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Is There Anything Unique in the Ethics of Synthetic Biology?

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ABSTRACT Synthetic biology does not create any ethical dilemmas that have not already been raised in the development of practices such as genetic screening, genetic engineering, and other interventions in the evolutionary processes. The issue is, nevertheless, ethically serious. Two different angles are examined: the philosophical legitimacy of human intervention in the shaping of human nature, and the more pragmatic (though by no means less important) question of the risks involved in such a novel line of research. As for the first, the claim made here is that in principle there is no constraint in human intervention in the world, since ultimately the source of any value lies in human interests, welfare, and values. This is an approach that is opposite to Habermas's. As for the practical problem of risk, research in synthetic biology calls for particular caution, since in at least the first stages of a new research or program, there is no social regulation, and society is wholly dependent on the scientist's ethical integrity.

THIS ARTICLE OPENS WITH A DISCLAIMER: I am not a scientist, and the science of synthetic biology is beyond my comprehension. I am a philosopher and an ethicist interested in moral issues in reproductive medicine. In my past research I have raised theoretical questions about the normative constraints on the creation of human beings, especially in the context of the debates on genetic screening and genetic engineering, on both the individual level and the collective, namely that pertaining to the intervention in the human genome.

Moral norms usually apply to our relations with other human beings. The questions of reproductive medicine are problematic, since although they relate to

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human beings, these human beings are not around yet—that is to say, the question is not how to treat them, but whether to bring them into life at all. Now, with synthetic biology, we are doubly removed from standard ethical frames of thought: the potential life that is considered is not only nonexistent yet, it is also not human. We are talking here of life in a much more rudimentary form than that of complex organisms like humans. Even though there is a passionate debate about the moral standing of future, potential human beings, there is no argument about the moral standing of small organisms such as bacteria. They simply do not have such a standing. Their value is completely instrumental: they can either benefit us or harm us (or have no effect on us either way).

So what is the ethical problem in synthetic biology? As I understand the research project, it concerns attempts to apply principles of design to produce new biological entities or organisms, using modules or BioBricks. Since 2010, we have acquired the ability to create a living bacterium that is self-replicating and based on a synthetic genome, that is to say a bacterium that has not existed and *could not have existed* without human interference. To some people, this could be the starting point for a critical warning against the practice of synthetic biology. Actually, it is two-staged: first, there is something wrong in interfering with natural processes and creating entities that nature has not as a matter of fact created by evolutionary means; and second, there is something even worse in creating an entity that nature could not have created in principle. The former kind of interference is milder, since it only hastens or facilitates certain natural processes in ways that are typical of many standard medical interventions. The latter, however, is a radical form of human interference with natural processes since it introduces completely novel factors into the world. These are "un-natural" in the sense that only the human mind could devise and design them. It is reminiscent of human artistic creation which could never in principle be achieved by merely natural processes: a Shakespeare sonnet could never be "written" by a monkey, let alone by the natural movement of physical particles in the world.

The core of the ethical issue involved in synthetic biology can be articulated in terms of the distinction between the natural and the artificial. Human beings are both natural products of natural causes and processes as well as artificers, creators, and inventors. Civilization is essentially the expression of the non-natural creative power of ideas and material objects that could never have existed through purely natural evolution. This applies to wheels, dams, agriculture, paintings, and philosophical or scientific ideas. Indeed, some of these products of civilization do not touch upon natural processes in any significant manner (like a Beethoven symphony), and some do so only to this or that degree (like the diversion of water by a canal system, or the nuclear pollution of the planet).

There is a general tendency to view the distinction between the artificial and the natural as fundamental to our world view. This implies that we keep the two apart. When human activity (such as art or science) is completely naturalized, it loses its meaning and value. Art is by definition artificial. Conversely, once the

artificial dominates the natural in some substantial degree, we become uneasy. But why? The best expression of this uneasiness is religious in its rhetoric: it is often articulated in terms of "playing God" (Heyd 1992). It relates to the line between the artificial and the natural in normative terms, viewing the path from one to the other as *transgression*, or crossing a line that in some sense is sacrosanct and deserving of respect. The line between nature and artifice does not apply to God. The act of creation is at once the ultimate grounds of what is considered as "natural," yet it is also the purest of artifices, since the world and the laws of nature are created ex nihilo, with no natural preexisting material at the disposal of its creator.

But this may exactly be the reason for the implicit prohibition on human beings' blurring the dividing line between artifice and nature. Trying to create something out of nothing is a divine prerogative, and a human attempt to emulate God is perceived as unacceptable hubris. Although human beings are the only artificers in the world, they should recognize that they are bound by the limits of their own natural place in it. In non-religious language, human beings, with their power of creation, are the product of a long process of evolution rather than its masters, and they should stay so. The recently developed genetic technologies (including cloning and the power to tamper with genes) constitute the most serious challenge to the natural-artificial distinction. Extending, as they do, beyond all the technological achievements of humanity in the realms of agriculture and industry, these practices are understandably considered as typical forms of playing God or interfering with the fundamental structure of nature. They open the question of the permanence of human essential nature, of that which makes us universally what we are.

Creating life de novo seems to entail a deep kind of interference with what is usually considered as a mystery or a miracle, the most remarkable part of divine creation or the unexplainable part of the history of the world's evolution. This is why synthetic biology is facing the public challenge that it is a transgression of legitimate boundaries. However, we must examine carefully the adverb "de novo." As far as I understand the science of synthetic biology, it is not life itself that is created out of nothing, but "only" the genomic arrangement of living organisms. Indeed, synthetic biology aims at creating new *forms* of life, but it does not presume to create life out of "dead matter." Aristotle believed that biological species were eternal and fixed, but Darwinian evolution demonstrated that this view is false, and that species are gradually formed and are bound to disappear in a long process that cannot be predicted. Modern genetic science is a further stage in this ongoing process, a stage in which humanity has some power over the forms of life that are to exist.

It is not easy to articulate the grounds for prohibiting such radical life changes as those involved in synthetic biology. Some philosophers of our age, most prominently Jürgen Habermas (2003), try to give a humanistically based, nonreligious justification for avoiding tampering with human life. His basic idea is that

human autonomy must ultimately presuppose some essential components that make us human, and that these cannot be tinkered with lest we lose our humanity. Even in what Habermas refers to as our "post metaphysical age," human beings remain responsible to themselves, and that includes treating themselves as persons rather than as things. We ought not deny future human beings the freedom to choose their own life plans by constraining their options through genetic means. Society should stick to some boundary line (albeit fluid) between the prevention of debilitating disease and pure enhancement. Others, such as Sandel (2007), focus more on the "givenness" of life and its particular natural form and argue that denying the limits of human design would necessarily lead to a complete change in the idea of human responsibility, both to future children and to the natural environment. The whole point of parenthood is an attitude of acceptance of the outcome of natural processes that are not fully controlled by parental choice and preferences.

However, I find both these lines of critique over the use of genetic technologies either invalid or at least irrelevant to the specific case of synthetic biology. The transformation of a bacterium by means of a synthetic genome by no means threatens the essential nature and life of human beings, at least not directly. In that sense, despite appearances, the practice of synthetic biology is less problematic from an ethical point of view than genetic technologies in human reproduction. One may put it this way: even if life is sacred, the supreme ethical value, it is only by being *human* life rather than simply biological life. In the same way and for the same reasons that we have no problem in destroying the life of organisms like bacteria by using antibiotics, so there is no moral obstacle to create completely new forms of living bacteria. It is true that without the life of small organisms human life would not have evolved. But that does not mean that the life of such organisms should be protected from interference or even destruction.

So in trying to deliberate about the ethics of synthetic biology, all we are left with is human interest: does this kind of biological research promote or undermine human welfare. Of course scientists are motivated by curiosity and by the urge to expand knowledge as an intrinsic value. But the research program also offers some good and bad potential to the quality of human life. It may be used to noble purposes like medical treatment, but equally to ignoble schemes of war and destruction. This brings us to the concrete and realistic discourse on the morality of synthetic biology. What are its predicted possible benefits?

Despite the scientifically dramatic nature of the most recent advances in synthetic biology, there seems to be nothing unique to it from an ethical point of view. It is true that the depth of human interference with natural processes is unprecedented, but it is not categorically different from that involved in current and future genetic technologies in human reproduction, or from that of nuclear physics that led to the creation of "the bomb." All scientific advances, from the invention of the wheel, are potentially double-pronged. It is true that in the current stage of research it is very difficult to predict both the benefits and the po-

tential harm of synthetic biology, but I believe it was similarly the case in the times of Watson and Crick in the 1950s, or in early 20th-century physics. Even in retrospect, we can say that it would have been quite fantastic to curb genetic research in the middle of the 20th century because of the risks of cloning or genetic engineering to human society.

This does not mean that we should be indifferent to the risks, some of them indeed extreme, of procedures we are developing in the laboratory today. For example, it is good moral and political practice to have a law prohibiting the cloning of human beings with the purpose of procreation (in contrast to therapeutic purposes), at least till the procedure and all its side effects are well understood. Similarly, to take up an example from Douglas and Savulescu's (2010) article on the ethics of synthetic biology, it would be reasonable in an extreme case to avoid publishing in *Nature* an article on cheap ways to produce synthetic viruses, if such a technology could be used by terrorist groups to bring calamity to humanity. I firmly believe that beyond the obvious and widely agreed principle of freedom of scientific research, the pursuit of knowledge is itself a social activity that must be ultimately bound to, or constrained by, social norms and values. Again, there is nothing unique to the project of synthetic biology in that respect.

The primary methodological and also social problem involved in the ethical regulation of synthetic biology research is that so little is known by scientists at this stage about the risks of the project. This implies that even much less is known to the public at large. Only with scientific advances in the field can the benefits and harms of the research be gradually revealed and better assessed. But the first to get warning signals about the risks are going to be the scientists, which lays a particular responsibility on them. They and only they would be able to approach society and inform it about the practical uses and abuses of synthetic biology. In the meantime, they will have to assume the role of self-regulators, as is often the case with cutting-edge research in science in the stages preceding legal regulation. But obviously, self-regulation is superior to premature social regulation which could curtail research in unnecessary ways. Society can regulate scientific or medical activity "in advance" in cases where values and human rights are involved (for example cloning, stem cell research, or sex selection for nonmedical purposes). These are cases in which the natural practice is well understood—together with the foreseeable benefit—yet moral values and principles serve as reasons for prohibiting it. But when we come to practices that can be judged only in terms of their benefit or harm to human beings, regulation is dependent primarily on empirical facts and probabilistic assessments, and in that case, regulation can be rationally based only on reliable data provided by the scientists themselves. Thus, the debate about abortion or stem cell research is a principled moral debate, in which scientists can be of only limited help; yet genetic engineering and synthetic biology are matters about which the debate is heavily dependent on scientific hypotheses and facts.

To conclude by returning to the fundamental distinction between the natural and the artificial, the very term *synthetic* exposes our ambivalence towards the distinction. In chemistry and pharmacology, for example, the ability to synthesize is considered an achievement. In contrast, in matters of taste the adjective *synthetic* has a markedly pejorative connotation. Hothouse tomatoes are stale; they have a synthetic taste. The implication here is that the natural is superior to the artificial. So are synthetic colors and artificial flowers. They are all treated with suspicion and reservation, since the "model" from which they derive is the natural specimen which is considered good in being natural (Heyd 2003). But to take our lead from the highly abstract but influential theory of the 18th-century philosopher Immanuel Kant, the ultimate core of human knowledge is synthesis, the bringing together of two different elements in a new way. This is a uniquely human function of reason that is categorically distinct from the natural aspects of being human (including genes, psychology, and the body itself). Now, "synthetic biology" could under these terms look like an oxymoron: for how can nature be synthesized? But of course Kant was speaking about synthesizing concepts and ideas, while we are concerned with the synthesis of natural components. However, in both cases synthesizing captures the essence of human creativity: on the one hand, the theoretical capacity to understand nature by means of making conceptual connections; on the other hand, the practical ability to combine in non-natural ways different elements in the natural world so as to form new entities. The promise of synthetic biology lies in both these theoretical and practical aspects.

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Discussion

MORANGE: You mention that today synthetic biologists are not creating anything de novo, or from scratch, as it is said; but if such an experiment was possible in the near future, do you consider that the ethical issues would be different and that maybe they require more discussion? That it would be really something different from scratch by a bottom-up approach?

HEYD: Yes. I think it would need a further discussion, because it would be one further step beyond synthesizing components which are already there. It would be really creating life in the most radical sense of playing God. Now,

if you ask me what I predict—my own approach—would be, I would say that, again, with certain constraints having to do with human interests, risks and benefits, I would endorse such scientific research, or even practices.

Yanni [Nevo] mentioned the book I wrote over 15 years ago, called *Genethics*, where I am not only dealing with genetic practices, but also with the idea of creation of human beings. I believe that we get the closest to God by parenting children, by creating children, because although it is not creating life ex nihilo, of course, from a scientific point of view, we are getting the closest to God in choosing to bring into life, or deciding the extent of life, at least on the human scale. . . . So in that sense I also interpret the "be fruitful and multiply" in the first chapter of Genesis, as the meaning of the image of God. I think there is potential creativity, biological-like parenthood, or reproduction; but also that creativity in general is the closer we get to creating something ex nihilo. . . . In principle, I don't see the reason why it shouldn't apply to life, which at this stage is a science fiction idea. But I think it would definitely, from a public point of view, be more difficult to justify, and involve another round of philosophical debates. Definitely.

Deichmann: Continuing here, you spoke of the creation of life ex nihilo, which comes closest to God, which is also the reason for many objections raised against synthetic life. But in history it has been different, I mean, since the time of Aristotle until the late 19th century, there was the assumption that life was constantly created ex nihilo from nonliving matter. So it was not only God who created life but it was assumed and adopted by the church and by rabbis in medieval times that there was a constant creation by nature of life from nonliving matter. From this historical perspective the idea that humans create life is just a continuation of something that people believed nature would do anyhow.

Heyd: In some sense I agree. But I think that's exactly the source of objection against presuming the role of either God, or—in your terms now—nature, by human beings who take upon themselves the very design of the world, or the creation of life. Philosophically and theologically the ideas are quite complicated, because Aristotle believed that all biological species, including us human beings, are eternal, that we have been here, around with the material world, from time immemorial, there was no beginning. So it's not true that there was ever, in Aristotle's case, dead matter out of which somehow miraculously life started, and that this creative beginning of life happens at every moment again and again. Soul and body, in the case of human beings, are synthesized . . . together in principle, from the very beginning of whatever . . . in fact I mean, there was no beginning. Life is eternal, like matter.

Deichmann: I don't know much about Aristotle, but I perceive a contradiction. Species were eternal and they didn't change, but on the other hand, according to Aristotle, primitive forms of organisms were constantly created.

HEYD: This is a different issue I think. If we take Aristotle, and the history of biology, what I'm questioning is the ethical meaning, or the philosophical meaning, of this fact. Or whether, as you mentioned yourself, there is transformation, or radical transformation, in human beings taking upon themselves, by technological design, to create new forms of life, thus expanding the universe in novel ways which were not dictated by the natural structure from the creation of the beginning of evolution, or whatever.

[Question inaudible]

HEYD: I think it's a very good and fair point that goes very deep into the distinction between the natural and the artificial, and it goes all the way down to our very existence. We are creatures who can interfere in human evolution. We can say we don't interfere, because we are ourselves the product of evolution, so that the interference with evolution is itself a part of evolution. Now this is a good point. It's a fine and central point, because it leads to a possible abolition of naturalizing all human activity. I think we have deep—regardless of synthetic biology and the ethics of that research program—we have a strong resistance to such a naturalizing attitude towards human creativity, because as I mentioned in the presentation, we find it very difficult to see a Shakespeare sonnet or Leonardo's *Mona Lisa* just as part of the explanation of nature, of the natural world.

[Question inaudible]

HEYD: You don't find any problem? You think that cultural products, like those of high culture, which challenge you in the most radical way, can be, let's say, explained in a scientific/natural way?

QUESTION: It's part of the human activity.

HEYD: It's part of the human activity, but what are human beings? I mean, human beings are not just natural creatures.

FALK: So foolish that we are not just natural. We invented ethics and God and all these things in order to be able to act socially.

HEYD: Well, that's quite a creation.

FALK: But that is natural.

NEVO: It doesn't mean that we can reduce the ethical to the scientific or the natural.

HEYD: Right. I think that scientific explanation will never give us an answer to the meaning of art or technology. I mean, it won't give us answers about the ethical questions themselves. Why not be honest?

QUESTION: Given it would be viewed as ethically unacceptable for a researcher to kill a lab animal for no other reason than kill a lab animal, and also given that the 20th century saw an increase of computational power between about

12 or 15 orders of magnitude, and that increase will rise across the 21st century, surely in some point in this century, we will be able to simulate fully at the atomistic quantum level a living organism. Once that organism is simulated, and it seems to be alive, and maybe even capable of self-replication or mating or reproduction, what ethical constraints do you think will be put on the simulator, the creation of the simulation?

Heyd: I can only repeat what I said throughout the presentation and the discussion: I think the constraints would necessarily belong to human interest. Not only the narrow egoistic ones that belong to a segment in society or scientists or the political parts, but to humanity at large, and that includes of course future humanity too. But we come here to a very deep ethical question with regard to which I hold quite—let's say—a minority view. I don't believe we have ethical duties to the environment or to nature as such. I think that values, ethical duties, and rights all belong to human beings, and therefore, as I mentioned before, I don't think that bacteria and viruses and small organisms have rights, of life, or not to be killed, or not to be manipulated genetically. And in that respect I think we are free to conduct research of the kind of genetic engineering and synthetic biology. We should be extremely careful not to violate the rights and welfare of future and present human beings. And in that respect that should be the ultimate moral concern. And that's not a small matter.

Nevo: But this raises again the question you began with, and let me put it this way: are there at all presuppositions of ethical judgments, such that technological interference with them would or should be considered as taboo or prohibited, just because technological interference, perhaps technological interference with humanity or some kind in some way, would undermine the very possibility of ethics? Are there such presuppositions?

Heyd: You are absolutely right. If we leave things as they are, without interfering with evolution, including human evolution, there will be some day human species that will change or will be completely destroyed or change to such a degree that the biological circumstance would not uphold or support any existence of ethical relations. I don't see that in itself as intrinsically bad. I don't think the world is worse before humanity started to evolve. So there isn't any addition of value to the world once human beings started their existence, and there won't be any loss of value, once we are completely lost. Human value applies only as long as we are here. Big *we*.