Re-Collecting Microbes with Hans Blumenberg's Concept of »Reoccupation« (*Umbesetzung*)

From Isolating/Cultivating towards Digitizing/Synthesizing

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1. Introduction

Microbes are attracting widespread interest. In the following,[1] we explore how recent microbiology has been approaching its objects, reached out to others, and continues to do so. Preconditions are collecting, isolating, and cultivating. These practices have been recognized as initial steps of making biofacts.[2] We will not refer to biofacts as such, but to how they acquired technical and universal potentials—both in- and outside the biobank. Collecting implies interruptions of biological life-times,[3] which, as we will see, interrelate with the historical understanding of world-time. It is no coincidence that microbiology developed out of botany and its agricultural cultivation practices used in the lab, as the making of biofacts culturally started with collecting seeds for breeding. In tacit alliance, microbiologists still speak of ›harvesting‹ their objects. The agricultural background is veiled by popular narratives about men fighting diseases, e.g. the physician Robert Koch—inventor of the paradigm of ›pure culture‹. Infiltrating whole societies with hygienic discourses[4] paved the way for »bioterror«[5] and the microbial enemy.

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2 Nicole C. Karafyllis: Die Samenbank als Paradigma einer Theorie der modernen Lebendsammlung, in: Nicole C. Karafyllis (ed.): Theorien der Lebendsammlung. Pflanzen, Mikroben und Tiere als Biofakte in Genbanken, Freiburg 2018, pp. 39–136.

3 How the seed bank changes the relation of the *perdurance* of the object and its *persistence* in time and place was analyzed in Nicole C. Karafyllis: »Hey Plants, Let's Take a Walk on the Wild Side!« The Ethics of Seeds and Seed Banks, in: Angela Kallhoff, Marcello Di Paola and Maria Schörgenhumer (eds.): Plant Ethics: Concepts and Applications, London 2018, pp. 188–203.

4 Cf. Bruno Latour: The Pasteurization of France (1984), Cambridge, MA/London 1993.

5 Cf. Philip Sarasin: »Anthrax«. Bioterror als Phantasma, Frankfurt am Main 2004.

In contrast, we will sketch and deconstruct the microbe as existential substance, which, as instance of life, is even more powerful. Instead of handling this topic in styles of cultural anthropology or history of science, we drag it onto the stage where phenomenology interacts with philosophy of history, referring to Hans Blumenberg (1920–1996). Since cultivation affects the conceptualization of history and historiography, it changes the yardstick of what can account for life-time within (and historiographically: against) world-time.[6] This will become apparent by scrutinizing the idea of the allegedly first and last unit of life: the microbe. The microscope was an instrumental breakthrough for generating the microcosmos, no doubt. However, it should neither be overestimated as a mere tool of visualizing microbial life nor as an instrumental-ontological unifier of what a microbe is (not only a cell), can be (e.g. not only an infectious agent), and how it can generate worlds. That a microbe is a very small living entity is just the logical minimum of the concept. It does not allow for the imagination of its dimensional scope, i.e. the prefiguring of microbes in the light of totality, generality, and concreteness. The recent acquisition of microbiologists' power is not a matter of technical progress and instrumental discontinuities in making microbes *visible*; rather, of constructing the microbes' ›own‹ ontological-metaphysical continuity. We thus focus on the microbial *culture* and its preservation in the collection as references for ›operative ontologies‹. In the biobank, the microbe's continuity and discontinuity appear to be the same thing. Ultimately, this mode of appearance makes nothing less than history operative. New high-tech methods such as molecular sequencing and big data genomics veil the fact that the ongoing transformation of biology into engineering still requires cultivating techniques. The related dematerialization began in the 1970s, when script-metaphorics and the genealogical construction of a hypothetic microbial ancestor of life went hand in hand, as we will exemplify with the case of biophysicist Carl R. Woese (1928–2012) and his method of 16S rRNA-sequencing.

Our line of argument involves three hypotheses: (1.) techniques and technologies model the bio-ontology of what *is* a microbe. At the same time, this affects the modeling of what *we* humans are. (2.) It is microbial collections of pure cultures[7] that make microbes *operative*. Cultivating is pre-operative and, at the same time, an operation itself. Here, the complex technique that transforms enrichment

6 Therefore, the concept of biofact as a hermeneutical tool aims at reflecting on and deconstructing what seems to be *self-explanatory* in the life sciences and their interrelations with the lifeworld.

7 Robert Koch's »Reinkulturtechnik« not only established the causal relation between a specific microbe and a disease, but also »enabled microbiology to designate itself as a true science—one that could order the microbial world with rigorous experimental investigations.« Maureen A. O'Malley: Philosophy of Microbiology, Cambridge 2014, p. 70.

Fig. 1: Stored glass ampoules with lyophilized cells (*Bacillus coagulans*) at the DSMZ-*German Collection of Microorganisms and Cell Cultures*, Acc.no. DSM-1, Photo: A. Waszynski, January 2019.

culture to pure culture will be sketched. (3.) Since mid-20th century, microbe banks function as *world models* of a newly constructed ›microbial world‹, representing the whole biosphere and, in this planetary perspective, reaching out to the lifeworld (*Lebenswelt*). The resulting arguments reach far beyond biology and are in need of philosophical exploration.

Figure 1 shows a bacterial storage unit in the microbe bank. Even if the latter usually contains bacteria, it can host biological entities of different types and forms, ranging from human cell cultures to algae and plant viruses. Note that ›microbe‹ is a conceptual unifier working across biological kingdoms. In today's banks, microbial strains are usually stored as freeze-dried granulate in glass ampoules at around +10 degrees Celsius.

The strain results from one colony or cell that has been singled-out by various isolation and purification techniques. It is the final stage of a »glass and apparatus-bound immortality«.[8] As turning a culture into a distinctive storage unit requires

8 Hannah Landecker: Culturing Life. How Cells Became Technologies, Cambridge, MA/London 2007, pp. 16f.

several precursors, we reject two common answers to the question »What is a microbe?«: either the cell or the glass containment. The microbe should be seen as *process* rather than a thing. In the following, this difference is exemplified by a historical case study on the *German Collection of Microorganisms and Cell Cultures* (short: DSMZ). It was founded in 1970 as national collection of West Germany, at that time termed »DSM« and located in Göttingen.[9] One of its founders, microbiologist Norbert Pfennig (1925–2008), worked as a renowned expert for cultivating the fragile phototrophic sulfur bacteria, which became the DSM's founding objects. Today, the DSMZ is part of the Leibniz Research Cooperation based in Braunschweig, being one of the biggest Microbial Resource Centers worldwide.[10]

2. The Microbe as Meta-operative Vacancy for ›Operative Ontologies‹

Considering ›operative ontologies‹, we transform the question »What *is* a microbe?« into: »What *makes* a microbe? And how does it make worlds?«[11] Long before it was made visible, it occurred as *contagion* causing diseases by touch; or as *miasma* that we inhale as poisonous vapor while existing in the same milieu; or as transubstantiating power turning wine into vinegar.[12] The idea of the co-existence of microbes and humans *in* the world, sharing a common base of ›creativity‹ (i. e. the potential of becoming a creature), is much older than the scientific concepts *Infusorium*, *Protist*, *Bacterium* or *Prokaryote* that emerged during the last 250 years. The history of the microbe as media anthropology of allegedly toxic media still needs to be written. It would be a story of contamination and decontamination, helping to explain why, even at the end of the 19th century, elderly people were afraid of breathing ›night air‹ and kept their windows shut in the dark.[13] Already

9 For archival sources and more references see our article: Das ganze Spektrum: Die Frühgeschichte der *Deutschen Sammlung von Mikroorganismen* DSM (ca. 1960–1979) [in review].

10 Jörg Overmann: Konzeption, Relevanz und Zukunftsperspektiven moderner biologischer Ressourcenzentren am Beispiel des Leibniz-Instituts DSMZ-*Deutsche Sammlung von Mikroorganismen und Zellkulturen*, in: Karafyllis (ed.): Theorien der Lebendsammlung (as note 2), pp. 229–249.

11 Referring to the two ›sides‹ of ›operative ontologies‹: »Verfertigen« and »Medialität«. Cf. Lorenz Engell and Bernhard Siegert: Editorial, in: Zeitschrift für Medien- und Kulturforschung 8/2 (2017), pp. 5–9.

12 Cf. Marianna Karamanou, George Panayiotakopoulos, Gregory Tsoucalas et al.: From Miasmas to Germs: a Historical Approach to Theories of Infectious Disease Transmission, in: Le infezioni in medicina 20/1 (2012), pp. 52–56; Alain Corbin: Le miasme et la jonquille. L'odorat et l'imaginaire social XVIIIe-XIXe siècles, Paris 1982.

13 Peter C. Baldwin: How Night Air Became Good Air, 1776–1930, in: Environmental History 8/3 (2003), pp. 412–429.

here, we can envision how the microbe helps to structure the mediality and phenomenality of the lifeworld, e.g. as dangerous night and safe daylight.

The history of microbes can be told as a history of *vacancies and latencies* on the ontological and metaphysical level. Thus we look for meta-operations with the vacant and un-written, operating with Blumenberg's concept of »reoccupation«. For ontological reasons, we should keep in mind the Greek term μονάς, not only still prominent in quotes from Leibniz' *Monadology* (1714), but also persistent in the taxonomic names, e.g. in the alga *Chlamydomonas* and in the bacterium *Pseudomonas*, which literally means: a false *monas*.[14] Here, the border between plants (microalgae) and bacteria has been blurred. This is important for understanding what makes the single living unit an original *world producer* also in its material sense: by embodying photosynthesis as the process of primary production. However, water, the medium of life, and oxygen, the medium of *our* life, can be imagined as replaceable in bacterial photosynthesis. The microbial star of our story, the photosynthetic bacterium *Chromatium okenii*, was once termed *Monas okenii*,[15] owing taxonomic reference to philosopher Lorenz Oken (1779–1851). In the long philosophical history of the term *monas*, we highlight only the following:

– literally, it means both unity and singularity, and thus is comparable to ›atom‹, i.e. the smallest possible particle of the world; *monas* was also a unifier to make the world a whole in pre-Socratic natural ontology.
– Other than ›atom‹, *monas* was thought of as the metaphysical substance of what is ›number‹ since Pythagoras. In arithmetic, it had a direct relation to countability and measurability (figure), and writing and reading numbers in Greek numerals. Its mathematical-metaphysical opponent[16] was the point in geometry (which can be made visible by a dot).[17]

Thus, *monas* always was an ontological operator and related to digitizing. Within its operationality falls the transfer of numerals into script and vice versa. This will

14 Norberto J. Palleroni: The *Pseudomonas* Story, in: Environmental Microbiology 12/6 (2010), pp. 1377–1383.

15 Christian G. Ehrenberg: Die Infusionsthierchen als vollkommene Organismen. Ein Blick in das tiefere organische Leben der Natur, Leipzig 1838, p. 15.

16 Cf. the »dead point«. In his *Enzyklopädie* (1830), Hegel describes plankton as »light points«. Cf. Georg W. F. Hegel: Enzyklopädie der philosophischen Wissenschaften im Grundrisse (1830). Zweiter Teil: Die Naturphilosophie, A. Die geologische Natur, § 341, in: Werke, Vol. 9, Frankfurt am Main 1978, pp. 360 f. (authors' translation).

17 Husserl identified the crisis of modern sciences in their technization, as a result of being based in an ultimate arithmetic that had gained supremacy over geometry. The latter had allowed visual access to the world as ›Anschauung‹ (appearance). Cf. Edmund Husserl: Die Krisis der europäischen Wissenschaften und die transzendentale Phänomenologie, in: Husserliana VI, ed. by Walter Biemel, Den Haag 1954.

matter for the ›microbial world formula‹ (see section 4). At all times, the substantial world-making capacities needed background topologies, predominantly the ones of light and dark, fluidity and solidity. As in Leibniz' *Monadology*, the monad has substance but not matter. An immaterial medium was needed to ›activate‹ the monad: the »light fluidum«. Monads are then seen as infinite entities of world units with a soul. They have no extension[18] and act across the boundaries of inorganic and organic with *entelecheia* or *appetitus* as properties on the primary level of monadology.[19]

This is how microbiology approaches ›the world of life‹ today, reaching back to the so-called Early Earth three billion years ago. Separating the world of life from the lifeworld is all but new. Leibniz synthesized the material world bottom-up and in single units for the sake of universality. This allowed for the world's totality, countability, and completeness (as if it were a universal library). In his *Die Lesbarkeit der Welt* (1981), Blumenberg opposes Leibniz: the world can neither be grasped by a universal chronology nor a world formula.[20] Obviously, it matters how we read the world before we make it.

3. Ubiquity of Microbes: The World with/of Life versus the Lifeworld

In the last decades, microbes seem to be everywhere ›in the world‹: high up in the clouds, deep down in the sea, ubiquitous in the human body (from skin to gut) and, recently detected, also in the brain. The microbe lives like a fluidum across classic ontologies. Allegedly, it is also overcoming the divide of body and soul. Epistemologically, microbes do not have an own world anymore, the *microcosmos*. Instead, they dominate our world as »our planet's invisible rulers.«[21] The microbe has become a universal substance without implying the need to represent it in particulars. Kant would have registered this as »pure concept« (*reiner Begriff*), and Hegel as »concrete universal« (*konkrete Allgemeinheit*). In the collection, this changes because the vacancy of representation needs to be filled. For microbiology counting as a true science, collecting is a must: a microbe does not exist unless it has a deposit in a bank. The bank transforms the speculative concrete universal into a

18 The conflict between geometry and arithmetic is prefigured in Leibniz and involved the problem of the *prima materia*, relating back to Plato and Aristotle.

19 Cf. the prominent schema Leibniz added in his letter to Des Bosses (19 August 1715). For details see Hans Poser: Leibniz' Philosophie, ed. by Wenchao Li, Hamburg 2016, pp. 305 f.

20 Hans Blumenberg: Die Lesbarkeit der Welt (1981), Frankfurt am Main 2000, chapter X.

21 Gerhard Gottschalk: Welt der Bakterien. Die unsichtbaren Beherrscher unseres Planeten, Weinheim 2009.

concrete universe, a material world with imaginary plenitude (biodiversity). Speculation, however, remains crucial.

In microbiology's imagination, the microbe constitutes the limits of world as such, a world with life, both in its extension—the biosphere—and in its genealogy, i.e. the occurrence of the first organism (›progenote‹)[22] on Early Earth. Against Hegel's insight[23] that a »general-alive« entity (*Generell-Lebendiges*) which would fall and specify into different pieces or branches never existed (because nature essentially has intellect, which already implies specification), microbiologists infer from a general ancestor past and future potentials: how life can take place. Where the microbe cannot live, nothing can live, nothing has lived, and nothing will ever live—a reason why astrobiology is also very much into microbiology. Contrary to the idea of a world with life is the assumed presence of microbes in the lifeworld, i.e. a world of actual experience—even though microbes as such are invisible to the naked eye.[24] Cultivating is an operation of making them visible. Obviously, regarding microbes as present here and now, is a matter of knowledge—and belief, intrinsically linked to the hidden, substantial powers of what microbes might do with you or not. The potentials are existential.

Two current examples highlight this. A costly new trend is the »fecal microbiota transfer«.[25] Here, the microbe constitutes an own world in each of us, a microbiome. It supposedly guarantees health by means of a »prestabilized harmony« (Leibniz): you receive a portioned gut flora of a healthy, preferably indigenous and »pure« person, and are then held responsible for cultivating your new microbiome by dietary rules and omitting antibiotics. This touches the philosophical distinction of *being* and *having*: not having microbes; being microbes.[26] Indeed, there is ontological debate in microbiology who is the super-organism: we hosting the

22 Its inventor calls this »›genomic‹ organism« at the primary evolution stage of »nucleic acid life« a »theoretical construct«, admitting that it »may have been a kind of entity outside of our direct experience«. Carl R. Woese: Bacterial Evolution, in: Microbiological Reviews, 51/2 (1987), pp. 222–271: 262 ff.

23 Cf. Hegel: Enzyklopädie (as note 16), § 338, p. 349.

24 Actual experience here does not refer to a physical object, rather an atmosphere or »Erlebnis« mediated by microbes. For Blumenberg, ›Lebenswelt‹ is a sphere of self-evidence. It cannot be grasped as such and marks a hypothetical state before the emergence of ›theory‹. Cf. Hans Blumenberg: Theorie der Lebenswelt, ed. by Manfred Sommer, Frankfurt am Main 2010. In this perspective, the reduction of self-evidence, e.g. by isolating and cultivating bacteria previously perceived as a color phenomenon in nature, already *is* a theoretical operation, which requires further exploration.

25 Rebeca Cruz Aguilar, Anastasia Tsakmaklis and Maria J. G. T. Vehreschild: Fäkaler Mikrobiota-Transfer bei Clostridium-difficile-Infektionen, in: Pharmakon 5/6 (2017), pp. 451–455.

26 This implies an economic perspective for the quantification of human life that, as Simmel has pointed out, might well be analogized with microbial-physiological processes within

microbiome, or the microbiome hosting ›us‹.[27] This question goes beyond mereological considerations. It demarcates the possibility of turning individual life-time into world-time by means of switching biological functions, as Blumenberg has figured out in his study on Karl E. von Baer's concept of entomology.[28]

The second example highlights the geological-planetary scope of an ›ecological‹ microbiology.[29] Characterizing microbial diversity nowadays aims at utilizing microbes »for the benefit of the planet and humankind«, e.g. by creating a »global Gene Atlas« of microbial communities.[30] Note the switch from the individual human with his/her intestines to the abstracting genus »humankind«. Günther Anders, among others, emphasized the contingencies that accompany the new dialectics of »World without Man« and »Man without World«, which emerged with Space Programs. Following also Anders' historiographic observation that the »epoch« of the human has been turned towards a »deadline« (*Frist*)—nowadays resembled in apocalyptic discourses on the Anthropocene—, we ask how this telescopic-planetary measure interrelated with the microscopic one. As the human body has been mapped along with the Earth, we might conclude that geodeterminism is allied with body determinism, including the brain. Over the last decades, the microbe thus gained power in intermediating the largest ontological scope known in philosophy: the relation between »I« and »World«.

Today's microbiologists regard both themselves and their organisms as saviors, e.g. in a recent »warning« to »humankind« regarding climate change solutions.[31] Referring to the »unseen majority« of microbes, microbiologists implicitly argue with the *law of large numbers* from probability theory. At the same time, they explicitly address microbes »yet to discover« and imagine a plenitude of the biotic world. This quantification paradigm triggers the idea of ubiquitous collecting, predominantly for human survival. In contrast to archives and libraries, the microbial collection makes it possible to present the ›microbial world‹ in its material and structural sense (a *project*), rather than representing merely a *prospect* (*Vorstellung*) of world. A mediator of this naturalistic meta-representation of world is taxonomy, based on a system of nature. The microbe has become not only the »measure of

the human body. Cf. Georg Simmel: Philosophie des Geldes (1900), Georg Simmel Gesamtausgabe, Vol. 6, Frankfurt am Main 2000, chapter 5.

27 Cf. Karafyllis: Samenbank als Paradigma (as note 2), p. 44.

28 Hans Blumenberg: Lebenszeit und Weltzeit (1986), Berlin [5]2016, pp. 267–294.

29 This perspective had its origin in late 19th century Russia. Cf. Lloyd Ackert: Sergei Vinogradskii and the Cycle of Life. From the Thermodynamics of Life to Ecological Microbiology, 1850–1950, Dordrecht 2013.

30 Cf. agenda *Earth Microbiome Project*: http://www.earthmicrobiome.org/ (6 January 2020).

31 Cf. Ricardo Cavicchioli, William J. Ripple, Kenneth N. Timmis et al.: Scientists' Warning to Humanity: Microorganisms and Climate Change, in: Nature Reviews Microbiology 17 (2019), pp. 569–586: 569.

all things« (the be-all and end-all), replacing the human in the famous phrase of Protagoras, but also the »measure of all times«, transforming how (if at all) to write history. This point will matter for understanding Blumenberg's concept of reoccupation.

4. Primary Production: Bacterial Photosynthesis and the World-Formula

The outreach for a ›microbial world‹ speeded up since the 1950s/60s.[32] Making the microbe a universal ›world unit‹ required a generalization strategy for a fragmented discipline that was ruled by medical doctors and infection paradigms.[33] The term ›general microbiology‹ methodologically mirrors this transformation. It was based on biochemistry, the chemical subdiscipline working at the edge of life and non-life, which later will operate the pair digitizing/synthesizing. Among its proponents were the chemist Cornelis B. van Niel (1897–1985) at *John Hopkins Marine Laboratory* and his scholar Roger Y. Stanier (1916–1982), and the Göttingen team at the DSM. Van Niel's strategy was based on *equalizing*, i.e. on a chemical equation that symbolizes productivity on Earth: photosynthesis. By studying sulfur bacteria, he found a generalized equation for *all* photoautotrophic— i.e. also anaerobic—processes. Anaerobes led back to the earliest metabolism on Earth, based on sulfur and hydrogen. The formula provides a strong example for Blumenberg's concept of reoccupation, even if it happens on the numerical level and is transferred into ordinary language afterwards. Van Niel constructed a chemical vacancy and made it operative by a symbol: the letter ›A‹ for the electron acceptor in a redox reaction. In the equation, ›A‹ allows to analogize sulfur with oxygen and to exchange the elements while keeping the equation balanced.

Equation of plant photosynthesis: $6\ H_2O + 6\ CO_2 + \text{Sunlight} \rightarrow C_6H_{12}O_6 + 6\ O_2$

Generalized equation: $2\ H_2A + CO_2 + \text{Sunlight} \rightarrow 2A + CH_2O + H_2O$

In consequence, the primary production of the world could be imagined to have started with microbes utilizing hydrogen sulfide (H_2S) rather than archaic plants splitting water. As within the concept of *monas*, letter, number, and digit operate together. Stoichiometrically, the photosynthetic generalization was possible as

[32] *Locus classicus* is Roger Y. Stanier, Michael Doudoroff and Edward A. Adelberg: The Microbial World, Englewood Cliffs 1957.

[33] Predecessor of this mid-20th century development was e.g. Marjory Stephenson: Bacterial Metabolism, London 1930.

both sulfur (no. 16) and oxygen (no. 8) are members of group 16 in the periodic table,[34] providing the background ontology for the switch. They are grouped together because of the six electrons in their valence shell, requiring two more according to the octet rule. Later it turned out that phototrophic bacteria even encompass five types of chlorophylls, while plants have only two (Chl. a+b). Bacteria (and microbiology) soon superseded the dominance of plants or, philosophically spoken, their *autarchy* in global primary production. As the formula worked for *all* autotrophic organisms, also chemoautotrophs, it served as ›world formula‹ in support of a ›general microbiology‹.

Whereas this strategy initially operated as a unifier inside of a then fragmented microbiology, the universalization strategy reached out to the world—by means of setting up collections. The microbial collection—like classical libraries aiming at universality—functioned as world model and model world, respectively. Its collecting, ordering and sorting structures prefigured what is relevant in the world, representative for the world, and worth keeping. Philosophically, the ›microbial world‹ manifested as ›assortment‹ (Heidegger: *Bestand*),[35] which allowed for semantically enframing and materially providing microbes as means for different ends—from basic research in taxonomy to biotechnology.

Therefore, it is no coincidence that in 1969, Göttingen based microbiologist Hans G. Schlegel (1924–2013), on the way of founding the *German Collection of Microorganisms*,[36] published the standard textbook *Allgemeine Mikrobiologie* (*General Microbiology*). In the preface, he stressed the quantity, flexibility, and »easy handling« of microbes. Figuring microbiology as vital contribution to »fundamental problems of biology« relied upon imperializing the »traditional disciplines« botany and zoology.[37] For doing so, he disguised the fact how difficult it is to *cultivate* microbes. Strategic narratives of easiness, unity, and simplicity accompany the new enframing of microbes as general units of life, which also helped to forget the subjective concept of life-time in general.[38]

For fundraising, Schlegel envisioned biotechnological usages of chemotrophic microbes for the nuclear age. In fact, the microbe bank was funded by the West-

34 According to IUPAC-nomenclature; old group VI A.

35 Cf. Karafyllis: Samenbank als Paradigma (as note 2), pp. 125–128.

36 See the blueprint of Hans G. Schlegel: Aufbau einer zentralen Kulturensammlung am Institut für Mikrobiologie der GSF in Göttingen (22 April 1968), in: Bundesarchiv Koblenz, folder B138/3340, pp. 16–29.

37 Hans G. Schlegel: Allgemeine Mikrobiologie, Stuttgart 1969, p. V.

38 For how cultivated organisms as research objects rule the life-time of research subjects, see Robert E. Kohler: Drosophila: A Life in the Laboratory, in: Journal of the History of Biology 26/2 (1993), pp. 281–310.

German *Society for Radiation Research* (GSF).[39] Nuclear power, assumed to be cheap, should help to fight world hunger. Schlegel was dreaming of low-cost nutrition by chemoautotrophic hydrogen bacteria kept in bioreactors, which only required energy for water electrolysis.[40] On the other side of the Atlantic, van Niel suggested on similar grounds a new perspective on life's origins, digging deep into world-time. Futurological, genealogical and territorial outreach went hand in hand. Early Earth with its simple geology, vague light conditions and the transition from hydrogen and sulfur atmosphere to oxygen atmosphere began to be scrutinized. After getting explanatory hold of the whole planet's autotrophy, the next steps needed for forming the world as concreteness were: making use of space and time, i.e. collecting ›everywhere‹ and thereby creating new genealogies.

What happened in the beginnings of life? Instead of assuming a first autocatalytic RNA-molecule, relying on the genetic information paradigm and its script-metaphorics (»RNA-world«),[41] van Niel and likewise the DSM-actors proclaimed: »Metabolism first!«, implying cellularization as a necessary precondition for life. This hypothesis was made operative by searching for an entity with a first metabolism, and, ultimately, for the »first microbe«, or philosophically: a primary substance. This speculative microbe is nowadays termed LUCA—last universal cellular ancestor. If it can account for being an organism is heavily debated. By extending the living ›*Bestand*‹ (Heidegger), the ›microbial world‹ in the bank approximated the extension of ›world‹ as planet's extent, i.e. spatially (*biosphere*). The ideal of collecting ›everywhere‹ not only required expeditions, sophisticated apparatus and instruments, but also knowledge of the modes for keeping the organisms in a purified state and alive long term.

5. Isolating and Cultivating at the DSM

This is where the operative ontology of isolating and cultivating as the crucial one sets in. It starts with making the East operative for the West of Germany. Already in 1958, just a few weeks after the GDR-bound Schlegel had become chair of the Microbiology Department at Göttingen University (FRG), he traveled back to his well-known pond near Halle (GDR), where he used to sample purple sulfur bacteria, particularly *Chromatium okenii*, during his PhD-time in botany. He har-

39 Cf. records GSF 7 and GSF 9 in Bayerisches Hauptstaatsarchiv, Munich.

40 Hans G. Schlegel and Robert M. Lafferty: Novel Energy and Carbon Sources. A: The Production of Biomass from Hydrogen and Carbon Dioxide, in: Advances in Biochemical Engineering 1 (1971), pp. 143–168.

41 Cf. Michael Yarus: Life from an RNA World: The Ancestor Within, Cambridge, MA 2010.

vested his epistemic object again and transferred it in a glass bottle through the Iron Curtain (the Wall was not built yet). Back in Göttingen, he handed it over to assistant professor Norbert Pfennig, pleading him to cultivate it. (At least we might imagine that it happened this way, the incident itself is documented). This was an almost impossible task. Nobody in the world so far had been successful in cultivating sulfur bacteria in pure, not even the group around van Niel. To avoid the cliffhanger: Pfennig was successful.

This happened with the help of a transatlantic cooperation and training on how to *cultivate* all the newly found and diversely adapted microbes. Most of them used to die within hours after sampling, unable to survive laboratory settings. Cultivating life forms from extreme habitats like the deep sea and from unknown biocoenoses became crucial for *really* generalizing microbiology on a planetary scope. In van Niel's programmatic view, the cultivator had to be as creative as nature itself. He proposed a quasi-natural variety of techniques and synthetic media. Opposing Koch's dogma of pure culture, he suggested enrichment culture.[42] Provokingly, we might say that microbiologists have had to imagine themselves as microbes, converting the famous paper title of philosopher Thomas Nagel (*What Is It Like to Be a Bat?*) into *What is it like to be a microbe?*—without taking into account that we neither can nor should attempt to leave the answer to the microbe, or the bat.[43]

In the early 1960s, Pfennig trained under van Niel's supervision in California. There, he also collected microbes later to be found in the DSM-catalogue. His colorful research objects should become the primary collection of the newly founded DSM, and they remain a core collection of today's DSMZ. Drawing on van Niel's enrichment cultures, Pfennig and Schlegel modified the media in the commonly used Winogradsky Column: a glass device with stratified media, especially suitable for enriching purple sulfur bacteria like *Chromatium*. Pfennig provided the crucial idea for intermediary cultivation, i.e. the operation in-between sampling/enriching and isolating.[44] While van Niel had failed by working with leaky glass-stoppered bottles, Pfennig used *air-tight* screw-cap bottles that prevented contamination. Up until that point, sulfur bacteria had resisted the dogma of pure culture predominantly because they require a metabolic partner (sulfur cycle). Instead, Pfennig became their partner as he manually fed them with hydrogen sulfide.

42 Cf. Cornelis B. van Niel: The »Delft School« and the Rise of General Microbiology, in: Bacteriological Review 13/3 (1949), pp. 161–174: 165.

43 Thomas Nagel: What Is It Like to Be a Bat?, in: The Philosophical Review 83/4 (1974), pp. 435–450.

44 These operations are shown in the scientific film PHOTOSYNTHESIS—PURPLE BACTERIA: VAN NIEL'S ISOLATION TECHNIQUE (ANAEROBIC PURE CULTURE), D: Norbert Pfennig, Eike Siefert and Bernd Lötsch, IWF Göttingen 1975.

Moreover, four sterile nutrient solutions were combined and Vitamin B_{12} was added, internationally known as »Pfennig's medium«.[45] The bacteria were pre-bred in the dark and underwent rhythmic shaking. Pfennig also experimented with monochromatic light for specifying light gaps in order to simulate natural habitats, like living 20 feet below water surface. *Chromatium okenii* transformed the DSM into an intensive care unit, and triggered the funding of the microbial bank. Its doctor on duty, Pfennig, was a confessed anthroposopher and admirer of Goethe and Rudolf Steiner.[46] He thought the world in self-sustaining rhythms, powers, and colors. Because of his highly unusual background ontology that successfully inspired his laboratory operations, the DSM soon counted as *the* institution for keeping difficult microbes alive.

This raised the question: *how*—not only: *what*—to cultivate in collections: which media, temperatures, and light conditions are to be considered and simulated? In Pfennig's view, the *operative* component in microbes is making use of media as *substrata*. He imagines microbes as activating *substances* in a world of light and water. Pfennig observes and interprets phenomena that the substance brings into appearance, not the substance itself. In his view, ontology consists of (lat.) *actus* and *potentia*, which resembles the Aristotelian pair (gr.) *energeia/dynamis*. An enlightened world is the overarching basic principle here. In Pfennig's words, the »power of sunlight« brings the »chemical potency« into appearance, »organic substances« then »bring in« (*einbringen*) this potency into microbes. Pfennig simulated the natural operation of bringing-to-appearance. Microbial life is »organically alive« (*organisch lebendig*), microbes are »process germs«. Hence, his background is a process ontology, not a thing ontology. By stressing »substance«, he purposely avoids the Latin dichotomy of matter and form, which makes the couple digitizing/synthesizing operative. Substance is necessarily object of change, i.e. continuously overcoming its form—*the* principle of life.

Pfennig deems his ability to ›read‹ in pure cultures »processual magnification«. For him, the glass bottles with nutrient solutions functioned as »physiological« optical instruments for visualizing each physiological type of microbial life. While the microscope visualizes entities, Pfennig visualizes the process of being ›itself‹. For doing so, the microbiologist has to consider »in detail« the preconditions that represent »specific constellations of environmental qualities, which we are able to experience [*erleben*] as mood or atmosphere«.[47]

45 For an overview see Hans G. Trüper: Sulfur and Light? History and »Thiology« of the Phototrophic Sulfur Bacteria, in: Christiane Dahl and Cornelius G. Friedrich (eds.): Microbial Sulfur Metabolism, Berlin et al. 2008, pp. 87–111.

46 Norbert Pfennig: Reflections of a Microbiologist, or How to Learn from the Microbes, in: Annual Review of Microbiology 47 (1993), pp. 1–29.

47 Norbert Pfennig and Jochen Bockemühl: Mikrobielle Prozesse und Pflanzenleben –

Pfennig himself did not seek out for microbial genealogies in the strict sense. However, making the sulfur bacteria »ready at hand« (Heidegger: *Zuhandensein*) enabled more research on the sulfur-cycle, and hence also the envisioning of its role on Early Earth. Relevant here is, among the options present around the 1960s, the later termed »Iron-Sulfur-World.«[48] Within this scenario, inorganic compounds had generated minerals like pyrite, supplying a first nutritional base for sulfur bacteria. It implies a background topology of liquidity and solidity, water and land, which—in the words of Hegel—enables the dead »crystal of life« to become »punctual and temporary vitality« in form of microorganisms.[49] The idea of a »pioneer organism« will settle on these ›grounds‹.[50]

6. Muddy Waters: Technologizing the Iron-Sulfur-World

The next practical step was *technologizing* the Iron-Sulfur-World for present problems of civilization. After all, collecting was a matter of funding. Thinking of industrial applications, the imagined Early Earth had affinities with the high-tech sewage plants of the 1970s. They newly included biological treatment of wastewater, especially the complex ones of chemical industry. Pfennig did several projects on degradation processes in sewage plants sustained by sulfur bacteria. For the researchers of the DSM, bacteria for biodegradation soon became research objects also in terms of bioinstrumentation and -production. Varying the purposes was possible by technically varying metabolic parameters and nutrition media. In consequence, microbes were framed as ›multipurpose‹ organisms, utilizing bio- and technosphere, but excluding medicine (also not to interfere with the Robert Koch-Institute's collections). The mud-loving sulfur bacteria were collected from liminal zones with low oxygen, e.g. the tidal coast zone or shallow ponds. These are also habitats of methanogens, likewise early epistemic objects of the DSM, difficult to cultivate, linked to Early Earth, and can be found in sewage plants.

Schlüssel zu einer Chemie des Lebendigen, in: Elemente der Naturwissenschaft 78/1 (2003), pp. 54–73; quotes pp. 54–57 (authors' translation).

48 Cf. Günter Wächtershäuser: Groundworks for an Evolutionary Biochemistry: The Iron-Sulphur World, in: Progress in Biophysics and Molecular Biology 58/2 (1992), pp. 85–201.

49 Hegel: Enzyklopädie (as note 16), § 341, pp. 360 f. (authors' translation). See also the passage (p. 363), where he characterizes the marine Infusoria and their general property of being alive, stating that this »organism results immediately and does not continue to procreate«.

50 Günter Wächtershäuser: From Volcanic Origins of Chemoautotrophic Life to Bacteria, Archaea and Eukarya, in: Philosophical transactions of the Royal Society of London. Series B, Biological Sciences 361/1474 (2006), pp. 1787–1806: 1787 f.

Until now, microbiology has suggested to combine ›clarifying‹ decontaminating applications with a ›microbial world ecology‹, e.g. in a 2010 article of Schlegel's scholar Gerhard Gottschalk: »Processes of this kind, especially sewage plants, are, so to say, the extended arm of microbes for closing metabolic cycles in nature.«[51] Ernst Kapp's understanding of techniques as *organ projection* (1877)[52] appears here in the light of philosophical geognostics.[53] The sewage plant is the extended metabolizing arm of the planetary microbe, which clears the whole world, so to say. Hence the functioning of the world is technomorphic, while appearing as natural or ecological. This technology-mediated ecologization of microbiology, happening from mid-20th century on,[54] goes along with the concept of contamination, as both are based on a concept of space (contrary to infection). Ecologization will turn out to be a pacemaker for systems biology, including synthetic biology.

7. From Sequencing to Digitizing/Synthetizing

As operator of metabolic cycles on the planetary scope, the microbe substantiates the whole biogeodynamics in chemical synthesis. In 1994, Carl Woese proclaimed: »Prokaryotes are the real chemists of this planet.«[55] And chemistry had already turned historical, striving for a molecular history. For the purpose of a molecular based, microbial-global history, the sewage plant and its super-metabolism were switched into nature again, which functioned as host for a developing script of life. Woese and his group in Urbana/IL intended to explore life's deep history by the revolutionary method of 16S rRNA-sequencing. Information was obtained only from the RNA in the small subunit (16S) of the ribosome, as this organelle is regarded conservative in the evolutionary sense. Several steps were mandatory: labeling microbes with phosphorus isotopes, extracting their rRNA, splitting it into fragments, running them through electrophoresis, ›burning‹ the

51 Gerhard Gottschalk: Mikrobiologie 2010. Entdeckungen und Entwicklungen in den zurückliegenden 25 Jahren, in: 25 Jahre VAAM (self-publication) 2010, pp. 4–19: 14 (authors' translation).

52 Ernst Kapp: Grundlinien einer Philosophie der Technik (1877), Hamburg 2015, pp. 40 ff.

53 Cf. Ernst Kapp: Philosophische oder vergleichende allgemeine Erdkunde als wissenschaftliche Darstellung der Erdverhältnisse und des Menschenlebens in ihrem inneren Zusammenhange, Braunschweig 1845. For a critique on geognostics (in alliance with Blumenberg's critique on a ›world chronicle‹), see Hegel: Enzyklopädie (as note 16), § 338 (addendum), pp. 347–349.

54 For the medical side: Susan D. Jones: Population Cycles, Disease, and Networks of Ecological Knowledge, in: Journal of the History of Biology 50/2 (2017), pp. 357–391.

55 Carl R. Woese: There Must Be a Prokaryote Somewhere: Microbiology's Search for Itself, in: Microbiological Reviews 58/1 (1994), pp. 1–9: 7.

radioactive fragments on X-ray films, inferring and calculating sequences, indexing and comparative cataloguing. The comparison involved huge amounts of data processed by an IBM computer fed with punch cards.[56] The outcomes challenged microbiology's proclaimed nuclear cell difference: *prokaryotes* without and *eukaryotes* with a nucleus. Now another group and difference structures became evident: microbes like methanogens that have no nucleus, a unique cell wall structure and allegedly very old metabolic pathways connected to Early Earth. Together with Otto Kandler[57] and Ralph Wolfe, Woese later proposed a *three-domain* model of superphyla: Eubacteria, Eukaryota, and Archaea (replacing the preliminary term »archaebacteria«).[58] Important is: Woese's sequencing still demanded cultivation, which he delegated to specialists in collecting.

For present industrial biotechnology, the framework for an operative ontology is built by systems biology that also informs the German strategic agenda of »Bioeconomy 2030« and its counterparts in other countries.[59] In favor are model organisms that physiologically and genetically are able to contribute to all levels of biological organization (vertical) and of biochemical pathways (horizontal), ranging from infection to biodegradation. In short: of interest are multipurpose organisms like the fast growing soil bacterium *Pseudomonas putida*, showing a unique metabolic versatility and being acknowledged as the first-ever patented organism.[60] Genetic engineering optimizes its ability to degrade recalcitrant substances, e.g. crude oil, even under extreme conditions. »Tailoring« the microbe as a host for diverse genetic inserts (*P. putida* KT 2440) took place at the *Gesellschaft für Biotechnologische Forschung* (GBF) in Braunschweig, since 1980 temporary head organization of the DSM. The created organisms served both environmental and

56 For this reconstruction cf. David Quammen: The Tangled Tree: A Radical New History of Life, New York 2018, pp. 50ff. and 196f.; Jan Sapp and George E. Fox: The Singular Quest for a Universal Tree of Life, in: Microbiology and Molecular Biology Reviews 77/4 (2013), pp. 541–550.

57 Munich based botanist Otto Kandler, a specialist for *Lactobacilli*, also helped to establish the DSM. The bank had a decentral structure with a headquarter in Göttingen and branches in West-Germany, the most recent was established in Munich.

58 Cf. Carl R. Woese, Otto Kandler and Mark L. Wheelis: Towards a Natural System of Organisms: Proposal for the Domains Archaea, Bacteria, and Eucarya, in: Proceedings of the National Academy of Sciences (USA) 87/12 (1990), pp. 4576–4579.

59 Cf. https://www.bmbf.de/en/bioeconomy---new-concepts-for-the-utilization-of-natural-resources-4543.html (7 October 2019).

60 United States Supreme Court: 447 U.S. 303, 1980, Diamond vs. Chakrabarty. Cf. Bernhard Gill and Veit Braun: Lost in Translation: Biofakte auf dem Weg vom Labor ins Patentamt: in Bernhard Gill, Franziska Torma, and Karin Zachmann (eds.): Mit Biofakten leben. Sprache und Materialität von Pflanzen und Lebensmitteln, Bielefeld 2018, pp. 128–154.

biotechnical applications, functioning as »cell factories« for producing chemicals and compounds. Natural phenomena were turned into »operating conditions«.[61]

In the new millennium, the developments increased in pace by bioinformatics, enabling scientists to decipher a »genome repertoire«[62] and to establish pathway modeling[63] in silico, leading to genome-driven cell engineering. The microbe has become a customizable and mobile frame for diverse applications. This technical connotation of biodiversity demands a de-singularized, simplified and digitally endowed potential of reproduction, mediated at the expense of an organism concept and its ontological interdependence of form and content. Nonetheless, cultivated model organisms remain crucial as wetware. Again, the biotechnological projection allies with a phylogenetic re-projection. In 2018, *Escherichia coli* was technically converted into an archaeon.[64] The outcomes do not suggest a single common ancestor, »but a mixture of multiple life-forms,« maybe just a membraneless archaic »soup protected by clay particles«.[65] The vacant ›place‹ of life's beginnings has been filled with a perfect match of bio-, techno- and theological imaginations.

8. Reoccupations in Conceptualizing Living Beings: Conclusions with Hans Blumenberg

We have sketched three stages of microbe-related ›operative ontologies‹: isolating/cultivating, sequencing/technologizing, and digitizing/synthetizing. They address a material vacancy: how to create a genealogy without fossil records? Ultimately, this addresses philosophy: how to conceptualize history and differentiate it from the past? With regard to media anthropology: which media do we accept as instances and substrates of history in order to address an adequate concept of ›human‹?

61 Victor de Lorenzo: Designing Microbial Systems for Gene Expression in the Field, in: Trends in Biotechnology 12/9 (1994), pp. 365–371: 365.

62 Pedro Soares-Castro and Pedro M. Santos: Deciphering the Genome Repertoire of *Pseudomonas* sp. M1 toward β-Myrcene Biotransformation, in: Genome Biology and Evolution 7/1 (2015), pp. 1–17.

63 Cf. Jacek Puchałka, Matthew A. Oberhardt, Miguel Godinho Ferreira et al.: Genome-Scale Reconstruction and Analysis of the *Pseudomonas putida* KT2440 Metabolic Network Facilitates Applications in Biotechnology, in: PLoS Computational Biology 4/10 (2008), doi: 10.1371/journal.pcbi.1000210.

64 Antonella Caforio, Melvin F. Siliakus, Marten Exterkate et al.: Converting *Escherichia coli* into an Archaebacterium with a Hybrid Heterochiral Membrane, in: PNAS 115/14 (2018), pp. 3704–3709, doi:10.1073/pnas.1721604115.

65 Arnold Driessen, quoted in Prachi Patel: Microbe Mistery, in: Scientific American 319 (July 2018), p. 18, doi:10.1038/scientificamerican0718-18a.

While Ian Hacking recommended a historical meta-epistemology for addressing continuities in the history of science, i.e. the »styles of thinking and doing« that should include the dynamic potential of instruments,[66] Blumenberg suggested to scrutinize our set of ›instruments‹ for making sense of history. In order to describe the dynamics involved at »epochal thresholds«, he coined the term »reoccupation« (*Umbesetzung*).[67] It rejects a substantialist intellectual historiography that would focus on changes in given ›substrates‹, as new theoretic approaches respond to questions that endure and persist. They persist in spite of answers already given. Blumenberg's concept implies that *vacant* places are being occupied anew.[68] With reference to modernity theory, these vacant places are often understood in terms of »metaphysical surpluses« which still remain after the proclaimed end of metaphysics.

The concept of »reoccupation« serves as an alternative to Thomas S. Kuhn's model of paradigm shifts in scientific revolutions. For Blumenberg, epoch formation needs to be discussed from its potential experience, crossing the threshold of the laboratory into the lifeworld. For applying this model to microbial life, we have to transform Blumenberg's overarching approach for explaining the threshold to modernity. On the other hand, we can thereby emphasize that modernity is characterized by *systematically* making use of life, or with Georg Simmel: by »Versachlichung des Lebens«,[69] i.e. the objectification of life also in the sphere of subjectivity. Regarding ›operative ontologies‹ it remains unclear, which relations between Man, World, and History could and should be considered. Fruitful seems the idea of systemic vacancies and their ongoing and competitive reoccupations; for the ›place‹ of the microbe has never fully been filled, neither that of ›world‹ nor ›man‹. The resulting vacancies are existential also in an anthropological sense. In this sense, Blumenberg's »reoccupations« have to be seen as necessities, by means of which the relation of humans to the world are continuously reshaped—in modernity, a world predominantly explained by science. Additionally, sciences make hermeneutical and conceptual offers for *understanding* the world. Microbiol-

66 Ian Hacking: »Style« for Historians and Philosophers (1992), in: Ian Hacking: Historical Ontologies, Cambridge, MA 2002, pp. 178–199.

67 Hans Blumenberg: The Legitimacy of the Modern Age (1966), transl. by Robert M. Wallace, Cambridge, MA 1991, p. 466.

68 »Der Begriff ›Umbesetzung‹ bezeichnet implikativ das Minimum an Identität, das noch in der bewegtesten Bewegung der Geschichte muß aufgefunden oder zumindest vorausgesetzt und gesucht werden können.« It implies, »daß differente Aussagen als Antworten auf identische Fragen verstanden werden können.« Hans Blumenberg: Aspekte der Epochenschwelle. Cusaner und Nolaner, exp. and rev. new ed. of *Legitimität der Neuzeit*, part IV, Frankfurt am Main 1985, p. 541. We use the translation »reoccupation« by Wallace as it alludes to violence and denotes that a transition might not be a ›smooth‹ shift.

69 Simmel: Philosophie des Geldes (as note 26), p. 723.

ogy seems to be able to answer the four Kantian questions, although shaping the answers requires technical procedures and living assortments. Intellectually, these assortments are reduced to an alliance of ›world formula‹ and ›world chronology‹. From Blumenberg's point of view, a natural history of microbes can never be understood as ›world history‹. Last but not least, »Umbesetzung« allows opposition against the idea of continuous progress, here: in microbiology.

The next decade will see a technological shift from DNAread to DNAwrite on the genomic and meta-genomic level.[70] Now that it seems clear how to *read* a whole genome, the challenge is to *write* or, as Hans Jonas said: to *rewrite* it.[71] We tried to show that this shift—and its acceptance—depends on the selected *mode* of ›reading‹ the world: in molecules, genomes, or cultures. Cultivating and sequencing imply not only two different concepts of reading, but also two divergent reading ›attitudes‹:[72] as parts of the 16S rRNA are regarded as evolutionary conservative, it functions as the minimal momentum of identity between life, history, and world—or: as an *operator of history*. Therefore, the 16S rRNA became both a substratum of microbial history (leading to ›us‹) and the supplementary material instance for a historiography of the Early Earth (leading to ›world‹). Ontologically, the microbe is a thing of ›condensed time‹ or even its monadic extreme: a point of time, understood literally. As such, it contrasts the liquid and organismic process of evolution it should help to explain.[73]

Reaching out for the whole planet's chemistry involved a large-scale biotechnological preview. Woese, the father of the 16S-rRNA-genealogy of life, was skeptical towards the »technological adventurism« of genetic engineering that speeded up in the 1980s.[74] His self-fashioning as a gate keeper of molecular genetics, restricting itself to basic research, appears doubtful. Alternatively, Woese's technique of constructing *hypothetic organisms* of the past—progenotes—can be regarded as door opener for constructing synthetic organisms in the future. In contrast, cultivators like Pfennig read in living processes presumably being birthed in world-water. It is the phenomenality of a substance in continuous transformation that is becoming readable, as if it were offering a gift to the gifted reader who

70 Cf. Jef Boeke, George Church, Andrew Hessel et al.: The Genome Project-Write, in: Science (2 June 2016) (online first), doi: 101126/science.aaf6850, pp. 1–3.

71 Hans Jonas: Philosophical Essays. From Ancient Creed to Technological Man, Englewood Cliffs 1974, p. 80.

72 On the ›attitude‹ (*Einstellung*) while reading see Hans Blumenberg: Phänomenologische Schriften 1981–1988, Frankfurt am Main 2018, pp. 401–404.

73 The microbe here is a living unit limited by its cell wall. At the same time, it resembles a historical unit indicating another time. The relevant process is not life itself, rather life situated in a geological past.

74 Carl R. Woese: Archaebacteria and Cellular Origins: An Overview, in: Otto Kandler (ed.): Archaebacteria, Stuttgart 1982, pp. 1–17: 2.

is practicing a naked-eye microbiology. Here, the minimum momentum of identity between life, history, and world is not a point or a punctual mutation. The momentum of identity appears as Gestalt (Pfennig: »Prozessgestalt«) within a subjective instance of time, which in German is termed ›*Augenblick*‹, a word which resists English translation in ›point of time‹.

In this visual regard of *how* and *what* to see with the naked eye, Blumenberg differentiated between clearness (*Anschaulichkeit*) and appearness (*Aussehen*) of scientific representations.[75] Traditionally, both relate to measures of spatial elements that ultimately rely upon the organic outfit of the human, including the sensory structure of perception. Pfennig's way of reading microbes by simulating their metabolic partners and mediating their vacant metabolisms through nutrition media relates to appearness, also in the light of temporality. This made it possible to relate the visual experience to subjective time, and yet comparable scientific procedures risk, as Blumenberg pointed out, that not the human remains »measure of all things«. Instead, all living beings would at last become the specific measure of all *their* things. This is just one part of a bigger and intrinsic problem of »Anschaulichkeit« in modern science: clearness tends to be a re-extraction (*Rückgewinnung*) from an already objectified world that has been given the form of ›nature‹ for the sake of the human and the discrete time of the subject. However, when the units of measure, being essentially related to human corporeality such as hand and eye, should grasp *cosmic* distances measured by means of large numbers (as in Woese's algorithmic-genealogical calculus), the measuring units lose power against the ›factor of its multiplication‹, and thus the clearness vanishes.

The need for harmonious processuality, embedded in what is metaphysically given, persists—despite of the next »reoccupations« in microbiology that will result from a new vacancy: skipping cultivation, a long wished-for and major flaw. To think in the binary code of ›collecting DNA‹ and directly ›sequencing DNA‹, without the time-consuming intermediary stages, is alluding in the light of efficiency. At the same time, rapid species extinction does not only recommend collecting, but also turning the organism into a genomic data set for assumingly eternal storage. In the case of vanishing microbes, most vacancies will not even appear as such in the lifeworld. The ›microbial world‹ together with its living representatives in the model world of collection might become virtual too: when the concept of history would be transformed into a processual past of digitalization, by which number, figure, and letter are fused together into one codical, meta-operative structure. But then the microbe would lose its feature of somehow sharing life with us.

75 Blumenberg: Lebenszeit und Weltzeit (as note 28), pp. 268 f.

For theoretical purposes, biobanks need to be analyzed as instances of both ordering worlds and, still neglected,[76] producing worlds. Finally, we address two insights from collection research: a collection collects what is regarded *similar*, and all collections are guided by the ideal of *representativity*.[77] In consequence, microbe banks allow to think both options: either assimilating the microbe to our understanding of world or assimilating us to their representations of world. The shown »reoccupations« have led to a technomorphic world view. It is a world the microbe was collected for—and now, even as a semi-synthesized object, fits in almost naturally. The question persists, how we want to fit into this world.

76 Cf. Bruno J. Strasser: Collecting Experiments: Making Big Data Biology, Chicago 2019.
77 Boris Groys: Logik der Sammlung. Am Ende des musealen Zeitalters, Wien 1997, p. 39.