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How a 'drive to make' shapes synthetic biology

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ABSTRACT

A commitment to 'making'—creating or producing things—can shape scientific and technological fields in important ways. This article demonstrates this by exploring synthetic biology, a field committed to making use of advanced techniques from molecular biology in order to *make* with living matter (and for some, to *engineer* living matter). I describe and analyse how this field's 'drive to make' shapes its organisational, methodological, epistemological, and ontological character. Synthetic biologists' ambition to make helps determine how their field demarcates itself, sets appropriate methods and practices, construes the purpose and character of knowledge, and views the things of the living world. Using empirical data from extensive ethnographic and interview-based research, I discuss the importance of seemingly simple and unimportant commitments—in this case, a focus on the making of things rather than the production of knowledge claims. I conclude by examining the ramifications of this line of research for studies of science and technology.

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1. Introduction

This article examines how a commitment to 'making'—that is, creating or producing—bears upon the character of a field in science and engineering. I argue that something seemingly straightforward—namely, that certain fields are in the business of *making things*—has important implications for how scientific and technological ventures demarcate themselves, define accepted practices, produce knowledge, and construe the nature of the things with which they engage. That is, my research shows that a 'drive to make' can shape the organisational, methodological, epistemological and ontological facets of a field.

I employ the term 'making' in its ordinary sense. That is, I understand making to be broadly synonymous with creating, constructing, building and producing; it is the putting together, bringing-into-material-existence of something. The plainness of this definition does little to convey the richness of its consequences for science and technology. Fields seeking to construct things differ in significant ways from those intent on other ends, such as developing knowledge claims and furthering understanding. All scientific and technological fields engage in making things and in producing knowledge, but not all fields have as their end-goal the production of artefacts or the making of knowledge claims. Distinctions in end-goals matter.

A 'drive to make' can help account for the presence of specific practitioners, the goals set by them, the practices undertaken, and all manner of topics of clear interest to scholars of science and technology. Making pervades such things as practice, discourse, norms and expectations. Moreover, particular varieties of making shape fields in correspondingly particular ways. As such, this article explores both how a broad commitment to making—a 'drive to make'—shapes a scientific and technological field, as well as how one particular style of making—an engineering-based configuration of practice—has particular implications for the same field.

My study focuses on synthetic biology, a loose conglomerate of researchers engaged in developing new tools and techniques for intervening in—and *making with*—the stuff of the living world. I examine how a 'drive to make' shapes synthetic biology in four arenas. First, making has *organisational* implications. As a number of studies have argued, constructing with biological things is a defining characteristic of synthetic biology (Calvert, 2010; Keller, 2009; O'Malley, 2009; O'Malley et al., 2007). As I demonstrate, making—in act and as ideal—serves to unify what is still a very heterogeneous and disconnected group of researchers (Lentzos,

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Bennett, Boeke, Endy, & Rabinow, 2008). That is, a 'drive to make' is crucial to acts of boundary setting and field delimitation (Gieryn, 1983). Second, making has *methodological* consequences. While the field may be committed to making in a broad sense, the way in which that making is to be carried out is a matter of serious, ongoing debate. A particularly vocal contingent of practitioners seek to make as do 'real' engineers, and set down their methodologies accordingly (e.g. Endy, 2005). Methods of making become implicated in setting down how to practice and who to be; particular methodologies (such as those of engineering) produce particular fields. Third, making moulds the field's *epistemological* character. Synthetic biology's drive to make influences what type of knowledge is to be produced, of what use that knowledge is, and how construction and knowing relate to one another. Different factions of practitioners construe this relationship differently, following particular understandings and practices of making. Last, the field's commitment to making is *ontologically* significant. This is the case for all styles of practice in the field, but appears most clearly for the contingent invested in the engineering-based vision of synthetic biology. For these, the things of living nature are constituted as ontologically equivalent to the inanimate materials employed by existing engineering fields: as usable substrate at the disposal of technology-making ventures.

My argument draws on extensive empirical research on synthetic biology. For 18 months in 2010 and 2011, I worked as a postdoctoral researcher at a synthetic biology laboratory in the United States. I conducted an extended ethnographic study of this research group and its partner lab, which shared space, instruments, supplies and some personnel with ours. As a member of the laboratory, I presented at weekly lab meetings, interacted closely with fellow lab members, and had access to all facilities pertaining to the group's work. I also conducted 24 in-depth qualitative interviews with synthetic biologists. These included fellow lab members as well as principal investigators, postdoctoral researchers and doctoral students at other institutions in the United States. Furthermore, I conducted short ethnographic visits to 7 additional laboratories, also in the United States. Some of these visits consisted of no more than one day, while others extended over the course of several weeks. Last, I attended events associated with synthetic biology, including: one-day symposia; large conferences such as The Fifth International Meeting on Synthetic Biology (SB 5.0); meetings of research networks such as the Synthetic Biology Engineering Research Center (SynBERC); and the yearly International Genetically Engineered Machine undergraduate competition (iGEM).

As an emerging field, synthetic biology is made up of various factions whose goals and practices differ from each other in key ways. As such, I chose research locations and interview participants based on the most viable criterion: self-identification with synthetic biology. I did not prefer one type of synthetic biology research over others. Although I often draw attention to the field's engineering-focused contingent, my research encompassed all manner of practitioners. Similarly, my argument applies to all of synthetic biology. Making is not the exclusive purview of one contingent. My examination of engineering-driven practitioners demonstrates how a particular form of making shapes the field in a particular way. Importantly then, my use of the term 'making' must not be understood as synonymous with the term 'engineering'. The latter is one specific variety of making, but not the sole one at work in synthetic biology.

The question of 'making' was never a direct query put to the interviewees, but the topic appeared consistently and in a significant manner across my enquiries. Moreover, it was prominent during my ethnographic investigation, and it is a key facet of the field's discourse. In pursuing the topic, I have found that examining and understanding synthetic biology demands a concern for 'making' and its implications. Here I identify and examine some of these, with a view to establishing the importance of this basic, but defining quality of certain fields in science and engineering.

2. Making a field

Synthetic biology is a field under construction. At present, those who self-identify with 'the field' of synthetic biology constitute a diversity of practitioners. Biologists, chemists, computer scientists, and all manner of engineers are some of the immigrants to synthetic biology; with them they bring different practices, tools, aims, and epistemic and ontological commitments. This pluralism does not yet exist within a common framing—'the field' lacks a unifying identity. As a result, the term 'synthetic biology' itself is employed without consistency by those who self-identify with 'the field.' Similarly, observers and analysts of the field, such as me, define and sort out the field differently (e.g. Calvert, 2010; Mackenzie, 2010). Work that may go unquestioned as synthetic biology in some quarters will often meet with scepticism in others. In many regards, the field is a 'fragmented' one.

Despite the multifariousness that is characteristic of synthetic biology (but perhaps also as a response to it) efforts to consolidate the field exist. Many of these draw on the drive to make as an axis around which the field can unify. 'Making' plays a crucial role in synthetic biologists' boundary-work—in simplest terms, the practice of constructing social borders around particular activities in order to distinguish them from others (Gieryn, 1983, 1995). My study suggests that different factions within the field, irrespective of divergent backgrounds, aims, and practices, all employ making as a characteristic that distinguishes synthetic biology from other research areas. Divisions internal to the field concern to what ends that making is put, and what form the process should take. Making itself is a shared commitment—a basis for establishing the boundaries of synthetic biology.

Those I observed and with whom I conducted interviews routinely commented on the importance of making, and building synthetic biological constructs was often characterised as a defining aspect of the field. More than just practice or method, making is set down as an imperative. Michael[1] is a doctoral student at my host laboratory. His work encompasses both computational simulation and analysis, and so-called 'wet-work'—laboratory bench-work with biological materials. Michael and a postdoctoral colleague currently seek to design and fabricate a counter—a genetic construct capable of retaining a record of previous events. Counters are in effect genetic memory devices. It is hoped that such devices will help researchers track cell lineages across generations and enable the production of more sophisticated constructs resembling electronic circuitry.[2] When asked how his work with counters fits into the broader field of synthetic biology, Michael responded:

> Some people want to build a house, some people want a bridge, some people want to build, you know, a swimming pool or whatever, right? It is the same in synthetic biology. You know,

[1] In order to ensure anonymity and confidentiality, I have given each interview participant an alias.

[2] Much of synthetic biology has focused on constructing biological analogues to electronic devices. For instance: oscillators (Elowitz & Leibler, 2000; McMillen et al., 2002; Strickler et al., 2008), logic gates (Lerderman et al., 2006; Rinaudo et al., 2007), and switches (Atkinson, Savageau, Myers, & Ninfa, 2003; Gardner, Cantor, & Collins, 2000; Lipshtat, Loinger, Balaban, & Biham, 2006).