Biology Meets Engineering

Emma Frow and Jane Calvert, Science, Technology & Innovation Studies,
University of Edinburgh, UK

Synthetic biology promises to make biology easier to engineer. More broadly, the idea of applying engineering ideas to biological systems may have significant impacts on the natural and social world. To date, we suggest that the study of engineering practice has been relatively neglected by Science & Technology Studies researchers, and the engineering of biology even more so.[1] In this note we draw attention to social, epistemological and ontological questions about engineering biology that we believe merit investment and sustained empirical inquiry.

Building on our previous work, the *Engineering Life* project[2] aims to provide insights into the engineering imagination, how it is applied to living things, and how it is challenged and expanded in interdisciplinary interactions. We propose to examine how ideas, practices and promises from engineering are being brought into the life sciences. What is meant by 'engineering' in a biological context? What relationships between making and knowing are being configured? And what implications are there for the design, building and control of our natural and social worlds? A focus on engineering ideas, practices and promises in biology is arguably of interest whether or not synthetic biology as a field retains its currently high visibility.

Engineering ideas: standardization, abstraction, decoupling, control

Key proponents of synthetic biology suggest that the import of engineering principles and work practices into molecular biology will facilitate the design of organisms with specified properties. Engineering metaphors are being adopted to describe and classify biological systems (e.g. as 'parts', 'devices', 'chassis'), and principles such as standardization, abstraction and decoupling are being transposed from engineering to create synthetic biology workflows. The imposition of engineering metaphors and practices might shape the types of things that are brought into the world – for example, is biology naturally modular, or can engineering create organisms that are more modular than their 'natural' counterparts?[3] Engineering ideals of standardization and decoupling are also inextricably coupled to imaginations of the social world, and systems of ownership, reward, labour and exchange. The objects and tools that synthetic biologists are building incorporate not just particular understandings of the nature of biological systems, but ambitions about the organization of scientific practice and the future of biomanufacturing.[4] We suggest that studies aimed at better understanding the connections across micro- and macro-scales of bioengineering can inform the development of effective governance strategies.

Designing biological systems

Importantly, biology as a substrate is quite different from common engineering materials. Biological systems are notoriously complex, and evolve and respond to their environment over a range of timescales. Does this complicate attempts to design with biology? Could bioengineering require the development of new engineering principles and practices, to take into account biological properties like self-replication, mutation and evolution? What kinds of expertise might be needed to engineer 'well' with biology, and how might different epistemic cultures come together around bioengineering? We see opportunities for interdisciplinary dialogue around questions like: what is the place of rational design and/or evolution in synthetic biology?[5]

Discussions of engineering draw our attention to practices of design. When something is designed, this raises a series of questions such as: is it designed well or not? For what purpose is it designed? Who is it designed for? Engineering is a social activity with a strongly ameliorative impulse; it is intimately bound up with economic, military, social, personal, and environmental needs. From this perspective it is not a criticism of engineering to say that it is instrumental: knowledge is a means to an end, not an end in itself. Important questions arise about what this implies when biology is the thing being engineered. How will we configure the relationships between knowing and making across bioengineering, given the aspiration to re-make natural systems for human purposes, according to our design choices and values? In what ways might synthetic biology challenge current distinctions between 'natural' objects and technical artefacts, between nature and culture?[6] How might governance regimes respond to such challenges?

Methods

We suggest that the topics and questions outlined above are best addressed through detailed empirical studies involving qualitative, mixed-methods approaches. Our project work will span three continents, and involves analysing policy documents and scientific literature, undertaking participant-observation at bioengineering meetings and conferences, performing semi-structured interviews with practitioners and policy stakeholders, and conducting ethnographic research in synthetic biology laboratories that are attempting to make biology easier to engineer. Reflections and ideas will be fed back to the practitioners involved in the project, with the aim of not just studying them but beginning to think *with* them. We also plan to engage in more experimental forms of collaboration, with the aim of creatively exploring the nature and contours of the engineering imagination.

Connections with funding and policy

Government bodies in the US and Europe have been eager to promote synthetic biology as an engine for growth, job creation, and an increasingly sustainable bio-based economy.[7] They hope and suggest that bioengineering will herald long-term benefits for our natural and social worlds. To what extent does synthetic biology represent a new way of doing biology? In what respects and with what inflections is an engineering ethos infusing the commitments and practices of bioengineers? How might this play out in terms of labour relations, distributions of responsibility, and social justice? When engineering meets biology, is 'better' design a result? We suggest that detailed empirical studies focused on understanding bioengineering ideas, practices and promises are key to tracking the evolution of 21st-century engineering imaginations. These grounded studies may be able to offer insights that bridge the technical and social dimensions of bioengineering, and could help to inform interdisciplinary training initiatives, research investments, and governance strategies.

Notes and references

[1] We have recently sought to open a dialogue with engineering studies researchers through a special issue of *Engineering Studies* on synthetic biology (February 2013).
[2] *Engineering Life* project, European Research Council Consolidator Grant to Jane Calvert (2014-2019)
[3] Calvert, J. (2010) *Sociological Review* 58 (s1): 95-112
[4] Frow, E.K. (2013) *BioSocieties* 8: 432-448
[5] *Induced Evolution of Yeast Synthetic Genomes* project, FP7 ERASynBio Grant to Cai, Calvert, Frow (2015-2018)
[6] Schyfter, P. (2013) *Studies in History & Philosophy of Biological & Biomedical Sciences* 44(4B): 632-640
[7] See for example the White House (2012) *National Bioeconomy Blueprint* (2012); the UK Technology Strategy Board (2012) *A Synthetic Biology Roadmap for the UK*.