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viewpoint

The role of social scientists in synthetic biology

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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.

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…

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'.

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…

However, many of these concerns are rather anticipatory. Most of the current work in synthetic biology is funded by public institutions rather than large

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.

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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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