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Articles

Gaia Theory: Between Autopoiesis and Sympoiesis

Gajos teorija: tarp autopoezės ir simpoezės

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Abstract: The article discusses the development of the Gaia Hypothesis as it was defined by James Lovelock in the 1970s and later elaborated in his collaboration with biologist Lynn Margulis. Margulis's research in symbiogenesis and her interest in Maturana and Varela's theory of autopoiesis helped to reshape the Gaia theory from a first-order systems theory to second-order systems theory. In contrast to the first-order systems theory, which is concerned with the processes of homeostasis, second-order systems incorporate emergence, complexity and contingency. In this respect Latour's and Stengers's takes on Gaia, even defining it as an "outlaw" or an anti-system, can be interpreted as specific kind of systems thinking. The article also discusses Haraway's interpretation of Gaia in terms of sympoiesis and argues that it presents a major reconceptualization of systems theory.

Keywords: Gaia, systems theory, Lovelock, Margulis, autopoiesis, sympoiesis.

Summary: Straipsnyje aptariama Gajos hipotezės raida, pradedant tuo, kaip Jamesas Lovelockas ją suformulavo 1970 metais, ir atskleidžiant, kaip vėliau ją modifikavo bendradarbiaudamas su biologe Lynn Margulis. Margulis simbiogenezės teorija bei iš Humberto Maturanos ir Francisco Varelos perimta autopoezės samprata padėjo performuluoti Gajos hipotezę iš pirmojo lygmens sistemų teorijos į antrojo lygmens sistemų teoriją. Priešingai nei pirmojo lygmens sistemų teorija, kuri remiasi homeostazės principu, antrojo lygmens sistemų teorija inkorporuoja netikėtai pasireiškiančius, sudėtingus ir atsitiktinius elementus. Šiuo požiūriu Bruno Latouro ir Isabelle Stengers pasiūlytos Gajos interpretacijos, net ir akcentuojančios „atskalūnišką" ir antisisteminį Gajos pobūdį, vis dar gali būti aiškinamos kaip sistemų teorijos atmainos. Straipsnyje autopoezės teorija taip pat lyginama su Donnos Haraway pasiūlyta simpoezės samprata bei teigiama, kad būtent simpoezė leidžia naujai konceptualizuoti pačią sistemų teoriją.

Keywords: Gaja, sistemų teorija, Lovelockas, Margulis, autopoezė, simpoezė.

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Introduction: The Gaia Hypothesis

Gaia theory emerged in the 1960s and expressed a very simple idea that life on Earth (the biota) is regulating not only the chemical composition of the air but also the climate to make it habitable. For a long time, Gaia theory was ridiculed as a New Age idea that the Earth is a living being (Lovelock 2000). However, later this hypothesis was proved by Lovelock and other independent researchers in many scholarly publications. Today, Gaia theory is a widely discussed idea which has entered philosophical discourse and posthumanist thinking. In recent years many important thinkers, such as Isabelle Stengers (2015a; 2015b), Bruno Latour (2017a; 2017b), and Donna Haraway (2016) addressed Gaia theory in one or another way. In my article I want to compare the novelty of their theoretical thinking with the original Gaia theory.

Although always publicly supporting each other, these authors come from different backgrounds and employ different methodologies. However, I argue that, regardless of their differences, these interventions can be read as different versions of second-order systems theory.

The Gaia Hypothesis was formulated by the chemist James Lovelock in the 1970s and later significantly remodelled through Lovelock's collaboration with biologist Lynn Margulis. The first insights of the Gaia Hypothesis emerged during the 1960s in a NASA laboratory, where Lovelock got an assignment to examine the physical and chemical properties of Mars and determine the planet's suitability for life. It was noticed that Mars is in a chemical-physical balance which leads to a perfect equilibrium. However, Lovelock turned the question about life on Mars upside down: he started from an obvious fact that there is life on Earth and that the Earth expresses a disequilibrium of atmospheric phenomena. Thus, if the disequilibrium of atmospheric phenomena is related to the existence of life on the Earth, then a perfect equilibrium of atmospheric processes on Mars leads to the conclusion that there is no life there. Later this assertion was confirmed by the *Viking* mission in 1976. But what is important for formulating the Gaia Hypothesis is not life on Mars but the first part of this equation – the relationship between life and the disequilibrium of atmospheric processes on Earth. Lovelock formulated a hypothesis that life on Earth is able to regulate the temperature and other planetary conditions just as living organisms are able to regulate their own body temperature. He asserted that chemical, physical, and biological processes taking place on Earth seek for a homeostasis, or the optimal conditions for life, that is achieved through the feedback loops operated automatically by the biota.

To prove this hypothesis that the Earth is able to regulate its temperature, Lovelock and his former student Andrew Watson developed a computer model called Daisyworld – a computer model of a planet, which is warmed by a sun with increasing heat. Thus the Daisyworld reduced the environment to the single property – temperature, and the biota – to one of the species, namely, daisies. The crucial question Lovelock asked himself was will the evolution of the Daisyworld ecosystem lead to the self-regulation of climate? (Harding 2014: 166). Thus as the climate warms up, black daisies appear first, because they absorb solar energy and increase the temperature on the planet. As the planet warms up further, the black daisies disappear and white ones appear. The white daisies reflect the solar energy and hence cool down the temperature on the planet. Thus throughout the evolution of Daisyworld the temperature was kept constant: "When the sun is relatively cold, Daisyworld increases its own temperature through solar energy absorption by the black daisies; as the sun get hotter, the temperature is gradually lowered because of the progressive predominance of energy-reflecting white daisies. Thus Daisyworld, without any foresight or planning, regulates its own temperature over a vast time range by the dance of the daisies" (Harding 2014: 167). The purpose of this model is to demonstrate that feedback loops interlinking

non-living and living systems (temperature and plants) can regulate climate and achieve the most favourable conditions.

Lovelock formulated his hypothesis of the Earth as a self-regulating system and presented it for the first time in 1969 in Princeton. His friend novelist William Golding, the author of *Lord of the Flies*, suggested the name of Gaia (the Greek word for Mother Earth) for his theory. In 1972 Lovelock published a first paper on his theory titled "Gaia as Seen Through the Atmosphere" (Lovelock 1972). At the same time a microbiologist Lynn Margulis was working on similar questions and investigating the smallest microorganisms. Margulis argued that the Earth's atmosphere is transformed by biological organisms and that bacteria play a crucial role here. All life is dependent on the metabolism of microbes which modulate the biosphere in which we live. "During the first billion years of evolution bacteria – the most basic forms of life – covered the planet with an intricate web of metabolic processes and began to regulate the temperature and chemical composition of the atmosphere so that it became conducive to the evolution of higher forms of life" (Capra, Luisi 2014: 351). Thus Margulis helped Lovelock revise his theory and admit that Gaia is not a single superorganism but a symbiogenesis of a variety of organisms. In *Symbiotic Planet: A New Look at Evolution* (1998), Margulis points out that "Gaia is not an organism. (...) Gaia, the living Earth, far transcends any single organism or even any population. (...) The sum of planetary life, Gaia, displays a physiology that we recognize as environmental regulation. Gaia itself is not an organism directly selected among many. It is an emergent property of interaction among organisms, the spherical planet on which they reside, and an energy source, the sun" (Margulis 1998: 119). Thus Gaia can be seen as a self-regulating system, which connects the metabolic processes of microorganisms and atmospheric processes of the Earth in feedback loops. As Greg Hinkle, a former student of Margulis, pointed out, "Gaia is just symbiosis as seen from space" (Margulis 1998: 2). In other words, it is a symbiosis extended to a planetary scale.

Both Lovelock and Margulis described Gaia in terms of first-order cybernetics: Gaia is a self-regulating system, having the capacity to maintain its equilibrium through feedback loops. For example, Margulis argues that bacteria can regulate the atmosphere by removing some chemical elements and expelling oxygen we need to breathe. Thus Gaia is seen as "a genius of recycling", because the waste produced by one species becomes the food for another (Margulis 1998: 121). Oxygen makes up one-fifth of the Earth's atmosphere and, combined with other gases, is highly explosive. However, the ecosystem reduces these gases faster than they can react, thus maintaining an optimal equilibrium. As Margulis points out, "the entire planetary surface, not just the living bodies but the atmosphere that we think of as an inert background, is so far from chemical equilibrium that the entire planetary surface is best regarded as alive" (Margulis 1998: 122-123). In this respect there is not a clean separation between the organic and the inorganic, between an organism

and its environment, because an organism is constantly creating and changing its environment.

However, the Gaia Hypothesis met with strong critique. Many critics have claimed that Gaia theory was unscientific because it was teleological. As Capra and Luisi point out, "the scientific establishment attacked the theory as teleological, because they could not imagine how life on Earth could create and regulate the conditions for its own existence without being conscious and purposeful" (Capra, Luisi 2014: 165). Lovelock responded to this critique by creating his mathematical model of Daisyworld, which we discussed earlier. Margulis replied to this criticism by explaining that life can simply repeat certain patterns as in computer algorithms. "Life produces fascinating 'designs' in a similar way by repeating the chemical cycles of its cellular growth and reproduction. Order is generated by nonconscious repetitious activities. Gaia, as the interweaving network of all life, is alive, aware, and conscious to various degrees in all its cells, bodies, and societies" (Margulis 1998: 126). In fact, synthetic biology confirms that life is built on these repetitive patterns and can be reproduced artificially. Another answer to this criticism is Margulis' notion of proprioception or self-awareness characteristic of living beings. "Proprioception, as self-awareness, evolved long before animals evolved, and long before their brains did. Sensitivity, awareness, and responses of plants, protocists, fungi, bacteria, and animals, each in its local environment, constitute the repeating pattern that ultimately underlies global sensitivity and the response of Gaia 'herself'" (Margulis 1998: 126). Similar to organisms and animals, which are aware of themselves, Gaia also has this primary sensitivity or proprioception. In this respect Margulis implicates a certain "planetary cognition" which indicates a move towards second-order systems theory.

Gaia and the Theory of Autopoiesis

At the same time as Lovelock and Margulis were trying to conceptualize the Gaia theory, the Chilean biologists Humberto Maturana and Francisco Varela were working on the theory of autopoiesis. The concept of autopoiesis was coined in the 1970s and it refers to the minimal organization of life, such as a cell (*auto* means "self" and refers to self-organizing systems, and *poiesis* means "making or creating"). The first publication on the theory of autopoiesis entitled "Autopoiesis: The Organization of Living Systems" appeared in English in 1974 (Varela, Maturana, Uribe 1974) with the help of Heinz von Foerster, founder of cybernetics. Autopoiesis refers to the minimal organization of a living system, which can both maintain itself in a closed circular process of self-production and interact with an environment in order to get nutrients and energy. In this respect an autopoietic organization is defined by several features. First, it is defined by self-maintenance, which means that the cell's main function is to maintain its individuality despite the many chemical reactions taking place in it (Maturana, Varela 1980). It also means that an autopoietic entity is autonomous, capable to

reproduce itself from within. In this sense an autopoietic organization is operationally closed. Second, an autopoietic unity interacts with the environment and gets information or energy from it. What distinguishes living systems from non-living systems is that the interaction between a living system and its environment creates a "structural coupling": "a living system relates to its environment *structurally* – that is, through recurrent interactions, each of which triggers structural changes in the system. For example, a cell membrane continually incorporates substances from its environment; an organism's nervous system changes its connectivity with every sensory perception" (Capra, Luisi 2014: 135). In other words, every encounter with the environment produces a structural change in the system which then again becomes autonomous. In this sense autopoietic entities are "structurally determined", that is, they are determined not by external forces (as in the case of non-living systems) but by their own internal structure. This leads to the third characteristic of living entities – life is an emergent property which cannot be reduced to the properties of the components. Emergence can be seen as the necessary part of self-organization.

Thus an autopoietic entity is self-maintaining and autonomous, it is structurally coupled with its environment and is constantly creating emergent properties that change the internal structure. Such a definition might seem contradictory, because autonomy and coupling with the environment seem to go in different directions. However, what it is important to understand is that this self-transcending movement is the necessary condition of life. As Evan Thompson observes, "the self-transcending movement of life is none other than metabolism, and metabolism is none other than the biochemical instantiation of the autopoietic organization. That organization must remain invariant – otherwise the organism dies – but the only way autopoiesis can stay in place is through the incessant material flux of metabolism. In other words, the operational *closure* of autopoiesis demands that the organism be an *open system*" (Thompson 2009: 85). Thus, the main feature of autopoietic systems is that they have to change in order to be alive – total closure or homeostasis would lead to death. This feature is also something that is shared by second-order systems. As Cary Wolfe points out, "all autopoietic entities are *closed* (...) on the level of *organization*, but *open* to environmental perturbations on the level of *structure*" (Wolfe 1995: 53). In this sense, autopoietic systems are structurally open and operationally closed at the same time.

The notion of structural coupling allows one to distinguish between living and non-living systems. If a non-living entity is disturbed by the environment, it will react according to a linear line of cause and effect, which is more or less predictable; if a living being is disturbed, it will respond with structural changes which are unpredictable (Capra, Luisi 2014: 136). In this sense Maturana and Varela argue that structural changes which occur in the system are acts of cognition. A living being is capable to learn and change itself according to the perturbations coming from the environment. In *Autopoiesis and Cognition* (1980), Maturana

and Varela argue that the process of cognition is coextensive with the process of life. "*Living systems are cognitive systems, and living as a process is a process of cognition*. This statement is valid for all organisms, with and without a nervous system" (Maturana, Varela 1980: 13). In other words, the capacity to self-organize is seen as a mental activity which can be discerned at all levels of life, from cells to human and non-human animals. "The interactions of a living organism – plant, animal, or human – with its environment are cognitive interactions. Thus life and cognition are inseparably connected. Mind – or, more accurately, mental activity – is immanent in matter at all levels of life" (Capra, Luisi 2014: 254). In this sense cognition and mind refer not only to beings with reflective consciousness, such as humans, but also to other living beings with or without brains.

Maturana and Varela's theory of autopoiesis and cognition could be seen as a universal characteristic applicable to a larger class of organization. However, the theorists were reluctant to extend the concept of autopoiesis to other fields of research. As Varela points out, "it is tempting to confuse autopoiesis with organizational closure and living autonomy with autonomy in general" (Varela 1980: 37). Regardless of these restrictions, the system theorist Niklas Luhmann interpreted autopoiesis as a general form of system building by using self-referential closure, and argued that general principles of autopoietic organization can be applied to social systems (Luhmann 1991: 2). At the same time, the theory of autopoiesis was related to Gaia theory: in 1988 Lovelock, Margulis and Varela participated in a Gaia theory symposium in Italy, where Varela made an explicit connection between the self-referential system and Gaia theory. "The quality we see in Gaia as being living-like, to me is the fact that it is a fully autonomous system... whose fundamental organization corresponds to operational closure. Operational closure is a form, if you like, of fully self-referential network constitution that specifies its own identity. Autonomy, in the sense of full operational closure, is the best way of describing that living-like quality of Gaia, and... the use of the concept of autonomy might liberate the theory from some of the more animistic notions that have parasitized it" (cited in Clark 2012: 69-70).

Varela made an important observation that Gaia is not alive but living-like, thus it can be credited as a scientific theory and not as a New Age animistic interpretation. The next thing is that Varela, even being reluctant to extend the term autopoiesis to other fields, acknowledged that Gaia can be described in terms of autopoiesis. In this sense autopoiesis is understood as a general mode of systemic self-reference, which can be applied both to living and living-like systems. Margulis seems to take Varela's point into account when she writes that "the simplest, smallest known autopoietic entity is a single bacterial cell. The largest is probably Gaia – life and its environment-regulating behaviour at the Earth's surface. Cells and Gaia display a general property of autopoietic entities: as their surroundings change unpredictably, they maintain their structural integrity and internal organization, at

the expense of solar energy, by remaking and interchanging their parts" (Margulis 1997: 267; 269). In this sense Margulis adopted the theory of autopoiesis and reframed Gaia theory in terms of autopoietic recursivity.

Varela's critique of Gaia theory at the 1988 symposium engendered a conceptual shift from first-order cybernetics to second-order cybernetics, from homeostatic regulation to autopoietic recursivity (Clarke 2012: 71). Similarly, Onori and Visconti agreed that, influenced by Margulis' investigations into autopoietic systems, Gaia theory moved to second-order cybernetics (Onori, Visconti 2012: 381). First-order cybernetics refers to operational circularity in natural and technological systems, whereas second-order cybernetics turns the logic of operational circularity upon itself. As Clarke asserts, "first-order cybernetics is hetero-referential, it concerns 'objects' such as natural and technological systems. Second-order cybernetics observes the self-reference of 'subjects', that is, the necessary recursivity of cognitive systems capable of producing observations in the first place" (Clarke 2012: 59). In this respect, second-order systems, from cells to Gaia, are not only observed but also observing, in other words, they have the capacity for learning and cognition. Thus, according to Clarke, "the Gaia hypothesis began as a thought experiment drawing on homeostasis, a basic first-order cybernetic model of self-regulation using negative feedback to correct deviations from a desired state of operation" (2017: 15). However, with the inclusion of autopoiesis, Gaia discourse was remodelled according to second-order systems theory which turned the logic of operational circularity upon itself and thus implied the notion of cognition.

Gaia and Actor Network Theory

Another important reconceptualization of Gaia theory is presented in Latour's *Facing Gaia: Eight Lectures on the New Climatic Regime* (2017a). Here Latour distances himself from cybernetic discourse and prefers to investigate Gaia in terms of his own Actor Network Theory (Latour 2005). First, Latour argues that Gaia is not a totality, a whole which is made of parts. The part-whole distinction is applicable only to technological systems, whereas Gaia is not a technology or a machine. Latour asserts that "as Gaia cannot be compared to a machine, it cannot be subjected to any sort of *re-engineering*" (Latour 2017a: 96-97). The components could be defined as parts existing in relation to the whole only on a dead planet; however, the Earth is alive, therefore such a distinction is not possible. Second, Gaia is not a totality in terms of a superorganism. Latour points out that "all the sciences, natural or social, are haunted by the specter of the 'organism', which always becomes, more or less surreptitiously, a '*superorganism*' – that is, a dispatcher to whom the task – or rather the holy mystery – of successfully coordinating the various parts is attributed" (Latour 2017a: 95). What Latour finds problematic here is not the concept of organism but an organism understood as a whole determining its parts.

Thus, instead of conceptualizing Gaia in terms of a totality, understood either as a machine or an organism, Latour prefers to define it in terms of agency and an agent which is involved in different interactions. Margulis's investigations into the kingdom of microorganisms, similar to those conducted by Louis Pasteur, reveals that the Earth is composed of invisible agents which can manipulate mountain formations, cloud layers, and even the movement of tectonic plates. As Latour points out, "the Earth's behavior is inexplicable without the addition of the work accomplished by living organisms, just as fermentation, for Pasteur, cannot be started without yeast. Just as the action of micro-organisms, in the nineteenth century, agitated beer, wine, vinegar, milk, and epidemics, from now on the incessant action of organisms succeeds in setting in motion air, water, soil, and, proceeding from one thing to another, the entire climate" (Latour 2017a: 93). Latour interprets Gaia as the network of agents where each agent is trying to manipulate the environment for its own interest. In this respect both human and nonhuman agents are equally involved into the attempts to change the environment around them. In this respect, humans have no exceptional qualities, because "the capacity of humans to rearrange everything around themselves is a *general property of living things*" (Latour 2017a: 99). In other words, both human and nonhuman agents express a certain intentionality and create an entire network of effects and connections. What is important for Latour is how to keep connectivity without being holistic (Latour 2017b: 75), how to avoid reducing these connections into a single acting totality, or a whole. In this sense Latour, going against the grain of Lovelock and Margulis's orientation towards systems theory, argues that Gaia is anti-systemic: "Gaia, the outlaw, is the anti-system" (Latour 2017a: 87). However, as Clarke points out, it is important not to conflate the notion of "whole" with that of "system" (Clarke 2017: 14). If something does not make a whole, it doesn't mean that it cannot be a system.

Latour associates this anti-systemic character of Gaia with Isabelle Stengers's interpretation of Gaia. As Stengers points out, Gaia exists on its own terms: "It is not a living being, and not a cybernetic one either; rather it is a being demanding that we complicate the divide between life and non-life, for Gaia is gifted with its own particular way of holding together and of answering to changes forced on it (...), thus breaking the general linear relation between causes and effects" (Stengers 2015b: 137; cited in Clarke 2017: 14). In her *In Catastrophic Times: Resisting the Coming Barbarism* (2015a), Stengers describes Gaia as an intruder which is incompatible with our expectations and conceptualizations. Gaia is "a ticklish assemblage of forces" that is absolutely transcendent in relation to our reasons and projects. "The intrusion of this type of transcendence, which I am calling Gaia, makes a major unknown, *which is here to stay*, exist at the heart of our lives. This is perhaps most difficult to conceptualize: no future can be foreseen in which she will give back to us the liberty of ignoring her" (Stengers 2015a: 47). Defined in this way, Gaia is intrusive, ticklish, and unforeseen, ready to destroy our human order. This radically unknown and unforeseen character of Gaia can be

traced to Stengers's collaboration with Ilya Prigogine (Prigogine, Stengers 1984) and her theoretical background in far from equilibrium systems theory. Interpreting Gaia from this point of view, we can recognize some contours of dissipative structures. Dissipative structures not only maintain themselves in a state far from equilibrium but may evolve into more complex structures (Capra, Luisi 2014: 159). In this regard Gaia the intruder, even being chaotic and unforeseen, may evolve into a new complex order and in this sense is compatible with systems theory. Clarke comes to a similar conclusion when he asserts that "the Gaia discourses of Stengers and Latour may be positively aligned with the systems theory that supports Lynn Margulis's autopoietic Gaia concept" and that "in both cases, their efforts to evade the cybernetics of Gaia simply reconstitute the systemic description they reject" (Clarke 2017: 7).

Cary Wolfe (2020) provides a less sympathetic reading of Latour's *Facing Gaia* and his attempts to shape Gaia in terms of Actor Network Theory. According to Wolfe, the main problem in Latour's theory is the insufficient understanding of the difference between a first-order and second order systems theory. "A crucial underlying problem, (...) is that Latour continues to understand the terms 'system' and 'autopoiesis' as if they were simply synonyms for homeostasis and command-and-control, and the fingerprints of this misunderstanding in *Facing Gaia* are all over his use of the term 'cybernetics'" (Wolfe 2020: 140). It seems that Latour understands cybernetics as based on "mereological" relations between parts and wholes, and, as Wolfe points out, "Latour cannot understand that, in second-order systems theory, the account of the relationship between the 'part' and the 'whole' (...) is actually the *opposite* of the caricature he offers here" (Wolfe 2020: 140). Latour's critique of cybernetics and systems theory misses the target because second-order cybernetics reconceptualises the notion of the system in such a way that it incorporates recursivity and contingency (Hui 2019).

Another problem appears when Latour is trying to explain the interaction between the "inside" and the "outside", or between an organism and its environment: on the one hand, he asserts that the borders are subverted, on the other hand, he describes the "waves of action", where an agent is manipulating its neighbours, and these neighbours are manipulating it in return (Latour 2017a: 101). What Latour describes as "manipulation" or "intention" and attributes to the sporadic actions of agents, is nothing other than the contingent nature of autopoietic second-order systems. According to Wolfe, "What Latour is unable to theorize here is the relationship (...) between 'inside' and 'outside', 'neighbor' and 'environment,' because he doesn't grasp the key insight of second-order systems theory and the theory of autopoiesis: that the *contingency* of the self-reference of autopoietic organisms *is* the 'wild card,' the 'outlaw,' at the core of everything Latour wants from the unpredictable 'agency' and 'intentions'..." (Wolfe 2020: 141). The contingent character of interactions arises not from the agent's intentions, but from the self-referential character of autopoietic systems which include contingency within themselves. Self-referential closure and

contingency do not contradict each other because the same system can be closed at an organizational level and open at an environmental level. As Luhmann points out, self-referential closure "does not contradict the system's *openness to the environment*. Instead, in the self-referential mode of operation, closure is a form of broadening possible environmental contacts; closure increases, by constituting elements more capable of being determined, the complexity of the environment that is possible for the system" (Luhmann 1995: 37). In second-order systems recursivity works in such a way that, by incorporating contingency, it makes the system more complex. This contingency explains the "anti-systemic" and "outlaw" character of Gaia, and this is what Latour's theory fails to explain.

Another important point of critique is that the notion of "agent" or "actant" fails to maintain the difference between living and non-living (physical) systems. As Wolfe points out, "the alterity, 'creativity', and 'outlaw' relations that obtain among what Latour calls 'actants' are (...) much more unruly and unpredictable among biological life forms and their environmental relations than between, say, stones or vacuum cleaners" (Wolfe 2020: 143). In this respect Latour's Actor Network Theory flattens the distinction between living and non-living systems and different orders of causality that these systems imply. Living organisms imply a different order of causality, which incorporate recursivity and contingency and allow them to change themselves and their environment. Recursivity in second-order systems is the source of internal transformation, and this is the main characteristic of living organisms. The difference between living and non-living systems is crucial if we want to understand the functioning of Gaia and the interface between physical, biological, and social systems.

Gaia and the Theory of Sympoiesis

A different take on Gaia appears in Donna Haraway's *Staying with the Trouble: Making Kin in the Chthulucene* (2016). Haraway seems sympathetic to Latour's and Stenger's theories of Gaia (although omitting their different backgrounds) and reads them as a continuation of Lovelock and Margulis's hypothesis: "[i]n this hypothesis, Gaia is autopoietic – self-forming, boundary maintaining, contingent, dynamic and stable under some conditions but not others. Gaia is not reducible to the sum of its parts, but achieves finite systemic coherence in the face of perturbations within parameters that are themselves responsive to dynamic systemic processes" (Haraway 2016: 43-44). Haraway is also sympathetic to Margulis's idea that life emerges through symbiosis and symbiogenesis, which leads to the increasing complexity of life forms. However, Haraway questions the underlying assumption that these emerging life forms are autopoietic and argues that Margulis perhaps "would have chosen the term *sympoietic*, but the word and concept had not yet surfaced" (Haraway 2016: 61). Haraway argues that nothing can really create itself. Therefore nothing is really autopoietic but needs other

organisms and environments to become what it is. In this regard the theory of autopoiesis should be coupled with the theory of sympoiesis, which refers not to autonomous but to collectively produced systems.

Haraway takes the term of sympoiesis from Beth Dempster's (2000) work, where she makes a distinction between sympoietic and autopoietic systems. Autopoietic systems, as defined by Maturana and Varela, are characterized by two basic features: first, they produce relations between their components that allow them to reproduce the same pattern of relations (they are self-referential); second, they have the ability to reproduce their own boundaries (they are self-defining). Autopoietic systems are organizationally closed, but structurally open: this means that they are not absolutely autonomous but that they internally define their boundaries and relationships with the environment. Sympoietic systems are organizationally ajar, with loosely defined boundaries. "Lacking self-defined boundaries, sympoietic systems consequently lack the same degree of control and are open to a continual flux of organizationally relevant information. (...) This dynamic, though restricted, flux of information allows sympoietic systems to evolve continuously by adapting to changing conditions and by generating new ones" (Dempster 2000: 9). Autopoietic and sympoietic systems manage information in different ways: autopoietic systems carry a kind of "packaged" information, whereas sympoietic systems carry different bits of information in their components (which are autopoietic in themselves) and lack a central control. This makes sympoietic systems more flexible and adaptive, in the sense that they can easily adapt to changing environments, and also create something new, produce new forms of organization (in this regard they are allopoietic): "autopoietic systems follow some sort of path from a less to a more developed stage, whereas sympoietic systems are continually, although not necessarily consistently, changing" (Dempster 2000: 10-11). This explains why sympoietic systems have bigger potential for change: if autopoietic systems are homeostatic, predictable and development-oriented, then sympoietic systems are allopoietic (producing otherness), unpredictable, and evolutionary oriented. In this sense sympoietic systems, which also include autopoietic systems as their components, have the ability to maintain their identity and the status quo, and, at the same time, have the potential to create changes and to adapt to changes coming from the environment.

Haraway adopts the theory of sympoiesis and suggests that "Gaia is a system mistaken for autopoietic that is really sympoietic" (Haraway 2016: 180, n 38). We can add that autopoiesis explains the functioning of bounded units or individuals, whereas sympoiesis is a term to explain the collaborative assemblages which acquire their identity in the process of interaction and becoming. By fusing different components, sympoiesis creates more complex life forms and gives rise to new emergent properties. Haraway refers to Margulis's notion of the holobiont, which indicates an organism plus persisting symbionts. A good example of such a holobiont is *Mixotricha paradoxa*, a critter that lives in the gut of an Australian

termite and helps it to digest cellulose. *Mixotricha paradoxa* looks like a single-celled critter, but after a closer examination it seems to consist of multiple bacterial symbionts. Margulis and Sagan (2001) described it as a "beast with five genomes": it is a composite organism containing a protist and at least four different types of bacteria. For Haraway, the notion of holobiont questions the idea of a self-organized individual and indicates that all living beings are dynamic organizing processes: "Like Margulis, I use *holobiont* to mean symbiotic assemblages, at whatever scale of space and time, which are more like knots of diverse intra-active relatings in dynamic complex systems, than like the entities in a biology made up of preexisting bounded units (genes, cells, organisms, etc.) in interactions that can only be conceived as competitive or cooperative" (Haraway 2016: 60). Haraway does not specify what these "dynamic complex systems" mean but it is clear from her description that they preclude any existence of bounded individuals.

The notion of the holobiont changes not only our understanding of the bacterial world but also the idea of what it means to be human. As Scott Gilbert points out, "the holobiont is powerful, in part, because it is not limited to nonhuman organisms. It also changes what it means to be a person" (Gilbert 2017: 75). Seen from this perspective, the human body is not a bounded individual but a complex ecosystem, which is related to other organisms through the reciprocal process of sympoiesis. For example, in defining anatomical individuality, Gilbert suggests that only about half the cells in our bodies contain a "human genome," and other cells include about 160 different bacterial genomes (Gilbert 2017: 75). Thus, according to genetic and anatomical criteria, we are far from individuals because our microbiome can be considered as a supplementary organ. From the immunological point of view, humans are also far from individuals because our immune system allows countless microbes to become parts of our bodies. As Gilbert points out, "without the proper microbial symbionts, important subsets of immune cells fail to form. (...) We are thus not individuals by immune criteria" (Gilbert 2017: 82). After discussing anatomical, genetic, developmental, physiological, immune, and evolutionary criteria, Gilbert comes to the conclusion that we are not individuals but holobionts – organisms persistently cooperating with communities of symbionts. This means that symbiosis is not a marginal or random case but an all-encompassing principle of life. "These major symbiotic webs rule the planet, and within these big symbioses are the smaller symbiotic webs of things we call organisms. (...) Symbiosis is the way of life on earth; we are all holobionts by birth" (Gilbert 2017: 84).

Haraway takes the notion of holobiont even further by decentralizing the relationships between a host and its symbionts: "my use of *holobiont* does not designate host + symbionts because all of the players are symbionts to each other, in diverse kinds of relationalities and with varying degrees of openness to attachments and assemblages with other holobionts" (Hawaway 2016: 60). In this sense sympoietic systems embrace both operational closure, as described by Luhmann, and operational openness. For Luhmann the system's autopoiesis makes the

components more determined and defined, and this leads the system to a certain evolutionary shift to a higher complexity. As was discussed, Luhmann asserts that autopoietic closure does not contradict the system's openness to the environment. However, the notion of sympoiesis allows us to conceptualize not the "openness from closure principle", as Wolfe (2010) has phrased it, but "operational openness", which means dynamic and complex interactions between different systems. Although on certain occasions Haraway expressed her resistance to systems theories of all kinds (Gane 2006), I argue that her notion of sympoiesis might be seen as a major reconceptualization of systems theory.

Thus Latour, Stengers, and Haraway invite us to rethink Gaia not as an autopoietic unity, closed onto itself in repetitive patterns, but as a complex and dynamic system, which is open to contingency and otherness. The theory of sympoiesis, proposed by Haraway, questions the notion of bounded individuals and allows us to rethink living beings (both human and nonhuman) as open systems. In this regard the theory of sympoiesis questions the principle of closure defining autopoietic systems and asserts operational openness. On the one hand, every individual needs to have boundaries to remain what it is; on the other hand, total enclosure within these boundaries means the repetition of the same that leads to death. To be alive we need to change, to give up our individuality, and to connect to different networks of symbionts. In this sense, the notion of autopoiesis should be rethought as allopoiesis or heteropoiesis that constantly produces otherness and is connected with something other than itself.

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References

Capra, F., Luisi, P. L. (eds.), 2014. *The Systems View of Life: A Unifying Vision*. Cambridge: Cambridge University Press.

Clarke, B., 2012. Autopiesis and the Planet. In: *Impasses of the Post-Global. Theory in the Era of Climate Change*. Ed. Henry Sussman. Ann Arbor: Open Humanities Press, 58-75.

Clarke, B., 2017. Rethinking Gaia: Stengers, Latour, Margulis. *Theory, Culture & Society* 34 (4): 3-26. https://doi.org/10.1177/0263276416686844

Dempster, B., 2000. Sympoietic and Autopoietic Systems: A New Distinction for Self-Organizing Systems. Available at: https://www.semanticscholar.org/paper/SYMPOIETIC-AND-AUTOPOIETIC-SYSTEMS%3A-A-NEW-FOR-Dempster/44299317a20afcd33b0a11d3b2bf4fc196088d45 (accessed 17 August 2020)

Gane, N., 2006. When We Have Never Been Human, What Is to Be Done? Interview with Donna Haraway. *Theory, Culture & Society* 23 (7-8): 135-158. https://doi.org/10.1177/0263276406069228

Harding, S., 2014. Daisyworld. In: Fritjof Capra and Pier Luigi Luisi (eds.). *The Systems View of Life: A Unifying Vision*. Cambridge: Cambridge University Press, 166-168.

Haraway, D. J., 2016. *Staying with the Trouble: Making Kin in the Chthulucene*. Durham, London: Duke University Press.

Hui, Y., 2019. *Recursivity and Contingency*. London, New York: Rowman and Littlefield.

Latour, B., 2005. *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press.

Latour, B., 2017a. *Facing Gaia: Eight Lectures on the New Climatic Regime*. Trans. Catherine Porter. Cambridge: Polity Press.

Latour, B., 2017b. Why Gaia is not a God of Totality. *Theory, Culture, & Society* 34 (2-3): 61-81.https://doi.org/10.1177/0263276416652700

Lovelock, J., 1972. Gaia as seen through the atmosphere. *Atmospheric Environment*, vol. 6, 579-580.

Lovelock, J., 2000. *Gaia: The Practical Science of Planetary Medicine*. Oxford: Oxford University Press.

Luhmann, N., 1991. Autopoiesis of Social Systems. In: *Essays on Self-Reference*. New York: Columbia University Press, 1-20.

Luhmann, N., 1995. *Social Systems.* Trans. John Bednarz, Jr. with Dirk Baecker. Stanford: Stanford University Press.

Margulis, L., 1997. Big Trouble in Biology: Physiological Autopoiesis Versus Mechanistic Neo-Darwinism. In: Margulis, L. and Sagan, D. (eds.) *Slanted Truths: Essays on Gaia, Symbiosis, and Evolution*. New York: Springer, 265-282.

Margulis, L., 1998. *Symbiotic Planet: A New Look at Evolution.* Amherst, Mass.: Basic Books.

Maturana, H., Varela, F., 1980. *Autopoiesis and Cognition: The Realization of the Living*. Boston: Riedel.

Onori, L., Visconti, G., 2012. The GAIA Theory: from Lovelock to Margulis. From homeostatic to cognitive autopoieic worldview. *Rendiconti Lincei* 23: 375-386. https://doi.org/10.1007/s12210-012-0187-z

Prigogine, I., Stengers, I., 1984. *Order out of Chaos*. New York: Bantam.

Stengers, I., 2015a. *In Catastrophic Times: Resisting the Coming Barbarism*. Trans. Andrew Goffey. London: Open Humanities Press.

Stengers, I., 2015b. Accepting the Reality of Gaia: A fundamental shift? In: Hamilton C., Bonneuil C., Gemenne, F. (eds.) *The Anthropocene and the Global Environmental Crisis: Rethinking Modernity in a New Epoch*. New York: Routledge, 77-93.

Thompson, E., 2009. Life and Mind: From Autopoiesis to Neurophenomenology. In Bruce Clarke and Mark B. N. Hansen (eds.). *Emergence and Embodiment: New Essays on Second-Order Systems Theory*. Durham and London: Duke University Press, 77-93.

Varela, F., Maturana, H., Uribe, R., 1974. Autopoiesis: The Organization of Living Systems, Its Characterization and a Model. *BioSystems* 5: 187-96.

Varela, F., 1980. Describing the Logic of the Living: The Adequacy and Limitations of the Idea of Autopoiesis. In: *Autopoiesis: A Theory of*

the Living organization. Ed. Milan Zeleny. New York: Elsevier North-Holland, 36-48.

Wolfe, C., 1995. In Search of Post-Humanist Theory: The Second-Order Cybernetics of Maturana and Varela. *Cultural Critique* 30: 33-70. https://doi.org/10.2307/1354432

Wolfe, C., 2010. *What Is Posthumanism?* Minneapolis, London: University of Minnesota Press.

Wolfe, C., 2020. What 'The Animal' Can Teach the Anthropocene? *Angelaki* 25 (3): 131-145. https://doi.org/10.1080/0969725X.2020.1754033