

<b>Institution: The University of Edinburgh</b>
<b>Unit of Assessment: 23 Sociology</b>
<b>3: Impacts of Research into Synthetic Biology: Novel Cultural Artefacts; Improved Policy</b>
<p><b>1. Summary of the impact</b></p> <p>Work on synthetic biology carried out by Calvert and Frow at the Univ. of Edinburgh since 2007 has led to two different types of impact: on creativity, culture and society; and on public policy. Their research on design in synthetic biology involved artists and designers from across the world. It has resulted in the production of novel cultural artefacts (exhibited in France, Austria, Ireland, the USA and Japan and viewed by 28,000 unique visitors to our website) as well as dedicated events, which have provided new opportunities for public discussion about synthetic biology and the design of living things. Their research findings on the importance of the early-stage involvement of social scientists in synthetic biology and the role of responsible innovation in the field were taken up in the UK Synthetic Biology Roadmap and have led to changes in UK research policy.</p>
<p><b>2. Underpinning research</b></p> <p>Synthetic biology is the design and construction of new biological entities for useful purposes. Calvert (University of Edinburgh since 2007) and Frow (University of Edinburgh since 2006) have been carrying out research into the nature and implications of this emerging field for the last five years.</p> <p>Calvert and Fujimura (2011) and Frow and Calvert (2013b) draw attention to the challenges of interdisciplinary collaborations across disciplines such as biology, engineering, computer science, physics and mathematics, which have different assumptions and objectives. They also point to the unexpected insights about the biological world that such collaborations can bring. Extending the discussion of interdisciplinarity a step further, Calvert has argued for the valuable contributions that social scientists can make to emerging fields such as synthetic biology, by becoming involved at an early stage as collaborators in the production of scientific knowledge (Calvert and Martin 2009).</p> <p>Calvert and Frow have taken these arguments forward in research into the ‘anticipatory governance’ of synthetic biology (Wiek et al. 2012). This work concludes that two key features of successful anticipatory governance are a) engagement with a variety of lay publics and stakeholder groups (who often have divergent preferences, expectations and concerns), and b) the close integration of the natural sciences and engineering with the social sciences, arts and humanities. Such engagement and integration enables discussion about what ‘responsible innovation’ might look like across different disciplinary fields, and across different communities of knowledge and practice.</p> <p>Frow and Calvert (2013a) have developed these ideas in a study focused on the future of synthetic biology, where they have shown that it is possible to generate a diversity of possible futures of synthetic biology that challenge familiar narratives, by involving a broader range of stakeholders and perspectives than is usually the case.</p> <p>Finally, Calvert (2010) has found that notions of ‘design’ are central to synthetic biology, and draws attention to the pressing social and ethical issues that arise when living things are themselves the object of design.</p> <p>Occasional collaborators in the above research include Joan Fujimura, University of Wisconsin, and Dave Guston and Arnim Wiek, Arizona State University. The impacts detailed in section 4.2 were achieved jointly with Claire Marris and Nikolas Rose (both King’s College London).</p>
<p><b>3. References to the research</b></p> <p>Calvert, J (2010) ‘Synthetic biology: constructing nature?’ in Parry, S and Dupré, J (Eds) <i>Nature After the Genome</i> Sociological Review Monographs, Oxford: Wiley-Blackwell, available from HEI.</p> <p>Calvert, J and Fujimura, J (2011) ‘Calculating life: Duelling discourses in interdisciplinary systems biology.’ <i>Studies in History and Philosophy of Biological and Biomedical Sciences</i> 42 (2): 155-163, DOI: <a href="https://doi.org/10.1016/j.shpsc.2010.11.022">10.1016/j.shpsc.2010.11.022</a>. In REF2.</p> <p>Calvert, J and Martin, P (2009) ‘The role of social scientists in synthetic biology.’ <i>EMBO reports</i>, 10 (3): 201-204, DOI: <a href="https://doi.org/10.1038/embor.2009.15">10.1038/embor.2009.15</a>.</p> <p>Wiek, A, Guston, D, Frow, E and Calvert, J (2012) ‘Sustainability and anticipatory governance in synthetic biology.’ <i>International Journal of Social Ecology and Sustainable Development</i> 3(2): 25-</p>

## Impact case study (REF3b)

38, DOI: [10.4018/jesed.2012040103](https://doi.org/10.4018/jesed.2012040103).

Frow, E and Calvert, J (2013a) 'Opening up the future(s) of synthetic biology.' *Futures*, 48: 32-43, DOI: [10.1016/j.futures.2013.03.001](https://doi.org/10.1016/j.futures.2013.03.001).

Frow, E and Calvert, J (2013b) "Can simple biological systems be built from standardized interchangeable parts?" Negotiating biology and engineering in a synthetic biology competition.' *Engineering Studies* 5(1): 42-58, DOI: [10.1080/19378629.2013.764881](https://doi.org/10.1080/19378629.2013.764881).

#### Underpinning research grant:

2009-2011: Synthetic aesthetics: connecting synthetic biology and creative design. Jane Calvert PI, with Alistair Elfick (Edinburgh) and Drew Endy (Stanford). EPSRC/NSF Synthetic Biology Sandpit grant: £335,254 (£131,533 EPSRC contribution: EP/H01912X/1).

### 4. Details of the impact

#### 4.1 Impacts on creativity, culture and society

Building on her research that demonstrated the importance of interdisciplinary collaborations in synthetic biology (Calvert and Fujimura 2011, Frow and Calvert 2013b) and the potentially profound significance of designing living things (Calvert 2010), Calvert initiated and led a project to bring together six synthetic biologists with six professional artists and designers from Europe, the US, Japan and Australia in paired exchanges. This EPSRC/NSF project, called 'Synthetic Aesthetics', was developed in collaboration with two engineers at a 'Sandpit' event held in Washington DC (30th March – 3rd April 2009).

The project has led to the production of cultural artefacts that would not have existed otherwise, such as: human cheese made from bacteria collected from body parts including feet, noses and armpits (winner of the UdK Award for Interdisciplinary Art and Science from the Universität der Künste, Berlin in 2012: see Figure 1); a 'design fiction' future packaging that creates a probiotic drink with the addition of water (recipient of a notable mention in the Core77 2012 Design Awards: see 5.3 and Figure 2); and cyanobacteria that digest computer circuit boards (see Figure 3). Such unconventional uses of synthetic biology have stimulated debate among stakeholders and publics, building on arguments we make in our underpinning research about the importance of increasing the diversity of voices that are able to contribute effectively to discussions of synthetic biology.

Figure 1



Figure 2

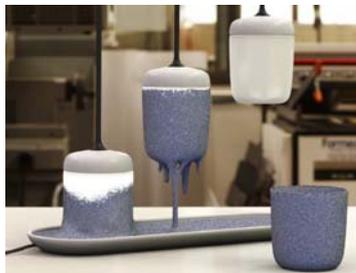
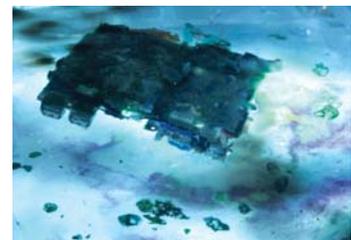


Figure 3



The project has reached a broad range of international audiences, and the artefacts have been exhibited in France, Austria, the Republic of Ireland, the USA and Japan. The Synthetic Aesthetics website has attracted over 28,000 unique visitors, and the project has over 1500 Twitter followers. The work has been discussed in journals with wide readership such as *Science* (see item 5.6), *Nature* (5.5) and *Cell* (5.2), and newspapers such as the *Toronto Standard* (5.4) and *Der Tagesspiegel* (5.1). The project team members have given over 50 talks on the project across the world, including a dedicated event at the Edinburgh International Science Festival in 2012, with an audience of 66. Additionally, a popular book with over 100 images is in production with MIT Press, and it will be launched at an event at the Museum of Modern Art in New York in early 2014. Most significantly, in the book the artists and designers co-authored chapters with their paired scientists and engineers. This was something none of project's participants had done before, and it required them all to modify their practices and re-think their assumptions.

In 2010, Calvert and colleagues received follow-on funding from the Wellcome Trust and the Royal Academy of Engineering to collaborate with the Arts Catalyst, a not-for-profit arts/science organisation. Together they organised a week-long art/science workshop with 28 participants, a film night with 70 attendees and a public debate with 52 attendees. Evaluation interviews were carried out with participants after the workshop, and they noted how the art/science work

stimulated creativity and promoted mutual understanding across disciplines. For example, one artist participant commented: *“it was really enlightening and somewhat revealing of the way that we talk about each other’s disciplines and the way we do our work. I definitely left feeling like everybody’s inadequately educated”*.

In sum, the unusual interdisciplinary collaborations instigated by the Synthetic Aesthetics project have given rise to new cultural artefacts and to new opportunities for public discussion about synthetic biology and the hopes and concerns provoked by attempts to design living things.

#### 4.2 Impacts on public policy

Calvert and Frow’s published research on (and close engagement with) the synthetic biology community has led to invitations to join national and international policy advisory committees including: the Royal Academy of Engineering Working Party on Synthetic Biology, the BBSRC Bioscience for Society Strategy Panel, the Nuffield Council on Bioethics Working Party on Emerging Biotechnologies, the EU-US Task Force on Biotechnology Working Party on Synthetic Biology, and the Hastings Center Working Group on Ethical Issues in Synthetic Biology, US. In addition, Frow has been working with the British Standards Institute and the US National Institute of Standards and Technology to inform national standards development initiatives in synthetic biology. For this case study, however, we focus on one key example of policy impact: the UK’s Synthetic Biology Roadmap (item 5.10).

In early 2012, Calvert (along with Claire Marris and Nikolas Rose) was invited to join the Synthetic Biology Roadmap Coordination Group (RCG), established by David Willetts, Minister of State for Universities and Science, and chaired by Lionel Clarke of Shell. Calvert’s, Marris’s and Rose’s research findings on the importance of the involvement of the social sciences in synthetic biology, specifically in respect to ‘responsible innovation’, were taken up in the Roadmap, which has as one of its recommendations that “Public sector investment in synthetic biology should take into account social, ethical and regulatory issues and increase awareness of responsible innovation” (item 5.10, p.31). Calvert’s, Marris’s and Rose’s arguments for widening disciplinary engagement in scientific governance also contributed to the recommendation that social scientists should be members of a Synthetic Biology Leadership Council (p.32), and that one meeting per year should be held in public. This recommendation aims to facilitate democratic participation in the field, and it differentiates the work of the Synthetic Biology Leadership Council from all existing leadership councils. As a direct result of these recommendations, in late 2012 the Synthetic Biology Leadership Council (jointly chaired by Willetts and Clarke) appointed a social science member (Prof Joyce Tait: see Case Study 4, Life Sciences Innovation).

The significance of the involvement of Calvert, Marris and Rose in the Roadmap Coordination Group was demonstrated in a symposium on synthetic biology in Washington, DC (jointly organised by the National Academies of the US, the UK and China), where a senior representative from the Department for Business, Innovation & Skills publicly stated how the involvement of social scientists (Calvert, Marris and Rose) in the roadmapping exercise had challenged and reshaped thinking within the UK government:

*“something we’ve done that is perhaps slightly different from what we’ve done in the past is to be more involved with social scientists in the process right from the outset. That’s made a real difference to actually how we’re thinking as a group, and how we’ve begun to think within government itself, and that’s been, for me, as part of the journey we’ve gone on, a real revelation actually”* (item 5.9).

The impact of social scientific involvement in this work has reached beyond the Synthetic Biology Roadmap. This is shown in an email from the Technology Strategy Board’s representative on the RCG on its £6.5 million funding competition for Feasibility Studies in synthetic biology:

*“You will note that ‘responsible innovation’ figures large in the competition, and that we plan to carry out an ethical, societal and regulatory assessment on every project funded through it before awarding the grants. The work of the RCG [Roadmap Coordination Group], with input from the workshops, has been highly influential in shaping this – the first time that any Technology Strategy Board competition has taken this approach. Many thanks, especially to social science colleagues, for helping to shape the thinking”* (email from Head of Development, Technology Strategy Board, 10th May 2012, on file at the University of Edinburgh).

**Impact case study (REF3b)**

Since the publication of the Roadmap, the idea of 'Embedding Responsible Research and Innovation' has been taken up by a £10M call for an Innovation and Knowledge Centre by the EPSRC, the Technology Strategy Board and the BBSRC (5.8), and an £80M call for six Synthetic Biology Research Centres by the BBSRC and the EPSRC, demonstrating the significance of this work for ongoing policy initiatives (5.7). Calvert and Frow have also been invited to contribute to the development of the Technology Strategy Board's 'Responsible Innovation Framework', which will be used in future decisions about funding in the area of synthetic biology.

Note re testimony: other than the artist quoted (who was a participant in the workshop), none of those quoted were participants in the process of impact delivery.

**5. Sources to corroborate the impact**

**In case of broken links**, PDFs of all weblinks are available at:

[www.wiki.ed.ac.uk/display/REF2014REF3B/UoA+23](http://www.wiki.ed.ac.uk/display/REF2014REF3B/UoA+23)

Synthetic Aesthetics: impacts on creativity, culture and society

5.1 Bauer, UM, Goltz, S (2012) 'Kunst in der Wissensgesellschaft (Art in the Knowledge Society)' *Der Tagesspiegel* (19 April 2012). Online at: <http://www.tagesspiegel.de/zeitung/kunst-in-der-wissensgesellschaft/6503380.html>

5.2 Bernstein, R (2011) 'Drop that Pipette: Science by Design.' *Cell* 147 (28 Oct 2011): 496-497, <http://tinyurl.com/pbsaxec>.

5.3 Core77 Design Awards (2012) 'Future Visions for Synthetic Biology.' Online at: <http://www.core77designawards.com/2012/recipients/future-visions-for-synthetic-biology/>

5.4 Cormier, Z (2011) 'Bacterial culture.' *Toronto Standard* (25th April 2011). Online at: <http://www.torontostandard.com/culture-design/bacterial-culture>

5.5 Gewin, V (2013) 'Interdisciplinarity: Artistic merit.' *Nature* 496 (7446): 537-539, DOI: 10.1038/nj7446-537a

5.6 Reardon, S (2011) 'Visions of synthetic biology.' *Science* 333 no 6047 (2nd Sept 2011): 1242-1243, DOI: 10.1126/science.333.6047.1242.

UK Synthetic Biology Roadmap: impacts on public policy

5.7 BBSRC and EPSRC (2013) 'Multidisciplinary research centres in synthetic biology.' Online at: <http://www.bbsrc.ac.uk/web/FILES/PreviousAwards/multidisciplinary-research-centres-in-synthetic-biology-background.pdf>

5.8 EPSRC, TSB and BBSRC (2012) 'Call For expressions of interest for an Innovation and Knowledge Centre (IKC) in synthetic biology.' Online at: <http://www.epsrc.ac.uk/SiteCollectionDocuments/Calls/2012/IKCForSyntheticBiologyEOI.pdf>

5.9 Uffindel, D (2012) talk on 'Perspectives on synthetic biology from within the political system' at Synthetic Biology for the Next Generation: The Six Academies Symposium, Washington, DC, June 12-13, 2012, viewable online at:

[http://events.tvworldwide.com/Events/IOM/NAS120612.aspx?VID=events/nas/120612\\_NAS\\_SyntheticBiology\\_1415.flv](http://events.tvworldwide.com/Events/IOM/NAS120612.aspx?VID=events/nas/120612_NAS_SyntheticBiology_1415.flv)

5.10 UK Synthetic Biology Roadmap Coordination Group (2012) *A Synthetic Biology Roadmap for the UK* Technology Strategy Board: Swindon. Online at:

<http://www.rcuk.ac.uk/documents/publications/SyntheticBiologyRoadmap.pdf>

**Individual users/beneficiaries who could be contacted to corroborate claims:**

The impact of the Synthetic Aesthetics project on art/science collaborations and its role in initiating discussion of synthetic biology amongst artists and designers can be corroborated by:

Director, The Arts Catalyst, London, UK (a not-for-profit arts/science organisation)

Principal, The Living, New York, USA (an architecture firm)

The impact of Calvert, Marris and Rose's involvement in the UK Synthetic Biology Roadmap can be corroborated by:

Head of Bio-Economy Unit, Department for Business, Innovation and Skills, London, UK

Head of Development, Technology Strategy Board, London, UK