

From validating to objecting: public appeals in synthetic biology

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April 2010

Abstract

The nascent science of synthetic biology appeals to multiple publics. Publics are addressed outside the science, as forces of legitimation and validation. Interestingly, publics are also addressed as potentially in the science, as somehow part of the doing of synthetic biology, and as making the doing of this science possible. How do these 'in-situ' publics differ from the ideal of the rational public imagined in many versions of public understanding or public engagement? No doubt, sciences have long enrolled specialized publics in processes of witnessing, demonstrating, and spectating. In certain respects, the presence of a well-regulated, trained, expert public can be seen as making science possible. Yet in the blending of popular media forms, borrowing of patterns of collaboration from recent network media, and reflexivity in relation to public governance of science, the in-situ publics of synthetic biology differ from conventional scientific publics. They are both in and outside the science. Their presence is troubling. What kind of public can exist in a science? Who can belong to such a public? And how does it affect the specific science in question, synthetic biology? These questions require site-specific answers, and attention to the specificities of how the public is addressed, how it is materialised, and how the potential of a public to object to or intervene in the science comes into being.

Keywords 3-6

synthetic biology, publics, media, performativity, politics

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Two ways to go public

There are at least two different ways in which a nascent scientific discipline might establish itself as worthwhile, as valuable or as imperative. Scientists could go out, as they do, into the world, into public forums and into the glare of mass media, and announce that what their science wants to do is momentous and vital to citizens and consumers. Or, scientists – and others – might start doing the science, and in doing so, try to make the doing of the science more accessible or interesting to a greater number of people. This also means going public, but public in a different way, this time with a view to making the expertise needed to do science popular and available. Both appeals to publics can be seen in synthetic biology, a high-profile, front-page, policy-aware promotion of the application of engineering design principles to biology.

These two ways of fostering synthetic biology by appeals to a public are not necessarily compatible. Although they are occurring at the same time, and are entangled with each other, there is a strong tension between them. Much of the public and media debate around synthetic biology concerns the possibility that the wrong kind of people, the wrong kind of public will start doing synthetic biology, or that undisciplined popular participation will tarnish the legitimacy of synthetic biology. At the same time, from the standpoint of those synthetic biologists and others who want to open synthetic biology to wider participation, the problem is the opposite. Without wider participation, synthetic biology will wither since that participation is precisely the pre-condition for the flourishing of the discipline. For some synthetic biologists, wider participation in the doing of synthetic biology, along the lines of open source software projects and other recent forms of networked collaboration, is vital to the emergence of the discipline.

The different versions of public participation in the development of synthetic biology raise important questions about the public mode of existence of knowledges and knowledge-based things. These questions include:

- (a) How are such different forms of participation negotiated or managed in the doing of synthetic biology?
- (b) Do tensions between different forms of participation retard the growth of an enterprise such as synthetic biology or can they be in some way generative, productive forces that advance it?

- (c) How different will be the resulting science if one rather than other were to prevail, or, as is more likely, if both co-exist?

How do publics validate science?

The case of synthetic biology provides a vivid and richly entangled contemporary example of a science being made in public. The term 'synthetic biology' surfaced approximately ten years ago in 2000 (Rawls 2000). The field has no solid definition, although many public discussions, 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 et al. 2009; J.D. Keasling 2008; Geddes 2008; Ferber 2004; de Lorenzo et al. 2006; Hayden & Ledford 2009; Benner et al. 2003; Venter et al. 2007). Synthetic biology depends heavily on the panoply of techniques developed by molecular biology as well as the ongoing transformations in the large-scale production of biological data in high-throughput whole genome sequencing. Synthetic biology displays promissory, communicational and imaginary facets that other more established but less high-profile forms of biological engineering such as biochemical engineering, bioprocess engineering, metabolic engineering, and tissue engineering – all fields that have existed for decades or more – lack.

Where do these defining facets – the promissory, communicational, imaginary elements – of synthetic biology come from? The difference between biological engineering and synthetic biology could be framed by reference to recent theories of publics developed in cultural studies and science and technology studies. In this work, two different notions of public can be found. In much of the work on public understanding, and public engagement in science, the public is seen to pre-exist the issue or matter of concern that they are asked to understand or engage in. But in other strands of this work, as we will see, publics are much more contingent, incoherent forms of collective agency that arise in certain situations. By taking on this latter account of publics (and I will rely on the work of Isabelle Stengers and Michael Warner in particular to present it), we might make some sense of how synthetic biology came to be.

Let us start from the more familiar assumption that there are pre-existing publics, or a public sphere, that validate science. Science and technology studies holds this public to be essential to contemporary science: '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) Or, 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 (such as synthetic biology, nanotechnology, stem cells, personalized genomics, etc.) are made.¹

The assumption that there is a public waiting to be informed about science underlies many attempts to stage debates about synthetic biology between proponents and opponents of the science. For instance, a relatively high-profile mass media event such as the launch episode of a new prime-time BBC television popular science program called 'Bang Goes the Theory' regarded synthetic biology as important enough to stage an interview on board the marine research yacht of perhaps the most famous 'synthetic biologist' today, J. Craig Venter (2009). In the years 2007-2010, Craig Venter has certainly been the most well-known public proponent of synthetic biology. Venter's authority to speak about synthetic biology rests heavily on the reputation that Venter established in the sequencing of the human genome. His utterances usually impute vital planetary significance to synthetic biology: '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' (2009, sec.03:20). For Venter, 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.* 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 synthetic biology.²

Synthetic biology as public relations

Much effort goes into maintaining a separation between the public and the science of synthetic biology. For instance, a public forum on synthetic biology took place at the London School of Economics (LSE), London, in October 2007. Craig Venter was touring Europe publicising his autobiography and talking about synthetic biology on radio, television and in newspaper interviews. A panel of scientists and social scientists were invited to respond to Venter (see (Lentzos et al. 2008) for transcript). Towards the end of the event, Craig Venter received questions from the audience. At one point, he hesitated, and turned to someone he addressed as his 'media handler' sitting near the stage, to ask whether he could say something. At this moment, techniques of public relations stepped to front-of-stage. While Venter made no attempt to hide the fact that his presence was staged in certain ways, a public academic event was now framed by a different set of intelligible forms and criteria, those of public and media relations. The social space and conversational customs of academic debate were flooded in this event, perhaps relatively briefly, by another form of public, the mass media public sphere. The appeal to the media handler performed the primacy of mass media as the

forum in which synthetic biology should be discussed and legitimated.

In late 2008, another public debate on synthetic biology 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 [synthetic biology], even as the science prepares to march forward' (Woodrow Wilson International Center for Scholars 2008, p.00:50) Although print media attention to synthetic biology had been trending upwards for the preceding three or four years, the August 2008 poll showed around 90% of respondents had not heard of synthetic biology (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, a public did know about something about synthetic biology, but not necessarily one that represents all the voices or standpoints amounting to *the* public. On the one hand, we have a scientist speaking at public events, on the BBC, or the UK Channel 4 evening television news (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 synthetic biology.

Any attempt to manage what is said about synthetic biology and any worry about the public's seeming ignorance both respond to the same imperative: to keep science and the public separate, even as citizen participation is staged, encouraged, solicited, polled and validated at every turn. Both the Woodrow Wilson Center and the LSE events were part of a much larger effort to address publics. A heavily interlaced, cross-referenced and largely consensual collection of public documents, utterances and images concerning synthetic biology 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 synthetic biology will engage with certain distinct ethical issues or problems. A plethora of studies, analyses and overviews of public perceptions, understanding, engagement and participation in synthetic biology, 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 et al. 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 synthetic biology 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.³ The shared and

hardly surprising conclusion of many of policy and ethical studies of synthetic biology is that unless the public is more engaged, a promising scientific-engineering enterprise might founder. The same conclusion can be found in mainstream mass media: '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 debate or accept synthetic biology's promises, they also need to be reminded that the matters of fact, the process of doing the science, are not matters of concern for them.

Could a public verify science?

Even if synthetic biology succeeds in dragging the public out of its allegedly phlegmatic ignorance into engaged citizenship, philosopher of science, Isabelle Stengers trenchantly repudiates the value of doing so: '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). In a rather stunning objection to the broad trend in science studies of the last several decades, Stengers denies the very possibility of meshing the public presentation of science with modes of citizenship in order to rescue the public from its irrational interests and prejudices. Her reasoning departs from a science-studies standpoint on the specificity of scientific knowledge as a practice of experimental witnessing that constantly negotiates and re-negotiates the differences between opinion and reason, ignorance and knowledge. She insists on the difference between objecting and participation/understanding/engagement. The power to *object* differs from participation, engagement or understanding. Objections do not ask the State or existing political institutions to solve a problem. Objections actually can salvage something of science from its subjection to the problematic opposition between opinion and reason, ignorant publics and knowing science. Objections – and this is the key point of intersection between Stengers' account of science and what we might make of the different publics in play around synthetic biology – invoke what Stengers in earlier work called 'the experimental invention': the power to confer on things a way of conferring on experimenters the power to speak in their name.⁴ In objecting, a public might verify rather than validate a science.

In Stengers' account, the power to object comes from the very process whereby a public is formed. As she 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)

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 take an interest in how 'objecting minority' comes to exist rather than assuming they do exist. Could such objecting minorities be found in synthetic biology? In synthetic biology, what would it take for an objecting minority to emerge and in doing so produce the power to object?

The possibility of an objecting synthetic biology public

As I have already hinted above, I think it is quite possible that the very term 'synthetic biology' is a form of address to a public. This term bundles a set of techniques, processes, organisations, efforts and tendencies that could already have been understood as biological engineering, and forwards them to a public. We might also say that synthetic biology is an attempt to make an 'addressable object,' something that people can refer to and talk about in various ways. For instance, synthetic biology is often named as something whose relevance to global problems of energy, food and health, as well as to 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. Different people address synthetic biology in different ways. In contrast to the naming of synthetic biology as global salvation by big-name scientists such as Venter or by commentators such as Stewart Brand, others present it as altering the conditions of biological work on living things, on organisms and biological materials and opening them to much wider participation.

Drew Endy, a Stanford University scientist is somewhat less visible in mass media than J Craig Venter, Jay Keasling or Stewart Brand. However, Endy, alongside a few other salient figures in synthetic biology such as George Church (Harvard), Ron Weiss (Princeton) or Christina Smolke (CalTech), conjure synthetic biology as an addressable object in terms such as design, 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 often reflects on the conditions for doing synthetic biology, nearly always referring to 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 synthetic biology under the tutelage of a white-coated scientist, 'System Sally' (Drew Endy 2005). While Endy also occasionally invokes the vital needs of the planet or the possibility of trillion dollar innovation, the emphasis falls much more directly on who will do synthetic biology and how they will do it. The objection here, we might say, concerns who will do biology and how.

The different modes of address personified here in Venter and Endy occasionally cross each other's paths. Venter at the 2007 London School of Economics public forum on synthetic biology summarily dismissed Endy's and associated work as a simple wish to be first kid on the block to engineer DNA constructs. Conversely, in his analysis of the publication in early 2008 of the first completely synthetically constructed whole genome (already regarded as a landmark synthetic biology publication) by Venter's group (Gibson 2008), Endy pointed out the widely ambivalent 'dual use' – a term begging for deconstruction – character of synthetic biology:

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)

Here Endy remarks on the implications of the Venter Institute publications how work in synthetic biology will be one. This remark could easily be seen as re-iterating the often voiced fear that synthetic biology will furnish terrorists with techniques for the construction of biological weapons. How can we grasp what in this statement is irreducible to a discourse on risk? Endy emphasises, I would argue, a change in the conditions under which the scientific-engineering work of synthetic biology is done: it becomes more 'publicly available.' As we will see, many aspects of the formation of synthetic biology concern what is 'publicly available' and to whom. While publics are often predicated in terms of pre-given categories, institutions, processes, values or norms, we could read Endy's comments on Venter's work as referring to something else.

Any public that is completely defined by pre-given processes and forms falls short of democratic political practice. Publics and public deliberation cannot be fully grounded or located in any specific political institution. Any attempt to attribute reality, efficacy, or legitimacy to a public has to run the risk of naming the dynamics that lend publics spontaneity and alterity in relation to pre-existing institutional norms and forms. While these dynamics clearly wax and wane, in principle, from this perspective, there has to be something excessive or disruptive about publics. This, after all, is the ground for Stengers' rejection of public consensus, participation and engagement as a way forward. It also motivates cultural studies accounts of publics as performative. Michael Warner, for instance, attributes a reflexive, performative 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 recursive feedback between discourse and an 'addressable object' affords spontaneity and potential alterity in the emergence of publics. It would be very tendentious to say that 'synthetic biology is public', yet certain aspects of it, instanced in Endy's observations, seek to conjure an 'addressable object.' In turn, synthetic biology as an addressable public object enables a discourse on biology, or strictly speaking, 'synthetic biology,' to take place.⁵ Endy's talking – and there is much of it scattered across print and online sources – could be seen as an example of the reflexive addressing of something as an object that then supports the address. The object here is synthetic biology done in and by a public.

OpenWetWare: a public address systems in synthetic biology

The most heavily literal address to a synthetic biology public today might be the wiki *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 seeks to make synthetic biology public, much pivots on how *OpenWetWare* addresses and performs synthetic biology as 'open' (and also as 'ware'). In almost any definition, being open is indeed a necessary condition for the existence of a public. As Nancy Fraser describes it, a public 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 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 devices to circulate and sharing information about techniques, publications, and various organisms and biological materials. *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-wikis unfurls from *OpenWetWare*. *OpenWetWare* itself, administered from MIT, 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 open the doing of synthetic biology to anyone affected.

OpenWetWare's address to synthetic biology can be understood along the lines conceptualised by Warner. In addressing an unknown public who would be interested or concerned in knowing about synthetic biology, it also seeks to bring into being a public who does synthetic biology and therefore reads and writes wiki contributions. No doubt, *OpenWetWare* is not as contagious as the news of Craig Venter or Jay Keasling's

latest advance. 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 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 synthetic biology's divergence from genomics and molecular biology more generally, a divergence that is deeply animated by encounters with network cultures (Terranova, 2004). Much more so than official public forums and public spheres whose processes of deliberation and validation run through institutional hierarchies (of funding bodies in particular) and elite policy forums, it is directly enmeshed in contemporary network media culture.

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

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

Also 'open' indissociably 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, it is claimed, 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. In this sense, it meets the formal criteria of publics. 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 named the highly animated blurring of lines between production and consumption that was driving 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' (Shaviro, 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. In allying biological engineering with contemporary network cultures, *OpenWetWare* tethers synthetic biology to the extractive processes of the network society.

Is Wetware addressable?

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 economic and social as well. The often artificial, strained and leaky

distinction between software and hardware allows whole sectors of industry to manage constant change in products and innovation. If the 'hard' vs 'soft' distinction has been so effective in communications and media, what might 'wetware' afford biology? Would wetware, then, refer not only to technical practices and materials of biology and biotechnology, but to a hope that they might become something different, something like software and hardware have become in network cultures?

I am suggesting, then, that if there is a public here, it predicates the possibility of the existence of 'wetware,' or more specifically, biological materials configured in such a way as to render them tractable to the practices of knowing, designing, circulating and making associated with networked collaboration using software-hardware formatted objects. 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, services and processes such as, to mention only one of the most salient, DNA synthesis services (a.k.a 'DNA foundries'). Since synthetic biology is not starting *de novo*, but relying on a century or more of previous biological work, the crucial issues for synthetic biology is: can these techniques, concepts and infrastructures can be reorganized and recognised as an engineering enterprise, and under what conditions? Could biological engineering become like software development? This is the addressable object that *OpenWetWare* and related forums and social spaces seeks to conjure up and to which an in-situ synthetic biology public would respond.

Again, Warner is useful here. He 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, pp.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 various ways, *OpenWetWare* is trying to bring wetware into being by addressing. And in a sense, wetware, if it does exist, would only exist to the extent that it offers a 'real path for the circulation of discourse.' One way to interpret the insistence on openness is as an attempt to make sure the path of circulation of discourse about synthetic biology is 'real.'

The distinctive turn offered by *OpenWetWare* concerns 'wetness.' How is wetness done in *OpenWetWare*? The standard laboratory microbe *e.coli* offers one way to parse 'wet' in *OpenWetWare*. *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 configure it as wetware? *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)

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, in the light of what they find on *OpenWetWare*, be able to work with e.coli as 'wetware.' They, by using what they find here, 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 performative outcome of all the writing, reading and editing that assembles *OpenWetWare*. At the same time, it seems to be a very partial and provisional one. Despite relatively high numbers of participants, many pages on the wiki are not maintained, and much of the wiki seems relatively static. Further research would be needed to understand how the site is used, by whom and for what. Some of these practices might contribute to the addressability of synthetic biology; others might be at odds with it.

Conclusion

The problem we started with was how two different appeals to publics associated with synthetic biology appeal to publics. One modality of public, exemplified in attention that Craig Venter draws, seeks validation for scientific enterprise through public debate and commentary. The need or desire for public validation of synthetic biology, I would argue, runs through many media, policy and public events and documents. Another modality enrolls participants in the science in order to verify both scientific results and the viability of the science itself. In the example of *OpenWetWare*, we can see one attempt to make participation easier. Practically, *OpenWetWare* shares know-how and information about techniques, projects, protocols and materials. In principle, *OpenWetWare* tries to make an *in-situ* synthetic biology public.

How do these different modalities of appealing to publics relate? The tension between them is generative. The fear that the wrong kind of stranger could do synthetic biology cannot be separated out from the hope that many strangers will do synthetic biology if only 'the technical barriers' are lowered. While they appear to lead somewhat separate lives, and indeed, are personified in different figures, they are entangled. This is partly because, as Warner's work helps us understand, the apparent spontaneity or alterity of a public comes from a performative process that brings an addressable object, a public into being, and at the same time, opens a path for the circulation of discourse about the public. Synthetic biology, I have argued, differentiates itself from biological engineering more generally by risking an address of this kind. It is a discourse about the possibility of wider participation in and public availability of biological engineering. In every version of synthetic biology this address to a public thing is more or less evident. When from time to time a scientist such as Craig Venter announces 'we can do X,' (for example, we can synthesise a whole genome), he is at the same time ineluctably saying: 'and, given the resources, so can someone else.' Any appeal to a public for

validation is haunted by an uncertainty about what that public can do. It might do more than validate. For *OpenWetWare*, this possibility is the starting point. The complication is that synthetic biology concerns materials and practices that are not yet, if at all, susceptible to organisation and configuration along the lines of software or computer hardware, the technocultures from which synthetic biology so heavily borrows. The very notion of wetware is a promise. This means that circulation of a discourse about synthetic biology remains somewhat anticipatory or prospective. There is no wetware, so the public of *OpenWetWare* remains somewhat virtual. It can only offer a promise: 'participate in this, and you will see it come into being.' It might well be that the in-situ public envisaged in *OpenWetWare* uses the visibility of the validating publics to compensate for its own virtuality.

As to the final problem, what would a science predicated on a verifying rather than validating public look like? Stengers' arguments frames a direct response to this problem. What are we make of Stenger's repudiation of the first mode of scientific public – public as validation – and her hope for the precarious possibility of objecting minorities? It finds some confirmation in political theory. As Nancy Fraser puts it, the very notion of 'a public' is necessary to 'critical social theory and democratic political practice' (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?). In its constitutive capacity to enter into dispute or to object, a public must be irreducible to state, market 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 discourse. By contrast, the power to de-legitimate is much more heterogeneous and unpredictable. There should occur in the life of a public, we might say, moments of truth in relation to power. Whether and how a public exists at a given time and in relation to what given problem is really open to question. Much political theory seeks to delineate the proper attributes of a public. The critical factors, according to political theory, are legitimacy and efficacy (Fraser, 2007). I think Stengers would add that the legitimacy and efficacy of a public are constantly troubled by doubts and uncertainties: how do we really know who a public comprises? And how do we really know what concerns it? How the in-situ publics of synthetic biology answer these questions is not yet clear. Whether *OpenWetWare* can really 'lower technical barriers, 'offer alternative ways of sharing knowledges, or even only modestly alter 'future reward structures for research' remains to be seen. Much of *OpenWetWare* seems very recognisable.

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[frame=header](http://rsif.royalsocietypublishing.org/content/early/2009/05/12/rsif.2009.0055.focus.full.pdf+html?frame=header)

- 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.
- 2 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.
- 3 Many of the reports on synthetic biology 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 synthetic biology 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 synthetic biology publics, with sometimes awkward or uncomfortable consequences.
- 4 This is Stengers' understanding of the experimental event in science. See (Mackenzie 2005; Stengers 2000)
- 5 A related take on this can be found in Chris Kelty's idea of 'recursive publics' in open source software (Kelty, 2008).