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Synthetic biology as understanding, control, construction, and creation? Techno-epistemic and socio-political implications of different stances in talking and doing technoscience

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ABSTRACT

Systems biology and synthetic biology are said to represent 'two sides of the same coin,' with systems biology focussing on understanding and synthetic biology on construction. This notion is based on the implicit assumption that understanding and construction (or science and engineering) are, in themselves, 'two sides of the same coin.' Moreover, synthetic biology has been framed as an approach that encompasses understanding as well as control, construction, and creation. In the 'talking' and 'doing' of synthetic biology, one can discern a contemplative, interventionist, constructionist, and creationist stance. It is the aim of this paper to illustrate these stances in detail and to discuss more generally their techno-epistemic and socio-political implications.

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1. Introduction: (techno)epistemic orientations

'Systems biology' and 'synthetic biology' emerged as labels for new research approaches around the turn of this century. In 2000, the Science Citation Index Expanded displayed four papers with the keyword 'systems biology' and one paper with the keyword 'synthetic biology'; for 2011, it reports 1378 'systems biology' papers and 363 'synthetic biology' papers.[1] In the same time period, large interdisciplinary research centres for systems biology were established in the US, the UK, and Germany, and various major funding initiatives were launched on both the national and international levels [1,2]. This also applies to synthetic biology on a smaller scale, albeit more so in the US [3, p. 3].

Since the coining of the terms, scientists as well as philosophers, historians, and sociologists of science have struggled to define their disciplinary status and scientific identity [4–11]. They have been categorised as new disciplines, fields, paradigms, and approaches. Definitions of synthetic biology often invoke the idea of 'bringing engineering into biology' so as to 'build life from scratch'; attempts to define systems biology hint at its interdisciplinary, collaborative nature and highlight its quest to understand living systems by relying on computational tools as well as biological data on the molecular level. These definitions rely strongly on comparison with existing fields (such as biology and engineering in general and computer science, molecular biology, and biochemistry more specifically), and references to historical developments (concerning technological breakthroughs, and availability of data and artefacts) and historical ancestors (for systems biology: Warren Weaver, Norbert Wiener, Ludwig von Bertalanffy). They invoke two general visions for modern bio(techno)science: to enhance the understanding of living systems (via systems biology) and to construct (or engineer) living systems (via

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[1] http://apps.webofknowledge.com/ (accessed 04.04.2012).

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synthetic biology). Websites of systems biology research institutions hence favour 'understanding' as a focal point of their activities, while websites of synthetic biology research institutions favour 'engineering,' 'control,' and 'construction' as focal points of their activities.

Descriptions of systems biology often include a reference to synthetic biology and vice versa, but in most cases this cross-referencing is rather casual. It relies on the perception that they are parallel strands of (techno)scientific[2] activities that emerged from very similar multidisciplinary environments; that they are connected by (potentially) mutually enabling relations (e.g. [12–14]), exchange of knowledge, know-how, artefacts, and technologies; and that they feature overlapping research communities. Systems biology is depicted as part of synthetic biology, and synthetic biology as a kind of spin-off of systems biology. Relatively often, one encounters the idea that they represent 'two sides of the same coin' (cp. also [15, p. 384]). In such statements, the two sides represent understanding versus creating; unravelling intra-organismic orchestrations versus creating cells with specific behaviour; studying natural biological systems versus building novel and artificial biological parts, devices, and systems; analysis versus design; reverse engineering versus forward engineering; capturing behaviour versus assembling components; and generating and applying information versus proposing and testing theories [16].

The general idea that there are two sides to the (techno)science 'coin'—understanding and engineering—can also be traced back in history. Scholars of science and technology have referred to Francis Bacon's 1620 portrait of a science that encompasses 'light-bringing' and 'fruit-bearing,' wherein knowledge of nature (especially natural laws) and the power to control it eventually converge (cp. [17]). They have referred to Giambattista Vico's 1710 assessment that 'truth and making are reciprocal,' and to Richard Feynman's 1988 statement, 'What I cannot create, I do not understand' (for both, see [15, p. 385], for the latter also [18]). Recently, Ian Hacking has taken up the contrasting pair of 'representing' and 'intervening' as a basis for revisiting different epistemological approaches and ontological assumptions of the philosophy of science [19].[3]

When looking beyond the discursive representations of emerging technoscientific fields and retracing the evolutions of (techno)scientific practices, one can discern multiple orientational configurations—for example, a contemplative, interventionist, constructionist, or creationist stance [22]. Identification of such diverse orientations within (techno)science enables a more detailed discussion of the specific characters and roles of these orientations within research. They can be understood as '(regulatory) Ideas' (as proposed by François Lyotard in reference to Kant's 'regulatory ideas') or as 'orientational myths' [23]. One can also try to explain their function within research cultures via Pierre Bourdieu's concept of the 'illusio' of a field [16]. All these reconstructions imply that day-to-day research practice is to some extent influenced by or even fundamentally built upon convictions of what science is and what it ultimately aims to do. Interestingly, the dominant orientations of day-to-day research are not congruent with the explicit visions of the currently propagated technosciences. Still, the latter become influential in their public presentation and perception, in technoscience governance, and in general societal visions.

The following paper will draw upon the two (techno)scientific orientations within representations of synthetic biology (Section 2) and the reconstruction of four (techno)epistemic stances within current (techno)scientific practice (Section 3). After a short summary of the relevance of these two aspects[4] to the understanding of synthetic biology, the paper will focus on the techno-epistemic and socio-political implications of following such orientations and stances (Section 4). Synthetic biology will be addressed as being situated within a specific epistemological and ontological context with a certain range of interpretive, practical, and organisational repertoires—not as a monolithic project with an unambiguous meaning in the present and a predetermined future development. The comparison and discussion of talking and doing synthetic biology allows for at least three conclusions: (1) talking and doing synthetic biology do not (currently) follow the same (techno)scientific orientations; (2) for both orientational configurations–the techno-epistemic orientation of talking synthetic biology and the diverse stances of doing synthetic biology–internal (i.e. scientific) quality control and external (i.e. societal) legitimation have become problematic; (3) the implicit stances and explicit visions, orientations, and stances of synthetic biology and other emerging research fields will continue to shape scientific practices and societal discourses, regardless of their feasibility or legitimacy.

2. The 'two sides of the same coin' thesis: synthetic biology as 'putting engineering into biology'[5]

> Although the road ahead is long and winding, it leads to a future where biology and medicine are transformed into precision engineering. [25, p. 209]

[2] In this paper, '(techno)scientific' refers to a scientific, technological, or technoscientific institution, while 'technoscientific' refers to a fundamentally hybrid institution; '(techno)epistemic' denotes a practice that is oriented towards the production of knowledge but might also be orientated towards engineering; 'techno-epistemic' denotes a fundamentally hybrid practice (as suggested by the 'two sides of the same coin' metaphor or Francis Bacon's scientific ideal).

[3] Neither Hacking's 'styles of scientific reasoning' [20] nor Crombie's 'styles of scientific thinking' [21] are referred to here, as they are too atomistic and universalistic for the purpose of this (empirically grounded) analysis.

[4] For a discussion of both of these aspects in more general terms, see [22] and [16].

[5] Quote from [24].

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