The Ethics of Synthetic Biology: Outlining the Agenda

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Abstract

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The Ethics of Synthetic Biology: Outlining the Agenda

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Abstract
The projects and aims of synthetic biology raise various ethical questions, challenging some of our basic moral concepts. This chapter addresses these issues in three steps.

Firstly, we present an overview of different types of ethical issues related to synthetic biology by assigning them to three main categories: method-related, application-related, and distribution-related issues. The first category concerns the procedure and aims of synthetic biology, the second deals with certain planned applications of synthetic biology and the third with questions of distribution and access to procedures and products of this technology.

Next, we address a statement that is often raised in the discussion about ethics of synthetic biology, namely that the ethical issues of synthetic biology have been discussed in previous debates and therefore do not need to be addressed again. We argue that preceding debates do not render the discussion of ethical issues superfluous because synthetic biology sets these issues in a new context and because the discussion of such issues fulfills in itself an important function by stimulating thought about our relationship to technology and nature. Furthermore, given that synthetic biology’s aims go beyond those of previous technologies, it does in fact raise novel ethical issues.

Finally, we present opinions of European synthetic biologists on ethical issues in their field. At such an early stage of technological development, synthetic biologists play an important role in the assessment of their discipline, and are best placed to estimate the scientific potential of the field. In an attempt to capture the intuitions of the European synthetic biology community, we have carried out interviews, the results of which we briefly summarize in the last section. By presenting an overview of the various ethical issues in synthetic biology and their actual and perceived importance, this chapter aims at providing a first outline for the agenda for an ethics of synthetic biology.
Introduction:
Synthetic biologists aim at revolutionizing biotechnology, promising new benefits and the addition of new levels of comfort to modern society. However, this technology is also bringing with it potential for various associated risks and dangers. Its main objective involves the control, design and synthesis of living organisms, a goal that affects, among others, two delicate societal concepts: ‘nature’ and ‘life’. By disassociating these two notions more vigorously than any previous technology, synthetic biology challenges some of our deeply held values and intuitions on this topic. Similarly to other biotechnologies, its science and application also have various other impacts on society, raising a spectrum of ethical concerns.

1. Three types of ethical issues associated with synthetic biology
The emergence of a novel technology such as synthetic biology raises different kinds of ethical issues. In order to organize the discussion of these questions we have divided them into three categories: method-related, application-related, and distribution-related issues. The first category deals with the aims, procedures and methodologies of synthetic biology. The second category concerns the social impact that certain applications and products of synthetic biology may have in the future and the third category comprises questions of access and ownership. Application- and distribution-related issues can largely overlap between various coexistent emerging technologies. The ethical issues most specific and exclusive to a technology are usually those related to its specific aims and methodology. In the case of synthetic biology, one of the most interesting questions deals with the concept of living entities and the normative consequences that may follow from it. Comparison to previous and parallel ethical discussions are a chance to improve the ethical assessment of synthetic biology, but reference to them cannot replace the current discussion, since certain concerns retain their relevance over time and across different fields. The categorization into method-, distribution- and application- related ethical questions can be useful to compare issues and existing debates in different technologies. There are, of course, overlaps between the categories: the distribution of a synthetic biology product will generally be closely related to its specific application and
moral questions concerning life and living organisms will also be largely informed by the discussion regarding applications.

1.1. Method-related questions

Because it is a very heterogeneous field we cannot talk of *the* method in synthetic biology. Procedures as different as DNA-synthesis, metabolic engineering, chemical synthesis of protocells, computer modeling or synthesis of alternative nucleobases all are part of synthetic biology [1]. Whereas there are some technological overlaps between certain forms of synthetic biology with traditional biotechnology and chemistry the specific aspect of synthetic biology is its objective, which is also what in one way or another is shared by all approaches. Synthetic biology aims at creating or designing new forms of life, following a human ‘architecture’ and plan. This aim per se raises certain ethical questions related to the relationship between humans and other living organisms and the moral status of the products of synthetic biology.

*Artificial organisms*

So far, living organisms have essentially been products of nature, even when they have been modified by breeding or genetic engineering, their overall body plan and metabolism still follows the natural design resulting from evolution. The idea that humans can synthesize life following their own design establishes a new concept of life. The difference between living organisms and machines becomes more transient, given that machines are often characterized by an existence for specific purposes dependent on human design. These machine-like features would also be true for an artificial cell as it is aspired by some synthetic biologists [2, 3]. However, human beings can typically control classical machines during their entire existence and machines can arbitrarily be switched on and off, which would not necessarily be the case for an artificial cell. Such a cell thus has some but not all the features of a machine. On the other hand the ultimate artificial cell should be autopoietic, meaning that it would be able of self-organisation and self-production, which would be a classical feature of living organisms [4]. It therefore remains unclear, whether such cells can be considered ‘alive’.

Positions arguing that living organisms have intrinsic value are confronted with the question about the moral status of artificial organisms and the responsibility that the
'creator’ would have towards it. However, we should be aware of the fact, that to date, scientists are far from being able to build a real artificial cell, not to mention multicellular organisms, therefore such settings should rather serve as philosophical thought-experiments, than as a basis to regulate synthetic biology.

**Living machines**

The bioengineering branch of synthetic biology aims at making biology an engineering discipline by systematizing genetic engineering, based on standardized parts at the DNA level, which can be combined into modules, which again can be combined into metabolic pathways [5, 6]. In this context some synthetic biologists call their products ‘Genetically Engineered Machines’ as illustrated by the title of the annual SB-competition : iGEM (The international Genetically Engineered Machine competition http://parts2.mit.edu/wiki/index.php/Main_Page ). The analogy to machines is based on the previously mentioned inherent purpose as well as human design and control, which are characteristic for machines. A genetically engineered machine would be a living machine, an interesting entity raising the questions whether it is possible to turn living organisms into machines whether there is any fundamental difference between living organisms and machines and if so, what such a distinction would be based on and whether it could be lost. This leads to the question whether taking the attribute ‘living’ from any organism would change its moral status. The answer to this question depends on the attitude towards nature and living organisms and probably cannot be answered definitively. However, it is clear that in this context synthetic biology raises interesting questions with a potentially high social impact.

**1.2. Application-related questions**

At such an early stage of a technology, we can at best speculate about the potential impacts of its future applications. This incertitude implies, on the one hand the risk of discussions about exaggerated hopes as well as about unnecessarily bleak scenarios. On the other hand an early start offers the opportunity to accompany and influence the development of the technology and to avoid the often encountered scenario where ethical assessment lags well behind technological development. In the following we address three different fields of applications that could raise ethical questions:
Release of synthetic organisms into the environment for bioremediation

One goal of synthetic biologists is the synthesis of microorganisms that could identify contaminated areas or that could degrade pollutants in the environment [7]. However, beyond the obvious advantages of such a system, some problems need to be considered. In order to clean up polluted areas, microorganisms must be released into the environment. Since synthetic organisms, unlike synthetic chemicals can reproduce and evolve, there is a certain danger that after the degradation of the pollutant the microorganisms might persist, interact with, affect or displace endogenous species. The ethical question in this context concerns our dealing with the environment; it is not clear to what extent we are permitted to expose nature to such a risk and whether we have the right to interfere with the composition of the ecosystem in such a direct way. On the other hand, it can also be argued that the degradation of pollutants is not only an advantage for humans but also for all other organisms and the environment, leading to a tradeoff between risks and benefits for nature and society.

Synthesis of pathogenic viruses or microorganisms

It has been shown that de novo DNA synthesis can be used to produce pathogenic viruses [8]. Given that the synthesis of DNA is ever becoming cheaper this possibility enormously facilitates the access to such pathogens. Furthermore, it is possible that novel types of infective viruses could be designed and produced. This is a serious biosafety and biosecurity issue that has been addressed in detail [9, 10, 11]. It is perhaps safe to imagine that all stakeholders would agree on the need of regulation to prevent misuse. The question is how far this regulation should go. At which point is it discriminatory to control members of certain countries more rigorously than others on whether they are using ordered DNA sequences for permissible purposes? At what point is freedom of research compromised, when scientists are not allowed to build certain viruses or order certain DNA sequences? To what point can such a tightly controlled DNA synthesis system lead to an unjust monopoly of certain companies? Is the power that is connected to this regulation at the right ‘place’, is it distributed justly? Given that these issues have to be balanced against the safety and security of human individuals and populations, there
are strong ethical arguments in favor of tight regulation of DNA-synthesis but attention needs to be paid to making this regulation just and fair also from a research perspective. 

_Synthetic biology in mammalian cells_

Originally, synthetic biologists designed artificial pathways for bacteria and unicellular eukaryotes such as yeast. But this technology is increasingly also applied in human cells [12], which might for example enable novel applications in gene therapy. This development of the technology can raise ethical question, particularly if it is applied in human embryonic stem cells [13]. Theoretically, such stem cells could be used for reproductive technologies. These procedures could be ethically even more problematic than the hitherto discussed selection of favored embryos among several ‘natural’ embryos because on this track synthetic biology could lead into extreme forms of human enhancement. However, to the authors’ knowledge such applications are currently not seriously intended and it would not be reasonable to base an ethical assessment too much on such futuristic applications. Nevertheless, it is necessary to keep such scenarios in mind and observe the application of synthetic biology in human embryonic stem cells critically.

3. Distribution-related questions

Each new technology, especially one dealing with living organisms, brings with it risks as well as benefits. It is ethically relevant to address the distribution of these positive and negative consequences as well as the access to the technology and its products

_Regulation of intellectual property_

The access to biotechnological products is generally regulated by patents, which should protect the creative work of authors and stimulate progress in science and technology [14]. For the latter purpose patents should promote the access to scientific information by making it public. However, by conferring monopolies on certain information, or in cases of extensive patenting (as e.g. in case of gene patents) patents can restrict accessibility to important inventions and discoveries [15]. Furthermore, patents in traditional biotechnology have raised ethical concerns because products affect vital sectors such as nutrition and medicine [16]. Synthetic biology might tighten this situation. Furthermore, the patent situation is complicated by the involvement of many different disciplines
(biology, chemistry, computer sciences, engineering), which means that researchers may be restricted by patents from different sides. This is particularly problematic because there is a tendency to patent not only final products but also basic techniques and ideas [17]. However, e.g. the BioBrick foundation provides a large collection of standardized biological parts for bioengineering, which is available to the public free of charge (http://bbf.openwetware.org/). Such a ‘distribution strategy’ reminding of the open software model is an interesting alternative to a very tight patenting system as found in traditional biotechnology. However, at the level of commercialized applications and products, a tighter regulation of access might economically be required. The question of IP regulation in synthetic biology requires further analysis and discussion, not only from economical or legal but also from a societal and ethical point of view.

*Global divide*

Another concern raised by the distribution of synthetic biology is that of the global access to its products and the scientific knowledge accruing from the research. Will synthetic biology significantly contribute to widening the economic and infrastructural gap between industrialized nations and developing countries? On the one hand, it has been argued that the development of synthetic biology products might replace less efficient procedures of producing the same or comparable products by traditional methods in the developing world as e.g. in case of the malaria drug artemisinin [18]. On the other hand, we are dealing with the problem that developing countries might not have access to products of synthetic biology. This issue is particularly relevant for biotechnology in general and synthetic biology in particular, because synthetic biology products such as medicines and therapies, bioremediation products or renewable and cheap energy sources might help to solve some of the problems that particularly plague these countries. The synthesis of such products by living organism can be expected to be more cost-effective than chemical synthesis. Therefore, such an application could indeed become an important developmental tool for poorer countries. However, research and development in synthetic biology requires the usual cost-intensive biotechnological equipments, and scientific knowledge and training, which, so far, have mainly been clustered in prosperous nations. If no effort is given to enhancing the scientific and technological infrastructure of developing nations along with the development of such application,
synthetic biology may only serve to reinforce the dependency of poor nations on rich nations. Similar problems, alternatively known as the ‘digital divide’ or ‘nano divide’ are being addressed by commentators in information and communication technology or nanotechnology [19, 20]. The synthetic biology community, if committed to preventing a global synthetic biology-divide, can certainly profit from this work, and contribute towards addressing a problem that is still far from being solved.

2. Addressing the ethical issues in synthetic biology

In the previous section, we have listed a set of potential ethical issues that may be raised by synthetic biology. Next, we would like to address the question of how to deal with such concerns.

It would be wrong to expect that ethical issues can easily be solved and to everybody’s satisfaction. The conclusions of different ethical theories, religious convictions or other norms sometimes may be in agreement with each other concerning an ethical issue, however, often, opinions differ substantially, even if each theory is fully consistent in itself.

An interesting approach that allows considering different ethical theories as well as concrete moral judgments, is the wide reflective equilibrium. In order to arrive at a wide reflective equilibrium we need to work back and forth among our moral judgment and intuitions, principles and rules and also the theoretical considerations that we are supporting. The aim is to arrive at acceptable coherence among these beliefs by revising our moral judgments, principles and the background theories until they ‘fit together’. This method of justification allows representatives from different positions to develop their judgment regarding one particular case taking ideas of other positions into consideration. This notion that moral judgments and theories are revisable facilitates representatives of different positions to arrive at a similar conclusion although each of them justifies it in light of its own beliefs and theory [21].

The process of looking for moral judgments that can be shared by different positions is an important process that asks for the interaction of the different parties as it takes place in a multi-stakeholder approach for technology assessment. The discussions among the stakeholders should not be considered merely as a means to an end, but they may
themselves be one of the most important aspects of the ethical assessment. They allow society and the different stakeholders to deal with difficult problems that affect deeply held values and beliefs. Ideally, they offer a platform allowing a solid reflection on other opinions as well as adjustment of one’s own position. Misunderstandings and conflicts, which are sometimes simply based on disagreement in assumptions or premises, can be conferred.

2.1. These ethical issues have been discussed before

Some commentators claim that synthetic biology does not present any novel ethical issue. They say that our society is already living with various technologies and that technologies such as genetic engineering are already interfering with the ‘natural state’ of living organisms, in other words, they seem to imply that the similarity to previous technologies renders the discussion of ethical issues in synthetic biology superfluous [22]. However, even if these commentators were right in saying that synthetic biology does not raise any fundamentally novel ethical issues, it would still be sensible to encourage a discussion for at least three reasons. First, if we act on the assumption that positions or arguments may change over time, new circumstances may lead to a different assessment of the same arguments. History has shown that moral opinions can change. Second, while the theoretical debate takes place at a somewhat abstract level, actual ethical decisions are often heavily influenced by existing societal contexts. Ethical priorities may vary not only according to values and preferences but also according to needs. What may be optional or palliative in one context may be seen as obligatory or impermissible in another context. Third, as mentioned above, the purpose of ethical discussion is not solely to find solutions but the process of discussing is required to deal with difficult issues and refine positions. Questions about the value of nature and our role in it will probably (and hopefully) engage many future generations and will most likely not be answered once and for all.

Additional motivation for an ethical assessment of synthetic biology comes from ethical questions, which are indeed novel. As mentioned in the first section of this chapter such questions are particularly raised by the new approach and more extreme techniques of synthetic biology. Whereas in the domestication and breeding of animals or in genetic
engineering the intended alterations of an organism were based on specific traits or genes, synthetic biology starts from an integral approach with the aim to create something fundamentally new. Its goal far exceeds that of traditional biotechnology. Synthetic biologists not only want to adapt living organisms to human purposes, they aim at producing living machines or completely artificial organisms, depending on the approach. Therefore the extent of ‘technologization’ of the living world caused by synthetic biology will be larger and more systematic. The creativity of human beings is entering a new domain, and the differences between living and non-living are getting further blurred. Therefore, the scientific characteristics, which, according to experts make synthetic biology a novel discipline, distinct from traditional biotechnology, are also those that pose novel ethical challenges.

2.2. The role of society in the ethical discussion

Any technology justifies its necessity and importance by pointing at its potential benefits for society. However, society is also deeply involved in different ethical concerns related to synthetic biology. For example the question of acceptable risks versus promised benefits or a challenge to the fundamental concepts anchored in culture and religion such as the concept of life should not be contained within academic debates. Opinions of the public, often reflecting some of our deeply held values, feed the academic or policy debate and are a crucial ingredient to a successful assessment of the technology. In case of a novel technology such as synthetic biology the public can only form a well-founded opinion, if it has certain knowledge about the technology. However, for laypersons it is generally difficult to access this information including professional predictions about potential consequences and side effects that are not entirely known to experts themselves. It is thus essential and it is a right of society to receive as much information about novel technologies as possible in order to be able to form an informed opinion. The GMO (genetically modified organisms) debate in Europe has shown impressively that the societal acceptance of a technology is not only ethically but also economically desirable [16] this should add to the motivation to keep the public informed.
2.3. The role of synthetic biologists in the ethical discussion

Synthetic biologists are of course part of society, but more than anybody else they should be able to ‘foresee the unpredictable’. However, they are undeniably biased in favor of their research, which implies the risk that problematic aspects may sometimes consciously but most of the time unconsciously be denied or overlooked against better judgment. There are thus at least two important reasons for involving synthetic biologists in the ethical discussion. On the one hand, they can provide other stakeholders with valuable scientific knowledge; on the other hand, the other parties can present various ethical concerns and dangers to the scientists. Both sides can therefore profit from such a dialog.

As a matter of fact, synthetic biologists are encouraging the dialog between different stakeholders. Social scientists and ethicists do have sessions at scientific synthetic biology conferences and assessment of synthetic biology is supported by scientific boards [9]. The framework for the discussion has been established; it is now a question of individual interest and participation on both sides, which will decide about the success of the interaction.

3. The opinion of synthetic biologists on ethical issues concerning their discipline

In order to understand the attitude of synthetic biologists on ethical issues in synthetic biology we performed interviews with 20 synthetic biologists participating in the NEST (New and Emerging Science and Technology) pathfinder initiative: Synthetic Biology, which is supported by the 6th framework program of the European Union [23]. In what follows, we briefly summarize the main topics, which came across in these discussions.

No specific ethical issues exist at the moment

In line with the opinions stated earlier, many scientists felt that synthetic biology did not pose any ethical issues, or, at least not any new ones. In the words of one of the respondents, creating artificial entities or working within the synthetic world is “part of what man does”, given that the nature of human beings is to “escape the natural”. Some respondents recognized that the ethical issues might be the same as those in science in general, but that synthetic biology posed not additional issue as such, or that the ethical
issues were the same as in traditional genetic engineering but more relevant or stronger, given the increased precision and efficiency of current methods and technology. Others still, felt that although future applications may pose ethical problems, synthetic biology at this stage (typically the single-cell manipulation stage) did not raise special issues. Finally, one respondent felt that synthetic biology might pose, at best, some interesting philosophical and metaphysical but no ethical questions as such. This last comment seemed to point towards questions related to nature and life. However, the normative implications of such questions do not seem to particularly concern scientists.

*Ethical issues are related to safety and security*

For those respondents who did think that there were ethical issues related to synthetic biology, almost all felt that these were mainly related to safety and security issues, at least in the short term. One respondent, echoing the concerns raised by the synthetic biology community in the US, emphasized that the ethical issues were related to the availability, with the advent of synthetic biology, of “cassette-like biological systems and the additional information on the internet, which may allow the easy production of dangerous and even lethal biological constructs and associated delivery systems”. Coupled with biosecurity worries were those related to biosafety. Respondents warned of the lack of knowledge regarding how synthetic organism may behave in nature: “it is ok as long as it is in the lab…not sure how it will interact once out!” On the other hand, one scientist explained that the “uncontrollability” fears stemmed from not knowing how natural organism react and interact, and that synthetic biology with its quest for higher controllability, was somehow the “answer to all these fears”.

*Ethical issues are related to the application and distribution of synthetic biology*

According to a few respondents, the main ethical issues in synthetic biology are related to applications and that it is not the technology, but the applications that “matter”. For example, to some, concerns may arise if synthetic biology is applied in higher organisms, especially if applied to the synthesis or manipulation of human DNA; as one respondent put it firmly: “no application for human genome manipulation, this is the only important (ethical issue)”. Reflecting on the various applications of synthetic biology, one respondent touched upon a concern that might be interpreted, the light of a response to a
question about ethics, as one of instrumentalization: we are bringing a “wholesale change to the genome, creating life to do something useful”.

At least two respondents raised the issue of commercial involvement and intellectual property (IP) rights. It was noted that IP rights were the product of western rich nations but that synthetic biology can have benefits for the whole world.

*Ethical issues are created by the public*

Although rarely explicitly expressed, there seemed to be a feeling among some respondents, that somehow ethical issues were related to public perception. In other words, ethical concerns were only what the public made them, or that ethical concerns regarding synthetic biology might only arise for those religious-minded. As such, one respondent predicted that if “weird” things were created in the lab, they might trigger a strong reaction. A few scientists, echoing this thought, mentioned the problem of the “Frankenstein factor” which might tilt the scale of public perception against synthetic biology. Taking the “Frankenstein factor” further, one respondent suggested that in order to avoid a strong public reaction, synthetic biology should not be said to be “creating life”, but rather aimed at creating “self-replicating biological complex entities”. This interestingly echoed the suggestion, at the height of the cloning debate, of many scientists, to refer to therapeutic cloning as simply SCNT (somatic cell nuclear transfer), and to avoid the emotive ‘cloning’ term.

Finally, suggesting that public participation might be of importance to the developing field of synthetic biology, one respondent stated: “We cannot expect to have a field with new life and ignore bioethical aspects. We need to avoid fundamentalism one way or another. Those who are opposed to it might be ignorant but should be taken into account”.

*The debate in synthetic biology can be compared to the GMO debate*

When respondents were asked whether they had, perhaps earlier on in their careers, faced similar debates regarding other biotechnologies, many drew a parallel between the GMO debate, perhaps more so given the history of the GMO debate in Europe and underlying concerns related to lobby groups and the possibly inflammatory role of the media. A number of the respondents were worried about a GMO-like backlash but interestingly scientists were divided in their conclusions of this comparison. While some felt that
synthetic biology might trigger stronger negative reactions because it promised more radical changes, others said that synthetic biology would receive a milder reaction because of its potential therapeutic promises. Unlike GMO, the products of synthetic biology might be seen to be important in the development of drugs and treatments, and not something “you would feed to your kids”.

*Ethical assessment concomitant with the development of synthetic biology might be advisable*

Among the scientists interviewed, some expressed the need for ethical enquiry in the field of synthetic biology but while advising a precautionary approach to development, felt that there were not (yet) any precise issues that needed attention. Other respondents advised that progress of synthetic biology should be “supervised and controlled”, or that there was a need for projects to be approved by ethical committees. Other expressed concern included the role and responsibility of scientists: “what will be our status: scientists? Creators?” it was further emphasized that as potential “creators” scientists would have the ethical responsibility to delineate what should or should not be created. According to another scientist, synthetic biologist had the further responsibility of preserving the natural habitat and preventing genetic pollution.

*Summary of the interviews*

The responses given in these interviews illustrate that there is a general awareness of ethical issues in synthetic biology among the interviewees and that they have heard of previous and similar ethical debates. Some answers indicate that scientists have already been thinking about these questions. This observation is in accord with the relatively important presence of societal topics at synthetic biology conferences and in scientific journals. Most probably, the ethical awareness of synthetic biologists is partially a cause of and partially a consequence of the fact that these questions are present in the scientific agenda.

As expected, none of the interviewees considered the ethical issues raised by synthetic biology alarming or insurmountable. Several respondents rather thought they were insignificant. However, many synthetic biologists did mention one or the other ethical question they regarded as relevant. Among these issues were application-related, distribution-related as well as method-related concerns.
The perception of the public opinion of ethical issues is again not uniform. Some responses indicated that the public opinion was perceived as threatening and unreasonable. However, other statements expressed understanding for public fears and the importance to inform people about the development of the technology.

4. Conclusion

Synthetic biology is a fascinating field not only for scientists and engineers involved in it but for anybody interested in its aims and ideas. The thought that human beings might soon be capable of synthesizing and controlling life evokes scenarios and utopias which are particularly concrete precisely because the idea of artificial life designed by human beings is not new but a recurrent topic in literature, film and philosophy. The euphoria and creativity with which the idea of synthetic biology is presented e.g. by the annual students competition iGEM mentioned before, may add to the popularization of this field. However, it is very important to distinguish clearly between utopias and reality and not to let emotions raised by the former, affect conclusions in the assessment of the other.

Our overview of different types of ethical issues raised by synthetic biology, the analysis of the dealing with these issues and the presentation of scientist’s perspective on them, aims at addressing ‘ethics of synthetic biology’ from a neutral point of view. We have referred to similar ethical discussions and pointed out that it is useful and reasonable to draw the parallel and profit from the previous debates. However, we have also pointed out that these similarities do not render the ethical discussion of synthetic biology superfluous because the discussion stands in a new context and because synthetic biology does raise novel issues. Synthetic biologists are exemplary in discussing ethical issues and consulting and involving social scientists and ethicists at a very early stage in the development of this technology. The awareness of these issues and the readiness to participate in a dialogue provide a positive precondition for a fruitful ethical assessment of synthetic biology.

5. References
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