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Engineers of Life?

A Critical Examination of the Concept of Life in the Debate on Synthetic Biology

Abstract The concept of life plays a crucial role in the debate on synthetic biology. The first part of this chapter outlines the controversial debate on the status of the concept of life in current science and philosophy. Against this background, synthetic biology and the discourse on its scientific and societal consequences is revealed as an exception. Here, the concept of life is not only used as buzzword but also discussed theoretically and links the ethical aspects with the epistemological prerequisites and the ontological consequences of synthetic biology. The second part examines this point of intersection and analyses some of the issues which are discussed in terms of the concept of life. The third part turns to the history of the concept of life. It offers an examination of scientific and philosophical discourses on life at the turn of the 20th century and suggests a surprising result: In the light of this history, synthetic biology leads to well-known debates, arguments, notions and questions. But it is concluded that the concept of life is too ambiguous and controversial to be useful for capturing the actual practice of synthetic biology. In the fourth part I argue that with regard to the ethical evaluation of synthetic biology, the ambiguity of the concept of life is not as problematic as sometimes held because other challenges are more important. The question whether the activity of synthetic biological systems should be conceived as life or not is primarily theoretical.

1 The Concept of Life. Its Return in the Debate on Synthetic Biology

The long and complex history of the concept of life has reached a paradoxical point: On the one hand, the term life is used ubiquitously. An array of disciplines under the umbrella

term ‘life sciences’ dominate the theoretical discourse of our times. In fields such as medicine, pharmacology and agriculture, numerous technological applications are changing our daily world. These applications can be understood as an indicator of the far-reaching implications that the scientific discourses on life have for society and culture. In the view of some, we are living in a “culture of life”, which moves away “from the ideals of the Enlightenment towards an idea of individual perfectibility and enhancement” (Knorr Cetina 2005, p. 76).

On the other hand, there is no precise and generally valid definition of life. This is not least because in current biology the status of the concept of life is controversial. In June 2007 an editorial article in the journal Nature claimed: “It would be a service to more than synthetic biology if we might now be permitted to dismiss the idea that life is a precise scientific concept” (Editorial 2007, p. 1032). Moreover, scientists assure us that “the impossibility of a sharp distinction between animate and inanimate would not create difficulties for the biology in its everyday scientific practice” (Budisa 2012, p. 101; see also Toepfer 2011, pp. 467-68).

Thus, for many scientists the possibility of a precise biological definition of life is not important. They regard life as a “fuzzy concept” and are satisfied with the notion that biology allows a plurality of approaches to life (see Witt 2012, p. 37). Some scientists, like Dominique Homberger, even claim that biologists have an intuitive knowledge of the border between inanimate matter and living beings, but are not able to explain the phenomenon of life physically (see Homberger 1998). Similarily, the philosopher Jean Gayon thinks that life could disappear as a scientific concept and remain only as a “folk concept” for our everyday practice. He claims: “When this point will be reached, life will be no longer a concept for the natural sciences, but just a convenient word in practice, in the world we inhabit. ‘Life’ will be a folk concept. Its specialists will be no longer chemists, biologists, and roboticists; life will be a subject for psychology, cognitive science and anthropology.” (Gayon 2010, p. 243). But Gayon does not only deny that there can be a scientific definition of life in the strong sense. He assumes also that “the recognition of ‘life’ has always been and remains primarily an intuitive process, for the scientists as for the layperson. However we should not expect, then, to be able to draw a definition from this original experience.” (Gayon 2010, p. 231). Against this background, it is not surprising that some critics assert that the concept of life is only used as a buzzword to create attention in a world in which the selling of a scientific result is as important as the result itself.

The concept of life has no better a reputation in current philosophy than in science. Traditionally, the philosophical concept of life points to a realm which cannot be captured completely by thinking. Wilhelm Dilthey, one of the most important philosophers of life, claimed around 1890: “The expression ‘life’ formulates what is most familiar and most

intimate to everyone, yet at the same time something most obscure indeed totally inscrutable. What life is remains an insoluble riddle. All reflection, inquiry, and thought arise from this inscrutable [source]" (Dilthey 2010b, p. 72). Dilthey was part of the development of a philosophy of life in the 19th century. The term philosophy of life (*Lebensphilosophie* in German) groups together highly different authors (e.g., Friedrich Nietzsche, Wilhelm Dilthey, Georg Simmel, Henri Bergson or Ludwig Klages), who are united more by their impact than by their doctrines. Most of them were driven by a critique of the one-sided emphasis on reason and rationality in both idealistic philosophy and science. Therefore, it is not surprising that there is a tension between systematic philosophy and philosophy of life. Moreover, since some philosophers of life were entangled in the theoretical foundation of National Socialism (see e.g., Lebovic 2013) – a part of the history of philosophy, which has still to be investigated – the philosophy of life tradition largely disappeared after 1945. While there have been a few attempts to renew philosophical reflection on life (see Fellmann 1993; Worms 2013), the concept of life is mostly used as a critical concept in political philosophy (see Agamben 1998; Esposito 2013). There is little systematic work on the concept of life in contemporary philosophy.

Against this background, synthetic biology and the discourse on its scientific and societal consequences is clearly an exception. Here, the concept of life is not only used as buzzword (a) but also discussed theoretically (b) and plays a crucial role in the debate about the ontological, epistemological and ethical dimensions of synthetic biology (c). In what follows, I will briefly outline these different aspects of its use[1]:

(a) Some protagonists of synthetic biology like Craig Venter consider the 'creation of life' as the central aim of their research. Moreover, 'the creation of artificial life' is advertised as "the most sensational success of synthetic biology with the promise to provide solutions to our energy, health, environmental and nutritional problems" (Budisa 2012, p. 103). Briefly speaking, a lot of hopes and concerns which are connected with the production of synthetic biological systems focus on the formula 'creation of life'. Public press and mass media have readily accepted this self-advertisement and have reported on scientific developments in synthetic biology from the beginning. Anna Deplazes-Zemp and Nikola Biller-Andorno remark correctly that this use of the expression 'creation of life' is based on the ambiguity in the concept of life: „Headlines such as 'Life 2.0', 'Engineering life: building a FAB for biology' or 'Synthetic life' illustrate this tendency [that synthetic biology would lead to ‚synthetic life'; J.S.] – such titles would not produce the same effect, if 'life' was purely a scientific concept." (Deplazes-Zemp and Biller-Andorno 2012, p. 959)

[1] For a discussion of life as metaphor in the context of synthetic biology see Falkner, this volume.

(b) A lot of scholars – philosophers as well as scientists – in synthetic biology assure us that they want to contribute to the basic understanding of life (see Deplazes-Zemp 2012, pp. 762-763). Due to experimental results like the „synthetic cell" (Gibson et al. 2010) created by Craig Venter and his colleagues, debate on the question 'what is life?' has reignited. Mark Bedau, for instance, emphasizes that „we now have an unprecedented opportunity to learn about life. Having complete control over the information in a genome provides a fantastic opportunity to probe the remaining secrets of how it works" (Bedau 2010, p. 422). Others, like Arthur Caplan, conclude that we have already learnt enough to end an old and for a while forgotten debate:

> Venter and his colleagues have shown that the material world can be manipulated to produce what we recognize as life. In doing so they bring to an end a debate about the nature of life that has lasted thousands of years. Their achievement undermines a fundamental belief about the nature of life that is likely to prove as momentous to our view of ourselves and our place in Universe as the discoveries of Galileo, Copernicus, Darwin and Einstein. (Caplan 2010, p. 423)

Craig Venter claims that his synthetic genomics approach will provide a reductionist explanation of life (Cho et al. 1999; Deplazes-Zemp 2012, p. 763). Since, as Michel Morange puts it, "life is on the way to being 'naturalized'", it thus seems "fully accessible to scientific enquiry" (Morange 2010, p. 181).

As one would expect, these claims have invited objections. Take, for example, Deplazes-Zemp and Biller-Andorno, who answer directly to Caplan:

> Synthetic biology, even with the production of a living protocell, could not bring an end to this debate [about the nature of life; J.S.]. Those who argue that life is more than merely a scientific phenomenon would say that a synthetic organism, if it is considered to be alive, also has features that cannot be captured by the life sciences. [...] Biocentrists argue that a synthetic organism has moral value, and other philosophers claim that a synthetic organism is an autonomous system with subjectivity and a self. (Deplazes-Zemp and Biller-Andorno 2012, p. 962)

As these few examples already show, there is a diverse debate[2] about the concept of life in synthetic biology, which is far away from a precise and universally accepted answer to the question 'what is life?'.

(c) The concept of life plays a crucial role in discussions about the societal dimensions of synthetic biology. This is because the special ethical relevance of synthetic biology is supposed to be explained by the conviction that synthetic biology "entails a confrontation with life" (Ruiz-Mirazo and Moreno 2013, p. 378). Therefore, some regard the concept of life as

[2] Further examples include Boldt et al. 2012; Bedau et al. 2010; Dabrock et al. 2011a; Hacker and Hecker 2012; Witt 2012.

the focal point of the ethical, legal and political questions raised by the development of synthetic biology (e.g. Dabrock et al. 2011b, p. 14). The relevance of the concept of life for the debate about the societal impact of synthetic biology is closely connected with its other meanings. Within the concept of life the ethical aspects are intrinsically linked with the epistemological prerequisites and the ontological consequences of synthetic biology.

In the next section I will examine this point of intersection, and analyse some of the issues which are discussed in terms of the concept of life. I will trace some typical arguments in the debate on synthetic biology. My analysis is based on the following assumption: If we take the idea that there is no precise and generally valid definition of the concept of life seriously, its use raises a question rather than a solution, contrary to what is often suggested.

2 Engineers of Life? Current Issues in the Debate on Synthetic Biology

2.1 Fabrication of Life? The Epistemological Question

The umbrella term synthetic biology groups together a set of different scientific and methodological disciplines, which share a constructive approach to their object (see Acevedo-Rocha in this volume; Billerbeck and Panke 2012; Bölker 2011). In this respect, synthetic biology can be seen as a new form and development of biotechnology. In contrast to other biotechnologies, synthetic biology systematically introduces engineering concepts and methodologies like standardization, modularization and hierarchical organisation (see Boldt 2013, pp. 391-392; Deplazes-Zemp 2012, p. 772). Moreover, as both practitioners and theoreticians of synthetic biology emphasise, synthetic biology research has a creative aim: Novel products with useful functions should be designed in a rational manner (see Boldt 2013, p. 392; Bölker 2011, p. 35-39). In the best case, the human designed biological systems cannot be found in nature.

Briefly speaking, with synthetic biology the engineer enters biology and gets an epistemological model of biological research. Since in contrast to other biotechnologies synthetic biology is not only the application of theoretical knowledge, the fabrication of biological systems should also lead to a better understanding of their composition and functioning. The phrase “knowledge through fabrication” (Ruiz-Mirazo and Moreno 2013, p. 377) summarizes the methodological approach of the various forms of synthetic biology (see also Köchy 2012a, pp. 160-161). To sum up their attitude, several scientists refer to Richard Feynman’s saying: “What I cannot create I do not understand” (see Deplazes-Zemp 2012, p. 762; Ruiz-Mirazo and Moreno 2013, p. 377; Weiss 2011, p. 17).

This *bon mot* condenses a long tradition of modern scientific thinking. Many studies mention the prehistory of the epistemological imperative of synthetic biology. It goes back at

least to the 17th Century, in which – after 300 years of progress in the production of mechanical gadgets and devices – a general scientific research strategy was established in the sciences.[3] René Descartes and Julien Offray de La Mettrie exemplify a scientific attitude which identifies the explanation of a natural phenomenon with a demonstration of how it can be generated by the action or activity of a mechanism (see Ruiz-Mirazo and Moreno 2013, p. 376; see also Deplazes-Zemp 2012, pp. 762-773). Thus, a constructive approach is essential for modern scientific thinking. From its early stages theory and practice are entangled. Synthetic biology introduces this epistemological principle into a new realm, the realm of biology. The ground breaking aim of synthetic biology "is to learn more about the living by means of re-construction or fabricating it" (Ruiz-Mirazo and Moreno 2013, p. 377).

In the debate on synthetic biology, it is exactly this combination – the engineering attitude and life forms as its objects – which mostly stands for both the potentials and problems of its way to gain and apply scientific knowledge. For instance, Deplazes-Zemp argues:

> […] that the notions of 'new life-forms' in synthetic biology, the way that synthetic biologists want to contribute to the understanding of life, and how they want to modify life by a rational design reveal a conception of life that differs from that of traditional biotechnology. As a result, synthetic biology adds a new facet to the multifarious notion of life. For certain ethical positions this production- and design-oriented conception of life may raise concerns. (Deplazes-Zemp 2012, p. 758)

Further, ethicists like Joachim Boldt completely reject the "conception of life as a toolbox" (Deplazes-Zemp 2012). Boldt adopts Hannah Arendt's distinction between "action" and "work" (he calls it "fabrication")[4] and criticises synthetic biology because it is an "implementation of the ideals of fabrication in the realm of the living" (Boldt 2013, p. 398). For Boldt, the notion of fabricating life encapsulates the problematic assumptions and implications of synthetic biology: It reduces life forms to "complex conglomerations governed by regularities that apply to physical and chemical matter" (ibid.) and is unable to explain their inherent value (ibid. p. 397). I return to this below.

2.2 Living Beings or Artefacts? The Ontological Question

The criticisms of synthetic biology as 'fabrication of life' presuppose that its objects have a particular ontological status and deduce ethical consequences from that status: Its objects

[3] Martin Weiss even argues with reference to Martin Heidegger that the association of knowledge with the notion of building characterizes the occidental philosophical tradition since Plato (see Weiss 2011, p. 179; this volume).

[4] As Boldt mentions, Arendt originally distinguishes three types of human activity: "labor", "work" and "action". Boldt drops "labor" with the pragmatic argument that "for the purpose of this article […] fabrication and action are the two types of human activity that are of special interest" (Boldt 2013, p. 393).

are regarded as new variants of life and have to be treated *as* forms of life. But there is a philosophical controversy about the ontological status of the products of synthetic biology (see, e.g., Gehring 2010, Brenner 2012, Beuttler 2011). This is not least because synthetic biology challenges the well-established distinction between nature and technology. The ontological relevance of this distinction can be traced back to Aristotle who classifies in his *Physics* "all the things that are" (Aristotle 2004, p. 49) into two forms: He claims that "some are by nature" (ibid.) and "others through other causes" (ibid.). Natural objects have the "source of motion and rest, either in place, or by growth and shrinkage, or by alteration" (ibid.) in themselves. The "other things" are produced and "none of them has in itself the source of its making" (ibid.).

This influential distinction between "physis" and "techne" is still used as a starting point to define life: Living beings are identified with natural objects whose definition is extended by, for example, the notion of autopoietical organisation (see, e.g., Brenner 2012, pp. 106-8). And, they are distinguished from artefacts which are fabricated by human beings and exist only in relation to their use. From such a dualistic perspective, a constructive approach to the realm of the living seems to be impossible. In fact, philosophers like Andreas Brenner, claim that synthetic biology is a misleading concept (see Brenner 2012, p. 118), because living beings cannot by definition be produced. Here, the notion of synthetic life is rejected as contradictio in adiecto. Since life emerges out of itself, human technology can only produce artefacts.

Such arguments are problematic, because they miss the significance of synthetic biology regarding the relation of nature and technology. Kristian Köchy emphasizes that nature and technology are closely related, although the well-established distinction suggests an opposition. Moreover, he shows convincingly that new technological possibilities change not only our concept of technology, but also our concept of nature (see Köchy 2012a, p. 159). Synthetic biology is clearly an example for the blurring of the demarcation between nature and technology, which can be interpreted in different ways.

Some scientists as well as philosophers regard synthetic biology as the ultimate proof of a technological understanding of nature and as the closer of the mechanistic world view of modern science (see, e.g., Morange 2009; Venter 2013). They put forward a reductionist concept of life and claim that the further development of synthetic biology will enable us to explain the animate part of nature by constructing it. Michel Morange claims, for example, that the "rise of synthetic biology is a return to the 'old' traditions: one can claim that a system has been fully described only when it has been possible to reconstruct it. […] the achievement of the distant goal of constructing an artificial living cell will be the ultimate proof that life has been fully explained." (Morange 2009, p. 52). The notion of constructing life

suggests to understand the products of synthetic biology as living machines.[5] What qualifies the synthetic biological systems as machines is not only their way of production, but also their rational design and their function. Anna Deplazes-Zemp remarks: "When synthetic biologists speak of their products as machines they imply these entities have lost their independence and are thus controllable." (Deplazes-Zemp 2012, p. 767)

But it is controversial, if the notion of synthetic biological systems as living machines captures the combination of natural and technological properties which you find in the existing results. Products like the "synthetic cell" made by the JCVI or Biobricks – the standardised biological parts which are used to engineer novel biological devices and systems – present a mixture of natural and technological properties on several levels. According to Köchy, in current research natural systems are used as material and models for both the products and the production process (see Köchy 2012b, 147-149).[6] Moreover, he shows that the technological approaches of synthetic biology are always framed by the requirements of complex biological systems (see Köchy 2012a, 165). Köchy defines these requirements as the natural prerequisites of the synthetic products and shows that their increasing complexity intensifies the mixture of natural and technological modes of production (see ibid. 172). Likewise, this complexity sets limits to the possibility of planning and controlling the process of production. According to Köchy, in synthetic biology the production process has to be conceived as a form of directed self-organisation (see ibid. 171; Köchy 2012b, 157). Thus, applying engineering principles in biology causes changes in the concept of technology and its relation to nature. These changes also affect the background beliefs which coin the self-understanding of synthetic biologists. Some refer to their research activity as "tinkering" (see, e.g., Benner et al. 2011), a concept which is in tension to essential features of the mechanistic paradigm, especially the idea to design biological system "in a rational and systematic way" (European Commission 2005, p. 5).

Some authors in the debate about the ontological status of the objects of synthetic biology claim that their mixed character can only be understood by a hermeneutic concept of life which connects nature and culture. From such a perspective, synthetic biology systems are life forms, because they are both natural objects and technological products. Here, the concept of life should achieve in theory what synthetic biology performs in practice: a dialectic of nature and technology. Ulrich Beuttler argues, for example, that on the one hand, synthetic biological systems like artificial cells would still be similar to natural life forms,

[5] For a discussion of the complex history of the analogy between living beings and machines see Köchy 2012b, pp. 150-157.

[6] Köchy indicates that the reference to natural systems is also important for the proclaimed future of synthetic biology and refers to the report of the NEST High-Level Expert Group for the European Commission which claims: "[…] synthetic biology aims to go one step further by building, i.e. synthesizing, novel biological systems from scratch using the design principles observed in nature […]" (European Commission 2005, p. 11).

insofar as they are constructed as self-maintaining systems, which serve their purpose in an independent way (see Beuttler 2011, p. 292). According to Beuttler, reductionist explanations cannot capture this form of selfhood. But in contrast to certain autopoietical theories (e.g., Brenner 2012) he also emphasizes that the self-reliance of a living being is not based on the form of its emergence: “Life moves, preserves, organises and develops itself, but it does not create itself.” (Beuttler 2011, p. 297; translated by J.S.) On the other hand, the entities of synthetic biology are as technological products part of human culture. As Beuttler emphasizes, his concept of life avoids the fatal alternative nature or technology, because it encompasses the sphere of culture without blurring all distinctions. He claims that in his theory life as culture and life as nature are united and distinguished likewise (see ibid. 300-301). Regardless of the details and validity of Beuttler’s view, such approaches are interesting, because they show that synthetic biology can be interpreted in a non-reductionist way and, thus, indicates the limits of a mere biological concept of life.

2.3 The Value of Synthetic Biological Systems? The Ethical Question

These epistemological and ontological considerations are closely related to ethical questions. The assumption that the products of synthetic biology are human-designed life forms extends the scope and depth of the relevant ethical considerations. Ethicists, like Joachim Boldt, emphasize that the ethical questions which are raised by synthetic biology are an inherent part of the research activity, and not just problems of technology assessment (see Boldt 2012, pp. 189-190). Here, the definition of the objects of synthetic biology as life forms is used to think of this research in terms of interactions between different life forms, i.e. human and non-human life. In other words, it adds an existential dimension to the practice of synthetic biology. From this perspective, the attitude of the researchers towards their objects becomes an important issue (see, e.g., Boldt 2013, pp. 397-400). Others argue that the artificial production of living beings is a new challenge regarding our responsibility for nature and its future form (see, e.g., Aurenque 2011, pp. 342-344).

But the concept of life also motivates immediate ethical claims. There are several versions of the argument: If synthetic biological systems are life forms, they have to be treated as life forms. All these arguments rest on the conviction that life has an inherent value and, thus, ethical relevance – a claim, which is intuitively right, but nevertheless controversial (see Toepfer 2014). Take, for example, Boldt's criticism of current synthetic biology, which is based on an axiological concept of life. He declares self-activity to be the bearer of the normative content of the concept of life. This cybernetic concept of life – life as self-activity and communicative interaction with an environment (see ibid.) – is combined with the holistic potential of the concept of life: The boundaries between the different life forms are sublated

(see Boldt 2013, p. 399) and all life forms are conceived as being engaged in seeking a common good. The good is a “practical notion of truth” (Boldt 2013, p. 398), because:

> The entity to which one relates is conceived of as taking part in the search for the good in which one is immersed oneself. Hence, on this view one does not have an a priori right to discard the interests and behavior of the entity, but is supposed to commence action towards it in order to get to know the entity and accommodate its interests, if this appears reasonable. The inherent value of the entity is a result of conceiving of the entity as a proto-subject. Thus, the observer is compelled to respect its ways of behaving and turns from observer into companion. (Boldt 2013, p. 397)

Another claim for the „attitude of respect for nature” (Taylor 1986, p. 59) rests on the „biocentric outlook on nature“ (ibid. p. 99). Biocentrists, like Paul Taylor, hold “that all organisms are teleological centers of life in the sense that each is a unique individual pursuing its own good in its own way” (ibid. p. 100). As moral agents, human beings are obliged to acknowledge the “inherent worth” of “entities that have a good of their own” (ibid. p. 75). Deplazes-Zemp remarks rightly that for biocentrists “the production of synthetic organisms would […] imply a moral responsibility towards the produced organism” (Deplazes-Zemp 2012, p. 770). Already in 1986, Taylor emphasizes the special relevance of an “ethics of the bioculture” which “is concerned with the human treatment of animals and plants in artificially created environments that are completely under human control” (Taylor 1986, p. 53). He argues that “it becomes a major responsibility of moral agents in this domain of ethics to work out a balance between effectiveness in producing human benefits, on the one hand, and proper restraint in the control and manipulation of living things, on the other” (ibid. pp. 57-58).

There are profound arguments which can be raised against both the cybernetic and the biocentric starting points. Georg Toepfer remarks, for example, that neither differentiates between the immanent normativity of every organic life form and the normativity which is posited by individual reflection and in distance to the organic presuppositions of life (see Toepfer 2014). But the purposes that guarantee the self-preservation of a system are not necessarily ethically valuable. There can be a difference between teleological purpose and the ethical good. Thus, both the cybernetic and the biocentric position are problematic because of their equivocation on the concept of purpose. In addition, they do not provide any possibility of deducing the reflexive normativity and can be accused of “immanentism” (ibid.).

3 The Concept of Life in Philosophical and Scientific Discourses around 1900. A Key Constellation

I have shown that the concept of life plays a crucial role in current debates on the philosophy of synthetic biology. I will now turn to the history of the concept of life. All of the issues I have discussed, have a long history in philosophical and scientific reflections on life. They are what we might call tropes in the modern discourse on life. The latter starts around 1800 and culminates in the late 19th century. But in the context of synthetic biology the turn of the 20th century is of special interest, because it was around this time that a strictly biological belief in the possibility of creating life arose. Scientists like Emil Fischer or Jacques Loeb concluded independently that the artificial production of life should be possible (see Budisa 2012 p. 106). For Fischer – as Nediljko Budisa emphasizes – the chemical synthesis of life seemed to be "an achievable goal":

> Fischer believed that modifications, design and creation of organisms with chemical methods is a kind of beginning of a grand future project: he expected new forms of life with novel/alternative chemical compositions created by synthetic means to have fundamental advantages over the known living organisms with great potentials to gain technological benefit for society. (Budisa 2012 p. 107).

Loeb was also convinced that the artificial production of living beings would be possible in the future. In his opinion, only technological problems explained the failure of contemporary attempts to synthesize life and he saw no reason why the artificial production of living organism should be impossible in principle (see Loeb 2008, p. 258). Loeb's lecture *Das Leben* (*Life*), which was delivered in 1911 at the first conference of the monists in Hamburg, explained the theoretical framework behind his belief in the possibility of "a practical, useful and controlled design of 'synthetic life'" (Budisa 2012, p. 106). He developed a rigid "philosophy of reductionist experimentation that sees living organisms as chemical machines" (ibid. p. 106). Moreover, Loeb claimed that if life could be explained completely by physics and chemistry, we could also build our social and ethical life on a scientific foundation (see Loeb 2008, p. 255). The engineering of natural life would enable us to engineer social life as well. His lecture ends with reflections on the natural basis of human ethics.

The social, political and ethical implications of Loeb's strict naturalism indicate two important features of the scientific and philosophical discourses on life around 1900: Firstly, the reduction of the social sphere to the scientific method points to the reach of the technical imperative of the engineer. Scientists like Loeb or Fischer saw themselves as engineers of life. Moreover, as Petra Gehring shows convincingly, the practical orientation of the social

sciences led to a technological understanding of society, which would enable its reform in the name of life (see Gehring 2009, pp.123, 134).[7]

Secondly, Loeb's integration of the social sphere into his naturalistic concept of life, together with the practical direction of his scientific approach, indicates the claim to comprehensiveness in the discourses on life around 1900. There were different approaches to life, which were connected to one another mainly because of their all-inclusive concept of life. Regardless whether the conceptualisation of life was based on nature (e.g., Loeb or Ernst Haeckel), culture (e.g., Georg Simmel) or history (e.g., Wilhelm Dilthey) it was supposed to comprise the whole of reality. Thus, new epistemological models arose that were mainly connected in that they strove to transcend the opposition between the natural sciences and the humanities. These methodological claims to comprehensiveness were based on the all-inclusiveness of the central concept of life. Its all-inclusiveness provided the possibility of undermining the epistemic dichotomy – so it was at least claimed.

Wilhelm Dilthey's philosophy of life is a surprising example of the attempt to overcome the dualism of nature and spirit (*Geist* in German) within the paradigm of life. From the moment life entered the systematic part of his philosophy, a new imperative started to guide his philosophy of science, with "life" providing the nexus that brought together all sciences without reducing any one science to any other. In particular, his writings from the 1890s show that this approach is based on the definition of life as a process of articulation. This idea also grounds Dilthey's attempt to develop a concept of mind out of biological structures.[8] The life of the spirit is considered as a more subtle and complex embodiment of structural characters, which are valid for all processes of life – for instance, thinking is, according to Dilthey, an interpolation between stimulus and response (see Dilthey 1981, p. 13). Dilthey posits continuity between the different life forms. Moreover, the relation between "higher" and "lower" life forms is defined as development, which is characterised by an increasing differentiation and delineation. In other words, life in itself develops continually more manifold and complex forms. The following passage articulates Dilthey's aim of grounding structures of meaning in biological processes:

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[7] Gehring analyses writings of Arthur Ruppin, Albert Hesse and Wilhelm Schallmayer on the significance of the theory of evolution for social and political issues as examples of this perspective of intervention. There are also other examples of the importance of an engineering approach in the social thinking of this time: in 1881 Julius Post published his contributions to „Social-Engineering" (*Arbeit statt Almosen. Beiträge zur Social-Technik*; *Labour rather than Charity. Contributions to Social-Engineering*). In 1899, Paul Natorp introduced the concept of social engineering in his *Sozialpädagogik.Theorie der Willenserziehung auf der Grundlage der Gemeinschaft* (*Social pedagogy. A theory of the cultivation of the will on the basis of community*). In 1904, Albert Kellner presented the *Gesellschaft für Ethische Kultur* (*Society for Ethical Culture*), his Social-Engineer (*Der Sozial-Ingenieur*) and reports about different approaches to enhancing working conditions in the United States and in Great Britain (see Neef 2012, pp. 257–259).

[8] This part of Dilthey's philosophy was and still is neglected. An exception, on which I base my own interpretation, are the works of Matthias Jung (see Jung 1996; 2003; 2008).

> Wherever psychic inwardness emerges, namely, in the entire animal and human world, the structure and articulation of life is the same. But what is still completely lacking in the lower forms of life is that manifold of discrete sensations and feelings on which psychology as a rule is built. The primordial nucleus of inner life is always and everywhere the progression from an impression stemming from the milieu of the living creature to the movement that adapts the relationship of the milieu of the living creature. There is no more original connection than this in all inner life. […] Seen from inside, the development of the living creature into higher forms involves an articulation; life articulates itself. And to the inner articulation there corresponds an external articulation of the animate, organic body in a series of stages. Intermediaries between the impression and the executed movement multiply. Both the initial impressions and the final response assume more complex forms. But everything happens on the basis of a schema common to animal and human life. And precisely in this great, encompassing nexus and its relation to our intellectual inner life there lies the convincing, unimpeachable proof that thought appears as part of life, is linked to it, and serves its sphere. A biological perspective is necessary in order to be convincing about the structure of life. (Dilthey 2010b, pp. 70-71)

This glance at Dilthey's hermeneutics of life shows that he was attempting to integrate biological concepts into his theory of mind without deducing the latter from a biological basis. In this respect, his philosophy is an example of the comprehensive claims of the discourses on life around 1900. Moreover, Dilthey's theoretical considerations on human nature always have a practical slant. The "practical nature of human beings" (Dilthey 2010b, p. 14) is the starting point of his epistemology. Therefore Dilthey developed an anthropology of knowledge in which the nexus of life and value plays a crucial role. He claims that the main work of life is to recognize what is really valuable for us (see Dilthey 2004, p. 88). Even knowledge of reality serves to elaborate life-values. It is this aim which gives human actions their teleological aspect. Moreover, Dilthey wanted to integrate humanity into the purposiveness of nature, and defined the individual as the reference point of purposiveness. Dilthey envisaged the human life-unit as a subject of self-preservation. The "course of a life" is defined as a "unity", which constitutes a "complete and self-enclosed, clearly delineated process" (Dilthey 2002, pp. 92-93). The lived experiences "belong to a nexus that persists as permanent amidst all sorts of changes throughout the entire course of life" (ibid. p. 102). On the level of culture, the continual process of individuation is exactly this 'permanent persistence'[9] of a single nexus in the course of life. The process of individuation has a biological foundation: Dilthey conceives individuation as a descendant of the self-preservation instinct. He thinks that the human life-unit is ultimately nothing but "a bundle of drives" (Dilthey 2010a, p. 14). And life-experience, in which the value of things is proved, can

[9] Manfred Sommer notes correctly that this phrase is an „emphatic pleonasm" (see Sommer 1984, p. 61). But his judgment that Dilthey's life-unit is isolated in itself is false. For Dilthey the life-unit is always exposed to "the pressure of the outside world" (Dilthey 2010a, p. 25). This difference is „first experienced in impulse and resistance" (ibid. p. 23) and develops into social interaction.

be seen as an enhancement of self-identity by reflective awareness (see Dilthey 1990b, p. 409). This process also enables the objectification of life values. Its highest form is philosophy, which develops a system of values and analyses their genesis and validity – a process from which non-human life-forms are nevertheless excluded by definition.

It is important to acknowledge that it is not just the philosophical discourse on life that is characterised by the practical turn, which entangles the concept of life with the concept of value. As Gehring emphasises:

> The oscillating concept of 'life-value' is a hinge of the discourse on life. Life is value and life – as valuating authority – signalises likewise what really has value […]. On the one hand 'life-value' is (almost) a pleonasm, but on the other hand the certainty of the 'value' of life constitutes what turns the mere discourse on life into a dispositif, in other words an effective guideline also for institutional actions outside science. [10] (Gehring 2009, p. 134; translated by J.S.)

Gehring convincingly argues that this action-theoretical and existential concept of reality emerged with this all-inclusive concept of life. The idea is that reality should be reshaped in the name of life and values (see Gehring 2009, p. 132). Already Friedrich Nietzsche refers in his *Untimely Mediations* to the "master builder of the future" ("Baumeister der Zukunft", Nietzsche 1874, p. 294; translated by J.S.), who shapes a new future by the power of their will. In a posthumous fragment Nietzsche also uses the phrase "master builder of life" ("Baumeister des Lebens", Nietzsche 1980a, p. 631; translated by J.S.). But Nietzsche points above all to a problem in the axiological concept of life. His vitalistic theory of history emphasises the destructive features of innovation. For Nietzsche, the creation of something new always presupposes the destruction of the established. Precisely in this sense, he conceives of history as life. For Nietzsche, "life always lives at the expense of other lives"[11] (Nietzsche 1980b, p. 167; translated by J.S.) since "in its basic functions" life "essentially […] harms, oppresses, exploits, and destroys, and cannot be conceived at all without this character."[12] (Nietzsche 1887, p. 312; translated by J.S.) It is exactly this essential connection between the preservation and destruction of life which is an argument against a cybernetic starting point for justifying an ethical dimension of the concept of life (see Toepfer

[10] See the German original: "Ein Gelenkstück des Lebensdiskurses ist der in sich changierende Begriff 'Lebenswert'. Leben *ist* Wert und Leben zeichnet zugleich – als wertende Instanz – 'das wirklich' Wertvolle aus […]. Einerseits ist 'Lebenswert' (fast) ein Pleonasmus, andererseits liegt in jener Gewissheit vom 'Wert' des Lebens das, was aus dem bloßen *Diskurs* des Lebens ein *Dispositiv* macht, also eine praxiswirksamen Leitstrahl auch für außerwissenschaftliches instituionelles Handeln." (Gehring 2009, p. 134)

[11] See the German original: "Leben lebt immer auf Unkosten andern Lebens". (Nietzsche 1980b, p. 167)

[12] See the whole sentence in the German original: "*An sich* von Recht und Unrecht reden entbehrt alles Sinns, *an sich* kann natürlich ein Verletzen, Vergewaltigen, Ausbeuten, Vernichten nichts 'Unrechtes' sein, insofern das Leben *essentiell*, nämlich in seinen Grundfunktionen verletzend, vergewaltigend, ausbeutend, vernichtend fungirt und gar nicht gedacht werden kann ohne diesen Charakter." (Nietzsche 1887, p. 312)

2011, pp. 457-458, Toepfer 2014). This argument holds in the realm of biology, because Nietzsche's view is proven by biological observation.

4 Life again? Conclusions

This short examination of an important part of the history of the concept of life suggests a surprising result. In the light of this history, synthetic biology leads to well-known debates, arguments, notions and questions – especially in the philosophical and ethical discourse on this new approach in biological research and technology. The concept of "life as a toolbox", which was shaped by the interpretation of the research activity of synthetic biology, has already been formulated in another context. It does not add "a new facet to the multifarious concept 'life'" as Deplazes-Zemp claims (2012, p. 772). There is a long tradition of discussing and answering the questions about life which synthetic biology raises. Therefore, the questions themselves have to be analysed critically. Do they capture the epistemological, ontological and ethical consequences of synthetic biology? And does the concept of life provide solutions to actual problems, or at least help to understand this new approach in biology, together with its societal impact? To answer these questions I return to the current issues:

(1) Our discussion of the current issues has shown that the phrase "fabrication of life" encapsulates many of the hopes and concerns connected with synthetic biology. Emphasis on this notion's historical roots permits a more sober judgement on synthetic biology and the expectations which are connected with this new technology.

(2) But should synthetic biological systems be defined as living? In my opinion, the concept of life is too ambiguous and controversial to be useful for capturing the actual practice of synthetic biology. Therefore, synthetic biology should follow other branches of biology in being reluctant to use the term. This would be helpful for both synthetic biology itself, and philosophical debates about it. Yet, from another angle, it is to be welcomed that because of this new constructive approach in biology, established dualisms such as that of nature and technology are being questioned again. In these debates, the concept of life could play a crucial role since, because of its ambiguity – especially its "double meaning as a material object […] and as a value of certain spiritual or even moral dimensions" (Budisa 2012, p. 101) – the concept of life could mediate between heterogeneous spheres like the natural sciences and the humanities, theory and practice, descriptive contexts and normative contexts. Following this view, synthetic biology could be considered as the latest example of the entanglement of theory and practice in modern science. It presents an essential feature of the life sciences, because they are characterized by their close relation to practical application. Moreover, their significance is based on their practical impact, which already

shapes our daily life. Thus, for a critical understanding of the life sciences it is all the more important to consider scientific research as a social practice. The concept of life could indicate this entanglement of science and society. Furthermore, it emphasises the existential dimension of every cultural practice.

(3) History tells us that the concept of life is strongly associated with the concept of value. There are various versions of the equation “life is value”. Nevertheless there are strong arguments against its ethical relevance, especially in the context of synthetic biology.[13] First, both concepts (life and value) are highly ambiguous and problematic. It would need careful elaboration to establish an ethics of life which is based on the intrinsic value of life. Second, in the history of the concept of life there have been arguments for and against its ethical relevance. Careful examination of the history of ethics would reveal that it is highly controversial whether life as such has an intrinsic value. Generally, life is regarded only as a prerequisite for the realization of ethically valuable qualities (see Toepfer 2014). Moreover, the historical findings clearly show that, for example, the cybernetic version of an ethics of life is not tenable. Third, the question remains, what counts as life? To use life as an ethical concept presupposes a precise and generally valid definition of life, which is not available so far – whether in biology or in philosophy.

But perhaps this fact does not matter because whether the objects of synthetic biology are conceived as living beings or not isn’t important for the ethical dimension of synthetic biology. Synthetic biology is definitely a further step in the mastery of nature; in others words, in its cultivation. It could even lead to “a parallel biological world” (Budisa 2012 p. 115). It is no accident that Budisa compares the route to such a world with “a road that follows a course that has to be optimally designed” (ibid). This “directed evolution” (ibid.) is distinguished from “natural evolution” which is described as “a contingent historical process, like the flow of the river” (ibid). This metaphor clearly presents synthetic biology as cultivating natural evolution. Not least because of this radical possibility, synthetic biology has to be seen as a new technology which raises old philosophical questions: Which attitude towards nature is reasonable? Is the “human intellect” (ibid.) a good “directing principle” (ibid.) for natural processes? How far should we change the face of the world? Can we take the responsibility for the consequences of such deep interventions, especially if we think of future generations? What can we know about the potential consequences? In the context of such questions, the special ethical challenge of synthetic biology becomes apparent. As several authors convincingly argue, its risks are not captured by traditional technology assessment (e.g., Engelhard 2011). Complex biological systems are difficult to predict (see, e.g., Köchy 2012a, pp. 172-173). The more they diverge from nature, the less models for comparison are

[13] See also Eichinger, this volume.

available. Therefore, in my opinion, the questions of biosafety and biosecurity are urgent. For a valid technology assessment it is certainly important to know, as concretely as possible, how synthetic biological systems behave. But the question whether this activity has to be conceived as life or not is a philosophical one. And in this context, Hegel's famous claim that "the owl of Minerva begins its flight only with the onset of dusk" is probably true:

> When philosophy paints its grey in grey, a shape of life has grown old, and it cannot be rejuvenated, but only recognized, by the grey in grey of philosophy. (Hegel 2003, p. 23)

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