The moral impact of synthesising living organisms: Biocentric views on synthetic biology

Deplazes-Zemp, Anna

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The Moral Impact of Synthesising Living Organisms: Biocentric Views on Synthetic Biology

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Biocentrism, Biotechnology, Synthetic biology, Synthetic organisms

Abstract

This essay examines how biocentric positions assess the aims and planned products of synthetic biology. In this emerging field, scientists and engineers aim at designing and producing new life forms by various procedures. In this paper I explore whether, for biocentrists, 1) synthetic organisms have moral standing and, 2) the process of synthesising living organisms has moral implications. Because naturalness plays a role in some biocentric theories, synthetic biology –at first sight– seems to challenge the idea that all living organisms have moral standing. However, according to the interpretations that I offer, the biocentric positions discussed here would also assign moral standing to synthetic organisms.

That living organisms have moral standing does not necessarily imply that it is morally problematic to synthesize them. However, different lines of biocentric argumentation suggest that in designing and synthesising living organisms, the moral standing of the product needs to be taken into account. This means among other things, that according to biocentrists, such procedures may lead to special responsibilities or require certain attitudes from scientists towards their products.

Introduction

In this essay, I address the general question whether there are any moral implications in the production of synthetic organisms. This question will be divided into two sub questions: 1) Do synthetic life forms have moral standing?[i] 2) Does the *process of synthesising living organisms* have any moral implications? The answers to these questions are likely to depend on which entities are considered to be morally considerable. I will address the above questions from a

biocentric point of view. Biocentrists argue that all living organisms have moral standing. Such a view might imply a particularly protective position towards all living beings. Therefore, biocentrism provides an interesting background for the discussion of the questions that I explore in this essay.

As is true for most theories, biocentrism has several different forms. I will begin by outlining the biocentric positions that will be considered. I will then attempt to establish the following argument: A detailed analysis of the biocentric arguments for moral standing indicates that 'naturalness' is a feature that is relevant for most biocentric approaches. Nevertheless, my understanding is that all the biocentric authors discussed here would assign moral standing to synthetic organisms. I also try to show that for none of these biocentric positions would the synthesis of living organisms *per se* be morally objectionable. However, that products of synthetic biology have moral standing implies that for consequentialist biocentrists as well as those who base their approach on virtue ethical reasoning, the synthesis of living organisms has certain moral implications. This means that synthetic biology should be accompanied by ethical reflections on the consequences for the produced organisms or the attitudes and responsibilities of the scientist.

Before outlining the different biocentric arguments, I will start with a short introduction to synthetic biology.

Synthetic Biology

The name 'synthetic biology' is used for at least four different types of technologies or scientific approaches with the aim of devising, designing and producing new forms of life (Deplazes, 2009).

1) Currently, *Bioengineering* is probably the most prominent branch of synthetic biology. It is based on the methodology of traditional gene technology but it applies this technology in a more systematic manner and on a larger scale. Whereas scientists who work in traditional gene technology normally change one or a few features of an existing organism at a time, synthetic biologists aim at designing new organisms as wholes. These researchers seek to design new regulatory mechanisms and metabolic pathways. As a result, they not only transfer features from one organism to another, but also create novel features (Baker, et al., 2006).

2) Scientists in *Synthetic genomics* produce genes and small genomes chemically and then introduce them into existing organisms. The goal is to replace the natural genome of an organism with a synthetic genome. Gibson *et al.,* from the Craig Venter Institute, have recently applied this genome transplantation method to produce a *mycoplasma mycoides* bacterium carrying a synthetic genome (Gibson, et al., 2010). A further objective of this approach is to create organisms with a genome that carries only the minimal number of genes required to survive under lab conditions. Such a minimal genome could then be used as a chassis genome to be expanded by natural or artificial genes targeting designated functions (Ball, 2007). In designing such organisms, synthetic genomics would presumably apply strategies borrowed from the bioengineering branch.

3) The ultimate aim in *protocell synthetic biology* is the production of synthetic cells from off-the-shelf chemical reagents. However, this is a long-term aim. Currently, scientists are working towards this objective by producing and analysing different forms of protocells. Protocells are chemically produced empty cells – so called liposomes – which enclose selected biological components. These components perform specific cellular functions such as nucleic acid transcription or protein translation. However, such protocells do not meet the biological characteristics of *living* organisms.[ii] Nevertheless, this research provides interesting information

about the functioning of cells and the origin of life. To date, none of the synthetic biologists of this branch have claimed to produce synthetic organisms. But it is conceivable that some day, artificial cells will be produced along these lines, which would meet the biological characteristics of living organisms (Deamer, 2005; Walde, 2010).

4) In *unnatural molecular biology,* scientists strive to produce forms of life that are new and artificial in yet another respect. The novelty in this case concerns the very basis of molecular biology, namely the molecular structure of the nucleic acids, the amino acids or the genetic code, based on which the 'message' of nucleic acids (RNA/DNA) is translated into proteins (Schmidt, 2010).

These different types of synthetic biology have developed from different scientific disciplines. Although research in each field is still more or less independent, there are overlaps and convergences between the different branches. Because of the reciprocal adaptation of aims and procedures between the different branches, they are unified under the common title 'synthetic biology'. The rapid increase in the efficiency of DNA synthesis is certainly one factor that has promoted the convergence between the various branches. Another factor is the rise of systems biology, which has led to important data for the computer modelling of cellular processes. Moreover, systems biology has encouraged a more integral perspective on organisms, which is to say that scientists are interested in organisms as wholes rather than in isolated mechanisms or pathways. This has highly influenced the systematic and integral design of living organisms as it is striven for in synthetic biology.

Different Biocentric Arguments

Biocentrists hold that all living organisms have moral standing and thus deserve moral consideration. Kenneth Goodpaster was one of the first authors to speak explicitly of moral

standing in all living organisms. He asserts that 'to have interests' is the morally decisive feature that distinguishes living beings from inanimate entities and makes the first, but not the latter, morally considerable (Goodpaster, 1978). Human life is not possible without using and even killing other forms of life. Therefore, to consider the moral standing of all living entities seems inevitably to lead us into moral dilemmas. To solve this problem Goodpaster highlights the difference between moral standing and moral significance. In contrast to moral standing, moral significance "*aims at governing comparative judgments of moral 'weight' in cases of conflict*". (Goodpaster, 1978: 311).

Although the proponents of different biocentric positions agree that all living organisms are morally considerable, they disagree concerning the basis and reasons for this considerability. In what follows, I outline three different biocentric arguments for moral standing in living organisms.

Living organisms are teleological centres of life

The phrase 'teleological centre of life' was introduced by Paul Taylor to describe the striving of all living organisms to preserve their existence and pursue their own goods (Taylor, 1986: 45, 121). This striving of living organisms for the realisation of their good implies that they can be benefited or harmed by interference with their goals (Taylor, 1986: 61-62). The reason to attribute moral standing to living organisms, refers to the attitude and belief-system on which environmental ethics is founded (Taylor, 1986: 71-72).Taylor distinguishes between different systems of ethics with different scopes. On the one hand, human ethics has to do with moral relations holding among human beings (Taylor, 1986: 33-41). On the other hand, environmental ethics is concerned with the moral relations between humans and the natural world (Taylor, 1986: 3, 44-47).

Taylor argues that humans are morally *not* superior over other living things (Taylor, 1986: 129-156). So, his biocentrism is usually referred to as 'egalitarian'. To make egalitarian biocentrism practicable, Taylor establishes a set of priority principles that regulate cases, in which claims of human ethics compete with claims of environmental ethics (Taylor, 1986: 257-310).

Interestingly, Taylor contrasts environmental ethics not only with human ethics but also with the ethics of the bioculture. This system of ethics deals with "*the human treatment of animals and plants in artificially created environments that are completely under human control*" (Taylor, 1986: 53). According to Taylor, the bioculture is that aspect of any human culture in which living organisms and their environments are manipulated towards human purposes. However, although these organisms exist for human purposes, they have a good of their own which needs to be considered (Taylor, 1986: 55).

Living organisms can flourish

Robin Attfield has elaborated the idea that the decisive criterion for moral standing is the ability of living organisms to flourish. His biocentrism shares several basic ideas with that of Goodpaster. Like Goodpaster, he emphasises that all living entities have interests, which must be taken into consideration. Moreover, Attfield also holds that moral standing is compatible with different degrees of moral significance (Attfield, 2003: 44).

Attfield argues that the flourishing and the well-being of organisms is valuable in itself and provides the 'good' of living beings. These properties give life positive quality. In "*Value, Obligation and Meta-Ethics*", Attfield maintains with regard to 'flourishing' that: "*One of the elements present in the flourishing of members of a species, or so I will maintain, consists in the development of those potentials in the absence of which from most of its members a species*

would not be recognizable as the species which it actually is in our world […] " (Attfield, 1995b: 48). What is required for the flourishing of an organism thus depends on the species to which it belongs.

Living organisms have subsystems with biological functions

According to Gary E. Varner the presence of biological functions in living organisms is the criterion that renders them morally considerable. Varner agrees with the previously discussed authors that living beings have needs, and thus interests in a way that inanimate entities do not (Varner, 1990; 1998: 64, 77). However, Varner considers functions to be the more appropriate criterion to describe interests of living organisms than goals, to which Taylor refers. Whereas goals tell something about the future of the respective entity, functions entail the aetiology of the system in question, and thus comprise information about its past (Varner, 1990; 1998). Varner refers to the definition for functions by Larry Wright according to whom the function of a system is a) a consequence of the system b) the system in turn exists because it results in the respective function. From these conditions, Varner derives a definition for the functions of living organisms, the so called biological functions: X is the biological function of some organ or subsystem S of organism O if a) it is a consequence of O's having the subsystem S, b) O has S because achieving X was adaptive for the organism's ancestors (Varner, 1990; 1998: 67). Biological functions are thus defined by an evolutionary origin. This makes it possible to distinguish between functions of subsystems in organisms and artefacts, whereas such a distinction cannot be made for goals (Varner, 1990; 1998: 67). Varner describes the relation between biological functions and interests as follows: an organism has interests in X if and only if X is the biological function of some organ or subsystem of the organism (Varner, 1990: 259). Varner agrees with Goodpaster that having interests is the criterion for moral standing. He writes that the satisfaction of interests

constitutes a fundamental moral value (Varner, 1998: 77). Varner is also a non-egalitarian biocentrist. He argues for priority rules between different types of interests (Varner, 1998: 77-97).

These three authors give different reasons why living organisms are morally considerable. But in spite of the differences, all the arguments point to the common idea that living organisms have their own *interests*. This notion underlies Taylor's teleological centres of life, Attfield's flourishing, and Varner's biological functions.

In the following sections, I address how biocentrists assess synthetic organisms, for this purpose I return to the two central questions posed at the outset: 1) Are synthetic organisms morally considerable? And 2) does the *process of synthesising living organisms* have any moral implications?

Would biocentrists consider synthetic organisms to be morally considerable?

For biocentrists, being alive is the decisive feature for moral standing. Therefore – at first sight – it seems clear that synthetic life forms should also be morally considerable. However, it is important to bear in mind that all biocentrists have developed their theory in respect to natural forms of life. Before any conclusion about synthetic organisms can be drawn, it is necessary to test whether the biocentric theories are also applicable to synthetic forms of life.

Are synthetic organisms less natural than genetically modified organisms?

As discussed in the introduction, synthetic biology is a technology composed of various branches. Thus far, scientists in all types of synthetic biology are still working on precursors of what could be called 'synthetic organisms'. However, I am focusing on the aims of synthetic biology rather than on its current achievements. The aim that is common to all types of synthetic biology and that is most significant for this discussion is to devise and produce organisms according to a rational human design. Depending on the type of synthetic biology, this design would concern different structures of the organism: the design of biochemical pathways in bioengineering, the design of the arrangement of genes and other DNA sequences in synthetic genomics, the design of the composition of a cell in protocell synthetic biology or the design of new types of nucleic acids or genetic codes in unnatural molecular biology (Deplazes-Zemp, 2011). The notion of designing new life forms is significantly different from that of breeding and traditional gene technology. For these procedures, scientists focused on the modification of singular traits and properties. Products of traditional gene technology are perceived as modifications of their natural ancestors, a version of the natural organism with some altered features or capabilities. This is different for synthetic organisms. Even if, in most types of synthetic biology, scientists start from natural organisms, these 'source organisms' are just tools towards something new.[iii] This tendency is exemplified in the idea of a minimal chassis organism, which should display just the very basic features of a living organism deprived of all species-specific properties. Thereby, it could be said to constitute 'naked life'. The source organisms, which would be used to produce such synthetic organisms, would merely be the source of the material required to produce the synthetic organism. It would not be the source of

the *properties* of the latter. The eventual products of all the various branches of synthetic biology would thus in their ultimate forms not be clearly ascribable to any natural ancestor or species any more.

There will be a new degree of artificiality in these future products of synthetic biology that I call 'synthetic organisms'.[iv] On the one hand, there is at least one branch of synthetic biology - protocell synthetic biology - that could lead to chemically produced life forms, which would be synthetic in the literal sense. On the other hand, even those synthetic biologists who are not striving for the chemical synthesis of organisms are driven by the idea of designing something new, not just a modification of natural organisms. This means that I consider those products of synthetic biology that are modifications of natural organisms as mere precursors of synthetic organisms.

Is naturalness morally relevant?

What generally distinguishes synthetic organisms from non-synthetic organisms is the highly reduced degree of naturalness in the former. I would therefore like to further explore what role the biocentric authors discussed above assign to naturalness.

I am using the term 'natural' as 'not intended[v] by a human design'. For biocentrists, naturalness in this sense may be morally relevant in two different ways. First, humans may be required to deal differently with entities that have moral standing in a natural environment compared to such entities in a non-natural environment. In this case, naturalness would be a criterion to decide how to deal with entities that have moral standing. Alternatively, naturalness may be one of the features deciding whether an entity has moral standing in the first place.

The only author discussed here for whom naturalness is mainly relevant in the first sense is Taylor. He states that whereas the organisms in an artificial environment belong to the ethics of the bioculture, those living in a natural environment are assessed by environmental ethics (Taylor, 1986: 53). The ethics of the bioculture requires us to respect the moral standing of living beings, but because all non-human organisms in the bioculture fulfil human purposes, their instrumental value for humans also needs to be considered. For Taylor it is thus not, in the first instance, the naturalness of the organism that matters but rather the naturalness of its environment. A lion in the zoo is assessed by a different type of ethics than a lion in the wild (Taylor, 1986: 53-54). This means that even synthetic organisms would be assessed by environmental ethics if they should escape or be released into a natural environment.

Naturalness matters in the second sense described above, when it influences judgement as to whether a living organism is morally considerable. None of the biocentric positions directly list 'naturalness' as one of the decisive criteria. However, naturalness can play an indirect role, by being implied in some of the criteria for moral standing.

Moral standing in living organisms based on their ability to flourish, may be related to naturalness in such an indirect way. As mentioned above, Attfield links the notion of flourishing to the potentials typical for the species of the respective living entity. He writes that flourishing is a species-dependent notion; flourishing 'as such' does not exist (Attfield, 1995b). This means that the species defines the interests of the organism. What are then the interests of a synthetic organism that is not 'member' of any species in the traditional sense? Is it possible for such an organism to flourish, a characteristic required for it being morally considerable? These questions, which I will address in more detail below, illustrate that for this conception of moral standing, naturalness *does* matter, even though it is not an explicit criterion.

For Varner's account of interests, based on the biological function in living organisms, naturalness is even more important. As discussed, biological functions imply that the traits in question have developed through natural evolution. One may wonder whether in this case, human designed synthetic organisms, which have not evolved naturally, could have interests. This leads to the question whether they would qualify as being morally considerable. These questions will be addressed in the two following sections.

How can synthetic organisms still be morally considerable if naturalness is morally relevant?

It's clear that synthetic organisms can be morally considerable according to a theory for which naturalness matters in the first sense, as described for Taylor's biocentrism. In this case, naturalness is not decisive for the attribution of moral standing. Furthermore, we have seen that it is the naturalness of the environment that counts, a type of naturalness that is also accessible for synthetic organisms.

It is naturalness mattering in the *second* sense that needs to be addressed here. One might assume that according to positions for which naturalness is indirectly required for moral standing, synthetic organisms could not be regarded as being morally considerable. However, this conclusion may be too hasty.

The fact that until now, flourishing has been linked to naturalness does not imply that naturalness is necessarily required for it. Because synthetic organisms will also reproduce, there are specific features typical to this 'synthetic species'. These features are propagated and they may be used to define the flourishing of a synthetic organism. Therefore, even organisms of the

parental generation (which have been produced synthetically) should be able to flourish if they can carry out the specific features that have been designed for them.

Varner's biological functions are defined as having been adaptive for the ancestor of the respective organism. In other words, they have developed through natural evolution. Even if a synthetic organism does not have any organs or subsystems with biological functions in this sense, one might find such adapted functions in its progeny. It is possible that subsystems of human-designed organisms will evolve novel functions in future generations. One could for example imagine a synthetic organism that has been designed with a specific biochemical pathway for the degradation of oil polluting the ocean. It is conceivable that after all the oil has been degraded, this metabolic pathway would evolve into a pathway that degrades other substances present under the novel conditions. This new function would have developed through evolution and thus be a biological function according to Varner's definition. Varner writes: "*So long as all and only living organisms evolve […] all and only living organisms will have subsystems with biological functions*" (Varner, 1990: 261). What does this mean for organisms carrying a chemically synthesized genome or even for artificial cells? None of the functions of the subsystems of these organisms would be the result of evolution. Would biological functions thus be missing in such organisms, and would they thus lack interests and moral standing? Varner seems to indicate that indeed the subsystems of such an artificial organism might not have any biological functions.[vi] Because of such special cases he confines his theory by calling it only a partial defence of biocentrism (Varner, 1990: 253). However, in the sentence quoted above, Varner seems to suggest that biological functions are characteristics of all organisms contributing to evolution. It thus seems to be sensible to modify his definition of biological function in a way that would consider synthetic copies of natural life forms or human-designed life forms, because of their capability to evolve novel functions in future generations. In this context, the criteria for

biological functions should therefore not be restricted to the condition that biological functions of subsystems of living organisms must have evolved naturally *in the past*. The criteria should allow one to speak of biological functions, if these functions could be subjected to the process of evolution *in future generations*. This leads to an adjusted definition of biological functions: X is the biological function of some organ or subsystem S of organism O if a) it is a consequence of O's having the subsystem S b) O has S because achieving X was adaptive for the organism's ancestors *or c) S could be adjusted by the means of evolution in future generations in order to adapt X to new circumstances*. Although this modified definition is not a direct application of Wright's definition of function any more, it does not refer to 'goals' as being the characteristic of living organisms. I point this out because for Varner it was important to avoid the reference to goals. Goals refer to the future of the individual organism. The modified definition of biological functions refers to the future of the respective type of organisms or species. With this modification, the problem of most living organisms without biological functions, – which seemed to weaken Varner's position – could be bypassed.[vii] At the same time, it would prevent the possibility that a living organism whose subsystems lack biological functions (a synthetic organism) and which does not have moral standing, could have offspring that fulfil the criteria for biological functions and would thus be morally considerable.

Do synthetic organisms have interests of their own?

All the biocentrists referred to here contrast mere things and traditional machines with living organisms. Mere things do not have interests of their own (Goodpaster, 1978: 319). The goal-oriented operations of machines are not inherent to them (Taylor, 1986: 124).[viii] Machines fulfil the good of the owner rather than a good of their own (Attfield, 1995b: 21). Missiles, as

examples of goal-directed machines, do not have biological functions (Varner, 1990: 257). Most of these statements focus on the machine not having any ends, goals or interests of its own. This suggests that in order to clarify the status of synthetic organisms, it is necessary to discuss whether or not they have interests of their own. I do not utilise the term 'interest' here in the sense of a conscious 'being interested in' but as 'being in the interest of'. This notion is compatible with the biocentric theories discussed here. It allows assigning interests to living organisms without consciousness or even without desires.

To explore interests of synthetic organisms it is helpful to introduce the distinction between proximate and ultimate interests. I am using the terms 'proximate' and 'ultimate' analogously to their usage for biological explanations. Proximate explanations in biology concern for instance the functions of an organ for the individual organism whereas ultimate explanations refer to why such an organ has evolved (Mayr, 1961). For natural organisms, evolution is the source for ultimate explanations. In case of synthetic organisms, ultimate explanations refer to the interests of an owner or designer. Proximate and ultimate interests can explain the behaviour of a synthetic organism, but only the former are really the organism's own interests. The ultimate interests of a designer also define machines, but only living beings have proximate interests. These interests are related to the development, maintenance and accomplishment of the organism's life. In simple organisms, these interests are largely dependent on, and determined by the genome of the organism. The genome defines what these organisms are striving for. It thus defines what is characteristic of a species and is what determines the flourishing in Attfield's sense. The genome also defines the biological functions of the organism and thus interests in Varner's sense.[ix]

Synthetic organisms have proximate interests related to the basic characteristics of living organisms such as the interest to survive. Additional interests may be defined by the rational human design of these organisms. Humans could for instance design an interest to consume

certain substances required for their artificial metabolism or an interest to avoid or seek certain environments. For the organism itself, it does not make any difference whether its proximate interests have evolved naturally or whether a synthetic biologist has designed them. However, if synthetic biologists define proximate interests that conflict with other proximate interests of the organism, this is significant for the organism. Such conflicting interests are bad for the organism and cause suffering. An example for such a situation that should be avoided would be the design of painful features in sentient organisms because sentient organisms try to avoid pain.[x]

The fact that an organism has been designed to fulfil human purposes, does not replace its proximate interests, but rather directs them. All living organisms, including those that are based on a rational human design, therefore have proximate interests. This is in contrast to non-biotic artefacts, such as mechanical machines. Machines may be programmed to fulfil certain functions, but at least for all machines known to date, these functions are not directly related to the development and maintenance of the machine. I would therefore not speak of proximate interests in traditional machines.

Even though, for biocentrists, synthetic organisms are also morally considerable, it remains possible that certain biocentric authors assign higher moral significance to natural organisms than to synthetic ones. For instance, the modified definition of Varner's biological functions might provide an argument for a difference between natural and synthetic organisms. Whereas the interests of natural organisms are mostly based on biological functions that fulfil all three of the listed conditions, biological functions in synthetic organisms only fulfil two of them.

For a biocentrist, does the process of synthesising living organisms have any moral implications?

In this section I address the second of the two questions mentioned at the outset: Does the *process of synthesising living organisms* have any moral implications? I will start from the more specific question whether biocentric theories provide any arguments against the synthesis of living organisms as striven for by synthetic biology.

The difficulty in biocentric arguments about the production of living organisms is that production is assessed with respect to the product itself. This raises the question whether it is possible that non-existence can be better for the synthetic organism than existence. Derek Parfit has described a similar problem as the 'non-identity problem'. As Melinda Roberts puts it the problem concerns "*the moral status of acts whose effects are restricted to persons who, at the time the act is performed, do not yet but will exist*" (Roberts, 2009). Parfit considers for example choices between different acts that not only have different welfare outcomes for future generations but also determine which persons will exist. We have strong intuitions that an act, which more adversely affects people who will exist in the future, is wrong. However, in these cases, the people who suffer would not have existed if that act had not been performed. Therefore, no individual persons have been harmed in the sense that they are worse off than they would have been had the act not been performed (Parfit, 1984 : 361-364).

Consequentialist argumentation

Attfield discusses the non-identity problem in context of gene technology in animals. He emphasizes that some spheres of morality are impersonal (Attfield, 1998: 180). This means that,

"*even where no individual creature is harmed or wronged, there can still be actions that are wrong because of their bearing on future creatures*" (Attfield, 1995a; 203). Attfield applies a consequentialist line of argumentation, meaning that he evaluates the consequences of a technology for the well-being and interests of the resulting organisms. He argues that it would be morally wrong to generate lives which necessarily result in suffering for the organisms in question, or to reduce capacities of the organism compared to the traditional capacities of this type of organism (Attfield, 1998). I will address the notion of generated lives that result in suffering later, and start with the argument on the reduction of capacities.

Alan Holland has argued that, in the case of transgenic animals, the ethical argumentation against reduced forms of life is not trivial. First, it is problematic to argue that an organism has reduced capacities because it is questionable whether one can speak of reduced forms of life in the case of organisms that, if not in this form, would not have existed at all. Second, even if synthetic or genetically modified organisms could be 'reduced' in comparison to their natural ancestors, it is not obvious why being reduced would necessarily be a bad thing. Several of the objectives of synthetic biologists imply the idea of producing extremely simple forms of life. This is true for an artificial cell, the aim of protocell scientists, as well as for a minimal chassis organism, striven for by scientists in synthetic genomics. If being reduced were morally objectionable *per se*, this would be a clear argument against the synthesis of such products. However, as Holland points out, even using a consequentialist reasoning, it is not obvious why the existence as a reduced form of life should be *per se* objectionable. There is no reason to assume that simple forms of life necessarily have an inferior quality of life compared to more complex forms (Holland, 2002). Attfield writes that reduced capacities lead to reduced opportunities for fulfilment (Attfield, 1998: 186). However, one might counter that also opportunities for non-fulfilment would increase with an increased number of capacities.

According to Attfield, not only reduction, but also the introduction of suffering would be morally objectionable. The notion of proximate interests as discussed above allows for the identification of suffering in simple life forms. A produced organism would suffer if a synthetic biologist designed it such that its poximate interests conflict with each other. Attfield would probably concede that this criterion is not highly significant for organisms as simple as those currently striven for in synthetic biology. For a non-egalitarian biocentrist, it is justified to override interests of simple life forms in order to protect more significant interests of complex organisms (for instance: Attfield, 2003: 44-46). Following this line of argumentation, it might, for instance, be justified to produce bacteria in a way that causes suffering to them for a medical application that could save human lives. However, even if there are potential justifications for causing suffering to simple organisms by generating them, Attfield points out that "*the prospect of predictable misery counts against generating that life*" (Attfield, 1995a: 203). This means that even simple life forms need to be taken into consideration. Synthetic biologists, in producing a new organism, are thus morally responsible for the quality of life of the entity in question. This responsibility implies that synthetic biologists should consider the interests of the product. They should refrain from producing a life that would result in suffering if no interests of higher moral significance are at stake. Attfield writes: *"* […] *morality* […] *does not simply concern whether identifiable individuals are benefited or harmed. Agents are also responsible for the quality of life of whoever or whatever lives, whatever its identity, insofar as this turns on their own action or inaction; and this supplement to the principles of benefiting and of abstention from harm is once again a consequentialist principle"* (Attfield, 1998: 187). As illustrated by the writings of Attfield, Taylor and others, similar responsibilities have been discussed for the products of genetic modification. However, in these cases one could argue that the producer is responsible towards a natural organism, which has some artificial aspects. This situation is comparable to the

responsibility towards domesticated animals kept and utilized for human purposes. However, in future synthetic organisms natural aspects will be minimized, which means that the producer would be responsible towards the very entity she is designing and producing. This is a special kind of moral responsibility because the entire form of existence of the synthetic organism, as the object of responsibility with regard to which the agent is responsible, depends on the agent.[xi]

Virtue-oriented argumentation

After this consequentialist line of reasoning, I will address the question, how the synthesis of living organisms should be assessed morally, from a virtue-oriented perspective. Virtue ethicists focus in their reasoning on the virtues and moral character of the agent and not primarily on the consequences of the action (Hursthouse, 2007). A virtue-based version of biocentrism emphasises the attitude towards living organisms because they are morally considerable. I start this section by outlining three suggestions how a virtue-oriented approach can be combined with biocentrism.

One model for such an approach was established by Jason Kawall. He proposes that such an attitude would be expressed by practicing the virtue of reverence for life. He writes: "*reverence for life involves valuing living beings, just as honesty involves valuing truth, or benevolence involves valuing increasing well-being*" (Kawall, 2003: 340). However, for Kawall reverence for life is only one among many virtues and life is not the only property of living beings that is valuable in itself. Therefore, he is also a non-egalitarian biocentrist, who does not require us to treat every living thing in the same way (Kawall, 2003).

Some authors combine virtue-oriented arguments with a deontological or a consequentialist approach. The deontological biocentrist Taylor, for instance, emphasizes the importance of the

agent's moral attitude (Taylor, 1986: 80). A moral attitude implies that the good of their own and moral standing of all living organisms are respected. A good character or virtues will allow the agent to think clearly and rationally about which action should be performed and to act in accordance with this reasoning (Taylor, 1986: 199).

In his elaborated virtue-oriented approach to environmental ethics, Ronald L. Sandler has established a typology of environmental virtues (Sandler, 2007: 83). The moral standing of living organisms is not as central to Sandler's ethics as it is for the biocentric authors discussed in this essay. Nevertheless, his theory is compatible with the idea that all living organisms have moral standing (Sandler, 2007: 42, 115).

These three examples indicate that biocentric thoughts can be combined with a virtue-oriented approach. How would the aim of synthesising new life forms be assessed within such a biocentric virtue-oriented framework? A virtuous dealing with living organisms could be guided by the virtue of reverence for life or some of the virtues Sandler lists as 'virtues of respect for nature'. As examples for such virtues, he mentions: care, compassion and nonmaleficence. It could be argued that certain statements by synthetic biologists express attitudes that are not compatible with these virtues towards living organisms, for instance when synthetic biologists compare organisms with computers (Andrianantoandro, et al., 2006) or speak of living beings as genetically engineered machines.[xii] However, two points deserve consideration in this context. First, as mentioned for Kawall, virtue-oriented biocentrists too can be non-egalitarian biocentrists. This is to say that there are other virtues, besides the virtues that are directed towards all living organisms, and that the value attributed to life is not the only value that has to be recognized. Even if understanding an organism as a machine were considered to be disrespectful towards the organism, it could thus be justified to apply this concept in order to practice other virtues or to take into account other values. The synthetic biologist might for instance act with the

intention to design a medical application that could save many human lives. Such an intention would be an expression of benevolence, care and respect towards humans. Second, in many cases, a potentially non-virtuous attitude towards the synthesised organism may not necessarily be inherent to the procedure of synthesising it. One bioengineer speaks of his product as a machine and thereby may fail to respect its moral standing or to practice the virtue of reverence for life. However, it is conceivable that another researcher performs the same procedures with a different attitude.[xiii] The remedy against a non-virtuous attitude towards the organisms, which are being produced by synthetic biology would not necessarily require prevention of the respective procedures. Instead, it would be necessary to change how certain synthetic biologists think and speak about their products.

In a similar way as outlined for the consequentialist approach, a virtue ethicist too, could hold that synthetic biologists need to assume responsibility towards their products. It could be argued that to assume responsibility towards the produced organism goes together with embracing reverence for life or attends a respectful, careful, compassionate, nonmaleficient attitude towards this organism.

The upshot of this section is that, based on different argumentations, the question whether *the process of synthesising living organisms* has any moral implications, can be answered affirmatively. Whereas certain arguments focus on the consequences for the organisms or the action itself, others emphasise the motives of the agent. However, none of the arguments discussed here, establish that the synthesis of living organisms was objectionable *per se*. They rather suggest that these procedures should be performed under certain conditions or with a certain attitude and that the scientists need to assume the resulting responsibilities.

Conclusion

In this essay, I have examined whether, for biocentric authors, designing and synthesizing of living organisms has moral implications. Synthetic organisms would, in many respects, not be considered natural because they are based on a rational human design. This distinguishes synthetic organisms from other living organisms. This fact is relevant for the assessment of synthetic organisms because their instrumental value, or their importance for living organisms with higher moral significance, needs to be considered. I have argued that, with some adaptations of Varner's position, all the biocentric authors discussed here would also assign moral standing to synthetic organisms. Some readers may have expected from the outset that every biocentric theory should, per definition, also be valid for synthetic organisms. These people could read my conclusion as a confirmation of the applicability of these biocentric theories to a future situation in which synthetic organisms will be produced.

The moral standing of synthetic organisms implies that their production has other ethical implications than the production of mere things. In some respects, the arguments about synthetic biology build on those concerning traditional genetic engineering. However, synthetic biology confronts us with a new degree of artificiality and instrumentalisation of living organisms and a different way of talking and thinking about living organisms (Deplazes and Huppenbauer, 2009, Deplazes-Zemp, 2011). Thereby, synthetic biology adds new elements to the ethical discussion on the dealing with life in biotechnology. Nevertheless, I have tried to show that a biocentric argumentation does not lead to the conclusion that the production of synthetic organisms should generally be prevented. Instead, the claim is that the design and production of living organisms need to be accompanied by ethical reflection, the awareness of moral responsibilities and in certain cases, ethical justification.

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Notes

[i] The phrase 'moral standing' is understood here in Allen Buchanan's sense, according to which a being that has moral standing counts morally in its own right. Moral standing in this sense is not a comparative notion, an entity cannot have a higher or a lower moral standing (Buchanan, 2009).

[ii] By 'biological characteristics' I mean a set of biological features of living organisms that are often mentioned such as: metabolism, reproduction and growth, homeostasis, genetic programme or evolution (Mayr, 1997: 20-23; Popa, 2004: 197-205; Weber, 2008)

[iii] 'New' needs of course to be understood within the scientific possibilities. It will not be possible to produce a mammal from a bacterial source organism, but new types of bacteria might be produced some day.

[iv] I agree with Keekok Lee, who considers naturalness and artificiality to be gradual properties. Entities are not either natural or artificial; they can be both to a higher or lower degree (Lee, 1999).

[v] I understand 'intended' in a wide sense not merely as direct intentions but rather in the sense of oblique or indirect intentions as introduced by J. Bentham and sometimes used in jurisprudence. Oblique intentions include foreseeable side effects (Bentham, 2000 (1781): 70).

[vi] Varner addresses Christopher Boorse's example of a species "*that simply springs into existence by an unparalleled saltation*". He states that for Wright the organs of such an organism would have no functions if it had no ancestors. This would for instance be the case for an artificial cell. Varner indicates that some day it might be possible that a genome was created '*ex nihilo*' but he immediately weakens this statement by adding that "*foreseeable DNA research either modifies one small portion of a given species' DNA or 'splices' in genetic material from another organism, and in either case many biological functions are left unaffected*" (Varner, 1990: 261; 1998: 70). Synthetic biologists went beyond this 'foreseeable DNA research' and realized the creation of a genome '*ex nihilo*'. It is not entirely clear, how Varner would assess an organism with a synthetic genome. He seems to indicate that such an organism would not have any biological ancestors and that therefore its subsystems would lack biological functions.

[vii] The case of a *sterile* synthetic organism remains unsolved by this modification. For such an organism achieving functions was neither evolutionary adaptive in the past nor will it be so in

the future. Based on an approach that gives such a central role to evolutionary adaptation, it seems not to be possible to assign biological functions to the subsystems of such an organism.

[viii] Although Taylor distinguishes living organisms from traditional machines, he considers it possible that in the future, artificial beings, for instance developed as 'artificial intelligence', could have a good of their own (Taylor, 1986: 125).

[ix] Besides these very basic interests, organisms with desires and intentions have other proximate interests, which are not directly determined by the genome. However, in this essay I focus on interests that are common to all living organisms including microbes.

[x] Potential moral implications resulting from the design of such conflicting interests will be discussed below.

[xi] Hans Lenk describes responsibility as a relational term with up to five positions including the following three positions: The *agent* (subject) is responsible *for something* (for instance an action) in view of an *addressee* (the object of responsibility) (Lenk, 1999: 106-109; Lenk and Maring, 2001).

[xii] See: http://parts.mit.edu/wiki/index.php/About_iGEM

[xiii] Although this is true for most current applications of synthetic biology, there may be certain procedures, such as the production of an organism with conflicting interests, which would be difficult to bring into accordance with a respectful attitude towards the product.