



## Gaia is alive

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## Gaia Is Alive

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Gaia, the global ecosystem, the entity made up of all living beings and the environment with which they interact, functions in a way comparable to that of an organism: for James Lovelock, the regulation of environmental variables within boundaries allowing life to thrive on Earth is reminiscent of the phenomena of regulation (or homeostasis) at work within organisms. This comparison has provoked many reactions and criticisms. For evolutionary biologists – studying organisms, populations, and their evolutionary history – organisms’ homeostasis can only be explained by the fact that they are subject to natural selection because of their particular characteristics, such as reproduction. These are lacking in Gaia: *terminus*, the metaphor must stop there and everyone must step down to earth.[1]

Of course, one could reply that the metaphor should have been taken for what it is – a metaphor – and therefore not as a literal analogy. In a way, this is what Lovelock and Lynn Margulis did, following different paths: Margulis carefully avoided (or even criticized) the metaphor, whereas Lovelock insisted that, aware of the limits of the metaphor, he nevertheless wanted to keep it for heuristic purposes. For, wasn’t it the metaphor that allowed him to make so many discoveries, from the role of dimethyl sulfide (DMS) in the sulfur cycle and climate regulation to the invention of the Daisyworld model?[2] Lovelock refused to take the comparison seriously (i.e., as a literal analogy) to such an extent that he often changed the metaphor, comparing Gaia to a thermostat.[3]

### Getting Rid of Analogies

Above all, Lovelock never took the trouble to explain and list the important properties of living beings in order to compare them carefully to Gaia’s properties. We must follow what Lovelock did, and take the time to unfold, as philosophers of language do, all the acts preceding a definition: Lovelock does not begin by *defining* life, but by *recognizing* living beings. The glossary of his first book, the only place where Lovelock tries to *define* life, is revealing: “Life: a common state of matter found at the Earth’s surface and throughout its oceans. It is composed of intricate combinations of the common elements hydrogen, carbon, oxygen, nitrogen, sulphur, and phosphorous with many other elements in trace quantities. Most forms of life can instantly be recognized without prior experience and are frequently edible. The state of life however, has so far resisted all attempts at a formal physical definition.”[4]

Life is not defined: it is instinctively recognized – just as it is instinctively recognized that a small heap of sand on an otherwise immaculate beach has been shaped by a living being[5] – and can often be eaten!

In the wake of Lovelock, we got used to reciting, like a mantra, Gaia’s historical origin: Lovelock’s search for a criterion for detecting life, while he was working at NASA. But we must instead go to the end and discuss the full consequences: an important beginning of Gaia is not the search for a definition – since the criterion for recognizing life is very different from a definition of life[6] – but the search for a sign to tell us if “some life” is present. To do this, we need to be less interested in what life *is* than in what it *does*. And, as Bruno Latour depicted it when he described Lovelock’s procedure, we must look at what the living do to their surroundings.[7] It was by looking at this that Lovelock was able to see how much living beings “do” on Earth, and to notice, for example, how they had transformed the atmosphere and continued to keep it out of equilibrium (see Lenton and Dutreuil, “What Exactly Is the Role of Gaia?,” this volume, xxx–xxx).

If we want to follow Lovelock and Margulis’s approach when developing Gaia and understand what exactly they were doing, we must also enrich the historical account of Gaia’s

development and go beyond both the account of evolutionary biologists who rejected Gaia as bad science and Lovelock's short account of the search for life at NASA.[8] In the 1960s and 1970s, Lovelock worked as an engineer and consultant for NASA, developing chemical analysis instruments for the space missions of that era. But most of his time was spent on Earth, not in space. Leaving a standard academic position in 1961, Lovelock gradually established himself as an engineer and scientific consultant: he worked for major chemical and petroleum companies such as Shell, DuPont, and Imperial Chemical Industries and at major academic institutions in Earth and environmental sciences, such as the American National Oceanic and Atmospheric Administration. His expertise was in analytical chemistry and chromatography: he was the international expert in the measurement of chemical compounds at very low concentrations.

Writing climate change reports for Shell, assessing the effects of burning fossil fuels and plankton-emitting DMS on acid rains and the sulfur cycle, crossing the oceans on oceanographic vessels to measure plankton DMS and anthropogenic chlorofluorocarbons (CFCs), tracking atmospheric air masses using chemical tracers, performing measurements in the upper atmosphere on board a military aircraft – Lovelock's daily life consisted of following the material (chemical) traces of what living beings and humans do on and to the Earth. Through these activities, Lovelock was at the heart of studying all of the emerging issues related to global environmental pollution: pesticides such as DDT, acid rain, climate, CFCs, and the hole in the ozone.

At the heart of this feverish activity, he collaborated with Lynn Margulis, a specialist in microbiology, a field with which Lovelock was unfamiliar. This collaboration connected chemical molecules from the atmosphere and oceans to the activity of living beings – especially microbes – and reduced the gap between biologists who were unaware of where all this methane goes and geochemists who ignored where all this methane comes from, to use Margulis's beautiful image,[9] and retrospectively illuminated the respective roles that the microbiologist and the chemist have played in the development of Gaia.

### **A Proper Name for a New Entity**

“Living beings,” “the total ensemble of living beings,” “the biosphere,” and sometimes “life” ... If so many expressions have been used interchangeably by Lovelock and Margulis, it is because they were interested in a new problem – what are “living beings” doing to their global environment? – and because they were referring to a new entity that had not been recognized as such, and for which words were lacking.

When Lovelock uses “life” to talk about all living beings, we must stop to understand his entirely new use of this word. Usually, in recognition of the specific entities in the inorganic world that we call living beings, we use “life” as a general term, a term for a class or a universal type of which the organisms are instances. Therefore, “life,” from a grammatical point of view, usually functions as *a class* (or a natural kind), defined by a list of necessary and sufficient properties (sometimes one insists on the metabolic properties of living beings, other times on their ability to reproduce and evolve).

When Lovelock uses “life,” however, he does not use it as a term for a class, but as a *proper name* designating a singular entity: all the living organisms that have succeeded each other since the origin of Life.[10] Let us use a capital letter for this new use of the term “life,” and we end up with two homonyms: “life” is the term of class used in biology; “Life” is the new individual recognized by Lovelock. With regard to Gaia, there is therefore some grain to be ground on questions of language and the meaning of the term “life”: but rather than getting bogged down into questions of definitions and analogy (first, defining “life”; second, analyzing whether Gaia meets the criteria), one must focus on the grammatical use of this term by Lovelock and recognize these homonyms “life” and “Life.”

The first way to understand this argument and to consider this individual (Life) is to see it as a form of generalizing the argument that if we follow the practice of evolutionary biologists, then biological species should not be considered as classes (or natural kinds), but as individuals in the sense of entities located in space and time.[11] A species is an individual whose organisms are the parties, linked by genealogical relationships. This argument can be generalized from species to all Life: all living organisms that have succeeded each other since the first organism appeared are linked by genealogical relationships and constitute an individual “located” in space and time – although this location is more difficult to grasp because it extends over several billion years and in every corner of the Earth.[12]

This way of seeing, however useful it may be, nevertheless slightly misses the question that Lovelock asked: what is most important for evolutionary biologists are *the genealogical links* (and what “binds” living organisms together is a genealogical continuity); what is most important for Lovelock are *the conditions for the existence* of Life. What are they, and how does Life transform and affect these conditions of existence?

Let us see what Lovelock writes in his first paper containing the word “Gaia”: “The purpose of this letter is to suggest that life [here we should read ‘Life’ with a capital L!] at an early stage of its evolution acquired the capacity to control the global environment to suit its needs and that this capacity has persisted and is still in use.”[13]

Lovelock goes on to highlight the importance of the discovery of this entity: “In this view the sum total of species is more than just a catalogue ‘The Biosphere,’ and like other associations in biology is an entity with properties greater than the simple sum of its parts. Such a large creature, even if only hypothetical, with the powerful capacity to homeostat the planetary environment needs a name ...: Gaia.”[14]

### **The Atmosphere, the Oceans, and the Earth’s Surface Are a *Part* of Life**

It is here that we can begin to understand what the expression “Gaia is alive” means and grasp the difference between Life and Gaia. This will allow us to understand Lovelock’s discovery not as a metaphor, however imperfect but evocative and powerful it may be. When Lovelock tells us that the interconnected whole of the oceans, the Earth’s surface, and the atmosphere *is* alive, we must not understand that this whole is *like* a living being but that it is a *part of* Life. Let us start with a familiar example. When we look at the physiology of termites, that is, what they do and what allows them to maintain themselves, we cannot fail to see that they live in a particular environment, isolated by the termite mound they have built, and within which temperature and gas concentration such as CO<sub>2</sub> are controlled by the termites – they can modify, for example, the aeration and orientation of the termite mound. In other words, if we are interested in the physiology of termites, we must recognize that the most important physiological activity, i.e. the regulation of certain vital variables, is not only exercised on Claude Bernard’s *milieu intérieur* – within the material boundaries delimited by the exoskeleton of each of the termites – but that it is also exercised outside these material boundaries, at the very level of the termite mound. Hence the conclusion drawn by physiologist Scott Turner: the termite mound corresponds to the “extended organism.”[15] Hence also the ambivalence of the idea that the termite mound would be alive or an “organism”: we can understand this idea either in the form of an analogy – the termite mound is “living” because it is *regulated as* organisms are – or in a very different way – the termite mound is a *part of* termites, because between termites and the termite mound, the flows of matter and energy are incessant so that it is no longer possible to isolate a termite from the living conditions it helps to create.

This is what Lovelock means when he tells us that the atmosphere is alive “like the fur of a mink or the shell of a snail.”[16] We have become accustomed to considering the atmosphere, oceans, soils, and rocks as “environment,” “abiotic,” “physico-chemical,”

“external conditions,” “geological.” By telling us that these elements *are* living, Lovelock does not tell us that they function *as* living beings, but that they are *part of* all those beings that we usually recognize as living and whose material boundaries we have become accustomed to stopping at their membranes and epidermis, because we have not paid enough attention to what these living beings do and what they depend on. It is because the activities of the beings we classically recognize as living overflow and exceed what we classically recognize as the inanimate world that we must, precisely, revise the idea that this world is inanimate.

From the mid-1970s onward, Lovelock used the term “Gaia” to designate the inextricable network of interconnections between Life and the environment with which it interacts. Gaia is therefore “Life” interconnected with its environment; or if you will, “Life” is Gaia deprived of its living conditions and of the maintenance of Earth’s habitability.

Here we see a fundamental difference between two readings of the idea that Gaia is alive. The first, the analogist reading, was the idea that Gaia is *like the* living in the sense that she shares some of their properties. The second, the reading that we will call “vital extension,” is the idea that Gaia is alive in the sense of being an extension of the material boundaries of Life: the oceans, the atmosphere, and the Earth’s surface are a *part of* Life. The second reading makes it possible to shed light on important points that are entirely glossed over by the first reading. In particular, we can understand why identifying regulatory phenomena on other planets such as Mars or Venus, but phenomena that are not related to the activity of living beings, would be uninteresting and far from a Gaian perspective: Mars or Venus would undoubtedly be regulated “as” living beings (or as thermostats) but these planets would remain “dead” planets (see Lenton and Dutreuil, “Distinguishing Gaia from the Earth System(s),” this volume, xxx–xxx). Moreover, finding “life” on Mars or Venus would mean that a new individual Life exists, but not necessarily that a Gaian form exists on Mars or Venus: a few bacteria isolated in a pond, without influencing the overall conditions of existence, would not constitute an entity similar to Gaia.

### **A New Living Entity to Study**

The recognition of a new living entity was accompanied, for Lovelock and Margulis, and for those who succeeded them, by a new research program and new questions to explore.

In a way, we found ourselves in a situation similar to that in which biology was established as a discipline at the end of the eighteenth century. This establishment was conditioned upon the possibility the recognition of life as a property common to all living beings and distinguishing them from other objects of nature such as minerals.[17] And it was a correlative of an epistemological reflection on the concept of organism, itself based on more general metaphysical considerations of order and purpose[18] – considerations that, as we know, also cut across all reflections on Gaia. Since then, biology, in its various forms, has explored diverse issues, but the organism has always remained a central entity: it has sometimes been a question of studying the interior of organisms – this has been the major program of physiology and then molecular and cellular biology, which has studied organs, cells, and genes – and sometimes it has been a question of studying how they are linked to each other and to their local environment – naturalistic biology, ecology, and evolutionary biology have studied populations, ecosystems, and species, and how they are linked to each other. This central position of the organism within the “life” sciences is partly related to the way in which the term “life” is commonly understood: a term of class in which organisms are the instances.

One could say, undoubtedly by forcing the argument, that Gaia initiated a new science of “Life,” in which the “organism” loses its centrality: because the scales of time and space

considered are such that, literally, one no longer “sees” organisms; and because the organism ceases to be the referent of the “Life” studied by this new “life” science.

We insist on this point both to emphasize that Gaia is as much a new science “of the Earth” (see Lenton and Dutreuil, “Distinguishing Gaia from the Earth System(s),” this volume, xxx–xxx) as it is a new science “of Life”; and also to thematize Gaia’s relationship with biology, and in particular evolutionary biology, on a different mode than that of conflict. Gaia is not in contradiction with evolutionary biology; it is simply the study of *a new being*. Lovelock has never ceased to be annoyed by others with the definition of Gaia: but “defining” Gaia, that is, following its material boundaries and understanding the kind of being it is, can only be the result of a long investigation, and the immense literature that has abounded on the subject in recent decades is still only partial.

Where does Life unfold? What is the long list of the effects it has on its environment? All of these empirical studies have been influenced by Lovelock, who has tirelessly repeated to his fellow geochemists and climatologists that they must take into account the influence of Life on its environment. And it is this research that ultimately makes it possible to draw up a provisional list of these effects (see Lenton and Dutreuil, “What Exactly Is the Role of Gaia?,” this volume, xxx–xxx). How did Life maintain its conditions of existence over time, i.e. Earth’s habitability? This is the question tirelessly tackled by Gaian scientists who have studied the past functioning of the Earth: the faint young sun paradox and rock weathering, the effect on climate of land colonization by plants, etc. What kind of being is Gaia? How does it behave? What are its most likely operating modes? These are all the theoretical and abstract questions considered from the studies on the Daisyworld model.

## **Conclusion**

By seeking to detect “life” on other planets, Lovelock discovered a new living entity on Earth: Life. Together with Margulis and their successors, he followed the effects of Life on his conditions of existence and named Gaia the entity constituted by the inextricable links between Life and its environment. It is indeed as the discovery of a new living entity, not studied as such before, that Gaia must be read. Too often, we have focused on an “analogue” interpretation according to which, if Gaia were alive, it would be because it has regulatory properties “like” those of organisms. Gaia has also been understood as a holistic vision of the Earth, seen from above, from space. But if the oceans, atmosphere, and surface of the Earth are “living,” it may be also, and more importantly, because they are a *part of* Life. This reading has been concealed by the analogue reading. Here, following the traces from below, from the ground, of the myriad of living beings who compose Life and their entanglements with their environment and their global living conditions is what makes it possible to realize that what was considered as “abiotic,” “geological,” or “external” is in fact a part of Life. Following the first reading, the microcosm and macrocosm are linked only by similarity and analogy relationships. According to the second reading, the microcosm and the macrocosm are linked by ecological relationships: the microcosm is no longer contained within the material boundaries of the cells of the living but extends outside and revitalizes the macrocosm.

## **References**

[1] See e.g. Richard Dawkins, *The Extended Phenotype* (Oxford: Oxford University Press, 1982).

[2] Daisyworld is a toy-model depicting a fictional planet with white and black daisies that differently reflect the solar luminosity. The varying proportion of black and white daisies regulate the climate. This model, proposed as an example of possible mechanisms of global

regulation by Life after Gaia, was criticized by evolutionary biologists. See Andrew Watson and James Lovelock, “Biological homeostasis of the global environment: the parable of Daisyworld,” *Tellus B* 35, no. 4 (1983): 286–9.

[3] See James Lovelock, *Gaia: A New Look at Life on Earth* (New York: Oxford University Press, 1979), esp. chap. 4.

[4] *Ibid.*, 144.

[5] See *ibid.*

[6] See Jean Gayon, “Defining life: A philosophical or scientific issue?” (lecture, Leopoldina Nationale Akademie der Wissenschaften, Halle, Germany, September 24, 2011).

[7] See Bruno Latour, “Why Gaia is not a God of Totality,” *Theory, Culture & Society* 34, no. 2–3 (2017): 61–82.

[8] See Sébastien Dutreuil, “Gaia: Hypothesis, research program for the Earth system, or philosophy of nature?” (PhD diss., University of Paris 1 Panthéon-Sorbonne, 2016).

[9] See Lynn Margulis and Gregory Hinkle, “The Biota and Gaia: 150 Years of Support for Environmental Sciences,” in *Scientists on Gaia*, ed. Stephen H. Schneider (Cambridge, MA: MIT Press, 1991), 11–18.

[10] See Sébastien Dutreuil, “La vie en biologie: enjeux et problèmes d’une définition; usages du terme,” *Philosophie*, no. 136 (2018): 67–94.

[11] See David L. Hull, “A Matter of Individuality,” *Philosophy of Science* 45, no. 3 (September 1978): 335–60.

[12] See Carlos Mariscal and W. Ford Doolittle, “Life and life only: a radical alternative to life definitionism,” *Synthese* (2018), <https://doi.org/10.1007/s11229-018-1852-2>.

[13] James Lovelock, “Gaia as seen through the atmosphere,” *Atmospheric Environment* 6, no. 8 (August 1972): 579f., here: 579.

[14] *Ibid.*

[15] Scott Turner, *The Extended Organism: The Physiology of Animal-Built Structures* (Cambridge, MA: Harvard University Press, 2000).

[16] Lovelock, “Gaia as seen through the atmosphere,” 580.

[17] See Michel Foucault, *The Order of Things* (New York: Vintage Books, 1970). First published in French as *Les mots et les choses* (Paris: Éditions Gallimard, 1966).

[18] See Philippe Huneman, *Métaphysique et biologie: Kant et la constitution du concept de l’organisme* (Paris: Kimé, 2008).