



Fake cells and the aura of life: A philosophical diagnostic of synthetic life

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ABSTRACT

Synthetic biology is often seen as the engineering turn in biology. Philosophically speaking, entities created by synthetic biology, from synthetic cells to xenobots, challenge the ontological divide between the organic and inorganic, as well as between the natural and the artificial. Entities such as synthetic cells can be seen as hybrid or transitory objects, or neo-things. However, what has remained philosophically underexplored so far is the impact these hybrid neo-things will have on (our phenomenological experience of) the living world. By extrapolating from Walter Benjamin's account of how technological reproducibility affects the aura of art, we embark upon an exploratory inquiry that seeks to fathom how the technological reproducibility of life itself may influence our experience and understanding of the living. We conclude that, much as technologies that enabled reproduction corroded the aura of original artworks (as Benjamin argued), so too will the aura of life be under siege in the era of synthetic lifeforms. This article zooms in on a specific case study, namely the research project *Building a Synthetic Cell* (BaSyC) and its mission to create a synthetic cell-like entity, as autonomous as possible, focusing on the properties that differentiate organic from synthetic cells.

Introduction

Starting with the work of the German chemist Friedrich Wöhler, who for the first time managed to produce an organic compound (urea) *in vitro* in 1828, a key impetus of modern technoscience has been to bridge the ontological divide between the inorganic and the organic, between *in vitro* and *in vivo*, between the artificial and the natural: creating life in the laboratory, as it is phrased in the popular domain. In the era of synthetic biology, this has evolved into the ambition to radically re-engineer nature, which is the precise aim of bottom-up biology as a recent strand of synthetic biology research (Fanalista et al., 2019; Nature, 2018; Wei & Endy, 2021). Bottom-up biology is a quickly expanding research field that aims to understand the mechanisms underlying biological processes via *in vitro* assembly of their essential components in synthetic cells.

Almost two centuries after Wöhler's inaugurating breakthrough, this development seems to be well on its way to reach a crucial milestone, as research teams around the globe race to execute large-scale collaborative projects devoted towards replicating life by creating "proto," "minimal," "artificial," or "synthetic" cells. Notwithstanding the subtle differences between these labels, discussed in greater detail below, the projects involved tend to share the same core idea: to build a model of a

biological cell convincing enough to function as a cell. And while this will involve technological support systems, the aim is to incrementally reduce this exogenous support so that synthetic cells may become as autonomous as possible. One stated aim of this research is to understand and refurbish the functions of a cell. At the same time, however, synthetic biologists are also creating "functional novel lifeforms" (Kriegman, Blackiston, Levin, & Bongard, 2020, p. 1853). One example of these are 'xenobots', framed as "living machines" by popular science magazine *Live Science*. They are neither robots nor a known species of animal. "It's a new class of artifact: a living, programmable organism" (Weisberger, 2020).

Compared to previous innovations, such as the genetic modification of living organisms, the attempt to create a working cell from basic nonliving substrates seems indeed a different matter. It challenges the distinction between life and nonlife. Synthetic cells and other synthetic lifeforms seem increasingly resistant to clear-cut ontological classifications. The envisioned jigsaw products have therefore been classified as hybrid entities (e.g., synthetic organisms or living machines), blurring the borderline between the born and the built, affecting our understanding of both organisms and machines (Deplazes & Huppenbauer, 2009; Deplazes-Zemp, 2016). While attempts to classify the creations of synthetic biology are relevant, not in the least because they in turn

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inform bio-ethical judgements, less attention has been given to how these synthetic life forms challenge the ontological status of life itself. And while questions of classification have notably been discussed by analytic philosophers, a Continental philosophical approach may provide additional insights by focusing on the ontological issues involved, which so far has tended to be overlooked.

Western science has moved from “we must *disassemble* life to understand it” to “we must *reassemble* it to understand it” (Zwart, 2022, p. 71). Both ambitions have never been merely academic. They have been motivated—at least in part—by the drive for control, from Faust and Frankenstein as *loci classici* (Zwart, 2019), up to Ray Kurzweil (2000) and Craig Venter (2013) in the current era. Being able to dissect provides certain powers over life; but, being able to reassemble may offer an even more pervasive sway over the living and may in principle be used for countless applications, both military and civilian. Such technoscientific applications to control the natural raise multiple concerns regarding responsibility. Here, however, we bracket these more normative issues to concentrate on the question of how this technoscientific control—and the complications it creates for the ontological divide between the organic and inorganic—affects the way we experience and understand life itself. As synthetic life forms have not yet left the laboratory (at least, not to our knowledge), this amounts to an anticipatory thought-experiment to explore future scenarios.

After outlining how contemporary synthetic biology is reframing the ontological divide between organic and inorganic (first section), we focus on the BaSyC project that will serve as our key example (second section). Then, in the subsequent sections, we develop a philosophical assessment of this development, building on a historical analogue to the current effort to replicate life via assemblage, namely Walter Benjamin's (1963 [1936]) *The Work of Art in the Age of Mechanical Reproduction* (*Das Kunstwerk im Zeitalter seiner technischen Reproduzierbarkeit*). We will compare the impact of synthetic biology on the experience of life to the effect that technical reproduction of art once had on the experience of the artwork's ‘aura’. Specifically, we will discuss the concept of aura to assess whether technological reproduction endangers the aura of living organisms. We will explore the tension between living cells as living beings (as original entities) and their emerging technoscientific replicas (various versions of synthetic cells) through Benjamin's concept of the ‘aura’ and the ‘auratic’ to gauge the future impact of fabricated life on the phenomenological experience of natural life.

Biological and technical machines

The effort to define, and subsequently to sublimate or obliterate the dividing line between the non-living and the living, chemistry and biology, technology and nature, *in vitro* and *in vivo*, has a long history in philosophy. This can be discerned, for instance, in long-standing debates between mechanistic and processual understandings of life (Nicholson and Dupré, 2018), where the latter focuses on self-organization and self-rectification (Deacon, 2011). While synthetic biologists currently claim to endorse an evolutionary, post-mechanistic, processual view on life, seeing artificial life as the next era in the history of evolution (Church & Regis, 2013), they at the same time often foster a bio-engineering and mechanistic attitude towards life, as will be discussed in the context of our example below. Therefore, synthetic cells emerge in the force-field of this debate.

Moreover, in the current scientific literature, resistance against the (allegedly inevitable) sublation of the ontological divide between the natural and the artificial is often thematized as “vitalism,” i.e., the argument that the origins and phenomena of life depend on an enigmatic force or principle which is different from the other chemical and physical forces studied by science. Some prominent scientists active in the synthetic biology arena, such as Craig Venter (2013) and George Church (Church & Regis, 2013), explicitly present synthetic biology as the ultimate negation or elimination of vitalism. If synthetic cell projects succeed, these authors argue, the specter of vitalism can finally be

declared dead once and for all. In other words, bottom-up biology, as a radical version of synthetic biology, is not only a technoscientific research field, but at the same time an ontological battlefield, a *Kampffplatz* in the Kantian sense, where the creation of a synthetic cell entails an ontological experiment designed to overcome the last strongholds of vitalism.

This debate concurs with an important insight which emerged during the twentieth century, namely that living entities such as cells are systems which rely on interactions between matter and information. Hegel already argued that there is intelligence (*Geist*, λόγος) in material nature, and in contemporary technoscientific discourse, this λόγος has been redefined as *information*. Due to the triumph of the information concept in contemporary technoscience, the “soul” (“*anima*”) of living beings is no longer seen as something enigmatic or opaque. Contrary to vitalism, which is often discarded as a belated form of animism (Myers, 1900; Wolfe, 2011), the vital element is now seen as something quite transparent and predictable, namely bio-information, stored in DNA (Hoffmeyer & Emmeche, 1991); something which can be sequenced, copied, read and edited with the help of technoscientific machinery. This basic conviction that the λόγος of life equals *information* is the “philosopheme” of contemporary life sciences research (Schilhab et al., 2012; Zwart, 2022). Cellular entities are seen as hypercycles of biomolecular signals that guide the circulation of material components inside the cell (Emmeche, Queiroz, & El-Hani, 2010, p. 630).

To explore this in more detail, we will now present the BaSyC project as our case study, analyzing it from an “oblique” perspective, so that the focus will not be on the technical details of the project as such, but on the ways in which the interaction and rapprochement between life sciences and living cellular nature is envisioned (Zwart, 2017). Dialectically speaking, contemporary research is evolving towards the sublation or supersession (*Aufhebung*) of the ontological divide between the living and the non-living, between nature and technology, to develop a more comprehensive understanding of the functioning of biological systems. At the same time, we notice the critical intuition that, to the extent that scientists allegedly bridge the gap between artificial and living cells, something may be overlooked or lost. There may be more to life than what these technologically engendered neothings manage to capture. And yet they may nevertheless affect our phenomenological experience of natural life.

BaSyC as a case study

BaSyC is a large-scale research project funded by the Dutch Research Council (NWO). The acronym stands for “Building a Synthetic Cell.” As mentioned in the introduction, synthetic cells are one of the synthetic lifeforms that are currently being designed and built in laboratories across the world and are subtly different from *proto*-cells, *minimal* cells and *artificial* cells. A “protocell” involves a self-assembled compartment of lipids allowing chemical processes to take place within, aimed at explaining the functioning of more complex biological systems (Rasmussen, Bedau, Chen, Deamer, Krakauer, Packard, & Stadler, 2009). A “minimal cell” is a cell whose genome has been reduced by deleting as many genes as possible, while still being able to grow and reproduce (Glass, Merryman, Wise, Hutchison, & Smith, 2017). This should ultimately lead to manufacturing a cell which contains only those genes that are essential to survival, allowing ample room for introducing new functionalities. An “artificial cell” is an engineered entity that mimics one or more functions of a biological cell, using a repertoire of naturally existing biomolecules, complemented with non-natural components. Finally, a “synthetic cell,” the most ambitious version, is an entity built from molecular components (“bottom up”) to deepen our understanding of the principles by which modern cellular life operates (Powell, 2018). New functionalities may subsequently be added, e.g., to enable the production of pharmaceutical compounds or biomaterials.

Recent developments such as membrane biophysics and microfluidics have made the synthesis of cells an imaginable goal (Powell,

2018; Szostak, Bartel, & Luisi, 2001). The prospects of creating chemical life-like ensembles in the form of a cell-like system able to self-maintain, self-reproduce and potentially evolve (Sole, Munteanu, Rodriguez-Caso, & Macia, 2007) is expected to deepen our understanding of “the mechanisms underlying biological processes via *in vitro* assembly of their essential components in synthetic cells” (Fanalista et al., 2019). During the past decades, technoscience has managed to unravel the biomolecular structure of virtually all basic cellular components, from nucleotides via adenosine triphosphate (ATP) up to cytoskeletons and lipids, and time now has come, these scientists argue, to put the components together to better understand their interactions and to “reveal the basic operating principles of life” (Huck, 2021). Mechanistic approaches to life play a major role in BaSyC, for instance in the bio-engineering effort to place synthetic cells on a microfluidic chip device to find functionally equivalent modules to re-enact distinct processes of living cells (Deshpande & Dekker, 2019). Ideally, such cells should become a fully autonomous and self-reproducing system, fulfilling the promise of a component-based engineered cell—no vital spark needed. From a philosophical perspective, however, this raises the question of whether such projects, to the extent that they manage to succeed, would indeed supersede the ontological divide between non-living and living. Arguably, creating things that mimic life, but are still hooked up to life-support systems *in vitro* (e.g., a microfluidic chip-device), is very different than creating life that can exist unplugged in natural environments.

As explained on the project’s website (BaSyC, 2022), while life sciences research has yielded extensive knowledge about the molecular building blocks that form the basis of modern life during the past decades, it is still unclear how these building blocks collectively manage to operate. The project opts for the approach of piecing together all the known pieces of a cell to see what happens. BaSyC proposes to build a synthetic cell from the bottom up, “which arguably is the most fundamental approach towards elucidating the cell’s intricate working and basic life-defining principles.” Owing to our involvement in the BaSyC project as Principal Investigator and PhD researcher tasked with addressing the philosophical and ethical issues involved, in this paper we develop our philosophical reflections “from within.”

Working “from the bottom up” (Powell, 2018) means starting with primary components, the parts list of living cells, and forging them into a coherent whole. *Compartmentalization* (the separation of biomolecules discretely in space), *metabolism* (the biochemistry that sustains life), and *informational control* (the storage and management of cellular instructions) are considered the three key challenges in this endeavor (BaSyC, 2022). The BaSyC project started in 2017 and is now entering its midterm as we recalibrate its methodologies and redefine its ambition. The fundamental objective—producing a cell-like entity able to mimic key processes of living cells, e.g., metabolism, growth, and division—is still in place, but some inevitable modifications have occurred in the process.

Notably-two questions are raised at this juncture. First, what will a synthetic cell look like? Will it be a look-alike of living cells? In other words, will it also replicate the visual gestalt of living cells? Or will the likeness be solely functional, so that the visual image of a synthetic cell becomes irrelevant? It was clear from the very start that the synthetic cell was not expected to resemble any particular type of cell, say, *E. coli* (Fanalista et al., 2019). Although the archetypal image of a cell is spherical, many natural cells are actually non-spherical and in the course of evolution cells “have radiated into a dazzling variety of morphologies, where prokaryotes are found in the shape of, for example, rods, spheres, and spirals, archaea can exhibit even triangular or flattened square shapes, and eukaryotic cells range from orderly shaped plant cells to the extensively branched dendritic cells of the immune system” (Fanalista et al., 2019). While basic components (DNA, a cytoskeleton, a membrane) should be in place in a synthetic cell, the actual shape and size may drastically differ optically, and likely in many other ways, from any naturally occurring cell. Although most synthetic

cell projects use simple spherical containers with a diameter of 10–50 μm , investigators of the BaSyC consortium argue that a synthetic cell may well attain a cylindrical or cubic structure (Fanalista et al., 2019). Given the considerations regarding shape at this juncture, it appears the most likely shape for a synthetic cell will be a rod, for two reasons. First, as this enables entropy-driven segregation more easily than other shapes; and, secondly, because the Min-system of rod-shaped bacteria is one of the best understood systems for symmetry-breaking in cells (Olivi et al., 2021). Ergo, the ambition to mimic living cells remains a functional one: mimicking the basic operating principles of cells.

A second important question, becoming increasingly urgent as the project progresses, concerns the level of autonomy of the envisioned cell. Complete self-sufficiency is unattainable even for natural cells, as all cells need supportive environments. Still, synthetic cells may prove significantly less autonomous and more fragile than living specimen, in the sense that they need an exceptionally supportive, artificial environment (*in vitro* rather than *in vivo*). While organic cells evolve in conducive natural environments, a synthetic cell is pieced together in such a way that it remains dependent on its artificial laboratory conditions. As academic lead of the BaSyC project bio-nano-physicist Marileen Dogterom phrases it, “our first synthetic cell will be a lousy mimic of what already exists, unable to survive and replicate if left to its own devices” (Powell, 2018, p. 175). For instance, the artificial production of ATP currently poses a challenge. Adenosine triphosphate (ATP) is the source of energy for cells. In addition to providing releasable energy, the breakdown of ATP serves a broad range of functions, including signaling and DNA/RNA synthesis. Therefore, it is an indispensable molecule in the continuous functioning of the cell.

This challenge was extensively discussed during BaSyC’s consortium meetings in Spring 2021. If artificial cells prove unable to produce enough ATP themselves, it will be necessary to supply ATP externally, the attendees concluded. In addition, the bottom-up synthetic production of ribosomes (responsible for protein synthesis) proves exceptionally difficult (compared to, for instance, the production of a cytoskeleton or the maintenance of a membrane). Again, this may result in the need to add proteins artificially, from the outside (while keeping the cell in a protected, *in vitro* environment). In consortium discussions, such procedures were referred to as “feeding” the cell, but when feeding replaces a metabolic function that the cell proves unable to achieve on its own, the synthetic cell would have to be permanently hooked up to an active life-support system, which would compromise the cell’s aspired autonomy even more drastically, and may even amount to “cheating.”

Some BaSyC researchers argue, however, that life *always* benefits from specific external environments (Deshpande & Dekker, 2019). If the environment is stable, i.e., well defined over a long time, and rich in essential metabolites and other bio-organic residues that derive from other life forms, as opposed to mere inorganic components in the environment, the living form can be simplified in terms of the functions that it needs to perform. If, on the other hand, the environment is poor and strongly fluctuating, organisms need a robust array of functionalities to survive. Defining life thus involves a subtle balance between the complexity that is provided by the environment against the built-in functions of the organism itself. What does this imply for synthetic cells, these authors wonder, where the aim is to mimic basic life-like characteristics (e.g., a growth-replication-division cycle) in micro-containers? The challenge, they argue, is to find the optimal balance between the specific support provided by the micro-environment and the desired functionality of the cell. The consensus currently emerging within the consortium is that a fully autonomous cell is unfeasible and that “feeding” (or “cheating”) will remain part of the procedure for the foreseeable future. From a societal perspective, this may seem reassuring. Like the homunculus created by Wagner (Faust’s pupil in Goethe’s drama), the synthetic cell will need a glass phial, i.e., a test-tube environment to survive (Zwart, 2019). Yet, this will not prevent the use of synthetic cells for other than purely academic purposes, provided the cell remains connected with its artificial support system.

Overall, scientists involved in the BaSyC project do not consider the necessity of life-support systems a problem. Even if we can only partially replicate a living cell, much insight can still be gained, while the remaining gaps can be redefined as targets for future projects (Deshpande & Dekker, 2019). As Heidegger (Heidegger, 1977) once argued (1977 [1938]; cf. Zwart, 2020a), science is not only a practice, but also an enterprise (*Betrieb*), aiming to ensure that this type of research can continue in the future to address additional challenges. Projects should not only yield results, but also secure pathways for follow-up activities. Still, the ideal remains to build a replica which mimics the living cell (the natural paradigm) as closely as possible.

The aura of life

By disclosing the molecular building blocks of life, and by directly challenging vitalism as an outdated view of life, synthetic biology presses to eliminate the enigma surrounding living systems. If it can be demonstrated that life, specifically the living cell as the concrete universal unit of life, is technologically reproducible—in principle at least—vitalism's stubborn recurrence as a viable position becomes untenable once and for all. Thus, synthetic biology is as much a technoscientific as it is a metaphysical endeavor, as we have argued. For those involved in projects like BaSyC, reproducing life can in principle be achieved by organizing matter, in the form of basic molecular components, and information—the engineering view of life.

Still, in this equation, something may be lost or overlooked. For instance: cells are goal-oriented. Living cells assess their environment, strive for homeostasis, health, and reproduction. In other words, life is teleological (Kauffman, 1993). And this directionality also means that living organisms are historical: all life forms with which we are familiar are the product of historical processes and evolved according to their specific *in vivo* environments. Furthermore, life has been defined in terms of autopoiesis (Maturana & Varela, 1992; Varela, Maturana, & Uribe, 1974): life is self-made. Will artificial cells (technical replicas) be able to capture and mimic the complexity of their autopoietic originals? Can they become truly autopoietic themselves, given that they were not made by themselves, but by scientists in a laboratory? Or is artificiality and dependency on technological life support an inherent signature feature of all technical replicas, so that the synthetic cell ultimately remains a counterfeit? An important aspect to keep in mind, of course, is that the synthetic cell project is not about naturalness in the sense of optical similitude. What scientists are trying to mimic is not the visual *Gestalt* or image of a living cell. The challenge of technical reproduction concerns the intricate hypercycle of interactions between information and matter at the cellular level (Pattee, 1982).

Even though key aspects of natural life (such as autopoiesis) may be overlooked in a bottom-up approach, our aim in this paper is not to question the feasibility of solving the riddle of life by building ahistorical life forms as such. Our aim is to show that, even if the technoscientific objectives are achieved, there may be more to natural life than just how it works. And it is exactly this “more” that we wish to emphasize and investigate. Precisely this “more” may be imperilled by ahistorical fabricated replicas. Vitalism was a product of the nineteenth century, revolving around the concept of “force,” positing the existence of a special “vital force” at work in living beings. Although this particular framing now seems untenable indeed, the basic intuition involved remains relevant, we will argue, even if we have to sacrifice the concept of “force” and the metaphysics it entails. The claim that current science

understands cells sufficiently to make them, implies that living things can be pieced together seamlessly, but what exactly is the difference, if such a difference exists, between living cells and their artificial replicas, between the original (living) version and the “fake” (technologically reproducible) one?¹¹ Or will it ultimately prove impossible to tell the one from the other? And if so, how will the synthetic reproducibility of life affect the phenomenological experience of the living? Answering this set of questions is the main aim of this paper.

To this end, we propose to use Walter Benjamin's essay on the technical reproducibility of art, written in 1936, as our point of departure. He, too, witnessed a phenomenological upheaval, in his case brought about by the technical reproducibility of artworks. Although the original title (*Das Kunstwerk im Zeitalter seiner technischen Reproduzierbarkeit*) is usually translated as *The Work of Art in the Age of Mechanical Reproduction*, “technical” would have been a more optimal translation than “mechanical.” We decided to reread his work precisely because the very claim of synthetic biology is to demonstrate that life is technically reproducible, and that technology can take on characteristics of biology. Thus, although Benjamin thematizes the relationship between the artistic (ποίησις) and the technical (τέχνη), we will argue that, now that life is allegedly becoming technologically reproducible, his key argument becomes quite pertinent the relationship between life (βίος) and the technical as well.

Shattering the aura

In his essay, rather than downright deploring the technical reproducibility of art (due to emerging technologies such as photography and cinema), Benjamin explores their ambiguous impact on the original works of art the replicas derive from. On the one hand, artworks become accessible to what in the 1930s was commonly referred to as “the masses,” so that, in principle, enjoying paintings or opera performances is no longer restricted to elite strata of society. There is, however, a downside to this, Benjamin argues, notably concerning the unicity of the artwork as something which can only exist here and now. With the mass-reaching technologies of reproduction comes the inexorable decontextualization of the original object. As all art occurs in a living social milieu, artworks are repackaged in order to meet prevailing popular tastes, so that art easily slides into mere entertainment (cf. Cross & Proctor, 2014). As Benjamin phrases it, technological developments brush aside seemingly outmoded concepts such as the uniqueness, eternal value, and the mystery of artworks, in other words: it eliminates their aura. A cathedral leaves its locale to enter a studio or a printing shop, a choral performance leaves the auditorium and resounds in the constrained acoustics of drawing rooms or school buildings. In a similar vein, we would argue, through the process of scientific dissection and reassembly, a cell becomes isolated from natural ecosystems, becomes dislocated and stripped of the contextual, semiotic infrastructure from which it emerged, entering an *in vitro* non-environment from where it may eventually proliferate. Similar to how artworks lose their unique value as they became reproducible—and therefore fall within the sphere of technological control—living natural beings may likewise be deprived of their phenomenological uniqueness and mystery. After all, cells, which so far always created themselves and reproduced according to their own devices, are about to find themselves under the sway of technoscientific mastery. Much like it once was for art, life's aura is now endangered because of the control inherent in reproducibility.

As Benjamin argues, the aura of the original artwork (be it a

¹¹ Speaking of “fakes,” Catelijne Coopmans (2021, p. 81) discusses how we “fake” precisely those things we value most, identifying fakes as “intercepting” our expectations while at the same time revealing our fetishizing of the real thing faked. She instructs us to pay attention to the implicit or explicit assumptions and expectations betrayed or disrupted by the fake, and this is highly relevant for coming to terms with synthetic cells as well, as we will argue.

cathedral, a statue, the performance of a symphony) is endangered or even eliminated by the desire to bring things closer to us: overcoming their uniqueness, humanizing them—the urge to get hold of an object at very close range. It is as if there is a necessary ontological trade-off between portability and fidelity. Prying an object from its shell which not only protects it but feeds it, Benjamin argues, means destroying its aura. As similar recalcitrance to removal or decontextualization can already be noticed in single-cell organisms which scientists try to keep alive in laboratory settings (Barras, 2015; Wu et al., 2011). One of the shifts such organisms undergo when extricated from their native habitats and set in agar (or other standardized laboratory media) is an ontological one. A microbe kept in a petri-dish (often genetically or bio-chemically modified) already becomes a de-naturalized laboratory artefact to a considerable extent. Thus, the aura of cells is already endangered by technoscientific efforts to observe, analyze, and zoom in on them *in vitro*, as in the case of micro-photographic reproductions, preceding all efforts to *synthetically* reproduce them. The inaugural step already occurs when the living cell is removed from its natural ecosystem and isolated in a petri dish or test tube or put under a microscope. As Gaston Bachelard (1970 [1938]) convincingly argues, all objects of technoscientific research are artefacts. Rather than studying them under natural conditions, a minimal artificial ecosystem (e.g., a petri dish) is created, thus maximizing the opportunities for manipulation and experimentation. Basically, a test tube, as innocent as it may seem, is already an instrument of control (Zwart, 2022). Under a microscope, these objects (e.g., bacteria, say, an *E. coli* bacterium) become colorful natural artworks, but researchers may determine how these organisms appear to us (in terms of color, size, proximity).

Some of these images, produced nowadays by high-tech photomicrography, may strike us as Klimt-like portraits, but their appearance actually results from complex interactions between natural properties and technological decisions. Microscopy is driven by the desire to bring minuscule entities (e.g., microbes) closer to us; but at the same time this desire creates an ontological divide between subject and object, as the observed become mediated through the technological apparatus, extending but also always diffracting our perceptions (cf. Barad, 2007). Microscopy is a practice of disclosure (of bacteria as natural artworks), but although the technology appears to reveal their beauty, putting them on display already endangers their aura, affecting the way how they show up to us. By enframing these cells through the microscope and photographing them, and by taking these observations to be representative and summative, they become objectified. Our replicas become more real to us than the actual entities they are meant to represent. Thus, we act on the basis of these technological representations rather than on the basis of an organism's own living existence. Through publications in journals such as *Nature*, *Science*, or *Cell*, these bacteria become visible and accessible to all, but their aura becomes obliterated to the extent that scientists determine *how* they show up to us.

Such scientific reproductions build on a long historical tradition, one could argue, inaugurated by Antonie Van Leeuwenhoek's beautiful and careful drawings of the animalcules ("little animals") spotted through his microscope, and by Robert Hooke's science classic *Micrographia*. In the era of technological reproduction, the astonishing beauty and intricacies of these living entities is suddenly revealed and brought to the surface for all to enjoy and learn from. At the same time, according to Benjamin's logic, something is lost by putting them on display in defining representations crafted by technological mediation: their aura. Although cells are depicted in meticulous detail, what is revealed by these stunning pictures, first and foremost, is the *technological prowess* of contemporary technoscience itself to penetrate the microbial realm.

Microscopy is about optical reproducibility. As a microphotographic *image*, a bacterium may strike us as awesome, but on closer inspection, we are *impressed by the technology* that allows us to bring these entities so closely into view. That is to say, insofar as a bacterium shows up according to the designs of our optics, we start overemphasizing certain aspects of the organism—those legible and interesting to us and our

technological apparatuses—and underemphasize others. Technology extends our senses, but this at the same time entails a tuning of our senses. For instance, the human fixation on discrete single organisms as the object of analysis suggests that something like "a" microbe can be considered apart from its co-constituted conspecifics (Varzi, 2011). Vis-à-vis an entity's aura, there seems to be an inverse relationship between integrity and legibility: the more portable, convertible, and readable the thing becomes, the less its aura is called forth or attended to.

A similar recalcitrance, we argue, is at work in the technical reproduction of life in laboratories (*in vitro*), and even in a more radical way. In bottom-up biology, the reproducibility question is even more pervasive. What is made reproducible is not the *Gestalt* of a bacterium, as in photomicrography, but the cell *as such*: the processes of interaction between information and matter on the cellular level which constitute a cell. It is an endeavor to "automate" the processes that maintain and reproduce cell life. The charge of bottom-up synthetic biologists is precisely to make the cell reproducible from within: to capture life *an sich* (in itself). And it is precisely this totalizing understanding which jettisons the very object of reproduction: the living cell—a consequence Benjamin (1963 [1936], p. 15) refers to as the "shattering of the aura" ("Zertrümmerung der Aura").

The eye of the beholder

At this point, important questions emerge which deserve to be addressed. First of all, if we attribute an auratic dimension to bacteria (only discernible with the help of microscopes), the question arises whether a bacterium ever had an aura, intrinsically as it were, prior to being discerned and photographed through our microscope. On closer inspection, for Benjamin, auras only seem to exist insofar humans experience them. A bacterium, prior to being spotted, strictly speaking would not yet constitute an auratic phenomenon. The aura results from the interaction between subject (the eye of the beholder) and object (the organism). In this section, we intend to zoom in on this and similar issues, offering some counterarguments which potentially negate our initial position (our thesis that the aura is endangered) adopted in the previous section. In the final section, however, we will offer a rebuttal (a negation of the negation).

When, in between its first appearance in front of a handmade microscope and the impressive images made by contemporary photomicrography, did the bacterium acquire the aura that it seems about to lose? Did the acquisition of the aura coincide with its discovery? An aura is a phenomenon which emerges through the interaction of an entity at the object pole (striking us as something which is appealing, precious and unique) and the beholder at the subject pole (sensitive to the phenomenon's appeal). Auras would not exist if the entities they are associated with were not perceived and experienced by us.

Thus, while it was claimed in the previous section that the beautiful image of a bacterium produced by microphotography strikes us as auratic, on closer inspection this claim raises a number of quandaries. First of all, the experience of spotting a bacterium is technologically mediated. It cannot be a vis-à-vis event. The microbe is not a phenomenon which reveals itself to us on its own accord, at least not visually. Does this diminish the sense of awe? If we hold on to the auratic nature of our experience, however, additional questions will emerge. Did the auratic dimension appear precisely when being viewed through a microscope, or was it diminished or even shattered afterwards, when being photographed, or printed in a journal paper? As indicated, if we follow Benjamin's logic, photographic reproductions and mass dissemination shatter the aura which appeals to us when we ourselves are confronted with what is revealed (cf. Guevara-Aristizábal, 2021). How could synthetic cell research endanger the aura of living cells if microphotography already destroyed it? If we claim that a synthetic cell will shatter the aura of living cells, we must nonetheless accept that the latter would not have an aura without being observed with the help of high-tech equipment in the first place.

We will now offer two counterarguments against our initial thesis, i. e., our claim that creating or manufacturing synthetic cells endangers the aura of living cells by making them technologically reproducible. The first counterargument posits that living cells either never had an aura or have lost it already. The second focuses on the levels of analysis involved in Benjamin's characterization of the aura and the way we employ it in the context of contemporary technoscience. In the final section, we intend to reflect on our initial experience by responding to these issues.

What comes to mind when thinking of a cell? Probably, for most readers, images from biology textbooks, lessons learned in high school, PowerPoint presentations at conferences, or pictures in journal articles. If cells ever had an aura for contemporary humans, it was shattered at the moment of its appearance, so it seems, due to these high-tech pictures or stylized diagrams of nucleus, ribosomes, and mitochondria. Such representations bring the cell close to us, and under our control. Cells are precisely these things that we already seem to understand reasonably well, even though they are too small to see with the naked eye outside technologically mediated laboratory environments. We witness them isolated from their context, against an agar backdrop, frozen in time, disassociated from their cycles of reproduction and death. They appear like snapshots: devoid of the aura of unicity and temporal existence. They become tokens of a type: some more exotic, others more mundane.

What is at stake here, we would argue, is not the involvement of technology as such. Technology is an inherent dimension of the human condition, and technologies played a significant role also when (to use Benjamin's examples) cathedrals were erected and musical compositions were performed. We could also point to the use of optical instruments by painters such as Johannes Vermeer (friend and colleague of Van Leeuwenhoek) (Chevalier, 1999); or, to use a slightly different example, we could think of the beautiful drawings of the Milky Way by astronomer Anton Pannekoek, working as a "homunculus" inside an enormous telescope (Pannekoek, 1982; Tai, Van der Steen, & Van Dongen, 2019). According to the logic of Benjamin's concept, the aura of things is not shattered by the technology-dependence of science as such, but by the *reproducibility* of the results. In the case of Pannekoek this would imply that, whereas his impressive handmade drawings as such can rightfully be considered as efforts to capture the auratic dimension of the Milky Way, this dimension is diminished as soon as his unique drawings become technologically reproduced (in newspapers and various other online media).

Technological mediation diminishes the aura of living cells insofar it makes them reproducible, bringing them under our control. Even so, the auratic dimension may reappear, for instance when sinister cancer cells loom up in a scan. In that case, life's aura may be seen to avenge itself: the resurgence of the repressed in the real. Suddenly cells have their aura again, as they resist our predictions and manipulations. Suddenly we fear these cells, their excessive autonomy—and therefore we want to eradicate them as soon as possible.

These considerations concerning the auratic dimension of cells do not contradict our preliminary observation, we would argue, namely that living cells cannot have an aura before our observing them. Nonetheless, as soon as they are technologically captured and pinned, like the resplendent but one-dimensional specimens of a lepidopterist, their aura is shattered by our will to control them. In scrunching their fullness to fit our search image of what these things should look like, and then taking this reduced and simplified version (or caricature even) and multiplying it, it becomes familiarized into a digestible trope in broadcasted knowledge. Apparently, the aura only flashes up when seeing still involves a unique, unprecedented event. In other words, as soon as we begin to realize that our technological mode of representing the living cell diminishes the auratic dimension, it has already happened. Maybe there will be an auratic moment when the first specimen of a synthetic cell starts to function and replicate, but even then, its aura will be short-lived, because before long, technological reproductions will circulate

through scientific and journalistic networks around the globe, in endless variations of photographic images and physical reproductions by different laboratories.

This brings us to a second possible counterargument. If having an aura is indeed the privilege of an original artwork, as Benjamin argues, something which technical reproductions cannot have because they are artificial, controllable, easy to produce, and multiply, then the original loses its aura precisely because of the availability and proliferation of these technical reproductions. In other words, the copies drown out the uniqueness and impact of the original, as the original becomes a fetishized version of the copy, with the copy taking primacy in the public imagination. A contemporary example of this, perversely, can be found in the burgeoning market for non-fungible tokens (NFTs) which take digital artifacts, like the first tweet of the CEO of Twitter (Reuters, 2021), that are infinitely copiable with zero marginal costs containing zero material differentiation between copy and original, and make them rare through artificial certifications. By assigning ownership and originality through legered blockchain—as if this criterion sufficed for imbuing aura—NFTs aim to create artificial originals—assigning a fake aura to something that never originally had it (Reuters, 2021; Roose, 2021). In the very same historical moment that we wish to capture and control the one thing that humans have not been able to master—life—we are giving life, or at least an aura of originality, to precisely those human artifacts that never had auras to begin with.

Likewise, a synthetic cell is artificial in itself. It is a replica from the very start, compared to a living cell, and therefore lacks the aura of a natural living cell that stakes its own claim (as great works of art do), by definition. At the same time, a synthetic cell is not a quick and easy copy of a living cell. Quite the opposite: it requires a complicated and carefully coordinated process of construction. The BaSyC program will last at least ten years while involving more than eighty researchers. Should we not consider the first synthetic cell as art, on the same level of artistic splendor as some of the examples of auratic phenomena mentioned by Benjamin such as cathedrals or choral performances? Would we consider the first model of the molecular structure of DNA fabricated by Watson and Crick in 1953 (Watson, 1968), and now on display in a science museum in London, as art? In both cases, we are confronted with impressive and unique originals, awesome perhaps, although, if we follow Benjamin's argument, the original model produced by Watson and Crick soon lost its aura because of the many reproductions (often including smiling scientists standing next to the thing which they produced). So, the question is not whether the *first* synthetic cell will have an aura or not—undoubtedly it will. The paradox is that once the first one is created, the second, third, and subsequent (re)creations will be seen increasingly as derivatives, and thus the original of something duplicable from the outset undermines its own immediacy.

If indeed there is something unique and awesome about the first synthetic cell, inexistent as of yet, we may argue that, once this cell has been built, this will give rise to a proliferation of technical reproductions, accessible not only for the scientific community but also for broader audiences via popular outlets. We may even be informed of its creation by push-notifications on our smartphones. This is when the *synthetic* cell loses its aura; taken out of its unique, authentic original state, and reproduced in a way that ignores its history and context. (One must think no further than the blip of world Internet attention received by the first photograph of a black hole's penumbra.) After all, we can expect the photos to last a great deal longer than the first synthetic cell will. Hyped, sensationalized, and reduced to a one-dimensional event, the fabricated cell becomes an artifact rather than something unpredictable and awful. The recalcitrance of life, the resistance to the total control and capture of human enframing, shared by great art against glaringly inferior technical replications, is precisely what grants the original its aura. It is our inability to wrap our heads around it, taunting us about an inscrutable ontological secret it seems to hold, which draws us into its aura, and represents a new way of being-in-the-world. To the extent that this line of reasoning is valid, however, we are already

refuting (negating) the objections made above and have already started our rebuttal.

Rebuttal (negation of the negation)

We would like to start our rebuttal to these caveats with the adage: *ars imitatur naturam* (Moritz, 2009). It could be argued that cathedrals are already reproductions. For instance, it has often been argued that cathedrals mimic natural forests—with pillars as trunks and vaults as branches, while light is filtering in through stained glass windows mimicking foliage (Zwart, 2020b, p. 19). Or they may be reminiscent of natural caves (especially Romanesque cathedrals). Paintings likewise can already be seen as technical reproductions of nature, immortalizing scenes, faces, events, drawing them out of their unique temporal existence. Therefore, as already argued above, to the extent that a synthetic cell is original and unique, existing *here and now*, in this particular laboratory, we could perhaps place it on a par with cathedrals, paintings and choral performances. The synthetic cell, if and when it is completed, will similarly be the result of a complicated and concerted effort of many scientists (acting as builders and designers). It will be art imitating nature, arguably in a way we have never seen before. It will presumably have its own aura, which will then be shattered by disseminated photographs and mass reproductions.

Let us now return to the argument initially presented in this article, namely that a synthetic cell entails an ontological risk: shattering the aura of living cells. If we position the synthetic cell as “a technoscientific artwork,” the argument can be made that its creation does not immediately diminish life’s aura. Rather it will have an auratic dimension of its own. At the same time, unlike a living cell, a synthetic cell will be technologically reproducible, under the sway of the producer. Not only in the sense that it will be photographed, but even more so in the sense that, once this milestone has been reached, other synthetic cells will doubtlessly be fabricated as well, eventually giving rise to an assembly-line production of synthetic cells. If that is the case, the aura will then be shattered, or even more extremely: the aura of life as such will be endangered.

We argued that the aura of microbiota is only visible if living cells are *made visible* by technical means, resulting in reproduction. This means that, if aura can be discerned in living cells, it is bound to be short-lived. This also seems applicable to synthetic cells. And yet, the status of the first synthetic cell would be highly ambiguous, for it would be both an original (the first synthetic cell) and a technological reproduction (mimicking a living cell) at the same time. A synthetic cell may be seen as a miniature cathedral designed by humans, but it also heralds an epoch when life itself is being made adaptable to our benefits, easier to grasp, to refurbish, to direct and to control.

Two final aspects of the auratic should be mentioned: autonomy and durability. Autonomy refers to the independent character of the original, which is a characteristic of natural life, self-sustainable and independent, albeit embedded in an ecosystem. A synthetic cell lacks this autonomy, for it will remain a fragile entity, dependent on human support. Outside the extensive protective sphere of apparatuses, it is neither self-sufficient nor durable, and entropy will swiftly result in decomposition—either by lack of energy or perhaps even due to a built-in mechanism, a killer-switch. A synthetic cell, therefore, lacks the autonomy and durability of artworks such as cathedrals, and this chronic dependency on human technological assistance diminishes its aura. In the longer run, however, synthetic cells may become increasingly self-sufficient. One day, they may achieve sufficient robustness to leave the laboratory environment and enter and evolve in real world settings, spreading like environmental carcinoma as it were, in the worst case replacing the original it sought to mimic. The image of a fragile synthetic cell, dependent on human support, may well be a temporary situation. In that case, the natural cell’s auratic dimension will evidently be affected.

Discussion and conclusion

This paper analyzes the claim that synthetic cells endanger the aura of natural cells. Whereas living cells lead an autonomous yet contextualized existence, synthetic cells exhibit qualities such as reproducibility, comparable to Benjamin’s photographs, recordings, and other technological reproductions. Yet, as soon as this comparison is made, multiple ambiguities arise. To begin with, the auratic features of living cells are revealed by technology already geared to immediately produce reproductions, so that the aura of living cells is endangered as soon as it is disclosed. The moment of discovery becomes cannibalized by the aim of replicability. Yet, given the complexity of the process of building a synthetic cell, it cannot be considered a quick and easy copy of a living cell. As a technological artwork, it may have an aura of its own, about to be shattered (to the extent that replication will become easier in the future).

Crucial here is on the one hand autonomy and on the other hand the level of exerted technological control. Reproducibility suggests the ability to control life processes, but to the extent that synthetic cells remain dependent on technological support, they will not be autopoietic. Therefore, the synthetic cell will not replace the living cell, but the living cell’s aura may nonetheless be endangered to the extent that synthetic cells evolve in the direction of increased autonomy, making increased use of the scaffolding of natural cells. Should synthetic cells result in total control over the basic processes of life, and monopolize the reproductive environment, then the aura of living cells would indeed be threatened. After all, our analysis emphasizes that it is not reproducibility in and of itself that is harmful to auratic experiences, but the level of control and reframing imposed therein.

Technoscience provides the opportunity to produce neontinities which are becoming increasingly more life-like, more cell-like even, a development we also notice in CRISPR-cas9 for instance, which uses a bacterial strategy to manipulate viral genetic information, incorporating bacterial adaptive strategies in our biotechnological repertoire. This may be seen as bringing living things closer to us. Yet, technology also moves in the opposite direction, towards distancing and objectification. Just as the postcard image of a church allows us to study it and perhaps delight in its composition, just as easily can it lead to the trivialization of the original object, fostering disregard for the real thing and short-circuiting the experience of awe. Thus it would not *really* succeed in bringing the thing closer to us, because it misses the confrontation with alterity, the novelty of experience of the real object encountered, which changes the observer (Hendlin, 2019). Benjamin’s concept of the auratic indicates how replacements cheapen the experience of the real thing, as the real thing becomes obfuscated by the copy, which allows for more widespread contact through popularized reproductions. Increasingly, engineered cells will fail to point beyond themselves—the originals—but rather mirror what human technology can establish.

The risk involved in framing such productions as reproductions is that technology makes us think that the cell is a sum of its parts, and all we have to do is to reassemble them. Besides more practical questions—what are the costs of sustaining a synthetic cell? How much energy is necessary? What actually is to be gained?—a more fundamental dimension is therefore entailed here as well. It is almost as if there is the hope that, with the artificial supply of ATP, the cell will start functioning on its own: as if even in this allegedly anti-vitalist project, there is a secret hope, a remnant of vitalism—namely that we only need to engineer the components in just the right way, and then the spark of life will somehow ignite. Thus, it could well be possible that at the depths of these scientific efforts to reproduce life, there is the hope that we may pinpoint the vitalistic moment or leap. This would mean that vitalism has not been dashed, but that it has been sublated into a moment of human creativity, incorporated in the will to control.

In short, a metaphysical question is entailed in bottom-up biology. If all it takes to create a cell is putting together the right molecules in the right places, and then adding energy (or lightning, as has been

hypothesized in some versions of how the primordial soup became autopoietic in abiogenesis), then all the tools we need to create life lie within reach. If, however, we acknowledge any incompleteness or limits to human technological prowess, then there may be aspects to life of which we are not even aware. And if living beings turn out not to be machines, but integrated systems relying on complex non-linear processes, then an engineering view of assembling even the simplest cells seems short-sighted.

To use a comparison mentioned earlier: the creation of so-called Non-Fungible Tokens (NFTs) could be seen as a longing for the return of the original artwork through an elaborate process of “certification” of originals: the creation of ownership value *ex nihilo*. In a similar manner, the first synthetic cell, and various components developed to realize it, may become certified (and then patented) as original versions. Here too, however, originality can only be attributed by formal bodies authorized to do so. The hope that we could reproduce and create cells (of our own creation) almost ignores the proliferation of cell division going on all around us (in the air, water, soil, in our bodies, in the parasites in and on us) ‘for free’—as if natural life is not enough.

What is a synthetic cell, then? Several possible answers may come to mind. Is it a micro-laboratory? A replica of a cell comparable to imitations of Giza or Venice, as constructed in the casinos of Las Vegas, Nevada? A technoscientific commons comparable to the human genome sequence? A toolbox for future applications? Or a scaffold for assembly-line production of pharmaceuticals and biomaterials? Probably, all options may apply. If this is the case, synthetic cells are created because biological evolution cannot be sufficiently controlled or harnessed to human intentions. However, natural evolution does not occur by putting parts together. It happens through complex ecological processes where relations and interactions are as crucial as components. Moreover, while artificial selection operates according to *prescription*, aiming at a specific pre-planned goal, natural selection operates on the basis of *proscription*, closing off many possibilities and then allowing for experimentation (Deacon, 2011; Hendlin, 2021).

If microscopy is about *optical* reproducibility, and microbiology about dissection, then bottom-up biology is about reconstruction, putting back together again components previously identified. But this already assumes we have grasped the object fully and in depth, that we can reduce an organism to its components, and that the organism and its parts can be extricated from its environment. From a systems perspective, it seems unlikely that a component approach enables us to exhaustively understand the whole system.

Comparing Benjamin’s concept of the auratic with the goals of bottom-up biology, it is worth noticing an interesting reversal of decontextualization at play. Whereas technology isolates the work of art from the environment that gives it its context, the synthetic cell requires curating an artificial environment from the start. The synthetic cell is not “free” to be “released” into any environment in which it can survive, because it is not actually living nor surviving. Instead, it is constantly being “fed” with inputs which purport to create the illusion of life, in the hope that eventually, enough of the requisite ingredients will be in the right place so that the spark of life takes over, and the life-support inputs can sluff off. So, while works of art technically reproduced are ripped from their contextual matrices, and thrust into any and every place on earth, the fabricated cell requires a world in its image, forcing its environment to mimic the laboratory which it needs to survive.

To conclude, perhaps we can compare the synthetic cell with the *Biosphere 2* experiment in Oracle, Arizona (Zimmer, 2019): a series of artificial environments, where synthetic cells may feel at home. Originally meant to demonstrate the viability of closed ecological systems to support and maintain life as a template for colonizing outer space, the *Biosphere 2* experiment failed, not because of technological flaws, but because something vital was lacking on the inside. Somehow the life processes needed to create a vibrant community of inhabitants, an intact ecosystem, did not materialize in a closed system. Accumulating chemical vapors and humidity were secretly off-gassed outside the

bubble, while food and supplies were being covertly shuttled in (Zimmer, 2019). In other words, and paradoxically perhaps, the synthetic cell experiment may shed a new light on vitalism, not of the classical type (positing a vital force), but as the acknowledgment of the crucial importance of processes, relations, communication, and interdependence, over and above components, structures, and codes.

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