Special Section: Synthetic Biology: Ethical and Philosophical Challenges

Finding Hope in Synthetic Biology

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Abstract: For some, synthetic biology represents great hope in offering possible solutions to many of the world's biggest problems, from hunger to sustainable development. Others remain fearful of the harmful uses, such as bioweapons, that synthetic biology can lend itself to, and most hold that issues of biosafety are of utmost importance. In this article, I will evaluate these points of view and conclude that although the biggest promises of synthetic biology are unlikely to become reality, and the probability of accidents is fairly substantial, synthetic biology could still be seen to benefit humanity by enhancing our ethical understanding and by offering a boost to world economy.

Keywords: synthetic biology; ethics; consequentialism; hope; invisible hand; biosafety; biosecurity

Synthetic biology has been advertised as the Nth industrial revolution that will, eventually, revolutionize life as we know it and bring about an era of sustainable development based on the systematic exploitation of biological resources.[1] The ethical questions that arise from it are numerous, but, for the most, these are issues that have been discussed with each new emerging technology. What are the potential benefits and how likely are they? What are the risks and how likely are they? How are the potential benefits and harms distributed? What are costs? Are biosecurity and biosafety adequately addressed? And for those with deontological leanings, the questions of boundaries not to be crossed and the limits of human interference are again important.

Although genetic engineering makes it possible to cross boundaries between species, synthetic biology takes this even further and blurs the lines between life and non-life; nature and artifact; organic and inorganic. This is ethically and philosophically interesting, and possibly problematic, as, conceptually, we are accustomed to thinking that there is more value to living, as opposed to not-living, entities. In this article, I will look into the idea of value in life in some more detail and argue that blurring the boundaries might actually be good for our ethical understanding.

Another difference between genetic manipulation and synthetic biology is that whereas genetic manipulation works within the perimeters of biology, synthetic biology approaches biological systems from an engineering point of view. This novel perspective opens biological systems to human design and, in theory at least, to countless applications. Quite another question is whether biological entities will ever conform to the principles of engineering. It is impossible, for the time being, to know whether synthetic biology will fulfill any, some, or all of its promises and which, if any, of the risks will actualize. Although it seems that it is more likely that something will go wrong before the scientists get it right, in what

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follows, I will argue that the mere promise of synthetic biology is of value and can contribute to human well-being.

In this article I will take synthetic biology to be (1) the design and construction of new biological parts, devices and systems; and (2) the redesign of existing, natural biological systems for useful purposes.[2] This is a definition given to synthetic biology by an open network of individuals, groups, and institutions working in the field. Interestingly, this definition also seems to include much of the work done in genetic engineering.

Synthetic biology comprises several disciplines and approaches; however, distinguishing among them is not necessary for my purposes here. In this article I will be talking about the field as a whole. I will start with a critical look at the promises associated with synthetic biology. I will give various reasons to doubt that the wildest visions will ever become a reality. I will then spend some time on looking at synthetic biology from a consequentialist point of view before discussing the suggestion that synthetic biology threatens the "value of life." Although, in my article, I give various reasons as to why synthetic biology should proceed with extreme caution, I will conclude by suggesting that there are two positive outcomes to the enterprise. First, by forcing us to scrutinize "values in life," synthetic biology deepens our ethical understanding. Second, by giving us hope of a better future, synthetic biology could offer a boost to world economy.

Fix to an Imperfect World

There is much hype around synthetic biology because of its virtually unlimited potential. It could revolutionize food supply and bring an end to hunger. Much of the nutrients could be synthetically produced and crops could be designed to produce bigger yields and be able to grow in harsh conditions. In the field of healthcare, the possibilities are, again, endless. Malfunctioning biological systems could be fixed; organs, bones, skin, limbs, and joints synthetically grown; and cheap synthetic medicines developed. This would significantly reduce the suffering caused by illness and injury, and perhaps one day, we could overcome aging. Synthetic biology could also revolutionize fuel production, as we might be able to move to renewable fuel sources and there would be enough energy for everyone forever. Also, it is hoped that nature could be saved and pollution reversed. Synthetic biology is sometimes marketed as the solution to most of the problems currently undermining human well-being. Or as one synthetic biologist put it: "Redesigning life: Fixing God's mistakes."[3]

All the items listed are potential applications and possible consequences of synthetic biology. For the time being, it is impossible to know which, if any, will be actualized and to what effect and degree. A further issue is that even if synthetic biology is able to deliver all its wildest promises, it is questionable whether this will mean the end of hunger and reduced suffering for all. Additionally, and against the utopia sketched in the foregoing, possible accidents and deliberate misuses of synthetic biology could lead to localized or even global disasters that would preempt the positive consequences.

Then, there are the issues of monetary cost, distribution of benefits, and political will. If synthetic biology is offered as a fix to world's problems, there are arguably other ways that would achieve many of the goals set more quickly. Redistributing wealth and resources, recycling, and taking decisive action against pollution

would arguably reach many of the goals far more quickly than waiting for the applications of synthetic biology to become available. However, there is no political will for such redistribution, and it is conceivable that the economic structures, built around the idea of perpetual growth and virtual money, could collapse with any major reorganization, thus simply to another type of disaster. And if there currently is no political will strong enough to make sure that goods are distributed fairly, there is no reason to assume that the possible benefits of synthetic biology will come to benefit everyone either. The most likely scenario is that the rich will reap the benefits, if any, and that there will still be hunger and unnecessary suffering among the less fortunate.

Then again, it is uncertain whether synthetic biology can ever live up to the hype. We are far away from the applications listed here and it is uncertain whether we can ever harness nature to do exactly what we want it to do. The biological systems could just turn out to be too complicated to be fully controlled; they interact with other systems, evolve, mutate, and reproduce. It seems that the more we learn, the more we realize how little we now. The genomes of organisms are constantly modified as a result of extragenomic factors,[4] and the function of individual genes depends on the functions of the surrounding genes. An organism that seems to work flawlessly in the controlled setting of a laboratory could do something totally different in an uncontrolled environment. The problem is that "synthetic organisms developed from genetic components do not always have predictable properties—at least not yet."[5] And we cannot know whether they ever will.

There is, however, a way in which synthetic biology as an idea can be seen to benefit humanity. As noted earlier, the world's economy revolves around the idea of perpetual growth and virtual wealth, but the looming shortage of natural resources and the limits of growth are causing financial crises, which always hit the worst off the hardest. One does not have to fully buy into Adam Smith's idea of an Invisible Hand[6] to see that when the world economy is thriving, even the worst off have a better chance of improvement in their conditions. This is where the idea of synthetic biology could be useful. If the markets start believing in synthetic biology, if they come to believe that sometime in the near-ish future, we will have unlimited renewable energy sources, synthetized food, better crops, better treatments, and cheaper medicines, this will boost the world economy and could potentially benefit everyone. Although I share the skepticism of many philosophers, social scientists and synthetic biologists themselves and think that much of the hype around synthetic biology is unfounded and that the likelihood of any major applications in the near future is low,[7] I would tend to think that believing in synthetic biology could a good thing. It would allow the economies to grow and buy us some more time. If synthetic biology is unable to fulfill its promises, by the time scientists figure that out, humanity will have probably come up with some other promising innovation.

Consequences, Risks, and Benefits

Much of the ethical discussion on synthetic biology centers around the possible outcomes: What are the possible benefits and what are the risks? Against these consequentialist analyses, it has been argued that the biggest problem of these debates is that no one really has any idea what the long-term consequences of

synthetic biology are, and, therefore, that speculating about the overall outcomes is ultimately pointless. However, this does not have to mean that consequentialism is useless in assessing the short-term consequences, just that it cannot aid in deciding whether synthetic biology as a whole is an ethical or an unethical enterprise in the long run.[8] Many contributors consider the uncontrolled self-replication and the unintentional spreading of synthetically modified organisms as the biggest threat, whereas others are more concerned with the deliberate misuse of synthetic biology by terrorist groups or other maleficent parties.[9,10] Biodesigner-hackers, private individuals working on synthetic biology, are seen both as an exceptional resource and as a huge risk. Their talk of life in the language of "hardware" and "software" seems to imply that, perhaps, not all of them have adequate understanding of how complex the biological systems are and how much is still unknown about their interconnectivity and interaction with the surrounding environment. This indeed provides fertile grounds for unprejudiced new ideas, but it could also easily lead to disasters if the created synthetic organisms are released and start reproducing and having untoward effects in their surroundings.

In terms of reducing the risks of synthetic biology, both biosafety and biosecurity are of the utmost importance. In institutional research projects, safety can be regulated and monitored; however, accidents can still happen (unforeseen consequences, system malfunctions, and human errors) and there is always the possibility of intentional breaches. However, with regard to individual entrepreneurs, whose intentions can be benevolent, neutral, or malign, there is precious little that can be done in terms of control, and this is even more so when it comes to malevolent governments and other bodies operating outside the law.

There is huge potential in synthetic biology; for the time being, however, it seems that it is more likely that something will go wrong before any of the actual benefits, if any, are seen.[11] In order for us to design and create stable biological parts, devices, or systems to perform particular useful functions, we need to learn a lot more about the function and interaction of genes, biological systems, and the environment. Conversely, one does not need to know that much to be able to create unstable organisms that behave in unpredictable ways.

Synthetic organisms that are accidentally, thoughtlessly, or with malevolent intent released to the natural environment are, as I see it, the biggest threat that synthetic biology currently presents. Combatting this threat is not easy. As for the accidental and thoughtless releases, one would hope that the synthetic biology community will remain respectful of how little is known, and wary of the risks of releasing modified organisms to nature. This way, one hopes that the biodesign hackers and other players in the field will be more likely to stay mindful of the risks and adequately appreciative of the complexities of nature. The malevolent parties are, and will continue to be, a problem. Synthetic biology know-how is available and it can be made use of by the benevolent and the malevolent alike. Already in 2002, a group of scientists managed to put together an infectious poliovirus from pieces of DNA ordered online.[12] And whereas synthetic biology is difficult, and it would be difficult to design and create new bioweapons, unfortunately it is still easier to cause harm than to construct beneficial applications. The latter need to be reliable, stable, and have exactly the needed properties, but when the aim is destruction, a few unforeseen side effects might not be such a big problem.

Life and Value

On a more conceptual, and perhaps even spiritual, level, the move from manipulation to creation has been seen as potentially undermining the value of life. The idea of looking at nature as a blank space to be filled with whatever we want is thought to threaten our inclination to see life as something with value.[13] In a similar vain, blurring the boundaries between life and non-life; nature and artifact; and the evolved and the designed; as well as the possibility of patenting life forms, are thought to be problematic.[14] What this boils down to is the question: Is there value in life in itself, as we now define it, or is there something in life that is of value? If we are open to the idea that there is something *in life that is of value*, rather than *life itself being of value*, then synthetic biology does not necessarily jeopardize that value. In this case, we would need to define more specifically what it is in life that we value and then use this criterion, or criteria, to assess any entity, whether evolved or designed, to see whether it has value. The origins need not matter, just the attributes. One would assume that these could include, for example, esthetic components, role and function, capacity to reproduce, spontaneity, movement, ability to feel pain, and self-awareness. However, what exactly those attributes would be, is a discussion that is only now starting and, therefore, beyond the scope of this article.

This is certainly not the first time that scientific advances have forced us to redefine objects of value. For example, the beginning and the end of human life (that is of moral value) have been, and still are, subjects of heated debates. At what stage does an embryo come to possess full human moral worth and how much of the brain function needs to be lost before the being with moral worth is gone? And are these the right questions in the first place?

It seems that synthetic biology will take us to gray areas not unlike the ones we are dealing with at the beginning and at the end of human life; questions about defining life that is of moral worth or value. There are complicated conceptual and ontological questions about life, moral worth, and value that synthetic biology forces us face.[15] And I agree with those authors who think that this might undermine the value of life in itself; however, unlike those authors, I do not see that as an unwelcome development. By compelling us to look at the attributes of value in life more closely, we might actually come to value those traits more and, more importantly, perhaps come to recognize those qualities elsewhere and thereby expand the scope of valued objects.

The idea that something has (more or less) value simply because it belongs to a certain, more or less artificially defined, group seems to be a part of the human psyche. However, here and there, we have come to realize the flaws in this kind of thinking. We have come to understand that being, for example, a white heterosexual male does not make one more valuable than being, for example, a black lesbian female. The amount of pigment on one's skin, one's sexual orientation, and one's gender are morally irrelevant categories. Perhaps life, purely and in and by itself, as it is now defined, is similarly morally irrelevant and it would, therefore, be important to study where the values in life lie. As we learn more about the attributes of value in life, we can move on to expand the range of valued entities. What I mean here is something that resembles the increased attention given to animal welfare because of a more defined understanding of morally relevant features. As we have come to realize that it is not simply about being a human

rather than a nonhuman animal that endows one with certain moral worth, but rather that the value comes with certain characteristics, such as an ability to feel pain and self-awareness, we have started to pay closer attention to animal welfare. With a more solid understanding of what is of value in life more generally, we should be able to see which of the creations of synthetic biology have value and we might bestow such value on parts of the inorganic world as well.

Conclusions

The ethical issues of synthetic biology will be with us for the years to come. Much emphasis on biosafety and biosecurity is needed, as the consequences of synthetic biology remain largely unknown. It is to be hoped that scientists and other people working on synthetic biology projects will remain cognizant of the complexity of biological systems and respectful towards the power and unpredictability of nature. Without reading any theological meanings into the idea, I would think it is fair to say that synthetic biologists are, when creating new life forms, metaphorically "playing God." I am not saying that there is anything wrong, as such, in playing God, only that those playing God should be aware of the massive consequences that their actions might have. They are crossing boundaries that can, according to the argument, be acceptable if you happen to be an omnipotent and omniscient being, but that can be dangerous in less proficient hands.[16,17] This means making sure that people working with synthetic biology have adequate understanding and have considered all the implications before pressing forward. This is not the time or the place for arrogance.

As I see it, no matter whether the synthetic biology project succeeds or not, it is beneficial on two accounts. First, conceptually, synthetic biology challenges the simplistic assumption of reducing value to life. Synthetic biology gives us an opportunity to reassess and reevaluate our conceptions of life and the notions of value attached to it. This will deepen and enhance our ethical understanding. Second, the mere existence of the promises that synthetic biology holds could give a substantial boost to the struggling world economy. The hope of continuous sustainable growth is what is needed to keep the wheels turning.

Notes

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