Our synthetic future

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Our synthetic future

Nigel M de S Cameron & Arthur Caplan

Two prominent ethicists provide their views on the ethical debates surrounding synthetic biology.

What do public attitudes to new technologies tell us about synthetic biology and its potential impact on society? To what extent will new capabilities in biological engineering empower the research community to realize applications that the public find most troubling? And how should engagement with the public on the implications of genome synthesis and engineering be managed going forward? Two ethicists provide their perspectives.

Beyond the silos

Nigel M de S Cameron

When a hot technology prospect like synthetic biology gets the *New Yorker* treatment[1], it has plainly arrived—at least in the conversation of the cognoscenti. This is something of a surprise because engagement with the implications of science and technology (aside from gadget worship) seems to be curiously absent from polite American conversation. Yet it is the United States that dominates global emerging technology R&D on a vast scale, and on which both the US economy and US security depend more than most people imagine.

This conversational failure is not limited to cocktail parties, or indeed to the United States, though Europeans are generally more predisposed to discuss such subjects. Moreover, the absence of serious dialog evinces a worrying cycle of disinterest that threads right through the high (and low) culture of the twenty-first century—including the media, culture's lens; and, of course, the political classes, to which generally falls the task of shaping our various national conversations.

The stakes could hardly be higher. By bringing engineering and biology to a common focus, synthetic biology offers the prospect of the design and manufacture of biological organisms with properties that are selected and may supersede, and indeed entirely eclipse, those present within the natural order of things. As pioneer Drew Endy of Stanford University sums it up in the *New Yorker* in a masterly epitome of both enthusiasm and soul-searching: "It's scary as hell. It's the coolest platform science has ever produced, but the questions it raises are the hardest to answer."

The past generation has witnessed the slow emergence of a fragmented science and technology policy agenda that bears assorted labels, most notably nanotechnology, neuroscience, artificial intelligence and now synthetic biology—often captured together in the tag 'converging technologies'. Convergence entails, among other things, an emerging commonality in the policy and ethical agenda that, increasingly, is seen to mirror technological development and that has come to haunt the more reflective scientists involved. That is to say, if the question is the reengineering of human life to give members of *Homo sapiens* new capacities, it may be secondary whether the process comes about through nanoscale engineering of neuroprosthetics or mechanisms of biological design.

Our culture is presented with what the lawyers would call a case of first impression. Although we have flirted since the advent of the nuclear age with the possibility of destroying ourselves, never before has the species faced the option of reinvention to order. And pressing attendant questions emerge: where is it that such a conversation should be located? How should a species make such a choice (assuming, of course, that there is a choice to be made)? While politics is focused on so many (other) issues of immediate moment, how are leaders to frame issues that seem so far ahead, fraught with uncertainty, yet gargantuan in their import? These are matters that should keep us awake at night—both leaders in science and technology and those in government and wider culture. And certainly not just in 'ethics'.

A big downside of the coinage and institutionalization of 'bioethics' has been the addition of yet another silo to public culture and policymaking, in which disaggregated units of conversation make all fundamental problems harder to tackle. If ethics bodies are to have a role in framing our conversation about the human future, they will need a new level of integration with a newly focused policy apparatus. 'Bioethics' as a public policy phenomenon has tended to offer a way of shunting issues off, not onto, the policy agenda. Yet in the democracies, policy represents an ineluctably ethical enterprise. Like it or not, practical ethics is the daily domain of the policy community.

Like nanotechnology, which has drawn a good deal more recent attention, synthetic biology offers a door to possibilities beyond our imagination that could flow from present, useful and relatively modest achievements (such as the development of new drugs). Like the genetics on which it builds, itself still stained disturbingly by the eugenics that shaped its past in the early twentieth century, synthetic biology offers the prospect (distant, but acknowledged) of designer choices by some humans in respect of others. The *New Yorker* illustrates its article with a full-page

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picture of a couple building their child from blocks of Lego.

Of course, it is not as if no one at all has been noticing. The lead synthetic biology critic as yet has been the memorably named Canadian 'Action Group on Erosion, Technology and Concentration' (ETC Group) that is active in international nongovernmental organization circles and made its name pressing for a nanotechnology moratorium. Its 2007 report is entitled "Extreme Genetic Engineering"[2]—a coinage that could misfire in a nation given to enthusiastically embracing 'extreme' sports and makeovers. I carried around a copy of the report during a visit to a leading synthetic biology lab, and, as I had hoped, it handily sparked some conversations. As research supports the commonsense view that how issues are framed has a lot more to do with how people assess new developments than we might wish, the question "who brands the conversation early?" is a vital one.

There were plainly no branding consultants present at the naming of synthetic biology "synbio", or the homonym would never have been allowed. In religious America, 'SinBio' might just catch on as the label 'Frankenfood' has in gourmet Europe—in an informal branding exercise that, for better or worse, has severely hobbled the spread of genetically modified (GM) crops. One of the lessons Europeans learned from the GM furor was to encourage 'upstream' discussion of emerging technologies, and get the critics to make their points early—so they can be either heeded or disputed, and help create a more mature public grasp of what is at stake. In the United States, despite wide agreement that the ELSI program (funding ethical, legal and social issues arising from the human genome project) was either a success or, at worst, a harmless investment in risk management, the two more recent big centers of controversial gravity—nanotechnology and now synthetic biology—have had far less generous (far-sighted?) attention.

There are three basic dimensions to the policy and ethics questions raised by synthetic biology. First, there is risk—essentially the issues raised by any technology: specifically, if something goes wrong, or, alternatively, if *someone* goes wrong. In the 9/11 century, haunted as we are by the prospect of retail weapons of mass destruction, what new capacities might synthetic biology put into the hands of smart dissidents—not least, in the context of 'open wetware'? The recent news that a scientist at a leading European research facility has been charged with Al

This cartoon and an article appearing in the pages of the *New Yorker* magazine this September signaled the arrival of synthetic biology in the intellectual mainstream, if not yet in the wider public's consciousness.

Qaeda involvement underlines the nontrivial nature of this anxiety. But what of innocent miscalculation, in a synthetic biology version of the risk scenarios discussed by Bill Joy in his provocative *Wired* essay "Why the future doesn't need us"[2] or, on the other side of the Atlantic, Sir Martin (now Lord) Rees's 2003 book *Our Final Century*[3] (set breathlessly before the US public in the less credible guise of *Our Final Hour*)?[4]

At the heart of the risk discussion lies the problem of uncertainty as to what future developments will arise, and the lack of any consensus as to the level of risk that the public is prepared to tolerate. People tolerate high levels of road fatalities as the price for the motor car's contribution to freedom of movement, but they expect essentially risk-free air travel and public transportation. Where on the spectrum will transformative technologies lie?

Second, there are concerns as to legal and non-accidental uses, especially by governments. This represents a subset of a vast and neglected question, as year-by-year technological advances place greater powers in the hands of governments—both over their citizens and to deploy in pursuit of security and other ends in the wider world.

And third, what are the implications of these new manipulative possibilities for the human future? How do they apply both in the design of individuals and to the shift in the nature and scope of the human experience and lifespan?

So what to do? As with nanotechnology, synthetic biology offers an entire arena of possibilities that complicate the policy discussion—and any approach to establishing norms, whether through regulation or otherwise. This is important as suggestions emerge for a similar approach to that of the storied 1975 Asilomar conference that faced head-on the implications of recombinant DNA and was key in building awareness of ethical and risk issues into the development of the technology—while mitigating public concerns as to its misuse.

So it is not possible simply to suggest a new Asilomar, although something like it—on an international scale—would take us a useful step down the road. What is required in parallel is continual capacity-building in the key agencies handling both technology policy and its ethical and social dimensions—within individual jurisdictions, and also within the relevant multilateral agencies (intergovernmental organizations). Such capacity building is especially important with respect to the public communications functions of these organizations and their engagement across both scientific disciplines and individual departments of government. The ELSI parallel also is useful, although the synthetic biology conversation needs to generate the kind of social and ethical discussion that ultimately shapes all policy and is too consequent to be shuffled off into an 'ethics' silo or simply contracted down through grant mechanisms into individual research efforts. On the global scale, the United Nations Educational, Scientific and Cultural Organization (UNESCO) Universal Declaration on Bioethics and Human Rights[5] offers a useful, if modest, point of departure; for the key to human engagement with the technological wonders of the twenty-first century is likely to lie in our classic concerns for human rights and dignity—always with an eye cast over our shoulders at the shadow of eugenics that so besmirched genetics a century ago—as we ponder our embrace of the new powers that we are being offered.

1. Specter, M. A life of its own. Where will synthetic biology lead us? *The New Yorker* 28 September 2009, 56.
2. <http://www.wired.com/wired/archive/8.04/joy.html>
3. Rees, M. *Our Final Century: Will the Human Race Survive the Twenty-first Century?* (Heinemann, London, 2003).
4. Rees, M. *Our Final Hour: A Scientist's Warning: How Terror, Error, and Environmental Disaster Threaten Humankind's Future In This Century—On Earth and Beyond* (Basic, New York, 2003).
5. <http://unesdoc.unesco.org/images/0014/001461/146180E.pdf>

Moving ahead but with greater controls

Arthur Caplan

A robust societal commitment to synthetic biology promises to yield all manner of benefits—the creation of adequate sources of cleaner fuels, the reduction of carbon emissions, the production of more and cheaper food, the identification of more efficient ways to create medicines, more fresh water and the building of bugs that will attack pests and pestilences that do so much harm to plants, animals and us. Indeed, according to some practitioners of synthetic biology, it is only our hubris about our own genome and ignorance of the microbial world around us that keeps the field from occupying center stage in the debates over where the biggest breakthroughs are most likely to occur in the coming decades.

So how could anyone play the role of ethical spoilsport when we have the means to solve our most pressing problems almost in our grasp? Still, some say no to the apparent Eden that lies before us if we will only permit microbial tweaking to energetically commence. Apparently immune to the huge promise invoked for synthetic biology, they counsel against moving forward with the creation of novel, designer life forms. Synthetic biology has engendered a bit of a moral backlash built mainly around the idea that it is not our place to make new life forms.

Some worry that engineering life is an activity that ought not be pursued because it is not appropriate for any power other than the divinity to engage in creation. Such concerns, however, are not likely to curtail synthetic biology. Nor should they. The issue of novel creation and humankind's role in it was settled long ago. There has simply been too large an impact on the constitution of the earth's living beings resulting from human intervention—tangerines, passenger pigeons, roses, collies and Louise Brown (the world's first test tube baby), among others. No major religion is opposed in principle to humanity trying to alter the natural environment. It is mainly secular critics of synthetic biology who invoke the divine in expressing ethical anxiety about synthetic biology.

Given its promise, synthetic biology should not be derailed by talk of the danger of 'playing God'. Scientists stuck writing grants year after year to continue their synthetic biology research do not see themselves as divine beings. And they are, as scientists, deadly serious rather than playful about extracting benefit from synthetic biology. The degree to which synthetic biologists are 'playing' when it comes to creating new life is tiny.

So, if metaphysical cautions are not going to derail things, is there nothing to worry about from the point of view of ethics and public policy as scientists begin aggressively manipulating viruses, bacteria, algae and other microbes to suit human purposes?

Once God is sent to the ethical bench, some serious sources of worry emerge—not serious enough to stop synthetic biology from moving ahead, but sufficient to warrant answers before the field goes much further.

Two worries in particular stand out. First, can we be sure that whatever is made will stay where its creators want it to? And second, can we be sure that those whose aims are malevolent will not gain access to techniques for designing life that could do enormous harm?

There is very little about the history of human activities involving living organisms that provides confidence that we can keep new life forms in their place. We do not have the national or international oversight and regulation requisite to minimize the risk of the creations of synthetic biology causing harm by showing up uninvited owing to accident, inadvertence or negligence. People have been introducing new life forms for hundreds of years into places where they create huge problems. Rabbits, kudzu, starlings, Japanese beetles, snakehead fish, smallpox, rabies and fruit flies are but a short sample of living things that have caused havoc for humanity simply by winding up in places we do not want them to be. Sometimes, those involved in creating new life forms have accidently lost track of the animals, insects or plants they were working with, as happened with the introduction of 'killer bees' into South, Central and North America. And in other cases inadequate attention to oversight allowed life forms to escape and wind up in places they were most certainly not wanted, such as the appearance in the food chain of genetically modified 'Starlink' corn containing the insecticidal Cry9C protein unapproved for human consumption.

A huge problem that has not been adequately addressed is what standards of control should govern the creation, introduction and release of novel life forms. Should there be specific restrictions on the kind of life forms that can be engineered so as to minimize threats to human, animal and plant health? Should synthetic life forms be engineered when possible to use a different amino acid code from 'natural' organisms or to expire after a finite period of time (an idea pioneered by Monsanto (St. Louis) with genetically modified seed containing terminator genes, which proved controversial as a way to protect intellectual property)? And if these rules are articulated, which agencies will have clear responsibility and authority for enforcing them? And can enforcement be made uniform, coordinated and transparent?

Not only is there a lack of agreed-upon regulations and regulators in place to help manage the products of synthetic biology, few provisions have been made to ensure that the techniques involved or the knowledge generated do not fall into the wrong hands. In an age of terrorism and bioweaponry, that may not be ethically sound public policy.

With the appearance of the nuclear bomb at the end of the Second World War, great efforts were made by the United States and other nations to keep secret the knowledge of how to create these deadly weapons. International organizations sought treaties that would control the proliferation of these weapons and even attempt to place the creation of some forms of weapons off limits. National restrictions were placed on who could work on nuclear weapons and what could be published about them. None of this has been done for synthetic biology, despite the potential danger posed by the creation of weaponized microbes, germs and viruses that might be engineered to decimate our food supply, poison our water or cause pandemic horror in human populations.

Both environmental control and protections against misuse merit more attention than they have received. International coordination is essential if the public is to feel comfortable that both matters are being managed. Neither poses an insurmountable obstacle to the advancement of synthetic biology. But a failure to vigorously attend to both could set the field back just as the promise of synthetic biology, if somewhat over-hyped, is ready to deliver much good.

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