

The
unplumbed
depths of SynBio
according to their
language
or

*how
SynBiologists
work with faulty terms
and cause epistemic as well
as ethical issues.
Submitted
by*

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October 27, 2010

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1 Introduction

Hier kommt ein Zitat von einer SynBio-Koryphäe wie
Venter oder Endy hin, die einen der betreffenden
Begriffe verwenden - am liebsten "artificial cell".

MARCUS THE GREAT

Synthetic Biology rises the endangerment that one of the most fundamental concepts of human development, nature on the one side and culture on the other, intermingle.¹ In the so far history were both concepts strictly apart — apart in a way, that the one was the antipole of the other. SynBio is about to fuse these poles. The productive human, the manipulator of his environment, the *homo faber*, who gears with his technics into nature, could carry with the assistance of SynBio technologies *in* nature itself; whereby it would desist from being nature in our current understanding, as a counterpoint of culture, and the *homo faber* would not just be a manipulator anymore, he would become a *creator*. So fear the critics of SynBio. If both concepts fuse, they create a new form of "being": the biofact, a hybrid between an artifact and a living being.

This fusion shall be retraced in the paper at hand from a philosophical point of view. That means to focus on the underlying concepts and the mentioned arguments. In doing so I will approach the problem through the terms itself. According to the aim to refuse the ancient distinctness of nature and culture SynBiologists speaks often about *artificial cells*, *living machines*, *protocells as chassis*, and much more similar terms. Such terms express impressively the aim of the SynBio as well as the appearing problems. In examining them we can see firstly, if the terms even rise the sketched problems and secondly, what kind of problems may ensue with them.

If we expect that SynBiologists achieve the goal of "synthesizing life". We have to consider, in what sense the new entity is "alive". The scientific definition of life is in several points problematic, whereby it just matters within the biologist's community and does not fit the everyday-life experience or perspectives from other sciences. Mostly it applies to three principles: metabolism, self-reproduction and evolvability.² The best known example for being unable to fit common intuitions represents the problems concerning hybrids like mules or geeps (sheep-goat chimeras). They are not able to breed, but nobody would deny their state as living beings.³

The human is settled into the world, which he is, of course, able to understand. Such an understanding is, however, not "pure" but filtered through concepts we have established.⁴ They preform and structure our perception as well as our sensation. The meaning of these concepts is learned by society, which also *defines* the meaning of words. An understanding of the world can, thus, be possible only within a linguistic and social context. Society and speech

¹In the following I'll use the abbreviation SynBio for the scientific approach and SynBiologists for scientists working in that field.

²See e. g. LUISI/FERRI/STANO: *Approaches*, 1, who see their definition directly in answer to the question: "What does 'alive' mean?"

³For other critical aspects according the "life" definition see TOEPFER: *Begriff*, 166-171.

⁴Such concepts are, for instance, the believe in causality, or XXXXX

are fundamental preconditions to understand the world and to act meaningful in selfsame. Exactly in that meaning one can understand the well-known aphorism by Wittgenstein: “The limits of my language represent the limits of my world.”⁵⁶

The understanding of the world depend on, thus, the ability to structure her through speech because speech expresses and mediates the concept with which we understand the world. Therefore, scientists should be very careful regarding the kind of expressions they use to explain their work. The problems which can rise from an inappropriate usage of words, we see impressively within the SynBio.

In the following we need to clarify several terms for an accurate use. I will define those terms so that we are able to deal with them in a proper way.

nature Everything that is *not* modified by humans and that is independant from human plans and design. But a strict seperation between the natural and the human-determined world has never existed and was mostly a case of grade than of clear distinctions.⁷

culture Everything that is modified or created by humans, opposit of nature.

technique The mostly natural scientific methods and means to modify the nature.

artifact Any object developed or produced by humans.

2 *Methods*

The aim of the investigation is to eclit the terms, that implies a fundamental differences from hitherto existing creatures (e. g. “artificial cell”) or a mixture of nature and technology (e. g. “living machines”), used by SynBiologists upon their ethical and philosophical issues. In a first step, the used terms shall be analyzed with the methods of the philosophy of language to elaborate their *meaning* and *reference*. This allows us to spot what the terms actually indicate and how far the terms may be appropriate in their semantic manner. Afterwards, the *cultural ideas*, which are associated with the reviewed terms, are examined. Cultural association patterns affect our actions in a variety of ways because they structure our perception of the world and thereby influence our decisions. In this sense, associations *can* also raise ethical problems, whose potential is traced in the last section. This indicated analytical framework, by the use of which it will be able to approach the later tasks, shall help to understand and to expound the problems of the terms and their related concepts.

The examination at hand will deal with several expressions: “living machines”, “artificial cells”, “minimal cells”, “protocells”, “synthetic cells”. To identify the *semantic value* of a term philosophers differentiate between the *meaning* and *reference* of a term.

⁵WITTGENSTEIN: *Tractatus*, Sentence 5.6.

⁶For a great introduction in the *Tractatus Logico-Philosophicus* see MORRIS: *Guidebook*.

⁷See DEPLAZES/HUPPENBAUER: *Synthetic organisms*, 55

Reference is understood as the relation between an expression and that what the speaker wants to denote with the expression. In this sense reference picks or singles something out, be it a person, property, group or something else. **Reference has an impact on the truth-value of sentences. If somebody says "Santa Claus exists" and if he actually do not refer to anything by the term "Santa Claus", then the sentence he just said is wrong. In the philosophy of language, two possibilities are discussed how this relation exactly works.**⁸ I chose the so called Description Theory, according to which reference is established if an entity fits the properties related to the term.⁹ It provides itself for generic expressions, that names a class of objects in contrast to an definite object, as considered in this analysis.¹⁰ **I prefer these theory because generics works through by descriptive designation. For instance, a term belongs to a group if the properties related to the term fits with the properties shared by the members of that certain group.**

To understand the *meaning* of a term, "one must have some grasp of how it applies to things in the world, and one must also be able to employ the word in an indefinite number of sentences."¹¹ When the reference clarifies the relation to the specific entity, the meaning expresses the ideas or types of ideas, that underlie the expression. When I understand the meaning of a term, I know in which context it is used and to what other terms it is related. The meaning denotes certain characteristics or properties on which connections to other terms are based so that one could use the term meaningfully within a discussion even if one does not know the reference of that term.¹²

The meaning of a term is closely connected to its associations. Unfortunaly there are no (psychological or societal) studies of the perception of the reviewed terms. We can, however, correspond on the one hand to the existing studies of the nature-culture distinction (which the terms pick up manifold – e. g. "living machine") and on the other side to newspaper articles and research papers that deal with SynBio where those terms are used. Common western industrialized societies perceive the interference of nature through genetic engineering approach as a far-reaching impact into the selfsame naturalness. ROZIN has conducted a study concerning the perception of the naturalness of objects modified by different approaches. Concerning physical transformation or domestication the naturalness was - in the eyes of the participants - reduced just about 10% whereas it was decreased about 54% from genetic engineering.¹³ **Therefore the participants associate a far-reaching impact in the natu-**

⁸Two theoris have formed, whereupon the first, the so called Description Theory, assumes that a term "refers via the descriptive content associated (by the speaker) with that name" (REIMER: *Reference*, paragraph 2.1). The second is called Causal Theory and assumes in contrast that "reference of a name is established by a dubbing ceremony (or "baptism") at which the dubee is indicated by a demonstration." In the following all uses of the name refer to that original dubee, "even if the speaker associates the name with a description that is untrue of that dubee." (CUMMING: *Names*, paragraph 2.5).

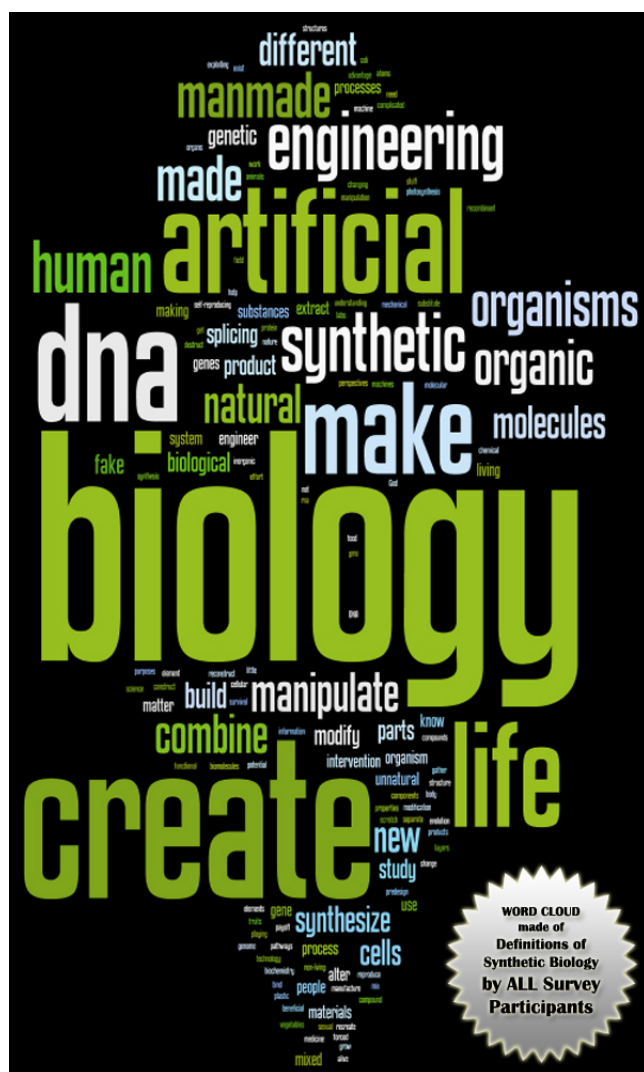
⁹For example, I can find out who "Barack Obama" is, when I find a person who fits the description ("being the president of the US", "being born in Honolulu at the fourth of August, 1961" and so on) connected to the term.

¹⁰For the inclusion of generics into the description theory see LUDLOW: *Descriptions*, 9 and SHARVY: *Theory*, passim.

¹¹CRANE: *Meaning*, 575.

¹²So could Urbain Le Verrier, a scientists and astronom in the middle of the 19th century, who calculates the existing of the planet Neptune only by observing discrepancies in the orbit of Uranus, even talk meaningful about Neptune although he has no idea what the name refers to.

¹³As a measure served the division into completely natural on the one side, wherefor the image of an unclimbed mountain in the Andes was used, and on the other side not natural at all, wherefor the image of a plastic pistol



The association of the phrase "synthetic biology" and the implications of its methods appears colorful in the word clouds designed by the British Columbia iGEM team. They conducted several surveys asking people for a definition of SynBio. Afterwards the team combined the words students have used to define SynBio according to their frequency. Thus, central concepts the term is curling around are ... (© British Columbia iGEM team)

ralness of an object through genetic engineering. SynBio will not perform better. By contrast there is evidence that society would judge or perceive SynBio worse, because it marks a more fundamental interference with a more far-reaching claim than genetic engineering.

To elaborate the meaning and reference of a term, allows us to estimate how far he is appropriate, i. e. how far he reflects the underlying concept. That shall prevent two phenomena; first, that the term pretends to have properties which it does not have at all. Second, that the term refers to an entity with certain and definitive qualities but we do not connect these qualities with that term generally. We have to reject both terms from a philosophical point of view, because they refer incorrectly. Moreover the associations related to the terms are from importance for the semantic value of a term. According to this an approach, we can be sure that the terms and phrases are coherent and are based upon consensual concepts. For example: the concepts associated with "living" as well as "machine" have to be able to be combined in a meaningful way. If that is not case the term is unable to carry a meaningful semantic function within the sentence ... and therefore, the respective scientific discussion would be nothing but nonsense.

3 Terms

In the following, two different terms will be analyzed which are often used within the scientific community of SynBiologists. For each term a couple of example sentences will be given to exemplify the common use. Afterwards the discussed methodical approach will be applied successive to the terms. Closing we should have a base of knowledge to consider the further approach and the related ethical and societal problems. ed which are often used within the scientific community of SynBiologists. For each term a couple of example sentences will be given to exemplify the common use. Afterwards the discussed methodical approach will be applied successive to the terms. Closing we should have a base of knowledge to consider the further approach and the related ethical and societal problems.

3.1 "Artificial cell"

The term "artificial cell" does not refer to a single entity, but it names a group of entities, which all share several fundamental qualities. In this sense, it is a generic expression. What the term *refers to* or what it *means* is hard to outline, because there is not a canonical definition or even everyday use of the term. The divergence appears impressively at the multitude of various terms: "prebiotic cell",¹⁴ "protocell",¹⁵ "minimal cell",¹⁶ or "synthetic cell"¹⁷. It is common in the corresponding papers that those terms are undefined or define each other. Apparently, SynBiologists utilize not only equivocal term but differ also how each term is to be used. Because of this undefined use I will focus on three terms ("protocell", "minimal

was used. The participants (in the first group were about 100 randomly selected Philadelphians with a mean age of 40 and in the second group were about 100 collegestudents with a mean age of 19) have to arrange now different objects within a scale from 100 (natural) to 0 (not natural at all). See ROZIN: *Meaning*, passim.

¹⁴MURTAS: *Synthesis*, 89.

¹⁵BEDAU/PARKE: *Introduction*, 1.

¹⁶GIBSON et al.: *Creation*, 52.

¹⁷NOIREAUX/LIBCHABER: *Bioreactor*, 17673.

cell" and "synthetic cell") which are often described as "artificial cells". After the examination what these three terms refer to and what they mean it would be easier to clear this point for "artificial cell".

The most profound ethical and social study according "artificial cells" was presented by an interdisciplinary collection edited by BEDAU/PARKE. They define "artificial cells" as follows: "Protocells are microscopic, self-organizing, evolving entities that spontaneously assemble from simple organic and inorganic materials. They are also known as artificial cells ..."¹⁸ They prefer the term "protocell", because "artificial cell" is also used to refer to things like red blood cells while protocells emphasize their similarity to simple single-celled life forms. Despite such a separation from other cells, Bedau/Parke have a broad understanding of the term "protocell". Not only do they use "protocell" and "artificial cell" as synonyms but they also do not differ between "protocell" and "minimal cell".¹⁹ For them a "protocell" can be generated by two kinds of approaches but we focus here just on one: the bottom-up approach. That is aiming to compose an organism from not living, sub-cellular parts. This could be done by two methods. First, scientists are trying to combine inorganic materials like silicon or newly created base-pairs to initiate a process chemically which they call "life". Second, scientists (as well as the teams participating at the iGEM competition) work to develop so called "BioBricks" that are defined DNA sequences associated with a certain function and designed to work in assembly (they are similar and able to "plug" together). Some scientists intend to combine a multitude of "BioBricks" to generate a complexity, at which "life" begins. All products resulting from this approach Bedau defines as "protocells".

Scientists often describe "minimal cells" as "artificial cells".²⁰ This is the second method to produce a "protocell" after Bedau/Triant. Craig Venter and his team presented several months ago a "minimal cell" in their view.²¹ In the special case of the paper the term "minimal cell" refers to *Mycoplasma mycoides* JCVI syn 1.0 - also called Synthia. But normally the term is used as generic expression and refers to cells modified and reduced from an existing cell to a point where the cell is barely alive. All organic structures which are not necessary for the survival are removed. Also Gibson et al. define their cell in a specific way although they are not talking about "artificial cells".

However, Gibson et. al. introduce an important modification: they replace "artificial" with "synthetic".²² Synthetic emphasizes that the cell was synthesized by humans, i. e. the base pairs were built and composed to DNA *chemically*. [Das noch ein wenig ausbauen]

Until now, three different types of "artificial cells" could be outlined, whose terms ("protocell", "minimal cell" and "synthetic cell") refer to different entities differing through the method they are produced. However, besides such a splitting of definitions one could also look for unitary explanations. After an introduction in several methods to produce "protocells" Bedau propose a definition for "artificial cells" (he uses both terms synonymously): "But protocells are simpler than any existing bacterium. And unlike bacteria, they are not

¹⁸BEDAU/PARKE: *Introduction*, 1.

¹⁹All three terms are widely used and highly unclear. For example see FELLERMANN/SOLÉ: *Minimal model*, 1803 and 1811, who uses the terms "artificial cell", "protocell" and "minimal cell" synonymously.

²⁰GODINHO/LAM/SANTOS: *Introduction*, 32.

²¹GIBSON et al.: *Creation*, 52.

²²The term "synthetic" may occur several dozen times, "artificial" not once.

natural but artificial, and exist only through human creation.”²³ The special character of “artificial cells” are, thus, composed of three elements: they are alive, artificial and exist only through human creation. “Alive” denotes to the three basic principles commonly associated with a definition of life or being alive: entities have to reproduce, evolve and have a kind of metabolism.²⁴ According Bedau/Parke, “artificial cells” fit those three principles.²⁵ They exist further “only through human creation”, thus they are man-made — an evident point that does not seem to be explained further. **So, wherein is the artificality grounded? The term (“artificial cell”) seems to imply that the entity to be referred is more than just man-made. Children emerge/result from *in-vitro* fertilisation are somehow also man-made because they would not live if not humans have combined the human egg with the sperm cell in an high-grade artificial process. But nobody would call the children for this reason “artificial”. Cultured animals rise similar considerations. They also exist through an active human interference into a “natural” process. Nonetheless nobody would call them “artificial”.**

After this examination we should be able to arrange the terms “artificial cell”, “protocell”, “minimal cell” and “synthetic cell” in a proper order. “Protocell” refers to an entity produced within the bottom-up approach whereupon it ensues two possibilities for realising such an entity. First by combining “BioBricks” to a level of complexity that they ‘begin to live’. Second by composing an organism of anorganic materials with the aid of e. g. nanotechnology. “Minimal cell” refers to a similar approach upcoming from the far side. An existing organism will be reduced to the lowest level of life conditions. “Synthetic cell” clarifies “artificial” in some points by emphasizing a method by which cells *can* be produced artificially. All of this analysed terms are “artificial cells”. This phrase is an umbrella term that was introduced to refer to any kind of new entity produced by SynBiologists. Anyway, to be “artificial” is still vague.

3.1.1 Meaning and Associations

In the following, it will be the aim to consider the meaning and the cultural associations connected with the terms. Both elements will be discussed together because they coincide in several points. Furthermore it might be possible to clarify the vague layers of meaning of “artificial” within this considerations. The aim, in doing so, would be to search for clearly defined concepts that result from the use of the words because certain names have to denote certain concepts (in other respect they are meaningless). Which names are connected to which concepts is due to the most frequented use of the terms.

At first it might be helpful that the term “cell” would be clarified because it is part of every reviewed phrase. Cells are small functional units of all living beings but sometimes nonetheless visible by eye. Most pupils in the industrialized countries have seen a cell through a microscope or have seen a picture or scheme of it somewhere (schoolbooks, television, billboards). And cells are connected essentially with concepts of “living” including all the broad associations outlined in chapter 2. Thus, “cell” carries the concept of living and nature

²³BEDAU/PARKE: *Introduction*, 1.

²⁴An intensived discussion according this principles will take place at chapter 3.2.

²⁵“[Protocells] grow by harvesting raw materials and energy from their environment and converting it into forms they can use, they sense and respond to their environment and take steps to keep themselves intact and pursue their needs, and they reproduce and ultimately evolve.” BEDAU/PARKE: *Introduction*, 1.

within the term.

“Protocell” refers to an entity produced through the bottom-up approach (combining “Bio-Bricks” or inorganic material to an organism). The term implicates to denote a first cell that underlies all others cells. The prefix “proto-” is the greek ordinal number for one so that “protocell” is a telling name. It pretend that humans are able to produce a cell that is a kind of archetype of all others. Moreover, it suggest that such an approach is even possible, i. e. that humans are able to design and produce a cell which has no organic forerunner/ancestor but was e. g. *de novo* synthesized. Such a “creation” is not possible at that moment even if scientists around the world are up to it. Moreover, the success of this approach could fail to appear in the near future or could even never occur. Thus, the term is associated to a wide range of concepts concerning technology, interference, “creation” (“proto-”) and nature, being, living (“cell”). The mixture of usually distinct concepts lays, thereby, not in the term itself but in the associated concepts.

“Minimal cell” on the other side refers to an organism that is reduced to its lowest possible form.²⁶ Scientists use, so, existing entities to minimize them in a certain way.

“Synthetic cell” was introduced as a specification of “minimal cells”. They refer to organisms which are produced by synthesizing their DNA. However, one has to be careful that his associations do not misguide. By far it is not possible that synthesizing life could mean “to create something from chemical parts in an entirely new way”. At the moment it could just mean “to compose subcellular elements in partially new combinations so that they build an animated cell or micro-organism”.²⁷ Nonetheless, scientists as well as the media suggest or pretend that the first meaning (“creation in entirely new way”) is not even possible but also achieved (as we will see below).

Considering the explanation to “cell”, “artificial” has on the other side also a broad, unclear meaning. Probably the most known case where the term is used is “artificial intelligence”. It designates something that is a kind of replacement for originally nature products (like artificial snow, artificial light and so on). The term is, thereby, connected to concepts like technical, man-made, simulated, not natural, fabrication, static, offish, alid and others. We think of machines, factory buildings, plastic and computers. In this sense, the term “artificial cell” is an impressive example of intermingling concepts of nature and technique. Because how could something be static and developing, how man-made and natural, how grown and fabricated at the same time? Those mixtures do not seem to fit common beliefs.

“Protocells” and “minimal cells” do not raise criticism in the same way as “artificial cells”, because they do not intermingle different associations in a so far-reaching way like “artificial cell”. But certainly, “minimal cell” seems to be less problematic than “protocell”, because it implies just that there is a cell which could be minimized in some way. Whereby “protocell” pretends the same as “artificial cell” but on a different level (just in concepts and not in the

²⁶Some scientists do not distinguish between “protocells” and “minimal cells”, because, so they say, both terms refer to a cell that genome is reduced to the absolute minimum (see GODINHO/LAM/SANTOS: *Introduction*, 32). At first, the way how such a minimalization is achieved, differ fundamentally and especially the method would be from an outstanding importance to consider the state and implications of such an entity. Second, it's undetermined if both approaches will lead to the same results. Thus a most careful and separate use of terms should be considered.

²⁷See for further explanations BOLDT/MÜLLER/MAIO: *Analyse*, 49.

term itself). Thus the claim of both terms differ whereupon “protocell” might provoke more resentments. “Synthetic cell” highlights one of the methods which generate “artificial cells”. Certainly, also this term can not clear all of our problems related to the vague “artificial cell”. For example, a “synthetic cell” is an “artificial cell” but an “minimal cell” which is also an “artificial cell” do not have to be produced by synthesizing. And a “protocell” do not have to be produced in the ways “synthetic cells” or “minimal cells” are. At this point we can state several epistemic problems related to the reviewed terms. [??? ??? ??? ??? ??? ??? ??? ???] And further they intermingle concepts what can rise ethical problems discussed in the last chapter.

Concluding, the notions of “artificial cell” as well as the other reviewed terms imply a fundamental difference from existing organisms. The terms are obviously defined to separate natural micro-organisms from “protocells”, “minimal cells”, etc. The entity denoted by the terms turns out to be something other, different and “new”.²⁸

To criticize or even analyse this supposed novelty is not easy at all because: “In general, it is a matter of unresolved philosophical speculation at what point an entity undergoing continuous changes turn from being one entity into being a new one.”²⁹ Thus, we are not able to refer to an accepted theory but it will be possible, nonetheless, to confront the use of the terms with several issues. Therefore, I will give an example for the pretension of a new entity through SynBiologists. Afterwards, I elaborate issues related to that pretension and outline why such suggestions can be problematic in general.

The most prosper making of an “artificial cell” can help us to clarify this point. Craig Venter and his team have elaborated a bacterium that is commonly called for example an “act of creation”³⁰ or it is mentioned that “Scientists Create First Self-Replicating Synthetic Life”.³¹ In addition such statements fit with the self-perception of the team.³² The perception is clear now but what is done by Craig Venter and his team? They took the DNA of the bacteria *Mycoplasma mycoides*, analyzed, synthesized it *de novo* and copied it into the bacteria *Mycoplasma capricolum* which was emptied out of its own DNA. The transformed DNA began to work within the new membrane and act like a *Mycoplasma mycoides*. Following Venter, his team has created the “first synthetic cell” and a “new species”.³³

Here we are at the crucial point. At first, there are two fundamental possibilities respectively something can be “new”. First, something could be “new” concerning the method of production. Second, the entity itself could be “new” because e. g. scientists used other materials

²⁸To be new and novel is one of the always recurring predication of the discussion. Venter claims, for example, to create “a new cell” (GIBSON et al.: *Creation*, 52) and Bedau/Parke see “a new kind of technology” (BEDAU/ PARKE: *Introduction*, 1) rise. Other predications in this way could be found at McCASKILL et al.: *Self-organization*, 1767 or NOIREAUX/LIBCHABER: *Bioreactor*, 17669.

²⁹BOLDT/MÜLLER: *Newtons*, 388.

³⁰BAHNSEN: *Schöpfungsakt*.

³¹Mentioned by SWABY: *Scientists*, although there are critical statements in federal newspaper like this one WADE: *Researchers* in the New York Times.

³²See for example: “We now have combined all of our previously established procedures and report the synthesis, assembly, cloning, and successful transplantation of the 1.08-Mbp *M. mycoides* JCVI-syn1.0 genome, to create a new cell controlled by this synthetic genome.” GIBSON et al.: *Creation*, 52.

³³Already in 2007 Venter and his team claimed to have created a new species by “transplant” a genome from one bacteria to another. His team did the same in 2010 with the important intermediate step of synthesizing the DNA “and transforming that cell into a new bacterial species.” See the announcement in May 2010 at http://www.ted.com/talks/craig_venter_unveils_synthetic_life.html.

for production. An example can illustrate this distinction: The impregnation with the in-vitro fertilization is a new method to breed, to reproduce. The method is high-grade artificial but certainly the entities resulting from that process are not. In contrast, when early humans had built the first statues, this was, in contrast to the living humans which had been the model, a totally new entity. The ontological state of the entity changed because it was produced with a new method as well as other materials. But not only the material is relevant, even more relevant are the concepts related to the material. For example the flesh-shoe (see figure 2) could confront our XXX but will not intermingle the concepts of nature and technology. But if the shoe



SHoe SHoe SHoe SHoe SHoe
SHoe SHoe SHoe SHoe SHoe
SHoe SHoe SHoe (© a_kep,
flickr.de)

Figure 2: "Flesh-shoe"

would not consist of dead biomass but of a living and evolving organism, one would judge otherwise. He would be an organism that could be used as a shoe but that is a difference which is at least so important as being artificial or artificially made.

The bacteria designed by Venter and his group belongs mostly to the first possibility. The process of producing an entity has changed but not the entity itself. Therefore, they had to use e. g. inorganic materials. However, Venter did more than just changing the process, the team did also interfere in the DNA and synthesized the genome. We can regard such interference in one way similarly to PID (preimplantation diagnostics) so that both resulting entities should have the same level, i. e. not being artificial. But how far the synthesis of the genome affects the state of the entity is a question that could not be answered satisfyingly within the paper at hand.

However, this example illustrates besides the mentioned issues that the transformation from one entity into another is a gradual process which knows no binary certainty. Rozin, who has conducted a study concerning the perception of naturalness, supports this thesis with his results and arrives, furthermore, at the conclusion "that [in the perception of the participants] process is more important than content in determining naturalness".³⁴ Important for further considerations is the fact that the first possibility does not change the moral state of an entity.³⁵

The terms used by SynBiologists imply a fundamental difference from hitherto existing creatures or a mixture of nature and technology. The previous subsection was conducted to elaborate the reference and meaning of the term "artificial cell". That shall clarify in which

³⁴See ROZIN: *Meaning*, 657.

³⁵See BAERTSCHI: *Vie artificielle*, chapter five. This point will be discussed intensively in the following chapter.

way the term could be problematic. Thereby occurred several problems. It was not possible to find out what the term is up to. Therefore, the paper focused on the “protocells”, “minimal cells” and “synthetic cells” which all were often used in terms of an “artificial cell”. The reference and meaning of each phrase could be elaborated. At this juncture, the terms appeared to raise also several issues related to that of “artificial cell”. The meaning of the terms is broad and iridescent. All terms intermingle concepts of nature and technique and imply a qualitative distinctiveness between natural micro-organisms and these new produced entities whereupon some terms are more problematic (“artificial cell”, “synthetic cell”, “protocell”) than others (“minimal cell”). Ensuing, it was possible to outline “artificial cell” that refers to any entity produced by SynBiologist within the methods of SynBio (synthesizing, bottom-up or top-down approach) and, according to the meaning of the other terms, pretends to produce organisms which are settled between the both concepts of nature and technology. This involves the idea of “creation” of new entities or even species via SynBio. Focusing on that issue, we could elaborate some of our intuitions concerning the ontological state of entities and distinguished between novelty by process of production (*in-vitro* fertilization) and novelty by essence (“living shoe”). Here we could have a good point to clarify the difference between “man-made” and artificial. Whereas “man-made” designate the process of manufacturing or producing an entity, “artificial” did also denote an entity itself. Several problems evolve from that mixing because it is e. g. unclear if the terms imply just to be made artificially or if they are artificial. This confuse and can rise, besides the epistemic issue, also ethical problems which will be analyzed in chapter chapter 4.

3.2 A ghost in the shell?

After the examination of the first phrase (“artificial cell”) with its related terms (“protocell”, “minimal cell” and “synthetic cell”), it is now the aim to focus on the second selected term: “living machine”. It has much in common with the first term so that it will be possible to attach to the previous considerations. The analysis will follow the same method as “artificial cell”. First, the reference will be clarified. Second, the meaning and the related associations of “living machine” will be outlined. Concluding, it shall be the aim to deal with the special character of the term which differ it from “artificial cell”.

“Living machine” raises related considerations like “artificial cells”. It is also used as a generic expression and, just as well as “artificial cell”, “living machine” is not a canonical one, but expand in a multitude of expressions like “universal biosynthetic machinery”,³⁶ “genetically engineered machines”,³⁷ “organic machine”³⁸ or “artificial self-replicating machines”.³⁹

“Living machine” refers thereby to mono- or multi-cellular entities that were modified or created through the methods of SynBio. This can happen within different approaches. First, scientists work on a “protocell” which could be used to assemble parts (so called “BioBricks”) to “create” a “living machine”. Second, an existing organism could be modified in a way to be programmable and to control its gene expression through standard parts and hence

³⁶NOIREAUX/LIBCHABER: *Bioreactor*, 17673.

³⁷The motto of the iGEM competition. See <http://2010.igem.org/About>.

³⁸NIOPEK: *E.colizenz*, 16.

³⁹NOIREAUX/LIBCHABER: *Bioreactor*, 17669.

modified biochemical pathways. The manufactured and mechanic usage of the cell is prior to this approach.

A machine who is alive, offend our common use of the terms "living" and "machine" because both differ greatly. A *machine* is something man-made to support humans in a certain way (power or energy transmission). They act mechanically and automatically and they have "no real independence or originality".⁴⁰ Furthermore machines are artifacts, i. e. they are designed and produced by humans out of inorganic materials to fulfill their purposes. In this case an "artificial machine" would be a pleonasm. A *living organism* on the other side consists of other properties (and is also a pleonasm). Beside the scientific definition of life, which is confront with several problems (see chapter 1), the term is commonly vague and unclear. XXXXXXXX As we could see, XXX the meaning of "living" and "machine" do not fit at all XXX but intermingle nature with technique similar to "artificial cell".

"The designing and fabrication aspects of these products define them as machines, but it would be hard to deny these entities are alive."⁴¹ As Deplazes/Huppenbauer states it, the notions of the two terms brings us to a paradox. That is why, Boldt/Müller refer to "living machine" as totally absurd because "the living" and "the mechanical" are, despite all analogy, strictly separated realms of objects.⁴² Indeed, the term "artificial cell" severely tests our intuitions and associations, but "living machine" will receive the most explosiveness.

While "artificial cell" is based on a changed, synthesized or produced organism, the term "living machine", in opposite, intend that the produced organism is prior to a machine added by elements related to concepts of "living". A machine is thereby something create to fulfill tasks and purposes. Thus, one is not only up to unify the most distant terms with this phrase, but also trying at the same moment to disrupt the "living machine" from the natural micro-organism (as well as the artifacts). Thus, the term "living machine" implies the commercialization and making available of cells in a new quality and quantity. The humans are, of course, aimed for this for a long time. It is one of the determining definition of all biotechnologies that they want to use the capacity of nature to enhance human life. Moreover, humans treat animals in terrible ways, for instance, by mass-farming or fur-production. Certainly, the method and aim of SynBio is more fundamental and far-reaching. This point seems to be crucial: Cells then will be available for humans in an entire new quality. The cell is losing its original function gained within the evolutionary process and is achieving a new one through humans. This new function has nothing to do with "being fit". But it was designed and produced by humans for their needs and purposes. The phrase goes even beyond that as it implies to treat organisms like machines.

Unfortunately the phrase lags behind its reflective abilities. The paradox laying into itself is not been used for a productive examination of the aims and approaches concerning the theory of science. Instead of questioning if the phrase is appropriate, what does it imply or what does it mean, when one takes it seriously; instead of all this the capability of the term is wasted and it is just used to express pictorial and political attractive ideas of the SynBio. Moreover the phrase may have given a clue to deal more extensively with findings of epistemology that had

⁴⁰DEPLAZES/HUPPENBAUER: *Synthetic organisms*, 57.

⁴¹Ibid., 59.

⁴²BOLDT/MÜLLER/MAIO: *Analyse*, 56.

analyzed the relation between living beings and machines for a long time.⁴³

So, what do “living machines” confront us with? A “living machine” is in fact an “artificial cell” which is modified by adding “BioBricks” for fitting certain purposes favored by humans. Thereby the line between an just modified “synthetic cell”, “minimal cell” or “protocell” and a “living machine” is profoundly porous. The phrase itself offends our intuitions and associations at least as “artificial cells”, it is still mixing not only concepts of nature and culture but implies also the extensive availability of cells for the human needs.

3.3 *First Conclusion*

The reviewed terms are fundamentally problematic. They presume to be something that they are not by recombining common expressions and perceptions. Our associations concerning nature and technique could be sorted by differentiating between an artificiality in terms of origin or manufacturing and quality. Apart from “protocell”, I could elaborate that all produced organisms referred to the reviewed terms are staying natural in a qualitative or phenomenological respect, although the way of producing is high-grade artificial. In this sense, the use of the reviewed terms is wrong. The produced cells are natural and they can be separated from artefacts easily. They are, of course, artificially made or man-made, but this is an important difference from being artificial. This phenomenological line could only be passed by a fusion of biological with nanotechnological approaches. Those considerations shall not deny the importance and recency of SynBio. She will have a stake in our future life. That does not change the fact, however, that the used terms should be selected more thoughtfully and accurately. They suggest to constitute a new class of objects (hybrids – neither natural nor artificial) that do not exist in the declared way. Thus the faulty terms have to be rejected from a linguistic and an epistemic perspective.

4 *From speech to tangle*

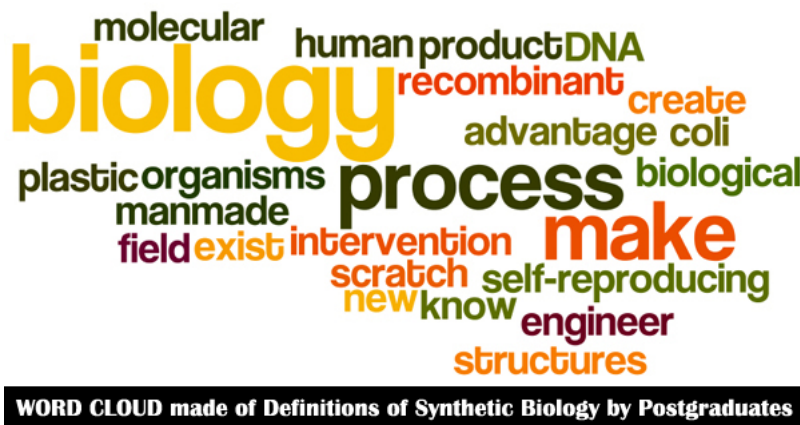
As we were able to see in the last chapter, the terms raise fundamental issues even on a semantic level. This problem gets worse. In the following, the ethical problems shall be analyzed that results from the semantic confusion sketched in the chapters before. At this juncture, the possible objection will be replied, that it is of no relevance how scientists names the things he produces because he knows what they are doing biologically. This chapter shall deal with three main problems arise from the inappropriate use of the terms.

4.1 *[Urteile die aneinander vorbeigehen]*

The terms do not express what they claim to express. This results in distorted opinions and ontological problems. One of this could concern the distinction in moral judgements between scientists and the rest of the society. Scientist do understand what the terms like “artificial cell” or “living machine” refer to and mean, because they understand the methods by which such cells are produced or modified. They know what that cells are about. The society does not have such knowledge or insight in the applied methods. Most people will just have a few

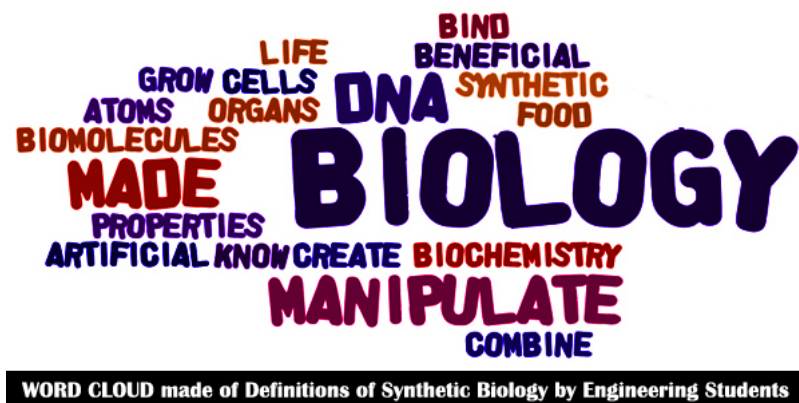
⁴³One of the most known exponent is CANGUILHEM: *Knowledge*.

snippets of information and their associations related to the terms. At this point, the problem of being misunderstood appears and of conducting a discussion that can not solve problems, but widen the gap between the positions.⁴⁴



This word cloud represents the frequency of certain words used by Postgraduates to define SynBio. Neither the words natural, living organism nor artificial, unnatural, machine or other charged terms were used. The definition is curling around process, make and biology. So they understand SynBio mostly as a process within biology or rather something biological is made. (© British Columbia iGEM team)

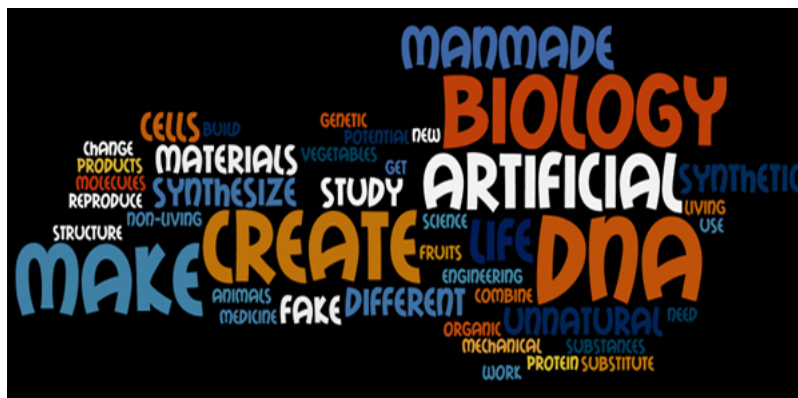
The word of the engineering students seems to be an intersection between those of the postgraduates and arts/commerce students. It entails more scientific terms and methods but picks up terms like artificial or create on a lower level, too. (© British Columbia iGEM team)



Such a development appears in the word clouds generate by the British Columbia iGEM team impressively (see figure 3 on page 17). In both clouds the definition of SynBio curls around different terms, whereby the difference between a group who has the insight and a group who have not the knowledge becomes evident. While the postgraduates pursue a more methodical and scientific definition, the arts and commerce students associate more the terms discussed in the paper at hand: artificial, man-made, create, synthetic, unnatural, cells, synthesis and so on. Such groups have, following the considerations above, a different understanding of SynBio and would judge to related problems in different ways.

This will, of course, effect also moral judgements like “artificial cells’ are good or evil”. For scientists, the terms mean something different from than for the rest of society. The terms of both groups will refer to the things scientists produce, but the society will have

⁴⁴The problem of the discursive mediation [diskursive Vermittlung] of knowledge between two groups with different levels of information can be impressively studied by Grice who elaborated the difference between speaker-meaning and sentence-meaning from an social psychological point of view. For an approach see LYCAN: *Language*, 100-114.



WORD CLOUD made of Definitions of Synthetic Biology by Arts and Commerce Students

The definition of the art and commerce students is nearly opposite to the one of the postgraduates. They use a lot of charged terms that were analyzed in the paper at hand. For them SynBio is about creating, artificiality and so on. (© British Columbia iGEM team)

Figure 3: Word clouds by the British Columbia iGEM team

a misguided understanding founded in the inappropriate use by scientists and the media. Moral judgements could not be shared meaningfully between scientist (defined as those who have the insight) and the rest. Thus, the communication-problem causes a confusion who makes people judge about things that they misunderstand due to inappropriate terminologies. An example shall clarify the importance of that point. Assuming that the term "baby" is misunderstood between two groups. One group has a clue what a baby is, the other not. The first group Give a non-SynBio-Example for that (For example: Babys as non-living Organ-ressources!)

4.2 From Is to Ought

Another ethical issue rise from terms which refer to entities changing the ontological state. Through the use of novel methods and approaches one could argue that several produced cells are "new". Instead of considering this kind of change, the opion may be at first hand, that together with the ontological state also the moral has changed. Certainly the moral state is not causally connected to the ontological: the genesis of an organism does not effect the selfsame moral state.⁴⁵ This point was illustrated by *in-vitro* fertilization. Cloning would lead to the same conclusion. The sheep Dolly, come into being through an high-grade artificial process is not artificial itself. It has the same moral state as any other sheep. Certainly the risk is given that these difference between ontology and ethic could be ignored. Critic are concerned about the societal establishing of a basic differentness between the products of SynBio and natural entities. They suggest that one could estimate the value of "artificial cells" subordinate to the value of "natural" entities. A similar developement happened in Germany in the last years concerning the attitude of the population regarding genetic engineering especially for agriculture. In this sense, Boldt proclaims the danger of an establishment of a "two-class biology" within the increase of SynBio.⁴⁶ The elaborated moral standards in the treatment of non-human creatures, as recorded e. g. in the Protection of Animals Acts, would lapse with it. Such standards shall protect creatures from cruelty and a not appropriate enviroment. A

⁴⁵See EKAH: *Biologie*, 11. This issue was analyzed in detail according especially the specific character of genetic engineering and SynBio by BAERTSCHI: *Vie artificielle*.

⁴⁶BOLDT/MÜLLER/MAIO: *Analyse*, 61.

“two-class biology” could lead to a treatment of animals as machines or artifacts.

4.3 *Emotional terms*

Finally, we consider some basic problems related to the terms. No matter how the previous problems were settled, all technique-related terms pose problems and should be reviewed. SynBio is about to raise social interests and will be centre of attention in the course of further research and new knowledge.⁴⁷ Especially since the relation to genetic engineering and the perception of SynBio, with good reason, as an advancement of genetic engineering, SynBio will initiate a difficult and often emotionally overcharged discussions. The terms and expressions are either highly metaphorical or emotionally charged, so that they will raise the people’s reservations and defensive demeanors. Not to fire the public opinion will be from an outstanding importance by reason of false associations or prejudice. But such prejudice or negative attitude is raised from the reviewed terms and it seems that they *have to* provoke rejection. Just a paradox like “living machine” seems to be made for provocation and affront the people and their views.

The situation presents itself as if somebody is watering a parched forest with gas.

4.4 *Any alternatives?*

As an alternative especially for the umbrella term “artificial cell” I want to introduce the term “biofact” devised by Karafyllis to clarify that also organisms could be high-grade artificial through the methods of modern biotechnology like genetic engineering. Biofact is a compound consisting of the greek word for life (“bios”) and artefact. An artefact is everything influenced, modified or produced by humans. “Biofact” means in this way an biological or organic entity profoundly influenced by humans. The term was introduced to name the products of modern biotechnology who differ in a qualitative respect from hitherto existing modified organisms like domesticated or cultured animals. The advantage would be not to intermingle the basic concepts nature and culture in an emotional or affronting way so that the term is fitting better for a high-grade emotional discussion and do not imply serious ethical problems. However one turns the issue one thing seems to be clear: SynBio has a veritable demand on serious terms.⁴⁸

5 *Conclusion*

Was war die Anfangsfrage
Wie sind wir dran gegangen
Wichtigste Erkenntnisse in den Abschnitten
Ethische Probleme
the semantic confusion causes ethical confusion

⁴⁷One just have to think about the media’s interest in Craig Venter’s bacteria.

⁴⁸Another alternative was brought into discussion by Boldt. He recommend the expression “animunculus” as a transfer of the well-known “homunculus” popularized by Goethe within his magnum opus “Faust” to specify modern issues related to word-finding difficulties. The term goes back to the classic latin age where it was used as a diminutive for homo and means thus ›little human‹. See BOLDT/MÜLLER/MAIO: *Analyse*, 58.

I have elaborated an approach consisting of three elements: the semantic value (reference and meaning), cultural implication and novelty of the certain term. Those allowed us to clarify if it is appropriate or not. In the following I have tried to enlighten the term “artificial cell” whereupon similar terms like “protocell”, “minimal cell” or “synthetic cell” become the focus of attention.

All these terms are related to severe issues, certainly some more than others. The terms “artificial cell” and “living machine” must be treated as unsustainable. According “artificial cell” the production process is used to denote the product in a way as it would be about a phenomenological new entity (“new”). But even if the term would refer to a “new” life-form it would stay natural in a qualitative ontological respect (it’s not “novel”). But these considerations do not imply that it is not necessary to develop terms for these entities made within new and high-grade artificial methods like genetic engineering or SynBio.

SynBio has a great part in its present and future problems and it will, moreover, raise with the increase of the products and approaches of SynBio. The highly charged and metaphoric speech of SynBiologists in research papers and announcements as well as in interviews and mediating papers gives rise to ethical and philosophical issues as well as dismissive associations that infect the societal attitude. This is a development SynBio can ill afford to do. Thus besides the ethical and philosophical issues related to the terms, SynBio is - without appropriate terms - cutting off its nose to spite its face.

The paper had have the aim to clarify central terms of SynBio which are often used to mediate the aims and methods of that field to the society. So, they are from an outstanding importance, because they influence the perception of SynBio within the society.

To be able to judge the selected terms, the following analytical framework was chosen: at first, the reference of the terms was examined to identify the entities they designate. Afterwards, the meaning and the related associations were analysed to figure out what kind of concepts and ideas were related to the terms. At this juncture, it was important to comprehend if the entity designated by the term fits the concepts the term implies. If that was not the case, the term was wrong and all its use generates just nonsense. This is even more important if we consider the importance of terms for our understanding of the world. The concepts by dint of those we are able to understand the world preshape the world. If we do not have appropriate terms, we are not able to communicate ourselves and to understand the world we are living in.

Firstly, the “artificial cell” was examined, but respective its ambiguity, the analysis focused on several other terms (“protocell”, “minimal cell” and “synthetic cell”) often related to “artificial cell” and used as synonym. All terms refer to different methodical approaches applied by SynBiologists to produce new entities. A “protocell” is an entity generated by the bottom-up approach, where inorganic elements shall be combined to produce an hitherto unknown organism. A “minimal cell” is an existing organism which shall be reduced to its lowest possible level, i. e. all elements within the cell shall be removed so that the cell is barely alive. A “synthetic cell” is a cell, whose DNA or genome was synthesized, i. e. newly combined from a subcellular level by chemistry. Based upon these considerations, an “artificial cell” is a umbrella term to name all cells produced by the methods of SynBio. The meaning of all

terms differ in several points, but all have in common the intermingling of the concepts nature and technology. Moreover, the implications concerning the "creation" of new entities or even species could be outlined. Thereby Here, it was possible to clarify wherein the vagueness of the term "artificial cell" lays. It can denote the

Secondly, the term "living machine" was analysed. He had much in common with "artificial cell" but differed. The term refers to a cell, which could be made by different approaches (bottom-up or top-down). A cell who could be used as a kind of "chassis" was customized with "BioBricks" who are defined and standardized DNA sequences with certain functions. The mechanic usage and the application for human needs are both crucial to this approach. The associations

The arising problems are manifold, but the three important from an ethical point of view were discussed. First, the mixture of concepts could lead to a situation where no meaningful discussion between scientists, who know what kind of organisms they produce, and the society, who do not have such an insight, will be possible. The society could have a misguided understanding of the terms due to the use of inappropriate terms by scientists and the media. The semantic confusion can thus cause an ethical confusion. Second, the terms could abet the establishing of a "two-class biology" because they indicate to name novel entities which are settled between nature and technology. But as long as nobody invents a functional "protocell", through a high-grade artificial process will not affect the moral state of an entity (Dolly!). Third, the emotionally charged terms could make the arising societal debate difficult. They could evoke negative associations which will bring people to reject SynBio even if they do not know what topics SynBio deals with.

Such a development will be even worse respective the dependency of SynBio on the acceptance of the society as well as the government. SynBio depend on the funding by fundings from the public purse. Besides the epistemic and ethical problems connected to the terms, it should be in its own interest to rethink the terms used to communicate their aims and methods. If not

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