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viewpoint

The role of social scientists in synthetic biology

Science & Society Series on Convergence Research

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Social scientists can adopt many different roles and responsibilities when they study scientific research: they can be advocates, intermediaries, translators, connoisseurs, critics, activists or reformers. They can reflect on the implications of a finished piece of research, or become involved at a much earlier stage. In newly emerging areas of scientific endeavour, we are seeing novel arrangements forming between natural and social scientists, whereby social scientists are becoming a required component of research programmes and are even involved in the creation of new fields. Here, we explore these developments and examine the various possible roles that social scientists may play in debates about new technologies using the example of synthetic biology.

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Synthetic biology is a 'field in the making' that combines the expertise and knowledge of biologists and engineers. It is accompanied by both high expectations and considerable uncertainty; there are debates about its definition, its potential applications, safety considerations and how it should be institutionalized. In common with other emerging areas of technology and science, synthetic biology covers a broad and disparate set of research activities, and there is, as yet, no consensus on how the field should be defined; although the most common definitions emphasize both the building of new biological entities and the improvement of existing ones. A group at the Massachusetts Institute of Technology (MIT; Cambridge, MA, USA), for example, defines synthetic biology as "the design and construction of new biological parts, devices, and systems and the re-design of existing, natural biological systems for useful purposes" (www.syntheticbiology.org).

In practice, many different activities are pursued under the heading of synthetic biology (O'Malley *et al*, 2008), including the construction of interchangeable biological parts and devices—often called BioBricks™—the generation and modification of whole genomes—including the synthesis of viral genomes from scratch and the reduction of existing bacterial genomes—and attempts to create 'protocells' from simple components. Given the range of work that describes itself as 'synthetic biology', it is hard to strictly delimit the field.

Many synthetic biologists aspire to make biology into an engineering discipline. By explicitly adopting engineering principles, including standardization, decoupling and abstraction, these synthetic biologists distinguish their work from previous genetic engineering (Endy, 2005). The possible practical applications of synthetic biology include the production of biofuels, new tools for bioremediation, biosensors, *in vivo* health applications, new drug development pathways, synthetic vaccines and bio-based manufacturing (ITI Life Sciences, 2007). Most notably, synthetic biologists have already generated a genetically modified bacterium that produces a precursor for the anti-malarial drug artemisinin (Ro *et al*, 2006).

Although synthetic biologists distinguish their work from genetic engineering, it is undeniable that this new field gives rise to similar fears, which means that there is already an established set of anxieties to which synthetic biology relates. Both genetic engineering and synthetic biology involve the modification of living organisms, which, by definition, are self-propagating. But synthetic biology adds a new dimension because the development of the internet and the routinization of many biotechnological procedures have made the field more easily accessible (Garfinkel *et al*, 2007). For example, each year, MIT organizes an undergraduate competition in which students 'programme' bacteria to perform certain functions (www.igem.org). In this way, we see the potential 'domestication' or 'deskilling' of biotechnology, which is leading to concerns about 'garage biology' and 'bio-hackers'.

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However, many of these concerns are rather anticipatory. Most of the current work in synthetic biology is funded by public institutions rather than large companies—an indication that much of it is still far from being suitable for commercial exploitation or routine application (De Vriend, 2006). Perhaps the only thing of which we can be sure is that the rapidly increasing speed, and the equally decreasing cost, of DNA synthesis will accelerate the progress of experimental research in the biological sciences (Endy, 2005).

Although there is no consensus on the definition of synthetic biology, there is a widespread conviction that it has important ethical, legal and social implications (ELSI), and that these should be explicitly addressed. Most reports about the field rehearse a standard list of these implications of synthetic biology, which include concerns about biosafety, biosecurity, intellectual property and the status of 'nature'.

One response to […] concerns about synthetic biology has been to institutionalize the involvement of social scientists in the field

What is particularly interesting about this new field is that the scientific community is aware that their research has the potential to be extremely contentious, and many scientists regularly write about and publicly discuss regulatory, social and ethical issues. For example, at the Second International Conference on Synthetic Biology in 2006, in Berkeley, CA, USA, the participants put forward a declaration on governance of the field, which focused on biosecurity issues and emphasized self-regulation. However, this was met with negative responses from a global coalition of civil society organizations, who wrote an open letter stating that "we believe that this potentially powerful technology is being developed without proper societal debate concerning socio-economic, security, health, environmental and human rights implications", and emphasized the necessity for broad and inclusive public debate (ETC Group, 2006).

One response to such concerns about synthetic biology has been to institutionalize the involvement of social scientists in the field. There have been a series of initiatives in which ELSI activities have become purposely incorporated into synthetic biology discussion and research. In the UK, four research councils have funded seven scientific networks in synthetic biology that require an ELSI component. The Biotechnology and Biological Sciences Research Council (BBSRC; Swindon, UK) explains this decision by stating that "[i]t is very important that ethical and other social issues are identified at this early stage in the development of Synthetic Biology, before new products and processes are made, so that research funders and researchers can take these into consideration" (BBSRC, 2008).

Similarly, the European Commission's Seventh Framework Programme funds a project called SYNBIOSAFE, which "aims to proactively stimulate a debate on these issues" (http://www.synbiosafe.eu/). The introduction on the project's website states that, "[i]n order to ensure a vital and successful development of this new scientific field—in addition to describ[ing] the potential benefits—it is absolutely necessary to gather information also about the risks and to devise possible biosafety strategies to minimize them". The overall goal of SYNBIOSAFE is to create "the framework within which Europe's fledgling synthetic biology industry can flourish". In particular, SYNBIOSAFE cites the ongoing debate about GM crops as an example of how this has failed in the past: "[p]ast experiences, especially in the field of GM crops, have shown the importance of an early bio-safety and ethics debate."

The USA has also incorporated ELSI activities into synthetic biology projects. The Synthetic Biology Engineering Research Center (SynBERC; Berkeley, CA, USA), funded by the US National Science Foundation (NSF; Arlington, VA, USA), has involved collaborations between the natural and human sciences from the outset. Unlike Europe, the USA has seen no bitter and divisive debate about GM crops. Instead, the ELSI component of SynBERC seems to mirror a similar ELSI component of nanotechnology (see, for example, http://cns.asu.edu/).

These examples are just a selection of the initiatives in which funding agencies are ensuring that the consideration of ELSIs relating to synthetic biology is integral to the development of the scientific research. This generates various questions for social scientists: why is this happening? Why are social scientists being invited to join the natural scientists? What roles are they expected to play? When these questions are asked in a European context, the most common answer is that scientists and policy-makers want to avoid another failed GM crop debate. Those who provide the funding for synthetic biology hope that by involving social scientists, ethicists and philosophers at an early stage, they will prevent such a failure from happening again.

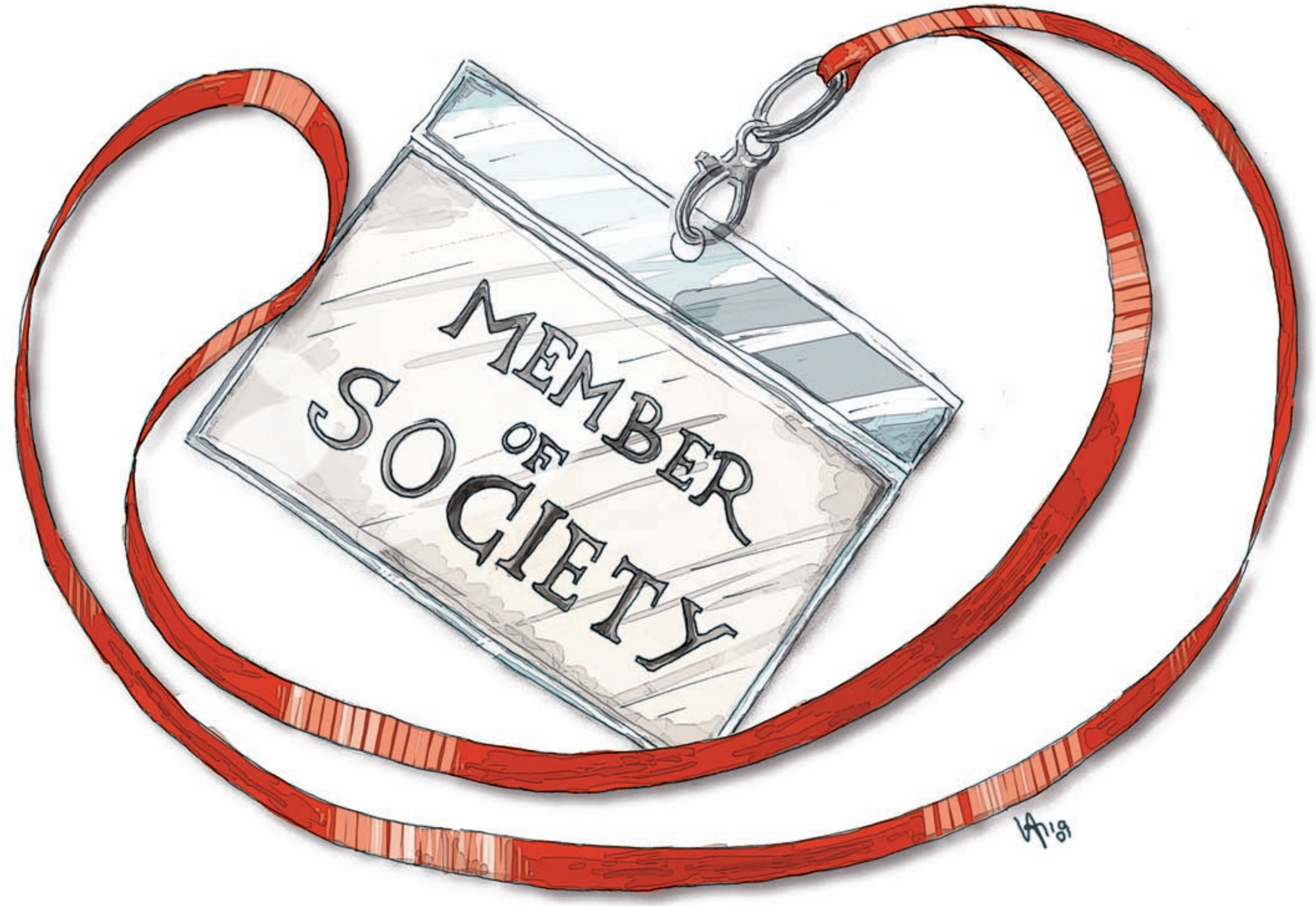
Given the increasing involvement of researchers from the social sciences in synthetic biology, we are left with the question of how these social scientists should become involved. Here, we put forward two contrasting ways of imagining a social scientist's role in a synthetic biology research programme: a 'contributor' and a 'collaborator'.

The hope is that an early prediction of the possible negative implications of new technologies may help them to be prevented

A 'contributor' is a social scientist who, as the name implies, contributes to and facilitates the progress of the field. A contributor can be easily 'plugged in' to ongoing debates to cover the ethical, legal and social implications of research. The involvement of a contributor is often accompanied by the assumption that those who study the 'social' dimensions of a scientific field also have the competence needed to cover the social, legal, regulatory, philosophical and ethical perspectives; the inclusion of such a 'jack-of-all-trades' thus means that input from other experts is not required. In fact, 'ethicist' is sometimes used as a catch-all term for those who study new technologies but who are not scientists or engineers.

SSS Science & Society Series on Convergence Research

This article is part of the *EMBO reports* Science & Society Series on Convergence Research, which features Viewpoints from authors who attended the 'Doing Society and Genomics—Convergence and Competence Building' workshop organized by Peter Stegmaier for the Centre for Society and Genomics at Radboud University (Nijmegen, the Netherlands) in September 2008. We hope that this Viewpoint series will help to introduce our readers to the new multi- and transdisciplinary developments among the life sciences and the social sciences and humanities.



A 'contributor' studies the effects or consequences of scientific research. Indeed, the 'I' of ELSI itself implies that once the natural scientists have done their work, the social scientists arrive to explore the 'implications' of the work for society, perhaps by drawing analogies with similar technological developments in the past. The hope is that an early prediction of the possible negative implications of new technologies may help them to be prevented.

Another way of 'contributing' to synthetic biology is to represent the 'public'. At one UK synthetic biology conference, social scientists were labelled as "members of society" in the programme. Obviously, the organizers assumed that the social scientists represented society more than the scientists and engineers at the conference, and perhaps thought that their presence democratized the proceedings.

Similar attitudes towards social scientists are found in the field of nanotechnology; Macnaghten *et al* (2005) argue that this relies on "[t]he appeal to social scientists as experts in the study of public opinion and political mobilization processes" with the aspiration that "such socially sensitive intelligence may help avoid future disruptive public controversy." Although it might not be accurate to label social scientists as representatives of the public in this manner, it shows recognition of a 'public' voice that needs to be taken into account.

Another imagined role for the social scientist is to be a 'broker', 'translator' or 'facilitator' between various groups of people, particularly scientists and the public. Social scientists have played this role in the nanotechnology debate, in which their knowledge of the field has allowed them to "better elaborate assessment of societal impacts and interact with publics accordingly" (Barden *et al*, 2008). The idea here is that the social scientist can transmit scientific knowledge to the public and, vice versa, knowledge about public attitudes to the scientists and policy-makers.

However, the role of 'contributor' is not the only one that social scientists can have in new scientific fields. An alternative view sees them as 'collaborators', which we define as involvement that can potentially influence the scientific knowledge that is produced. For a collaborator, the demand for social scientific input into debates about synthetic biology is a unique opportunity. The UK's research councils require an ELSI component in network proposals in synthetic biology and, although this could end up as a token contribution, it could also become a more genuinely collaborative exercise. There is an opportunity for authentic interdisciplinary work to take place that does not just follow the scientific research, but interacts with it. This is made more likely because social scientists are being involved in synthetic biology at the 'upstream' end, when the research is in its early stages.

Synthetic biology is a fascinating field, not only for biologists and engineers, but also for social scientists…

Much of the literature that discusses disruptive technologies such as GM crops and nanotechnology, suggests that the role of the social scientist in these situations should be to explore the normative assumptions that lie behind the choices that are made or to engage in "opening up", as Stirling (2005) has said. This involves asking broader questions that go beyond the specific technology under scrutiny, such as questions about the aims of scientific research and what is meant by "good science" (Wilsdon *et al*, 2005). This is far from merely reflecting on the 'implications' of a technology on society.

Other commentators talk about the importance of making scientists "more self-aware of their own taken-for-granted expectations, visions, and imaginations of the ultimate ends of knowledge" (Macnaghten *et al*, 2005). The objective of such processes is to create 'citizen scientists' who become "sensitised through engagement to wider social imaginations" (Wilsdon *et al*, 2005), and who reflect on the social and ethical dimensions of their work. However, we think that this attempt to examine one's own assumptions—sometimes called 'reflexivity'—can go beyond facilitating social and ethical reflection among natural scientists and engineers. Discussions about implicit assumptions could potentially allow both scientists and social scientists to imagine their work differently, in ways that are not habitual or familiar. This 'reciprocal reflexivity' could contribute to a new set of expectations about the research.

There are positive indications that such attempts to engage in reciprocal reflexivity might work. The synthetic biology community is remarkably open to collaboration with people from outside the field and keen to initiate discussions of their work. During our involvement in synthetic biology, we have already come across some possibilities for genuine collaboration.

Synthetic biology is a fascinating field, not only for biologists and engineers, but also for social scientists, because the anticipation of its ethical, legal and social implications is becoming institutionalized. It is thus important for social scientists to define their role more proactively in these emerging configurations, as the role that they imagine for themselves and the role that other groups imagine for them might differ. We should also be aware that there have been similar discussions in other emerging scientific fields, and that much can be learnt from work on other potentially disruptive new technologies.

As we have shown, the role of a social scientist in synthetic biology can be defined either as a contributor—an easily plugged-in ELSI expert who enters the scene after the scientific knowledge has been produced—or as a collaborator. As a contributor, they might represent the public, or become a translator between the natural scientists and the public. But we would argue that the role of a collaborator—as an alternative way to understand social scientific involvement in synthetic biology—is preferable, as it represents a genuine opportunity for truly collaborative work. This could involve scrutinizing the assumptions underlying the research of both natural and social scientists, and challenging habitual ways of thinking among both groups. Perhaps the involvement of social scientists in synthetic biology could lead to the development of a new form of reciprocally reflexive science that brings about new forms of collaboration, learns from previous problems, and helps to create a more ethically acceptable and socially useful field of study and application.

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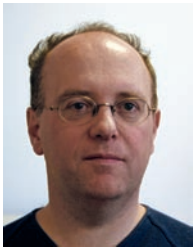

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