The Ultimate Technology: The End of Technology and the Task of Nature

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Abstract One of the most influential philosophers of the 20th century, Martin Heidegger (1889–1976), died prior to the remarkable cloning of the sheep Dolly and before Dr. Venter started his experiments on creating synthetic life, and he never explicitly discussed living technologies. However, by reinterpreting his notion of "modern technology," this article shows how it is possible to philosophically assess living technologies and to recognize ways in which Heidegger anticipated this phenomenon with his notion of cybernetics. The interpretation elucidates the fundamental process of technology becoming living and simultaneously presents living technology as the ultimate technology. The thesis of this article is that living technology is not just one more technology; rather, it is the perfection of technology as understood by Aristotle. Aristotle's thinking is in this way a key example of a profound reassessment of nature and technology. Aristotle clearly separates these two domains of being in his definition, but in doing so, he also connects them to one another in a highly influential way. Following this line of thought, the article finally offers an original perspective involving renewed respect for the perpetual self-unfolding nature of living technology.

1 Introduction

Many people are astounded when they realize the remarkable potential of living technology. Living technologies might indeed mark the end of a number of horrible diseases, lead to an incredible enhancement of human power, and give us the tools to design radical new life forms and to experiment with nature in previously unknown ways. For this reason, living technology could come to demarcate the beginning of a new era—an era of new chances and new dangers. But what is living technology from a philosophical point of view, and why was its development a goal? Based on a new interpretation of one of the leading philosophers in the 20th century, Martin Heidegger, and more specifically one of his most influential and relevant philosophical inquiries, "The Question Concerning Technology," this article endeavors to unfold a philosophical analysis of living technology.

Martin Heidegger (1889–1976) died prior to the remarkable cloning of the sheep Dolly and before Dr. Venter started his experiments on creating synthetic life, and he never explicitly discussed living technologies. However, by reinterpreting his notion of "modern technology," this article will show how it is possible to philosophically assess living technologies and to recognize ways in which

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Heidegger anticipates this phenomenon with his notion of cybernetics. The following interpretation elucidates the fundamental process of technology becoming living and simultaneously presents living technology as the ultimate technology. The thesis of this article is that living technology is not just one more technology; rather it is the perfection of technology as understood by Aristotle. Aristotle's thinking is in this way a key example of a profound and very forceful reassessment of nature and technology. Aristotle clearly separates these two domains of being in his definition, but in doing so, he also connects them to one another in a highly influential way. Following this line of thought, the article will finally offer an original perspective involving renewed respect for the perpetual self-unfolding nature of living technology.

To Heidegger, modern technology and especially the idea of living technology indeed represent a profound danger. He is thus often considered a conservative, who points out the immense differences between modern and ancient technologies. In what follows, I will question this account of Heidegger's understanding of technologies. By reinterpreting the thoughts and arguments presented in "The Question Concerning Technology" and addressing Heidegger's view on cybernetics, I will argue that the ambiguity at play in understanding living technologies is fundamental and of great consequence for understanding the historical framework of technology development. Investigating this ambiguity will grant access to a conception of the origin of living technology as well as facilitate a critical interpretation of Heidegger's thinking concerning modern technology and his understanding of nature and cybernetics.

In the following sections I will first present the background for understanding Heidegger's argument and for my subsequent analysis of the development of living technology. I will start by briefly explaining what is commonly known about Heidegger's critique of modern technology. I will then criticize this view and endeavor to interpret and discuss the traces of another beginning of modern technology—a beginning that encourages a development toward realizing living technology.

2 Challenging Nature

The fundamental lesson to be learned from Heidegger's study of technology is that technology is not first and foremost to be understood as a specific artefact, but essentially as a way of bringing-forth beings, and thus as actualizing new or unseen potentials of the world. By analyzing technology within the framework of bringing-forth beings, Heidegger links technology to the ancient Greek understanding of the concept of truth, *alêtheia*. In doing so he makes the assessment of technology a crucial enterprise to philosophy. According to Heidegger, the ancient Greeks understood *alêtheia* as the phenomenon of revealing beings, which also includes the phenomenon of bringing-forth beings. In his investigation of technology, Heidegger writes: "But where have we strayed to? We are questioning concerning technology, and we have arrived now at *alêtheia*, at revealing. What has the essence of technology to do with revealing? The answer: everything. For every bringing-forth is grounded in revealing" [13, p. 318]. Heidegger emphasizes that the ancient Greek understanding of truth is a reminder to us that an object first needs to be revealed, stand out, and be intelligible before it can be analyzed in detail, for example in the sciences, and be the object of a comparison with other objects (see also [10, p. 149f]). Before it is possible to decide whether or not a description of an object is correct or incorrect, it first needs to be revealed or brought-forth as an object with a specific identity. In other words, Heidegger's point is that identities are the result of a specific framing, which is in itself non-neutral, and needs to be understood as the result of a particular intervention or revealing process—a process that also is a defining criterion of the operation of technologies. These two phases [(1) obtaining an identity and (2) analyzing an identity][1] illustrate the precedence of the ancient Greek understanding of truth over a conception of truth in terms of correspondence, according to Heidegger. He maintains that *alêtheia* describes the very revealing and rendering intelligible of beings to our experience (see also [29]).

1 These might be intermingled in practice, but it is important to understand the systematic difference between the two.

Against this backdrop, Heidegger distinguishes modern from ancient technology. He argues that the way in which modern technology reveals beings is fundamentally different from that of ancient technology. The essence of modern technology, or *das Gestell*[2] as Heidegger calls it, is a *challenging* bringing-forth. In Heidegger's line of thinking this is to say that modern technology brings-forth in order to sap energy from what is brought-forth or to use it as a resource in an endless chain of production. "The revealing that rules in modern technology is a challenging, which puts to nature the unreasonable demand that it supply energy which can be extracted and stored as such" [13, p. 327]. And "such challenging happens in that the energy concealed in nature is unlocked, what is unlocked is transformed, what is transformed is stored up, what is stored up is in turn distributed, and what is distributed is switched about ever anew" [13, p. 322]. This is also concisely described by the Heidegger expert, Andrew Feenberg, who at the same time addresses modern technologies' negative reciprocal influence on humans:

> Nature is "challenged" to deliver up its wealth for arbitrary human ends. It is transformed into a source of energy to be extracted and delivered. But even as human beings take themselves for the masters of being, being "challenges" them to challenge beings [...] This "*Gestell*," this "enframing" within which human being and being are ordered, is now the way in which Being reveals itself. ([6, p. 21]; see also [38, p. 61f])

As opposed to modern technology, Heidegger claims that the bringing-forth belonging to ancient technology is characterized by "setting free" instead of "challenging" [13, p. 316]. Ancient technology is in Heidegger's view simply responsible for "starting something on its way into arrival" [13, p. 316], and thus is much more sensitive to the material it is working on. That is to say, ancient technology brings the *proper* potential or the natural *telos* (end) of something into appearance, whereas modern technology challenges its object to stand out and be treated as a mere resource in an endless search for still more resources.

However, this separation between ancient and modern technology seems not to stand the test of empirical evidence and philosophical inquiry (see also [30]). When this is realized, it is possible to discover an underlying continuity between the two and to reassess the implied innocence of premodern technologies as well as the danger of modern technologies. In "The Question Concerning Technology" Heidegger implies that an ancient silver vessel should somehow "set free" the essential being of silver, or rather, the essential feature of *silver ore*, but I contend that this claim is a radical ontological *challenge* and a fundamental *demand* on nature, in the sense of regarding nature as only a resource for production ([13, p. 315]; see also [31] and [32]). In the inferred framework of understanding, silver ore becomes itself, is "set free," and follows its natural *telos* when it is turned into an artifact. Along these lines of thinking, the role of bringing-forth pertaining to ancient technology and its implicit appropriation of nature is certainly "challenging" by Heidegger's own standards. Furthermore, if identity is always grounded in a non-neutral framing or revealing, then it does not make sense to speak of identity as if it were something naturally given in the world. Viewed from the reverse perspective: If a silver vessel is thought to disclose the proper potential of silver ore, how is it that silver or silver ore in ancient Greece was used to create all kinds of *different* artifacts, from jewelry to everyday tools? The answer must be that the bringing-forth manifest in ancient technology in fact reveals silver ore as a very flexible resource—what readily could be called "standing reserve"—namely, as being ready to be used to create all kinds of different artifacts [31].

Now that a number of Heidegger's most important concepts regarding technology have been conveyed and his key differentiation between ancient and modern technology has been questioned, a continuity between ancient and modern technology is emerging. We now need to focus on another passage of "The Question Concerning Technology" and from there return to the initial query. This approach will allow us to link the origin of modern technology with its ultimate consequence: *living technology*.

2 Because the English translation of *das Gestell*, "the enframing," does not refer to a specific "stand" pertaining to the German word *stellen*, I shall continue to use the term *das Gestell* to characterize what Heidegger means by the essence of modern technology. Another translation of *das Gestell*, which would call attention to this feature, would be "setup."

3 Living Technology and Cybernetics

3.1 Beyond Artifacts

In Heidegger's view, a new technology is in one sense the very youngest technology, but, understood genuinely historically, the youngest technology is the technology that needs the longest preparation, and therefore this technology can also be assessed as the oldest. Heidegger sees history as a continuing unfolding process defined by an ancient origin, and from this reversed perspective, living technology, which normally is regarded as the youngest technology, was the longest time in the making and needs to be understood in relation to the beginning of ancient technology:

> The last is that which not only needs the longest fore-runnership but also itself *is*: not the ceasing, but the deepest beginning, which reaches out furthest and catches up with itself with the greatest of difficulty. Therefore, the "last" withdraws from all calculation and therefore must be able to bear the burden of *the loudest and most frequent misinterpretations*. Otherwise, how could it continue to be "the surpassing" [*das Überholende*]? [16, p. 285; emphasis added]

From the latter perspective, history and chronology stand in an inverse relation. Based on this conception of history, living technology has the earliest origin and the longest "fore-runnership," and it furthermore suffers the most misunderstandings. Bearing in mind that Heidegger first and foremost views a historical development from its beginning instead of from its final result, there is a passage in "The Question Concerning Technology" that stands out and calls for interpretation. In this passage Heidegger discusses the antique generic concept of bringing-forth, *poiêsis*. In doing so, Heidegger wants to illustrate the rather broad meaning of bringing-forth, but at the same time he also implicitly calls attention to an important aspect of the development of living technology, which is crucial for the argument presented in this article:

> It is of utmost importance that we think bringing-forth in its full scope and at the same time in the sense in which the Greeks thought it. Not only handicraft manufacture, not only artistic and poetical bringing into appearance and concrete imagery, is a bringing-forth, poiêsis. Physis, also, the arising of something from out of itself, is a bringing-forth, poiêsis. *Physis is indeed poiêsis in the highest sense*. For what presences by physis has the irruption belonging to bringing-forth, e.g., the bursting of a blossom into bloom, in itself (en heautôi). In contrast, what is brought-forth by the artisan or the artist, e.g., the silver chalice, has the irruption belonging to bringing-forth, not in itself, but in another (en allôi), in the craftsman or artist. [13, p. 317][3]

Heidegger argues that *nature* manifests bringing-forth *in the highest sense*, because the process of bringing-forth in nature happens *by itself*. This *autopoiesis* makes nature significantly different from technology. In other words, in Greek antiquity the bringing-forth of nature is understood as the *ideal* kind of bringing-forth, since it does not need the intervention of an outside force as the production of artifacts does, that is, nature does not need a craftsperson in order to produce and develop. The basic logic of this fundamental understanding of technology and of nature is that technological development is not supposed to halt before it reaches the ideal form of bringing-forth. I argue that the reciprocal revealing of nature and technology, according to which technology is understood as a qualitatively privative way of bringing-forth, initiates a development, the goal of which is to actualize living, self-moving technology. Living technology and biotechnology[4] are in this way rooted in the initial conception of technology in Greek antiquity. What was "primally thought"

3 See also Aristotle, *Physics B1*, 192b8-32, Metaph. Theta 8, 1049b5-10, and Theta 1 1046a9-19. I am grateful to Prof. Alan Code for helping me find these further references to Aristotle.

4 *Bios* means life in Greek. I, however, use "biotechnology" for a subset of living technologies, as the latter also refers to non-biological self-moving systems [5].

about nature and technology, how nature was initially grasped and framed, urged the development of living technologies.

Heidegger did not carry out an explicit investigation of living technology. Nevertheless, at one point he addresses what can readily be called a critical step in the development of living technologies. Here he seems to reinforce the claim that living technology manifests the ultimate power of *das Gestell*, that is, the "essence" of modern technology. This might also be the reason why he considers such a technological innovation as more dangerous than the production of the hydrogen bomb. No matter how dangerous, the hydrogen bomb is not an instance of the *self-reproductive* rule of *das Gestell*:

> The international meeting of Nobel Prize winners took place again in the summer of this year of 1955 in Lindau. There the American chemist, Stanley [Wendell], had this to say: "The hour is near when life will be placed in the hands of the chemist who will be able to synthesize, split and change living substance at will". We take notice of such a statement. We even marvel at the daring of scientific research, without thinking about it. We do not stop to consider that an attack with technological means is being prepared upon life and nature of man compared with which the explosion of the hydrogen bombs means little. For precisely if the hydrogen bombs do *not* explode and human life on earth is preserved, an uncanny change in the world moves upon us. [11, p. 20][5]

My claim is that what Heidegger describes as the "uncanny change in the world" is the convergence of technology and biology, which is manifest in living technology. According to the line of thought presented in this article, living technology is precisely the "coming of the dawn," that is, the ultimate fruits of the early-planted seeds pertaining to Greek metaphysics, by which we ought to be "astounded," in Heidegger's terminology [13, p. 327]. The vision of Stanley Wedell highlighted by Heidegger indeed addresses a crucial aspect of living technology, which it is possible to understand better today. In more recent biotechnology research programs such as Dr. Venter's, Wendell's vision takes on increasingly clear shape [40]:

> Many of the things that were discussed as science fiction five years ago have already happened. This is not just a change of techniques, it is a new way of seeing. It is now possible to think of making organisms to a specification to carry out particular industrial tasks. The limitations of species can be transcended by splitting organisms, combining functions, dovetailing abilities and linking together chains of properties. *The living world can now be viewed as a vast Lego kit inviting combination, hybridisation and continual rebuilding. Life is manipulability.* [42, p. 15]

And

> During our lifetimes we expect to see technology that is robust, autonomous, self-repairing, self-reproducing, evolving, adapting, and learning—a powerful combination of life's core properties that no current technology yet embodies. […] During our lifetimes we can expect purely artificial technology to acquire life's core properties and thus vastly outperform all current technology. This transition will be a truly singular event in human history. [4, pp. 90, 95]

According to the defining criteria of technology, which have been governing since Aristotle and which also influenced Heidegger's understanding of technology [6, p. 21f.; 40] technology ceases to

5 It is interesting to see that Norbert Wiener saw this quite oppositely. He was horrified by the explosion of the atomic bomb, but did not see a problem in analyzing the human body and social behavior in general within a cybernetic framework (see [8, p. 254]). See also Lacques Loeb, 1890: "The idea is now hovering before me that man himself can act as creator, even in living nature, forming it eventually according to his will. Man can at least succeed in a technology of living substance." (Quoted in [21, p. 1].)

be technology when it is able to reproduce itself without the aid of an external force such as a craftsperson. At that point it attains the core property of life, *autopoiesis*, and thus more accurately belongs to the sphere of nature (*physis*).

As argued above, it is crucial to understand that Aristotle views nature as the ideal kind of production, which technology should imitate. It is equally important, however, to recognize the unique role Aristotle ascribes to technology, which positively separates it from nature:

> Now action is for the sake of an end; therefore the nature of things also is so. Thus if a house, e.g. had been a thing made by nature, it would have been made in the same way as it is now by art; and if things made by nature were made not only by nature but also by art, they would come to be in the same way as by nature. The one, then, is for the sake of the other; *and generally art in some cases completes what nature cannot bring to a finish, and in others imitates nature* [2, II 199a, emphasis added].[6]

Aristotle maintains that technology not only imitates nature; it is also capable of creating what nature cannot bring-forth on its own. From the dual vantage point pertaining to Aristotle's conception of technology and nature, living technology is the ideal synthesis of natural and technical production. This is because it is self-reproductive as well as capable of bringing-forth what nature cannot produce by itself (e.g., organisms attacking cancer cells, bacteria producing biodiesel), and one day living technology will probably also make the growth of a whole range of different tools possible [4, p. 92]. Actualizing the immense potential of living technology only seems to be a matter of time (see also [41] and [37, p. 173]). In this way, living technology is also the technology of the future; it brings about the ultimate way of producing within the framework of bringing-forth that has been ruling since the beginning of Western metaphysics. In other words, the *end of technology* is to be understood as the fulfillment of the ancient ideal of production and thus as the realization of the ultimate technology. This historical development has to be seen in relation to the fundamental reassessment of technology taking place when technology is enabled to reproduce itself and copy the defining characteristic of nature.

In this context I shall finally argue that the "end of technology" is connected to the "task of nature"—as reflected in the title of this article. In living technology, nature is modified in such a way that it by itself fulfills a designed task and becomes capable of producing what it originally cannot do on its own. In other words, technology takes over the core properties of life and becomes self-reproductive. Through living technology, nature becomes the object of a "demand" in a much more radical sense than Heidegger's own examples in "The Questions Concerning Technology" suggest. In living technology the "demand on nature," which Heidegger is so concerned about, becomes internalized and inseparable from the living systems at stake.[7] Furthermore, living technology feeds off the core self-mobilization of nature, its sheer movement, its basic force—which is to say that living technology reveals nature as an energy resource. Living technology may thus be seen as the final enactment of the rule of *das Gestell*.

The technological dimension of living technology is not responsible for the process of bringing forth taking place; the "craftsman" is only initially present in order to *steer* the self-unfolding process

6 See also Aristotle: "Now mistakes occur even in the operations of art: the literate man makes a mistake in writing and the doctor pours out the wrong dose. *Hence clearly mistakes are possible in the operations of nature also*. If then in art there are cases in which what is rightly produced serves a purpose, and if where mistakes occur there was a purpose in what was attempted, only it was not attained, *so must it be also in natural products, and monstrosities will be failures in the purposive effort*" [2, II 199a–199b, emphasis added]. The Aristotelian understanding of nature as being able to make "mistakes" is a statement "we should take notice of" as well. Implicit in this understanding of nature there is a profound accusation of and attack on nature, as it not only allows but in fact also encourages humans to intervene in nature—in order to "correct" it. This paradigmatic and fundamental challenge to nature is also a driving force behind the development of biotechnology.

7 In this context it is also interesting to note that Aristotle did not think of any restrictions on technical experimentation with nature: "However, there is not a single place in the entire authentic corpus aristotelicum where Aristotle explicitly places constraints on human technological creativity, beyond the trivial limitation that technicians must start with raw natural products and can do only what is ontologically possible" [36, p. 118].

and thus to modify its growth or outcome. The self-reproduction, the bringing-forth of living technology, is an emerging property of what is reproduced: The new material complex has dispensed with the craftsman and shows itself by itself. To exemplify, this means that it is not due to technology that a new microorganism will be able to metabolize, but through technical alteration an organism may be modified in such a way that it invades and destroy cancer cells [1] or that the metabolism results in the generation of biodiesel [35]: "butanol could be made from a robust, highly engineerable microbe such as *Escherichia coli*. Recently, Atsumi et al. introduced six genes from *C. acetobutylicum* into *E. coli* to transfer the butanol producing metabolic pathway. In addition, they mutated a number of *E. coli* genes to enhance butanol production" [35, p. 14].

Bacteria such as *E. coli* self-replicate on their own. But through biotechnology this natural process may be modified so that the bacteria are able to produce butanol. By changing the initial reproductive system, in this case the DNA of the bacteria, living technology modifies the plan according to which nature operates and brings-forth. Instead of having chemists and machines standing and mixing chemicals in the laboratory to produce butanol, living technology is in principle capable of enabling a bacterium to do the same by itself. In this way living technology dispenses with the external agent, the scientist, and naturalizes technology. The steering mechanisms of nature itself (its governing system) have been altered in such a way that these mechanisms work in order to fulfill targets set by humans.

Against this backdrop it is also possible to view embryonic stem cells as the ultimate resources. They can be turned into virtually any other cell through technological intervention and afterward, in theory, by themselves grow into nearly any kind of tissue or "spare part" for other living organisms.[8] From this perspective, embryonic stem cells are the "basic atom" of living substance—they are the flexible resource *par excellence*. To rephrase, it is not a coincidence that embryonic stem cells have become a fundamental area of investigation within living technology research, as they have the capacity to realize the great potential of living technology.

3.2 The Automatic Factory and Other Reflexive Technologies

Interpreting living technology along these lines intersects with Heidegger's philosophy of technology in another significant way as well. This intersection gives further evidence for describing living technology as *the ultimate technology*. As mentioned above, Heidegger sees the development initiated by ancient Greek metaphysics as culminating in what he describes as *cybernetics*. In two different texts he writes: "Philosophy is ending in the present age. It has found its place in the scientific attitude of socially active humanity. But the fundamental characteristic of this scientific attitude is its *cybernetic*, that is, technological character" [14, p. 432f., emphasis added]. Everything including human beings is ultimately viewed as something controllable in cybernetics, according to Heidegger's understanding thereof. This makes cybernetics a candidate for the most profound rule of *das Gestell*: "Meanwhile, cybernetics can be certain about its matter, i.e. to account everything that is as a controllable process, because the idea prevails, to determine the human freedom as something humanly planed and controllable" [17, p. 623].[9] In his critique, Heidegger wants to call attention to the ancient Greek root of "cybernetics" and through this reference better understand the final phase of the ancient paradigm of technology. According to its etymology, "cybernetics" derives from the Greek word for steering

8 Heidegger already bemoaned the implicit understanding of humans expressed in the praxis of modern hospitals. This assessment can also be seen as a sign of his radical critique of such a phenomenon as biotechnology. "Only to the extent that man for his part is already challenged to exploit the energies of nature can this revealing that orders happen. If man is challenged, ordered, to do this, then does not man himself belong even more originally than nature within the standing-reserve? The current talk about human resources [*Menschenmaterial*], about the supply of patients [*Krankenmaterial*] for a clinic, gives evidence for this" [13, p. 323].

9 My translation: "Indes kann sie ihrer Sache, alles, was ist, als gesteuerten Vorgang zu errechnen, schon sicher sein, weil sich der Gedanke regt, die Freiheit des Menschen als seine geplante, das heißt steuerbare zu bestimmen." And this assessment of cybernetics indeed reflects Norbert Wiener's research. So also: "We [Wiener and Rosenblueth] believe that men and other animals are like machines from the scientific standpoint because we believe that the only fruitful methods for the study of human and animal behavior are the methods applicable to the behavior of mechanical objects as well. Thus, our main reason for selecting the terms in question was to emphasize that, as objects of scientific enquiry, humans do not differ from machines" [34, p. 328].

and the *kybernetes* was originally the steersman of a boat [22, p. 456]. The steersman of a boat has a particular function. He is not doing all the hard work of moving the boat as a rower does; instead he uses a special technique by which he acts through the technical systems of sails and the rudder to optimally take advantage of forces of nature, such as wind and current. By physically doing almost nothing, the steersman makes sure that the technical system he is operating is profiting the most from nature. Or, viewed from the perspective of nature: The steersman steers the boat in such a way that it follows the forces of nature, but in order to reach the goal of the steersman. *Natura non vincitur nisi parendo* ("Nature to be commanded must be obeyed" [3, p. 39]). Understood in this context, cybernetics can be understood today as the technical enterprise that strives to design technologies that take over the function of the steersman in the example above. These subtle cybernetic technologies become the *embodied performative* "brains" of the system at stake (see [26, p. 6f.]). In this sense cybernetics may also be understood as a meta-technology.

Moreover, in the example of the steersman of a sailing boat, it is difficult to conclude whether technology rules nature or vice versa, and this is exactly the point. That is to say, Heidegger's use of the concept of cybernetics may also be interpreted as his notion of the intelligent union of technology and nature, and in this sense the meaning of cybernetics is analogous to the meaning of living technology, as it is presented in this paper: Living technology is the joining of forces of nature and technology. To Heidegger, cybernetics describes the last phase of technology, in which a branch of technology, in a manner of speaking, recedes as far as possible only to steer and coordinate technological systems (including nature understood as an automatic production system—which is in line with Aristotle's understanding of nature; see also [41]). In the epoch of cybernetics, technology in a way turns back on itself, and the ultimate technology must be the one directing the others. Cybernetics may thus also be viewed as a pragmatic self-reflexive technology or as a meta-technology. Cybernetics hooks on to the power or streams of information[10] in other technological systems and strives to steer them in order to produce and reproduce an initially envisioned result more efficiently or without human intervention. The cybernetic system is purely pragmatic and does not strive to create intermediary representations such as formal knowledge in order to achieve the intended result. This would be considered only a *suboptimal detour*. The fewer intermediaries between cause and effect, between input and output, the better—it is the fastest way to the envisioned result that counts. Producing translations of any given state of the system, such as formal knowledge, which an outside "craftsman" is supposed to react to, would not only slow down the system, but also compromise the autopoiesis and autonomy of the system.[11] In other words, the task of cybernetics is to produce the biggest outcome of a process with the smallest possible amount of (human) work.

An interesting example of cybernetics from Britain in the early 1960s illustrates the above description of technology. In this period, the cybernetician, Stafford Beer, attempted to frame and calibrate the biological processes of a natural pond's ecosystem to effectively operate the various technologies in a factory without any human intervention (see [26]). The goal of the experiment may be described as the creation of an effective hybrid of nature and technology, which in principle could regulate itself and produce different tools at the same time. To get a clearer idea of how this joining together of technology and biology was supposed to work, I refer to the work of one of the leading researchers of cybernetics, Andrew Pickering. To understand Beer's experiment, he writes as follows:

> In a steady state, an ecosystem like a pond, for example, exists in a state of dynamic equilibrium with its environment, homeostatically responding to fluctuations that threaten its viability. And if

10 The concept of information is often associated with cybernetics; however, it is information understood as that which steers the power or direction of any given system, that is, that which has to be manipulated in order to accommodate or take over the system at stake—no matter whether it is technical or natural.

11 Note also: "Cybernetics placed the inexhaustible powers of nature at its centre, where Modern technoscience has representation instead. Modernity is thus characterised by its enormous detours through knowledge and industry, while cybernetics stays close to the performative world as found, abstaining from the attempt to unwrap Black Boxes" [26, p. 490].

> the environment changes, the ecosystem will reconfigure itself to achieve a dynamic equilibrium with that. […] Beer's idea was that if one could only couple such an adaptive system to a factory, say, making the factory part of the pond's environment, and vice versa, the health of each could be made to hinge on that of the other, in a process that Beer called *reciprocal vetoing*. Disturbances from the factory might trip the ecosystem into a new configuration, which would in turn perturb the operation of the factory, and if the factory in its new state was still unstable, new disturbances would travel back to the ecosystem—and so until the pond and the factory achieved a collective state of dynamic equilibrium with each other and their outside environments. This is the way in which a pond with some small organisms and a leech could serve as an adaptive brain for the automatic factory. An amazing idea, though I can see no reason in principle why it should not work. ([26, p. 479]; see also [27, pp. 215f])[12]

From the point of view presented in this article there is a clear continuity between this understanding of cybernetics and the earlier foundational work of Norbert Wiener. Heidegger also knew Wiener's work, as it was here that the term cybernetics was coined for the first time in 1947 [8, p. 232]. Wiener's discussion of feedback systems, such as the classical governing mechanism of a steam engine, makes it easier to understand why cybernetics may also be understood as a smart meta-technology and a *forerunner* of the cybernetic factory proposed above, as well as living technology. Wiener writes:

> In the original form designed by Watt, it [the governing mechanism of a classical steam engine] consists of two balls attached to pendulum rods and swinging on opposite sides of a rotating shaft. They are kept down by their own weight or by a spring, and they are swung upwards by a centrifugal action dependent on the angular velocity of the shaft. They thus assume a compromise position likewise dependent on the angular velocity. This position is transmitted by other rods to a collar about the shaft, which actuates a member which serves to open the intake valves of the cylinder when the engine slows down and the balls fall, and to close them when the engine speeds up and the balls rise. [39, p. 115][13]

This feedback mechanism of the steam engine works so effectively only because it is a part of the steam engine itself. The continuous movement of the steam engine resembles the self-movement of nature, and I contend that the feedback loops between Watt's new technology and the power of the steam engine in principle are analogous to the relation of nature and technology in the case of living technological systems and the cybernetic factory. The apparent sense of "control" and "regulation" in cybernetic systems is not stronger than in other technical systems. On the contrary, *in these systems the governing mechanism is smarter and more unnoticeable as it becomes an integrated part of the system itself*. When the cybernetic system is working, it is ideally autonomous and not controlled by an outside force. That is to say, in cybernetics and living technology, regulation becomes an immanent part of the designed entity.

It is in this sense that I have argued that Heidegger sees cybernetics as belonging to the end of technology understood as the ultimate expression of the technological development that has proceeded since antiquity. Based on the explanation above, cybernetics and living technology are analogous. Heidegger's understanding of cybernetics describes the kind of logic that also co-defines living technology. This claim is also confirmed by one of the leading experts on living technology,

12 In this version of cybernetics it seems quite harmless and not so much challenging as obeying nature. Yet, Heidegger would point out that we need to pay attention to the implicit revealing of nature as "system" that goes along with it (ecosystem, etc.). If the factory every year had to raise its profit by 10%, for example, then the cybernetic system eventually would have to challenge, control, and change the pond in such a way that it eventually would fit into Heidegger's critique of cybernetics.

13 See also Peter Galison: "The self-correction is exactly what Wiener's machines did. Indeed, in every piece of his writing on cybernetics, from the first technical exposition of the AA predictor before Pearl Harbor up through his essays of the 1960s on science and society, Wiener puts feedback in the foreground, returning again and again to the torpedo, the guided missile, and his antiaircraft director" [8, p. 258].

Norman H. Packard, who writes that cybernetics "is properly seen as a forerunner of both artificial life and living technology" ([24, p. 122]; see also [33, p. 200]). However, living technology materializes the synthesis of nature and technology more clearly than cybernetics does, which is crucial for me to point out in this article. Cybernetics still implies the notion of a steersman, which is more or less a part of the system itself. Living technology more readily focuses on the ultimate synthesis between technology and life's core features, and therefore I maintain that it can be assessed more precisely as the *end of technology*.

Yet, when technology becomes a part of nature and the rule of *das Gestell* seems to become fully automated, a subversive phenomenon occurs. In the final section below, I explain what I mean by this phenomenon—a phenomenon Heidegger never addresses. Living technology threatens to turn Heidegger's critique of technology around in yet another important way, and this potential reversal may also be the reason why Heidegger never explicitly addresses it and speaks of Stanley Wendell's claim as *uncanny* (see also [19, p. 74f.]).[14]

4 The Re-disclosure of Nature

4.1 The True Sensation of Self-Movement

In nature the process of bringing-forth and thus the phenomenon of *alêtheia* are continually and directly evident, as pointed out in the first part of this article. In Heidegger's interpretation, nature has to be understood first and foremost in connection with its self-movement [15, p. 191]. The self-movement of nature, its agency, manifests itself when something concealed is being unconcealed, for instance, the flower coming from the sprout. And this process of disclosing is the exact definition of truth (*alêtheia*) according to Heidegger.

The very purpose of living technology is to give way to and direct the agency of nature, allow its unfolding to happen by itself and thus to benefit from the highest kind of bringing-forth in the Aristotelian sense. This means that living technology does not as such change the production process taking place in nature; it only changes the outcome of this process, that is, that which is brought-forth. What is brought-forth by living technology is due to technology as well as nature—in living technology the two elements cannot be fully separated, as the self-disclosure belonging to living organisms becomes apparent only as altered by technology.

Arguably, living technology detracts attention from the fundamental characteristic of nature in the Heideggerian sense, namely its self-unfolding, by directing attention to nature's manipulability. Yet, we may also easily overlook the fundamental characteristic of nature in nature itself: Heidegger stresses that to attain an understanding of what is most fundamental to nature through the things in nature is already very difficult, since that which is right in front of one's own eyes is mostly overlooked—just as we most often do not understand the very beginning before the end, where the original small sprout is fully unfolded as a flower [13, p. 327]:

> What appears antecedently—as does [physis] in the [physei onta: natural things], as history does in all historical occurrences, as art does in all artworks, as "life" does in all living things—what already stands in view is seen with the greatest difficulty, is grasped very seldomly, is almost always falsified into a mere addendum, and for these reasons simply overlooked. [15, p. 201]

In other words, I argue that living technology does not seem to make the task of seeing and grasping the essence of nature more difficult than it already is, and in connection thereto, living technology does not change that which Heidegger maintains is the core property of nature, namely its self-unfolding. This may also be presented differently: We cannot, simply by looking at the

14 Part of my inspiration for this reassessment of technology I have found in Andrew Pickering's understanding of British cybernetics [23].

self-movement of the cloned sheep Dolly or a genetically engineered plant, tell if it presents artificial or real life (see also [41]).

Even though living technology is defined by steering the disclosing or unfolding process of nature, it does not cause this process—even in the case of the bottom-up construction of living technologies from inanimate materiel [5, 28]. On the contrary, also the latter is dependent on adhering to the criteria of self-movement in nature and on the possibilities granted by nature. In order for living technology to work, nature must be able to change, move, and unfold itself.[15] And it is exactly this phenomenon, this brute fact, that is stunning. Living technology might lead one astray from this fact and make it look like technology is in control of nature, but the amalgamation of technology and nature belonging to living technology in fact also re-discloses what Heidegger describes as the essence of nature.

In a certain way this understanding of living technology parallels Heidegger's own interpretation of the instrumental account of technology. Heidegger argues that understanding technology as controlled by human beings is misguided; he instead maintains that humans basically are controlled by the technological world disclosure, that is, that we humans are governed by a "world picture," in which nature appears only as a resource. According to Heidegger we have to turn the instrumental account of technology on its head [13, p. 311f.]. Along these lines I argue that technology is not fundamentally a control of nature in the case of living technology; with Heidegger's help we might learn to view it the other way around. On a different level, living technology manifests a crucial dependence on the elementary self-unfolding of nature in the case of living technology. It is the astonishing and autonomous autopoiesis of nature that grants the possibility of living technology. Living technology acknowledges the fantastic autonomous force of nature, which can be accommodated only by respecting the basic rules of nature itself: Only a few constructions may adopt the core features of life, and conversely, it is possible to bend and manipulate a living organism only so much before it ceases to live.[16] In other words, living technology calls for sensitivity to the elementary forces of nature—whereas ancient technology does not depend on keeping systems alive. Due to the ambiguity of the integration of nature in technology, living technology and cybernetics can be interpreted either as a more gentle and sustainable kind of technology or as a more restrictive and challenging one.[17] Even so, from the point of view of my interpretation, they both belong to the final phase of the same paradigm of technology.

Based on Heidegger's own line of thinking, it would therefore be superficial and misleading to claim that the understanding of the phenomenon of truth is ruled out by living technology—the contrary is the case. Truth understood as *alêtheia* is evident in living technology too, and it is this fundamental phenomenon that has "saving power," according to Heidegger [13, p. 33]. Living

15 So also: "The priority of nature does not consist just in the fact that nature provides the materials that technology appropriates, although it must come first as material resource. To see nature in this way as resource is already to see from within technology, as Heidegger makes clear in 'The Question Concerning Technology.' Rather, to see nature through eyes opened by Heidegger's account of ancient science is to retrieve the claim that nature is that which moves on its own accord. It is at best borrowed, not overcome by technology" [9, p. 206].

16 See also Hannah Landecker, when she calls attention to a significant part of living technology: "Although living things can be radically manipulated, part of the particularity of biological plasticity is that biological matter may change or react to intervention in totally unexpected ways" [21, p. 10].

17 It is interesting to note that Andrew Pickering understands cybernetics similarly to the way Alfred Nordmann views biotechnology, namely, as examples of technologies beyond control; but, based on this assessment, they draw opposite conclusions. This points to the ambiguity I have described above: "In The Mangle, I wanted to conjure up a picture of both human and material agency as indefinitely open-ended, bound by no such finite range of possibilities.… There is space for a lot of interesting, constructive work to be done here" [25, p. 418]. "Genetically modified organisms [elude comprehension].… The most advanced technological research programs are thus bringing about a curiously regressive inversion of the relation between humans, technology, and nature. No longer a means of controlling nature in order to protect, shield, or empower humans, technology dissolves into nature and becomes *uncanny, incomprehensible, beyond perceptual and conceptual control*. Technology might thus end up being as enchanted and perhaps frightening as nature used to be when humanity started the technological process of disenchantment and rationalization. *Good design* might counteract this inversion, for example, by creating human interfaces even with technologies that are meant to be too small to be experienced" [23, p. 173, emphasis added].

technology allows us to understand the primacy of the creation and revealing of new entities over their fixation and analysis.[18] In relation to living technology, Heidegger's famous reference to the German poet Friedrich Hölderlin might even be understood better and more literally: "But where danger is, *grows*/the saving power also" [13, p. 333; emphasis added]. Living technology might be dangerous in the Heideggerian sense, but its "growth," that is, its self-unfolding, manifests the phenomenon of truth (*alêtheia*), the revealing of potentiality. This has "saving power" according to Heidegger's analysis, because it allows humans to attain a concept of a realm of possibilities, and thus to understand freedom in relation to human existence [13, p. 317]. To recast this interpretation, ruled by living technology or not, nature demonstrates the event of self-disclosure, that is, the event of *alêtheia*. The sensation of the self-unfolding nature is not lost in living technology, but instead reenacted, re-disclosed, and more ambiguous.[19]

4.2 The Abyss of Nature

The Heidegger-inspired insight into the "saving power" of living technology also has another significant consequence. It is now possible to understand that pre-technological "nature" by itself also must disclosure a "danger." This consequence follows from Heidegger's phenomenology, and for this reason he was most likely very well aware of it. Heidegger never discussed living technology explicitly, and this may be exactly because living technology would also call attention to this aspect of nature, revealing the limits of his own interpretation and pointing to the same kind of ambiguity in nature as the one he ascribes to *das Gestell*.

Toward the end of "The Question Concerning Technology," Heidegger writes the following about the ambiguity of the essence of technology, which should be taken into account to better understand the final argument presented in this article:

> The essential unfolding of technology threatens revealing, threatens it with the possibility that all revealing will be consumed in ordering and that everything will present itself only in the unconcealment of standing-reserve. Human activity can never directly counter this danger. Human achievement alone can never banish it. But human reflection [*Besinnung*] can ponder the fact that all saving power must be of a higher essence than what is endangered, though at the same time kindred to it. [13, p. 339]

Translated into the previous conception of nature and turned upside down, Heidegger's insight means that through reflection we can come to see how the "saving power" of nature must be "kindred" to a danger as well. If the "saving power" prevails, then it is indeed of a "higher essence" than the danger, and would prove Heidegger right. However, this outcome is not granted in advance. If that were the case, there would be no real danger—it would only be a matter of time before the "saving power" would triumph. Heidegger's analysis of modern technology shows that he in fact thinks otherwise, and thus deems it possible that the danger will be fully actualized in the end.

But what, on the other hand, is the danger of nature that Heidegger is not telling us about? In an interpretation of the work of Hölderlin, Heidegger gives us a first impression of the danger of nature and its affinity to the rule of *das Gestell*. This interpretation comes prior to his preoccupation with

18 It might be inferred that living technology fixates the living processes, so that it is not possible to speak of genuine creation. A response to this would be, that nature in many ways is predictable and that reproduction is more common than creative leaps, that is, apple trees produce apples almost every year, and so on. However, the suggested fixation of nature in living technology is not so stable that it may not be destabilized over time—just as apple trees some years may not yield any apples. Furthermore, new stabilities attained though living technology are often more fragile than old ones, which have adapted to their surroundings and proved capable of living over longer periods of time. From this perspective, *uncertainty*, not stability, is at the heart of living technology. To understand more about the political implication of this uncertainty see Sheila Jasanoff's book *Designs on Nature* [20, p. 123f.].

19 To read more about how this ambiguity plays out concretely, see Sarah Franklin's unusual and unconventional book on the cloning of the sheep Dolly [7].

technology and thus provides us with insight into issues that Heidegger had not tried to coordinate in advance with his critique of modern technology. In 1939 Heidegger wrote:

> However, nature's "light embrace" does not at all suggest an impotent weakness. The "all-present" [nature] is, after all, called "powerful." From where does nature take her power, then, if she is prior to all that is present? Nature does not have to borrow her power from somewhere else. She herself is that which bestows power.… This omnipresence [of nature] holds in opposition to each other *the extreme opposites, the highest heaven and the deepest abyss*. But thereby the opposites that are held out to one another remain separated from one another through a kind of *stubborn unruliness*. [18, p. 76; emphasis added]

This reflection is written without reference to technology, and its perspective on nature is different from the one Heidegger depicts in "The Question Concerning Technology." Hence this concept of nature may reveal what has been concealed until now: the danger belonging to nature. From this perspective, nature is the mighty, omnipresent, and unstoppable force that constantly unfolds itself and creates new beings, only to decompose and revive them in an endless oscillation. The ontological mobilization of nature has no final destination—it is circular and just continues to reproduce itself forever. In other words, from this viewpoint, nature does not grow old, but goes on unfolding and reviving itself: It is endless.[20] The endless and repetitive production and mobilization of all things shows nature as a force that has no meaning apart from keeping itself in motion—and this is the very definition of a nihilistic power.[21] To understand nature as a perpetual motion that encompasses all beings through "stubborn unruliness," as Heidegger calls it, is the same as to reveal nihilism at the heart of all natural beings. This presents the other side [*die Kehrseite*] of nature—that which is hidden behind the autonomous self-*organization*. It is at this exact point that the rule of nature stands out as resembling the rule of modern technology, *das Gestell*. Heidegger is pointing out the danger of the rule of *das Gestell*, because it strives to appropriate all domains of being only to sap their energy in order to sap more energy from other beings, indefinitely. This process leads to the mobilization of all beings as it transforms everything into the most agile of resources, namely energy. In other words, Heidegger criticizes the rule of *das Gestell* for revealing all beings as part of a nihilistic mobilization process [6, p. 21]. However, his own concept of nature has the exact same core properties. The rule of *das Gestell* and the rule of nature are analogous powers, and from a Heideggerian perspective they both manifest the highest saving power and the ultimate danger.

The ultimate synthesis of technology and nature belonging to living technology does not automatically actualize the ultimate danger, but rather the ultimate ambiguity.[22] Through an argument based on Heidegger's own insights, living technology is much more ambiguous than the technologies he mentions in "The Questions Concerning Technology" and indeed also has the potential to create a positive understanding for the event of truth (*alētheia*) and for leading the way to a new kind of technology, which does not necessarily exploit nature, but has the capacity of bringing-forth in a way that supports and revitalizes nature.[23] Living technology is not only a way of steering natural growth; it is just

20 See also: "But generation [pertaining to nature] is *this* kind of generation—that is, [kinesis] in the narrower sense of movement as opposed to rest—*only* insofar as that which is appropriate has *not yet* brought its appropriateness to its end, and so is [a-teles]—that is only insofar as the standing-in-the-work is not yet within its end" [15, p. 218].

21 A process that the hypothesis of a God can save us from [12]—but Heidegger makes no *deus ex machina* argument here.

22 See also Alfred Nordmann, who writes that in the most advanced technological research programs, "technology dissolves into nature and becomes uncanny, incomprehensible, beyond perceptual and conceptual control. Technology might thus end up being as enchanted and perhaps frightening as nature used to be when humanity started the technological process of disenchantment and rationalization" [23, p. 173].

23 This point has parallels in the two paradigms in the history of science and technology, which Andrew Pickering points out—yet the primary difference between my account and his is that I situate the two possible paradigms within cybernetics itself: "The history of British cybernetics offers us a different form of science and engineering, one that does not seek to dominate nature through knowledge. I want to say that one can distinguish two different paradigms in the history of science and technology: the one that Heidegger despised, which we could call the Modern paradigm, and another, cybernetic, nonModern, paradigm that he might have approved of"

as much an admiration of nature and a manifestation of modesty on the part of technology. Carefully reexamined, Heidegger's work not only shows the danger of living technology—it may also help us understand living technology as the ultimate technology, which has the potential of creating a renewed respect for the perpetual autopoiesis of nature and re-disclosing the phenomenon of truth.

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[26, p. 469]. And: "What I have been trying to do is contrast a nonModern cybernetic paradigm with the Modern technoscientific paradigm that Heidegger railed against. […] Cybernetics placed the inexhaustible powers of nature at its centre, where Modern technoscience has representation instead. Modernity is thus characterised by its enormous detours through knowledge and industry, while cybernetics stays close to the performative world as found, abstaining from the attempt to unwrap Black Boxes. And if Modernity is defined by projects of domination, then cybernetics is marked by a symmetric accommodation to the ultimately uncontrollable" [26, p. 490].

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