Engineering Biology: between hope and hubris.
Tom Curtis, Civil Engineering and Geosciences, Newcastle University
EPSRC Dream Fellow

Engineering, we are told, is the “art of directing the great sources of Power in Nature for the use and convenience of man” and we would hope women. Engineering has expanded as it has sought and exploited new sources of Power in Nature and new concepts and tools by which said sources can be manipulated. Biology we are told is the next. However, much of the work and excitement to date has confined itself to the lab and the single pure cultures. Many of the problems are in the real and complex world of open engineered systems where genetically manipulated organisms will fail. This is a challenge that is tacitly, even cynically, ignored by many of the enthusiasts for synthetic biology. For some this is mere naïveté, others gamesmanship: but if it is not addressed it will become fraud. There are at least two avenues we might pursue to obtain solutions.

Firstly, use existing “organic” organisms: the use of synthetic organisms is predicated on the assumption that nothing exists in nature to do fulfil the desired function. This need not be the case. Synthetic biology uses organisms in culture. However, since only 0.0001% of taxa are found in culture, it seems hard to make a case that this assumption has been thoroughly examined and many engineering challenges can be met without resorting to the lab. However, even when we know that organisms exists in nature we still find it very difficult to explicitly engineer any microbial community. Building a suite of ecological theory that can be deployed in design has made progress; however design is still strongly dependent upon experimentation.

Secondly, it would require churlish hubris to assume that someone somewhere could not engineer an organism with a useful function not found in nature. The question is how to deploy it. There is little evidence that we can get an organism from the lab’ into the field in any kind of systematic way. Those mindful of the fears of rampant microbes have spoken of forms of genetic containment, sequencing tweaks that would ensure the demise of a released but unwanted organism. They hardly need bother. Genetically manipulated seem to simply die away when faced with the rigours of the environment. We have no idea how to design an organism to exist, even transiently, in an open microbial community.

My colleagues and I believe that both organic and synthetic approaches can be tractable if we can generate a new approach to design and simulation grounded in simplifying principles that unite the first principles of biological life, most notably energy with evolution and ultimately ecology. Exploring this approach will give us tractable fundamental concepts we can use to run large scale simulations of new designs in engineering biology that will allow us to test prototypes in much the same way as marine engineers might use numerical simulations in lieu of a scale model and a towing tank. Crucially, these same principles will be those that any synthetic organism will have to obey to function in a complex community: they thus constitute the design principle for any putative new organism that we might wish to engineer. Moreover, these putative designs can be tried in silico before they are developed in vitro. It is by no means certain that these new approaches will work. But engineering is not mere aspiration and if engineering biology is to mature and flower we must need more than hope and never succumb to hubris.