techne* (Cheah, 2007, p. 78)

In Cheah's formulation, there is no possibility of an autonomous public without 'economic conditions' and 'instrumental action'. Again, it would be difficult to argue that any substantial aspect of synbio has undergone 'public deliberation.' However, it might be possible to analyse how '*techne*' inevitably affects the economic conditions for an in-situ public, and how an in-situ synbio public might negotiate with or respond to its own material conditions. Attention to how economic and media processes condition the very existence of a public is, I will argue, key to understanding any contemporary public participation in science and technology.

The third theoretical premise I start from here concerns publics as forces of objection and intervention. The premise here is that a power to intervene or object comes from the very process whereby a public is formed. By exploring the recursive addressability and the material-mediatic conditioning of an in-situ public, we might be in a position to envisage why the contemporary chances of a public coming into existence are so precarious. As Isabelle Stengers writes,

there may be a small precarious, possibility, part of our epoch, that a new kind of public is emerging, and that such a public may be able to make another kind of difference. ... These may be called "objecting minorities," minorities producing not as their aim but in the very process of their emergence the power to object and to intervene in matters which they discover concern them. (Stengers, 2005, p. 160)

The precarious possibility that a public might emerge with the power to object and intervene seems worth considering, especially in the light of the many attempts to do 'ethical engineering' (C. Hayden, 2003) or to construct sanitised publics. Stengers' formulation stresses that the power to object and intervene stems from the process of emergence, it arises *in situ*. It suggests that we should examine how an 'objecting minority' comes to exist. In synbio, what would it take for an objecting minority to emerge and produce a power of intervention?

Naming and performing: 'synthetic biology' as 'addressable object'

Taking into account these three characteristics of recursing, materially-conditioned and emerging-objecting, we can begin to track what it would take for an *in-situ* public, not just associated with, but *in* synthetic biology to exist. The problem here is that synbio is a very tangled phenomenon. Synbio has been publicly conjured or made addressable in several different ways. The very term 'synthetic biology' aggregates a set of techniques, processes, organisations, efforts and tendencies that we might generally understand as biological engineering, and transcribes them into a more public register. In Warner's terms, we might say that synthetic biology as an 'addressable object' takes at least two disparate forms. On the one hand, synbio is named as something whose relevance to global problems of energy, food and health, as well as economic development and the environment is very potentially very high, but whose success depends on rapid development, strong private and public investment, and above all, public acceptance. On the other hand, synbio is performed as a means of altering the conditions of biological work on living things, on organisms and biological materials and opening them to much wider participation. The tension between what I am loosely calling 'naming' and 'performing' produces many complications.

To illustrate naming as a form of addressability, we could begin by examining the way that many proponents of synbio speak publicly. For instance, a relatively a high-profile mass media venue such as the launch episode of a new prime-time BBC television popular science program called 'Bang Goes the Theory' regards synthetic biology as worth an interview on board the marine research yacht of perhaps the most famous 'synthetic biologist' today, Craig Venter ("Bang Goes the Theory," 2009). The form of addressability of synthetic biology in this case is defined very much by Venter's name, and by utterances that impute vital planetary significance to his scientific projects: 'we have 6.5 billion people on the planet, and in 40 years, there's going to be 9 billion people. We can't provide food, medicine, clean water, and energy for the 6.5 billion. We have to have new science, new knowledge to be able to survive' ("Bang Goes the Theory," 2009, sec. 03:20). Venter's synthetic biology will answer this urgent need by taking existing organisms such as marine microbes and algae that capture carbon dioxide and re-building them to provide energy. Indeed Venter's company *Synthetic Genomics Inc.* has signed an agreement with the petrochemical giant Exxon Mobil to do this (Jha, 2009) The investment by Exxon of \$US600 million over 5 years attests to a substantial

promise of delivery, and this investment by an oil company (instead of venture capitalists) lends authority to Venter's naming of synbio.³

In contrast to the naming of synbio by big-name scientists such as Venter, the figure of Drew Endy, a scientist closely involved in setting up *OpenWetWare*, is less visible in mass media. However, Endy, alongside a few relatively well-known figures in synthetic biology such as George Church (Harvard), Ron Weiss (Princeton) or Christina Smolke (CalTech), embodies a conjuring of synbio as an addressable object through the performance of design work, standardisation, collaboration and communication. Like Venter, Endy's writings, lectures and addresses comprise essays, opinion pieces and interviews scattered across popular science and public scientific journals such as *Scientific American* (Baker et al., 2006), *Bulletin of the Atomic Scientists* (Siegel, 2007), *Wired* (Morton, 2005), *Nature* (Drew Endy, 2007), *Science* (Drew Endy, 2008), quasi-public events such as the conference of the *Long Now Foundation*, Berlin's *Chaos Computer Club Congress* (the most well-known computer hacker conference in Europe), as well as numerous online videos, comics, websites and blogs. In writings and talks directed to scientists, students, computer programmers and software engineers, Endy consistently reflects on the conditions for doing biological engineering or performing synbio. The content of these talks often concerns the need for reorganisation of biological work to allow it to be done by many more people. For instance, Endy, in collaboration with the comic artist Chuck Wadey, produced a comic that tells the story of a teenager starting to do synbio under the tutelage of a white-coated scientist, 'System Sally' (Drew Endy, 2005). While Endy also occasionally invokes the vital needs of the planet, the emphasis falls much more directly on who will do synthetic biology and how they will do it.

In his analysis of the publication in early 2008 of the first completely synthetically constructed whole genome (already regarded as a landmark synbio publication) by Venter's group at the Craig Venter Institute (Gibson, 2008), Endy writes:

The 582,970-bp “synthetic” genome produced by Gibson et al. also unequivocally demonstrates that it is now possible to construct the genomes for all known human viruses, including strictly regulated pathogens (such as smallpox), from publicly available DNA sequence data, methods, and materials (Drew Endy, 2008, p. 1195)

There are two relevant aspects in this extract. Firstly, it remarks on the implications of Venter's work for other work in synbio (by contrast, Venter seems to remark on other people's work only rarely). This kind of talking could be seen as an example of the reflexive addressing of an object in order to enable a discourse that can then give imbue synbio with what Warner might view as the reality of a public. Secondly, while this

remark could easily be read in terms of the fear that synbio will supply techniques to terrorists for the construction of biological weapons, it emphasises, I would argue, the notion that synbio alters the conditions under which the scientific-engineering work of synbio is done. It makes them more public. As we will see, many aspects of the formation of an in-situ synbio public concern what is 'publicly available' and to whom.

Open in synbio

The most heavily literal performance of an in-situ synbio public today might be *OpenWetWare*.

OpenWetWare is 'an effort to promote the sharing of information, know-how, and wisdom among researchers and groups who are working in biology & biological engineering' (OWW, 2009a) Insofar as it constitutes a public – and again, I think it would be tendentious to say that it is – much pivots on how it addresses and performs synbio as 'open.' In almost any definition, being open is indeed a necessary condition for the existence of a public. As Nancy Fraser describes it, the definitive feature of a public is that it is 'open to everyone potentially affected' (N. Fraser, 2007, p. 19) (Put differently: 'a public might almost be said to be stranger-relationality in a pure form' writes (Warner, 2002, p. 56) However, openness – and closure – can take different forms. Openness in *OpenWetWare* takes the form of a 'wiki,' a website that allows anyone using web browser software to edit or create interlinked Web pages as part of the website: 'wikis are often used to create collaborative websites, to for community websites, and for note taking' (Wikipedia, 2009). In biology and life sciences, wikis have become fairly common forums of communication and sharing of information. *OpenWetWare*, for instance, lists three dozen or so 'sister wikis' (OWW, n.d.) focusing on everything from flu, energy, bacteria, and protein structures to personalized genomics, as well as lists of other wikis in medicine, physics, chemistry and general science. An entire media ecology of science-technology wikis begins to unfurl from here. *OpenWetWare* itself, administered from MIT Cambridge, comprises roughly 5000 users and 50,000 web pages (OWW, 2009b) The website presents laboratories, groups, resources, references and blogs, as well as numerous web-links to other online resources, nearly all relating to molecular biology and biological engineering. In all its inconsistencies, gaps, confusions as well as forms of hierarchical orderings and workflows, *OpenWetWare* can be seen as part of an effort to engender a minor in-situ synbio public.

OpenWetWare is in some ways much more provocative instance than the general public addressed in more or less high profile press releases, ethics reviews and reports on the governance of synbio. It's naming of synbio is not as contagious as the media attention given to Craig Venter or Jay Keasling. It not as if in *OpenWetWare* we find highly developed cosmopolitan debate of global issues, inequalities or problems. Although issues of poverty, disease (AIDS, cancer, malaria), food security, environmental toxins, energy crisis, and sustainability are all under discussion there in various forms, the forms of engagement are not explicitly political or contestatory. Instead, they mainly concern the possibilities of knowing about and manipulating

lifeforms for various scientific, technological, pedagogical and artistic ends. Many specific attributes of the organisation, content and growth of *OpenWetWare* can only be understood by reference to synbio's divergence from genomics and molecular biology more generally, a divergence that is deeply animated by encounters with network cultures (Terranova, 2004). It is flatly positioned in contemporary network media culture, much more so than official public forums and public spheres whose processes of dialogue and deliberation run through institutional hierarchies (of funding bodies in particular) and elite policy forums.

Many aspects of *OpenWetWare* owe their existence to the forms of collaborative work intensively developed in the network cultures of 1990s and early 2000s as the web and other internet media rapidly changed. From its name on down, *OpenWetWare* borrows much from software and hardware cultures of networked, digital media. It is worth pausing for a moment on the name itself. The very syllables of the name '*OpenWetWare*' embody internal tensions: 'Open', 'Wet', 'Ware'. No doubt, *OpenWetWare* belongs to wider efforts to 'open science.' (These include *Journal of Visualised Experiments*, *Public Library of Science* and *Science Commons* (*JoVE*, 2006; *PLoS*, 2009; *Science Commons*, 2009)). *OpenWetWare*'s mission statement invokes different forms of open at every turn:

1. Lower the technical barriers to sharing and dissemination of knowledge in biological research
2. Build a community of researchers in biology and biological engineering that values, practices, and innovates the open sharing of information
3. Integrate *OpenWetWare* into existing and future reward structures in research

[\(OWW, 2008\)](#)

Yet 'open' also unavoidably refers to software cultures of the late nineties and early 2000s. There, 'open source' became a fetish term that encompassed wide-ranging re-organisation of practices of production and circulation of software. The software industry was radically changed by the participation of thousands of programmers scattered around the world in collectively producing, configuring and maintaining large scale software projects (Moody, 2001). 'Open' in that context meant, in principle, that anyone can read software code and modify it. On the one hand, a notion of openness is no stranger to science, since the publication of scientific data, findings and details of methods has long been a prerequisite for participation in the life of science. On the other hand, to the extent that *OpenWetWare* is explicitly open, it deliberately reaffirms ideals of belonging and membership that reflect the classic forms of public rather than private life. This need to assert openness, then, can only be a response to a perception that the openness of science, or biological

engineering in particular, is threatened or constrained by something (such as intellectual property law, or commercial considerations).

Being formally open, rather than closed, *OpenWetWare* allows anyone interested to participate. The practices of openness here include reading, writing, editing and adding new pages or groups of pages to the website. If we look at the membership of *OpenWetWare*, principal categories of membership include laboratories of named scientists ('Keasling Lab,' 'Smolke Lab,' 'Grierson Lab', etc), university courses, ('Spring 2008 – Imperial College – 'Introduction to Synthetic Biology'), blogs ('ScienceInTheOpen', 'FreeGenes,'), a variety of groups ('Institute of Biological Engineering,' 'Biological Energy Interest Group,' 'Fanconi Anemia Research Community'), as well as a variety of technical research resources on methods, materials and protocols ('Vectors,' 'e.coli', etc). Everything in *OpenWetWare* is subject to editing (to varying extents), comment, or addition by any registered user. However, we need to be aware that the very word 'open' as it took hold during the 1990s gradually accumulated indissolubly strong associations with networked re-organisation of production in the globalisation of high-tech information technology work. 'Open' effectively helped consolidate the highly productive blurring of lines between production and consumption that occurred in the growth of network cultures. As cultural theorist Steven Shapiro writes '[t]he one real innovation of the network society is this: surplus extraction is at the center of consumption as well as production' (Shapiro, 2003, p. 249). Hence, although it meets the formal conditions of inclusiveness required of publics, *OpenWetWare* also ineluctably bends that inclusion or openness into an operational process of generating more knowledge. As a condition of allying biological engineering with contemporary network cultures, *OpenWetWare* and by implication biological engineering in the guise of synbio, tethers its openness to the extractive processes of the network society.

Wetware: an addressable object?

If as a social-media space, *OpenWetWare* meets the criteria for the openness of a public, what does it actually mean to participate in it? In what way are people affected so that they participate in it, and thereby in biological engineering? The second and third syllable, 'WetWare' implicitly refers to 'software' and 'hardware,' the well-known (and still problematic) distinction that acts as a cornerstone of many contemporary information services, products, and technologies. This distinction between software and hardware is not purely technical. It is indissociably economic and social as well. Maintaining an often artificial, strained and leaky distinction between software and hardware allows whole sectors of industry to manage constant change in products. If the 'hard' vs 'soft' distinction has been so effective in communications and media, what might 'wetware' mean for biological engineering? Wetware, then, refers to not only technical practices and materials of biology and biotechnology, but to a hope that they might become something different, something more like software and hardware have become in network cultures more

generally.⁴

I am suggesting, then, that if there is a public here, it is concerned with the possibility of the existence of 'wetware.' The formal openness and inclusiveness of *OpenWetWare* addresses people who are concerned about specific technical practices and ways of working with a kind of wet thing, biological substance, entangled with forms of market relations. At the moment, we might say that 'wetware' does not fully exist. The practices that might produce it have a history as techniques of working with living things (Landecker, 2007); are guided by certain kinds of biological concepts such as gene, pathway, transfection, acetylation, (Keller, 2002); and rely on specific kinds of globally extended infrastructures and materials (Thacker, 2005). Since biological engineering is not starting *de novo*, but relying on a century or more of previous biological work, the contemporary question is: can these techniques, concepts and infrastructures can be reorganized and recognised as a substantial entity in their own right, and under what conditions? Could there be something like software in biological engineering? This is the addressable object that *OpenWetWare* and related forums and social spaces seeks to conjure up and to which an in-situ synbio public would respond. Again, Warner describes how writing to a public helps bring objects of address into being:

Writing to a public helps to make a world, insofar as the object of address is brought into being partly by postulating and characterizing it. This performative ability depends, however, on that object's being not entirely fictitious—not postulated merely, but recognized as a real path for the circulation of discourse. That path is then treated as a social entity {Warner, 2002 #857,62-3}

OpenWetWare is a form of writing to a public, I would argue, that seeks to bring the object of its address, wetware, into being. In a sense, wetware, if it does ever exist, would be the product of a 'real path for the circulation of discourse.' In order for wetware to exist, the forms of writing we find on the site have to inject openness into the 'wet.'

How does *OpenWetWare* deal with 'wetness'? There are different paths along which we might pursue this question. The standard laboratory microbe *e.coli* offers one way to parse 'wet' in *OpenWetWare*. We know that *e.coli*, along with yeast and *mycoplasma* are key 'wet' materials in synthetic biology and biological research more generally. (*E.coli* is actually a world of its own and this paper could just as well have analysed EcoliWiki (EcoliWiki, 2009).) What does *OpenWetWare* do with the typical 'wet' material, *e.coli* in order to postulate wetware? How in *OpenWetWare* does *e.coli* become more open or differently open? On *OpenWetWare*, lists roughly 2500 different entries on *e.coli*. Approximately 75 separate pages describe several dozen different strains and their genotypes (OWW, 2009c) different aspects of working with the microbe, attempts to standardise it for synthetic biology, how to culture it, how to do PCR with it, how to do

electroporation with it, how to count it, and how to isolate plasmid DNA from it, etc, etc. Under 'Materials,' one of the main headings on the site, it lists hundreds of strains of *e.coli* and brief details of how different strains might be useful for different techniques. *OpenWetWare* documents many highly specific technical procedures, traits and properties of different strains of the microbe. Many protocols are described (e.g. (OWW, 2009d)). These descriptions often, as we would expect, cite scientific publications. In the light of all these different descriptions and treatments, *E.coli* itself undergoes a transformations in status. *E.coli* appears in the many course and teaching materials embedded in *OpenWetWare*. For instance, a course at Imperial College, London on 'Synthetic Biology' (OWW, 2008a) makes use of *e.coli* in wet lab practicals as well as in the computer modelling sessions. Other pages, relating to the student iGEM competition, describe ambitious projects to re-engineer *e.coli* as a therapeutic organism:

Our aim is to engineer a strain of *E. coli* that will overexpress folate such that a person without access to green, leafy vegetables or folate-supplemented foods can still obtain the necessary daily amount by having this strain residing in their gut. (OWW, 2008b)

iGEM projects, in particular, make heavy use of *e.coli*. Finally, other pages display an engineering outlook. They describe designs, results and data about *e.coli* as a 'chassis' (OWW, 2007), as a standard biological part ((OWW, 2009)) or about the energy requirements of *e.coli* (OWW, 2008a) Complicated discussions can often be found here about what would constitute a 'standard biological part' based on *e.coli*. 'Talk' (OWW, 2008b). Finally, threaded throughout almost everything *OpenWetWare* has to say about *e.coli*, there is awareness that 'ware' refers to something that can be packaged up and circulated as private property, usually in the form of a commodity. The presence of private property and commerce in any public should not be ignored, but it presents large-scale problems for any formal notion of a public as above of private interests. Many of the strains listed here refer to 'different sources' and to commercial products produced by companies such as 'Invitrogen' or 'Stratagene' ([Invitrogen Corporation, 2009](#)) Indeed, nearly all of the protocols and techniques documented on *OpenWetWare* rely on commercial services and products ranging from laboratory equipment and consumables to the DNA synthesis and sequencing services described above.

Making the information available, telling people where to find particular strains of *e.coli*, debating how *e.coli* could be standardized or made more predictable in its experimental behaviour, or experimenting with modifications of *e.coli* for the purposes of nutrition, health or bioremediation: all of these acts address as-yet-unknown strangers who might concern themselves with 'wetware.' They also develop the potential to address the thing, 'wetware,' a name for engineered biological constructs interlaced with products, services and networked patterns of collaborative knowledge production using design tools. The addressability of 'wetware' might, at least from the perspective of *in situ* publics, be the most significant outcome of all the writing, reading and editing that assembles *OpenWetWare*.

Contaminated publics: the need for DNA synthesis

Up to this point, my discussion of *OpenWetWare* has focused on Warner's conception of a public as a reflexively or recursively generated addressable object of discourse. At this point, we might turn to Cheah's arguments concerning the 'inhuman conditioning' of any public: 'the spontaneity of *Offentlichkeit* [the public] is not quite that of the self-recursive organism.' Warner's understanding of a public leaves itself constitutionally open to the possibility of contamination by instrumental manipulation.⁵ However, I would suggest that Cheah has in mind here something other than instrumental actions (market research, public relations, etc) that seek to manipulate public opinion or response. He refers to 'the economic conditions for public deliberation' as 'established by instrumental action or *techne*' such that 'its spontaneity is itself is a product of *techne*.' What would the 'economic conditions for public deliberation' in relation to synbio be? Here I suggest, we need to countenance the possibility that the conditioning of a public by economic, technical or media conditions both goes deeper and is more specific than the well-recognised possibility of manipulation of media public spheres.

It is often said that the key economic condition for the existence of synbio today is commercial DNA synthesis (see for instance, long descriptions of this at the Edge Foundation event on synthetic biology in July 2009 (Edge Foundation, 2009). At the heart of the re-organisation of biological work represented by synbio, lies a concerted effort to divide the work of designing biological constructs off from the work of crafting them or making them. Engineering living things relies on assembling long strands of DNA and inserting them into the nucleus of cells. DNA synthesis companies such as GeneArt, Codon Devices (now defunct as a DNA provider, but still operating as a synthetic DNA design service), DNA2.0, BlueHeron, or Integrated DNA Technologies are absolutely central to synthetic biology as a design-driven scientific enterprise. It is also very widely recognised that the primary economic condition for participation in synthetic biology is ever-cheaper commercial DNA synthesis, usually ordered over the web and paid for with a credit card like books from Amazon.com. This has two consequences. Firstly, because anyone can order DNA over the web, many people fear that synbio brings the risk of uncontrolled production of pathological lifeforms. Secondly, DNA synthesis has become a high-tech business, subject to intense competition. While Venter fairly casually describes it in his interviews and on-screen appearances as 'you only need four bottles of chemicals' ("Bang Goes the Theory," 2009), and Endy in his YouTube videos flippantly says 'Give me your credit card' (*iGEM - Drew Endy Defining Synthetic Biology (video)*, 2007) a quick examination of the methods section of any of the most highly cited recent scientific publications in synthetic biology shows strong reliance on commercial synthesis.⁶ In almost every guise that synbio takes, cheap, large-scale commercial DNA synthesis appears as a necessary condition for both what synbio does and who will do it. Both the highly financed work of Venter and the legion student synbio projects that take place as part of the annual iGEM (international Genetically Engineered Machine) competition rely on it. Hence, nearly all the DNA synthesis companies sponsor the iGEM competition or specific teams in it. The falling price of DNA

synthesis is treated as the 'Moore's Law' of synbio. Because DNA synthesis (and sequencing) is ever cheaper, synbio becomes more viable.

If, publics are in-situ in synbio, how are they conditioned by this specific economic condition? Again, while the usual narrative is that cheap DNA means more synbio and more people doing it (hence, an incipient public of synthetic biologists), I would argue that the economic conditioning is more complicated than simply cheap DNA synthesis. Take for instance the annual report of the global leader in DNA synthesis, *GeneArt AG*. *GeneArt* sponsors the annual synbio IGEM competition, and has large contracts for DNA synthesis with various major research institutions in Europe and North America. In 2008, financial results were only slightly positive. This was a strange result for a corporation that otherwise exhibits very health growth. What happened to Geneart's profits in 2008, amidst a boom for synthetic biology? The cost of the important solvent acetonitrile rose steeply (GENEART AG, 2009, p. 34) due to a global public event, the Beijing Olympics, as well as a slowdown in the global automotive industry (acetonitrile is a by-product of industrial processes used to produce plastics widely used by carmakers). In the leadup to the Games, the Chinese government ordered industry in and around Beijing to cease production in order to minimise pollution (Love, 2009). The global supply of the acetonitrile depends on a factory near Beijing. A shortage of acetonitrile pushed prices much higher and affected GeneArt's profits. The price of acetonitrile, of course, is hardly a significant public event in its own right. However, if we regard the Beijing Olympics or automotive industry slowdown (as well as Hurricane Ike's effect on an acetonitrile producing factory in the US) as public events, the economic conditioning of publics takes on a different complexion.

In order to separate the work of design from the work of production, synbio relies on a wide span of commercial and infrastructural materials. DNA synthesis is only one component of this, and it itself is conditioned by other forms of publicness. Other important economic conditions that play out in the separation of design and manufacture, or opening wider participation in synbio include access through the internet to vast quantities of genomic, protein, pathway and metabolic sequence data for a variety of organisms, as well as the bundle of contagious tendencies that might be labelled 'open source biology' (Herper & Langreth, 2007; Martha Lagace, 2006; Dean, 2008; Katsnelson, 2007) The promise of wider participation in biological engineering depends on these services, infrastructures and tendencies. Like DNA synthesis services, the availability of genome sequence data or the models of working that foster 'openness' deep affect the constitution of the field. Web-services and databases do not constitute a self-sufficient or spontaneous public *per se*. However, they do suggest that it is impossible to make sense of even the elementary technical tendencies and potentialities of contemporary synthetic biology without reference to notions of public. This is a further sense of what it might mean to say that 'economic conditions for public deliberation' are 'contaminated' by *techne*. On the one hand, the very possibility of an in-situ synbio public – with all its positive and negative implications – relies on DNA synthesis. On the other hand, DNA synthesis

– regarded as the primary economic precondition of synbio – itself cannot be isolated from other publics (public databases, global public events). Nowhere do we find a purely technical synthetic biology nor pure public deliberation. There can be no in-situ synbio public without the economic development entailed not only in DNA synthesis, but in the networked organisation of communicative labour embodied in *OpenWetWare*.

An emerging public

If an in situ synbio public did emerge as part of this science in the making, it could only develop a capacity to act normatively as a form of public reason if it engaged with these conditions or forces that lies beyond it. As Cheah writes, rethinking the normativity of public reason calls for 'interminable negotiation with and responsibility to the forces that give us ourselves' (Cheah, 2007, p. 79) The material – physical and socio-political – conditions of public reason always undergo technical crafting. The question is, how does a public engage with and respond to that crafting or *techne*? This brings us to the third and final theoretical premise concerning in situ publics: Stengers's suggestion that the emergence of a minority grouping, a new kind of public, can also generate a power to object or intervene. What does it take for such a group to emerge with the power to object?

Almost by definition, this would not take place in the public presentation of synbio, or in any setting where public opinion and science are separated from each other. For the most part however, every effort goes into maintaining that separation. For instance, a public forum on synbio took place at the London School of Economics, London, in October 2007. A panel of scientists and social scientists spoke (see (Lentzos, Bennett, Boeke, Drew Endy, & Rabinow, 2008) for transcript). Towards the end of the event, Craig Venter received questions from the public. At one point, he hesitated, and suddenly consulted his media handler, a public relations expert, sitting near the stage, and checked whether he could say something. Even in a high visibility academic event, this seemed like a break from normal procedures. Suddenly, techniques of public relations stepped to front-of-stage in an exemplary performance of the democratic public sphere of science and society. Academic debate was crosscut by a different set of intelligible forms and criteria, those of public relations. Insofar as academic debate instances a form of openness to strangers, the organization of its discourse by shared social space and habitus collided in this event, perhaps relatively trivially, with another form of public, the mass media public sphere. Does this mean that we should see mass media as constituting the primary *techne* in which a synbio public – a representative, legitimate and efficacious collective deliberation on the value, implications and need for synbio – is conjured up? In late 2008, another public debate on synbio in a high-visibility academic setting was staged, this time between two journalists – Rick Weiss (former *Washington Post* science journalist) and Denise Carruso (also a former journalist, and now chair of the *Hybrid Vigor Institute*) – at the Woodrow Wilson Center for International Scholars in Washington

D.C. Referring to a public opinion poll conducted in the USA several months earlier, the chair observed:

We can assume that the public is totally uninformed about this [synbio], even as the science prepares to march forward (Woodrow Wilson International Center for Scholars, 2008, p. 00:50)

Although print media attention to synbio had been trending upwards for the last three or four years, the August 2008 poll showed around 90% of respondents had not heard of synbio (Project on Emerging Nanotechnologies, 2009). (Of course, 10% of the US population – around 30 million people – had heard about it, and presumably had some view of it. That is, there is *a* synbio public, but not necessarily one that represents all voices, all standpoints, or modes of participation.) On the one hand, we have a scientist speaking at public events, on the BBC, or the UK Channel 4 evening television news (*Synthetic Biology*, 2007) with such a degree of sensitivity to possible public reaction that the advice of a media handler is required. On the other hand, at the Woodrow Wilson Center, the starting point for public discussion is that the public or the masses somehow stubbornly resist knowing about or becoming aware of the existence of synbio. Where is the middle ground between efforts made to manage the concerns and ways of speaking about synbio and a complaint about the public's relative silence or indifference to what is said to them about it? As science tries to understand 'the public,' the most general public seems to treat synbio with indifference and passivity. How to reconcile these two?

Both events respond to the same imperative: to keep science and public opinion separate, even as citizen participation is staged, encouraged, solicited, polled and validated at every turn. As Stengers writes:

Science must matter for the public which is thereby defined as mere opinion, to be convinced that [science] is its only chance to escape irrational belief and blind interests. (Stengers, 2005, p. 159)

Both the Woodrow Wilson Center and the LSE events were part of a much more effort to convince publics. A heavily interlaced, cross-referenced and largely consensual collection of public documents, utterances and images concerning synbio also participate in this effort. A series of public-facing events and documents have sought to channel debate by pre-emptively defining the key issues. Behind the media attention in *The Economist*, *The Guardian*, *Frankfurter Allgemeine Zeitung*, *Washington Post*, *The Wall Street Journal* and *New York Times*, there is a widely shared assumption that any potential public for synbio will engage with certain distinct ethical issues or problems. A plethora of studies, analyses and overviews of public perceptions, understanding, engagement and participation in synbio, funded by various policy and research institutions in Europe and North America (Balmer, A. and Martin, P., 2008; European Commission, 2008; Garfinkel et al., 2007; Boldt & O. Mueller, 2008; M. Schmidt et al., 2008; Russ, 2008; Agomoni Ganguli-

Mitra, Markus Schmidt, Helge Torgersen, Anna Deplazes, & Nikola Biller-Andorno, 2009; Parens & Johnston, 2009) or indeed by national legislatures (Parliamentary Office of Science and Technology, 2008) have appeared. Many of these focus on ethical issues, and particularly on ethical issues that pre-date synbio such as health, safety and security risks, as well as the general philosophico-ethical questions of how and to what extent the engineering of life is desirable.⁷ The shared and hardly surprising conclusion of many of policy and ethical studies of synbio is that unless the public is more engaged, a promising technological project might falter. The same conclusion can be found in mainstream mass media: for example, 'Time to Convince the Public' announces a headline in *The Times* in late 2007 (Henderson, 2007). All of these materials, projects, and utterances attempt to maintain a separation between synthetic biology and its publics. While publics need to be convinced of synthetic biology's promises, they also need to be convinced that the matters of fact, the process of doing the science, are not matters of concern.

Even if it were possible to budge the public from its phlegmatic ignorance of synbio, Stengers is adamant on one point: 'the consensual transformation of the "ignorant public" masterword into the "citizens" masterword is an Empty Great Idea. It will not work' (Stengers, 2005, pp. 159-160). This is a rather stunning objection to the broad trend in science studies of the last several decades. The alternative proposed by Stengers in the form of 'objecting' minorities cuts right across the consensus that the public presentation of science can be meshed with modes of citizenship, and in fact, needs to be meshed in order to both rescue the public from irrational interests and prejudices, and garner support for the doing of science itself. By contrast, the power to *object* differs from participation, engagement or understanding since objections do not ask the State or existing political institutions to solve the problem (as for instance, Dewey's 'issue-based' publics do). Objections actually can salvage something of science from its binding to the problematic opposition between opinion and reason, ignorant publics and knowing science. For objections – and this is the key point of intersection between Stengers' account of science and the notion of an in situ synbio public – address the experimental invention of the power to confer on things a way of conferring on experimenters the power to speak in their name.⁸ From this perspective, what at the outset of this paper seemed like a hypothetical possibility – what it would mean for a public to exist in situ in science – becomes a crucial possibility, and indeed even vitally necessary to preserve the power of science to diverge or differ from its consensual, static form.

On this point, it seems to me, the real significance of something like *OpenWetWare* lies in the way that it kindles a sense of possible participation for many people in doing science. What form of objection occurs here? In some respects, I think, *OpenWetWare* displays greater reflexive addressability than some of the more prominent synbio public forums and debates. It is important to note that sites such as *OpenWetWare* are often treated in the synbio public forums as either trivial or as biosecurity risk. For instance, in some public debates, Venter has dismissed it as the 'being the first kid on the block', while Carruso (Woodrow Wilson

International Center for Scholars, 2008) sees it as a major regulatory concern, calling for licensing of synbio techniques and practices. Indeed, *OpenWetWare* seems to lie quite a long way away from the public debates, the policy forums and discussions of governance, regulation and ethics of synbio. It is hard to define 'the issue' it addresses. However, the lack it displays on this point only reflects a preconception of a public that both privileges citizen-talk as the essence of public life and makes many normative assumptions about the economic and communicative conditions that publics depend on.

Much recent political and social theory starts from the assumption, as Nancy Fraser puts it, that the very notion of 'a public' is necessary to 'critical social theory and democratic political practice' (Nancy Fraser, 1999, p. 520). In principle, a public comprises the ways in which collective existence is transformed through debate, questioning and communication of various kinds (above all, in forms of dialogue and debate, but also in other ways?). By virtue of its constitutive capacity to enter into dispute, a public must be irreducible to state, economy or private interests. Although it legitimates some exercises of state power (as when citizens vote to elect a government), it de-legitimizes others. The power to contest and legitimate mainly depends on participation in deliberation. The power to de-legitimize is much more heterogeneous and unpredictable. In the life of a public (or in public life), we might say, occur moments of truth in relation to power.⁹ Whether or how the public exists at a given time and in relation to any given problem is really open to question. The critical factors, according to political theory, are legitimacy and efficacy (N. Fraser, 2007). The legitimacy and efficacy of a public are constantly troubled by doubts and ambiguities: how do we really know who a public comprises? How do we really know what it thinks, etc. How do we know it includes every voice affected? How do we know that it is not dominated by some sectional or elite interests?¹⁰

Any constructive effort to develop alternative models of democracy around late-capitalist science and technology needs to comprehend both the necessity of the idea of the public, and at the same time the actual vicissitudes which that idea undergoes in the production of interested publics. There is a divergence here between the idea of the public that science seeks as an ally in legitimating its own making and the reality of objecting minorities *in situ*. Ironically, the autonomous life of the organism is precisely what synbio puts into question in its efforts to re-design, modularise and render generic lifeforms as technological platforms. What is worse, in synbio, it is popular culture and the masses that are effectively about to get their hands on life. The twin demons of modernity – technology and popular culture – again are holding hands. In the case of synbio, a public, if it existed, would respond to contemporary biosciences, which themselves are entwined with economic conditions, and complicated regimes of governance. Are there modes of objection or intervention that do not take the form of debate around an issue? Are there publics that cannot be recognised in terms of pre-formed citizens in conversation? In synbio, it is hard to avoid the feeling that much is being done to neutralise or perhaps *counter-actualise* the occurrence of any real public dispute, and this is coupled with a rapid effervescence of technological promise and imagining around synbio and bioengineering as

answer to energy, environmental and health-related problems. This promise pivots on the idea of increased, standardised and commodified control over processes of transcription in cells. Synbio promises to replace the time-consuming craftwork of recombinant DNA genetic engineering with a full-fledged engineering design process that will quickly yield new materials, new understandings and new ways of producing existing materials (biofuels, drugs). It promises to both open biotechnology to wider participation and to accelerate it. Put simply, the core idea here is that publics come into existence in science and technology, not apart from it, before it or after it. There is no public engagement, only more or less in-situ publics.

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- 1 In the wake of the genetic engineering revolution of the 1970s, and the GM foods controversies in Europe, there is long-standing debate in science studies about how publics relate to science. In fact, it may be that there is no part of science studies that is not touched by the question of the mode of existence of publics for sciences and technologies. It is now well-recognised by many participants in political and scientific processes that public opinion or a public has power to deliberate, to contest and to legitimate political decisions, scientific practices and also commercial arrangements. The effects of that power have in several biotechnological and biomedical cases have been surprising (see Jasanoff 2005 on this).
- 2 A related take on this can be found in Chris Kelty's idea of 'recursive publics' in open source software (Kelty, 2008).
- 3 A similar illustration could be drawn from *Esquire*, *Rolling Stone* (*Rolling Stone*, 2009), *Time*, and *Newsweek's* (Interlandi, 2008) favourite synthetic biologists of 2008, Jay Keasling. Keasling's work on anti-malarial compounds and biofuels also fit the bill of globally significant justifications of synthetic biology.
- 4 However, the practices and materials are very different from those of the software cultures. It is also worth noting, however, that there is an implicit teleology of technological development ordering the relations between these terms. They run in the order: hard-soft-wet. 'Wet' is apogee or telos of technological complexity. (For instance, already in the late 1990s, new media artists were saying that biotechnology would be the next technological revolution. See 'Biotech Hobbyist' of 1998.)
- 5 Indeed, the many materials (reports, polls, surveys, conferences) circulating around synbio in many ways can be seen as equipment or tactical movements designed to manage public opinion, public investment and State regulation in certain ways (for instance, the report 'Synthetic Biology: Options for Governance' (Garfinkel et al., 2007) is funded directly by the J. Craig Venter Institute).
- 6 In one of the most highly publicised scientific papers of 2008, scientists at the J. Craig Venter Institute describe how they synthesised a slightly re-designed entire bacterial genome from scratch (Gibson, 2008). They mention their use of several commercial DNA synthesis services simultaneously in order to produce the 300,000 or so base pairs of DNA constituting the 'minimal genome' they had designed. At this time (late 2007), the global capacity to synthesise DNA as represented by the three major operators BlueHeron, DNA2.0 and GeneArt was briefly monopolised by one experiment. However, ongoing reductions in the price of DNA synthesis suggest that participation in synbio will continue to become easier.
- 7 Many of the reports on synbio produced by research councils and public science policy institutes (such as the Ratenauer Institute, the Royal Society, the Royal Society of Engineers, the Hastings Centre) exhort social science researchers to participate in establishing and legitimating synbio by studying its ethical implications and researching public perception of them. In response, social scientists have definitely become a part and parcel of the process of pre-emptive engagement of a synbio publics, with sometimes awkward or uncomfortable consequences. See (Rabinow & Bennett, 2008) for a discussion of one experience of this; (Yearley, 2009) offers reflections on the fundamental inadequacies of the ethical review format that often pre-configures social science contributions.
- 8 This is Stengers' understanding of the experimental event in science. See (Mackenzie, 2005; Stengers, 2000)
- 9 Bruno Latour defines public life as 'the progressive constitution of the common world' {Latour, 2004 #226,222}, and the whole of *The Politics of Nature* can be seen as an extended argument for a re-constructed notion of the public. We might also broadly think of publics as engaged in the articulation of being-in-common {Nancy, 2000 #833; Nancy, 2007 #845}. There are some big questions in the background here that affect whether it would be common world, being-in-common, democracy, freedom, or humanity that motivates recourse to concept of a public. I leave those aside here.
- 10 However, there are problems in bringing this kind of purely political theory to bear on the biosciences and biology. It seems to me that underlying Fraser, and Habermas, there is a latent notion of the purely political public that would somehow transcend both the inhuman reconfigurations of biotechnology and perhaps the messy manipulations of popular cultures. Theories of public often rely on notions of autonomy that are philosophically problematic. Shades of this still appear in Warner's notion of reflexively constituted addressable objects. Most of these notions of autonomy can be traced back to notions of the autopoietic life of the organism developed in nineteenth century German idealism (see (Cheah, 2007) on this).