Linguistic Frontiers • 5(3) • 2022
DOI: 10.2478/lf-2022-0019

Linguistic **Frontiers**

From biosemiotics to physiosemiotics. Towards a speculative semiotics of the inorganic world.

Original study

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Received: July 2022; Accepted: November 2022

Abstract: In the first part of the article, biosemiotics will be presented in its historical and theoretical dynamics. New areas of research that have emerged in the speculative field of biosemiotics, such as ecosemiotics, will be explored. In all its developments, biosemiotics, which identifies semiosis with life, excludes inorganic matter from any semiotics processes. However, the inorganic world is a fundamental part of the biosphere, especially if we consider the emergence of life. In order to include inorganic matter within semiotic processes of the biosphere we will use James Lovelock's Gaia hypothesis reinterpreted in the light of semiotics. If we use the hypothesis of planet Earth as a living system in its complexity and if we consider that every living system is intrinsically semiotic, then inorganic matter must also participate in semiotics processes. In this sense, the semiotics of the inorganic world reveals that it participates in a sort of non-human agency. This type of speculative semiotics engages semiotics processes that are constitutive of matter and that can be read as the story of the planet itself. In conclusion, I will propose a *physiosemiotics* as semiotics of matter.

Keywords: Agency; Ecosemiotics; Inorganic semiotics; Physiosemiotics; Semiogenesis.

INTRODUCTION

The term biosemiotics, a union of biology and semiotics, was first coined by a German psychiatrist Friedrich S. Rothschild in his article "Laws of symbolic mediation in the dynamics of self and personality" in 1962 (Kull 1999). Rothschild used it to refer to the study of life's communicative processes that convey meaning. However, it is thanks to the Hungarian-born semiologist Thomas Sebeok that biosemiotics become an autonomous field of study investigating the relationship between signs and meaning in living organisms (Kull et al. 2008). At the beginning of his work, the term was used to refer to the study of signs in organic life. In the first part of his studies, Sebeok considered semiosis as the basis of every vital process; later he identified semiosis with life itself (Sebeok 1988). For this reason, the fundamental proposal of biosemiotics consists in suggesting semiosis as belonging not only to humans, but also to animals (Sebeok 1963).

Sebeok took his cue from the notion of *Umwelt* coined by Jacob von Uexküll (1921). This concept refers to the fact that every species and every individual lives in a subjective world (or subjective environment) consisting of perceptual marks that are significant for the organism's life. These perceptual marks can be interpreted as signs useful for the survival of the living being. In this sense, signs must be read and interpreted by the living being in order to survive in each environment (Uexküll 1982).

1. SEMIOSIS IN LIVING SYSTEMS

Every living system, from an animal to a plant, has a capacity to communicate because their survival is determined

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by an organism's ability to exchange information with its environment[2]. As Barbieri (2009) stated, the extension of semiosis beyond the animal world was given a further boost in 1981, when Martin Krampen argued that plants are also involved in semiosis. Phytosemiotics is a concept proposed by the German semiologist Martin Krampen as a new field of study of plant life. He began to show how plants were also immersed in an Umwelt, unlike Jacob von Uexküll who used the term *Wohnhülle* for the plant world. According to Jacob von Uexküll (1982), plants can make use of a meaning relevant to them through their form, which is specifically organized according to its components.

The communication channels of plants are mainly chemical, electrical, energetic, etc. In this sense, the question of whether plants do semiosis and what kind of semiosis was attempted to break the view of plants as purely mechanical systems. Krampen also points out that "[…] the difficulty of this enterprise is to avoid anthropomorphizing the behavior of plants and to adopt, as an observer, the correct "phytocentric" perspective" (Krampen 1986, 729).

Phytosemiotics use the concept of "biological need" as the primary holistic process in living systems (Kull 2000). The holistic view, which challenges the mechanistic paradigm, studies the processes of information exchange in botany through semiotics.

This field can also be mixed with the complexity and systemic theories of Maturana and Varela[3] (1980) in which every living system is an autopoietic and self-organizing system. This means that the continuous exchange of information in living things is useful both for the internal maintenance of a certain equilibrium and for the development of more complexity towards increased disorder. As Kalevi Kull (2000) points out, *meaning* is constituted in the part-interrelationships and therefore it can be said that plant semiotics is based on meronomy[4]. It is in the constituted difference of the organism within and outside that the realm of meaning is determined.

In this sense, there is no signification without functional differentiation or, in Gregory Bateson's (1972) terms, without "a difference that makes a difference". Semiosis is activated by active selection by the living being in respect of different external signs. It is the selection and hierarchy resulting from the encounter between plant form and environmental signs that produces a process of semiotic differentiation. In other words, it is the choice in front of an infinite number of potential threats or events[5] that prescribes the possibility of semiosis as a non-predetermined selectivity. Any plant chooses for its survival (in an unpredictable way) a very limited number of signals that become information. What we have just described is a mechanism of pertinentization. This is where the information obtained by and through channels is a difference-maker. The information that travels along the plant's communicative and selective channels is continuously transformed (by energetic, chemical, electrical processes). The transformative process as well as the semiotic process could be said to be already involved (as argued by Jacob von Uexküll) in the form of the living being.

According to the ecosemiotic perspective (Farina 2012, 2021; Maran 2020), studying sign interactions and processes as ecological phenomena, every function and resource is necessarily mediated by a semiotic component in the *ecofield interface* (Farina, Belgrano 2004, 2005) that serves the organism to interpret correctly how to use a resource. The environment is therefore an active and dynamic part of the individual's cognitive processes. In this new field of study, every activity of an organism is studied as a constant interaction between the patterns of the individual and the properties of the environment. However, in the constituent properties of the environment, understood as an ecosystem, there are also the inorganic materials that contribute to its constitution. This is because every ecosystem is not only made up of organic agents but it is, above all, a network of interdependent elements. The ecosystem is a functional unit comprising the set of living organisms and non-living substances with which the former establish an exchange of materials and energy in a defined area (Capra, Luisi 2014).

Ecosemiotics has stressed that environmental signs and the organism's creation of meaning[6] meet in a process that is always dynamic. In our interpretation of ecosemiotics, we want to extend interactions not only

2 In order to function effectively as complex, organized systems, living organisms must constantly collect and use information about both the external environment in which they live and their own internal states. Furthermore, for a complex system to behave as a teleonomic whole, there must be effective communication both between the components of the system and between them and the external environment. In biology, the series of modules that carry out this communication are the "signaling pathways" (Nurse 2020).

3 Although Varela never wanted to overlap his field of research with semiotics (Weber 2001).

4 Meronomy expresses a relationship between terms denoting a part and the whole such as branch/tree; thumb/finger/wrist/arm. The notion denotes the part of a whole in a semantic hierarchy. Moreover, the relationship that is established is between directly related intermediate parts that we are able to recognize thanks to segmentation.

5 Event as a static or dynamic property of objects or surfaces independent of the nature of the perceiver (Stoffregen 2000).

6 We want to specify that by "creation of meaning" we are referring to Giorgio Prodi's idea. For Prodi (2021, 39), "presence of meaning" means the existence of an object that is *meaningful for*. Meaning and the attribution of meaning are material processes that presuppose a world to be explored but also a structure capable of exploration.

in the sphere of the living, but also in the non-living that is part of an ecosystem. This allows us to broadly define a *semiotics of nature* (Zengiaro 2022). This has made it possible to think of thresholds as ever-expanding semiospheres (Lotman 1985) in which new meanings emerge. Complexity theories, in fact, have removed the possibility of thinking about the objects of the world separately (Capra 1996). Everything is taken into a network that we can call the "semiotics of nature".

2. PHYSIOSEMIOTICS

In our working proposal "towards a semiotics of the inorganic" we are taking James Lovelock's "Gaia hypothesis"[7] and analyzing it with the tools of biosemiotics and a philosophical reading. The aim is to provide a working hypothesis on the existence of a continuity in semiotic processes before the organic life.

In order to investigate the semiotics of the inorganic in a speculative way, we will use physiosemiotics. By "physiosemiotics" we mean[8] a semiotics of nature, but also of the matter in a broadest sense. The semiotic process in this field is proposed as a material event that emerges from the intrinsic relationality of the objects of the world (Zengiaro 2022a).

The term "physiosemiosis" was initially used by Walter A. Koch (1987) with the notion of *physicosemiotics*, and by John Deely (1990) with *physiosemiotics*. However, the notion further developed thanks to authors such as Claus Emmeche (1994, 1999) and Winfried Nöth (1999, 2001). Starting from the reading of the Gaia hypothesis, in the light of semiotics, we will try to initiate a new interpretation of physiosemiotics by reinterpreting it through complexity theories. This will allow us to define an agency of the inorganic in a complex and interwoven system such as that of our planet understood as a unity.

In the second half of the 1970s James Lovelock (1979), with Lynn Margulis — another supporter of this theory — proposed the hypothesis according to which it is possible to see the planet Earth as a complex system engaged in a continuous process of self-regulation. This hypothesis, according to which living organisms interact with the inorganic components that surround them to form a complex self-regulating system, has the advantage of explaining the emergence of life on the planet through a homeostatic model. In this sense, Lovelock refers to the concept of homeostasis of the planet in which the temperature, oxidation, acidity and salinity of the seas and other parameters remain essentially constant despite all the changes that life creates in different ecosystems.

If life coincides with semiosis and living systems also interact with inorganic components, this means that semiotic processes have to deal with inorganic matter. The fundamental problem of the intervention of physiosemiotics in the biosemiotic debate is that this field does not share the identification of semiosis with life[9]. Since biosemiotics is strictly biocentric, it cannot make this working hypothesis part of its theories (unless it changes them from the beginning). This brings us to a topic that has not yet been debated: the usefulness of thinking about the border that divides life from non-life. What we are pointing out is that this boundary is very blurred, often undecidable[10]. As we state that we cannot establish exactly where life begins and ends once and for all, in the same way *it is not possible to fix a priori a semiotic threshold*.

The inorganic matter from which life emerged, thought of in a semiotic-holistic view, makes it possible not to fall back into mechanism. Consider what has been shown above: the environment is not an empty container of signs from which animals and plants extract their meanings but it is an active producer with a certain kind of agency.

2.1. AGENCY AND PHYSIOSEMIOSIS

The term "inorganic agency" refers to Bruno Latour's metaphor of the missing mass in the universe. Latour (2006), in order to introduce the theme of non-human agency, refers to the existence of non-directly observable matter assumed by astrophysics. The metaphor is used to show that there are missing masses in the social universe, that are non-human. They do not constitute inert matter at the mercy of the human but are active subjects with the capacity to produce effects on social relations and society (Bennett 2010). The value of agency is used to explain multiple processes of social change. Latour (2015) defines the notion of *agency* in the sense of "power to act".

The relevance of the agency of the inorganic must be conceived not so much through the entity's belonging to

7 This hypothesis, although considered pseudoscientific because of New Age interpretations, helps us to show the intertwining that takes place between the planet's elements.

8 Physiosemiotics is not a well-defined field of semiotics, so we propose a different reading from the authors who have dealt with it.

9 As pointed out by the referees, to have a true abiotic semiosis, the comparison must propose the existence of an abiotic interpretant. This is a problem, also pointed out by Champagne (2013), that cannot be completely solved through a triadic semiotics. Indeed, following Prodi's insights, we can see material semiotics through dyadic relations. Prodi creates a semiotic system that "end up deflating the role of Thirdness and Firstness, in favour of Secondness, the category that, more than the others, exemplifies the intrinsic relationality of *natural* semiosis" (Cimatti 2018, 41).

10 Viruses, for example, stand halfway between the living and the non-living. On the one hand they are alive when they are chemically active and reproduce in host cells, on the other hand they are non-living when they exist as chemically inert entities outside the cell (Nurse 2020).

social or cultural processes that turn around the human, but rather through the relationship it establishes with the environment. Therefore, the question must be approached from a relational point of view, conceiving the forces produced by the relationality of inorganic elements with their surroundings; this starting from the fact that, always following Latour, every actor (human or non-human) is at the same time a network in its constitution, a collective in which hybrid, complex and semiotic agents take part.

As a proof of this, we need to realize that it is not only artefacts that disrupt and modify the social (Malafouris 2013), but also natural catastrophic events formed by complex inorganic elements. We are thinking of movements of the Earth's crust that form tsunamis, earthquakes, but also atmospheric events such as tornadoes. Indeed, one can also speak of the production of self-organizing behavior with regard to complex physical events. Swenson and Turvey (1991) describe such organizations by the term "autocatakinetics" (the etymology of the word refers to: "of the motion of material bodies and the forces and energy associated therewith to cause move"). This term is used to describe a state of order or self-organization[11]. The behavior of physical events in complex systems, comparable to the directionality of evolution of organism according to certain intensities and interactions, is "an autocatakinetic system [that] maintains its 'self' as a state constituted by, and empirically traceable to, a set of nonlinear (circular causal) relations through the dissipation or breakdown of field potentials (or resources) in the continuous coordinated motion of its components […]" (Ivi, 336). In this sense, we can redefine the notion of agency to include events emerging from certain organic and inorganic activities with specific effects and directionality. So we can define *"agency" as the force arising from relationships that bring along events that did not exist before*. "Force" is used as physical vector quantity that manifests itself in the reciprocal interaction of two or more bodies, both at the macroscopic level and at the level of elementary particles. Events create virtual signs that emerge from complex concatenations.

3. EMERGENCE OF LIFE AND ORGANIZATION

The emergence of living organisms from inanimate matter is not a modern idea. In the history of Western philosophy, Aristotle was the first to reflect on the problem of the origin of life, admitting the possibility of spontaneous generation. The thesis of spontaneous generation was refuted only in the mid-19th century.

In 1929 the biologist John Burdon Sanderson Haldane proposed the idea of a reducing atmosphere in the early stages of the planet characterized by the presence of C, O and N and an excess of hydrogen and helium as the original cloud that led to the aggregation of matter. The hypothesis was taken up by Aleksandr Oparin and Harold Urey who showed in 1952 that the primitive atmosphere had to be a reducing atmosphere and chemically stable. The first experiment of this theory was performed by Stanley Miller in 1953, simulating the primordial environment in a laboratory (LeDoux 2019).

After Miller, many researchers showed that in conditions of reducing atmosphere containing only H2, CH4, NH3, H2O (vapor), a wide variety of different molecular species are produced. This is the theory of the "primordial soup", according to which 4.5 billion years ago the Earth's crust, now cooled, allowed the condensation of water vapor, forming the oceans. Gaseous molecules synthesized in the atmosphere and accumulated in the oceans could chemically react since they were protected from ultraviolet radiation by ocean waters. The formation occurred, according to different hypotheses, in shallow pools near volcanoes, in hydrothermal vents or in the cavities of rocks. Among the various hypotheses on the emergence of life, the most credited hypothesis is that, thanks to the cavities in the siliceous rocks and clays in the water, certain inorganic chemicals could be catalyzed, creating the conditions for life to appear (LeDoux 2019). Physiosemiotics as a theoretical proposition seeks to interpret these dynamics according to a semiotic reading of matter.

We can say that physiosemiotics, as we understand it, is a semiotics that investigates the relationships of matter. A potential branch to interpret the dynamics between organic and inorganic life, showing how their organization can be understood through semiotic processes. In this sense, we can investigate both the relationship that inorganic matter has with organisms and the compositional and organizational relationships that underlie the material constitution of an object. However, in opposition to biosemiotics, physiosemiotics defends the existence of a semiotic process even below the threshold of life, based on constitutive qualities and relationality. In other words, it seeks to identify a principle of semiosis already presents in molecular organization and in material relations, reactions, and interactions.

3.1. MOLECULES AND NORMATIVITY

In the recent article "How Molecules Became Signs", Terrence Deacon (2021) explains how a molecule like DNA could be used as a source of information about the relationships among other molecules. The idea is that the origin of information, as well as the centrality of interpretation, can be better understood if we turn to simple models. The most basic model in this sense of the history of the planet is precisely the process of the emergence of life and molecular organization. Deacon's intent

11 Swenson proposed the notion of an "autocatakinetics system" that is more environmentally oriented and in line with the laws of thermodynamics than Maturana and Varela's notion of "autopoiesis", which involves the organization of the living beings.

is to develop a minimal model to explore an information code at the origin of life.

Deacon's idea is to analyze the structure of a hypothetical virus, consisting of RNA or DNA molecules, that can replicate itself. Beyond the virus idea, in which we are not interested in this chapter, the author takes a study by Stuart Kauffman and colleagues (2008) to argue that the work that allows the release of energy in those early stages has few degrees of freedom[12]. At the same time, however, it takes constraints to determine degrees of freedom, and these degrees of freedom create the existence of constraints in a circular way. "[…] It takes constraints on the release of energy for work to happen, but work for the constraints themselves to come into existence" (Deacon 2021, 29). With the example of the virus, Deacon wants to show that it is the constraints themselves that allow information to circulate. Constraint determines both a degree of freedom and work and shows a basic pattern for understanding semiosis[13]. Indeed, semiosis must originate and end with iconism at these levels of (non)complexity.

> All semiosis must therefore originate from and terminate with iconism in this most generic sense. It marks the point where no more developed interpretant can be generated. Importantly, this treats iconism *not* as a feature of a sign vehicle but rather as a function of interpretive *in*-distinction. This again reiterates what in the introduction I proposed as the central dogma of semiotics: that semiotic properties are not identified with sign vehicle properties but rather with how these properties provide affordances for an agent's interpretive competence (Ivi, 11).

What he wants to do is to create a code that is based on a mapping established between the components of related elements, something similar to the code designated by Marcello Barbieri (2015) for DNA sequence.

Tom Froese (2022) has recently analyzed and critiqued Deacon's article starting with a general assumption with respect to the author's hypotheses:

> This return to the origin of life is a strategic move by Deacon, which serves the purpose of developing a minimal model of a possible physical implementation of what he calls, following the tradition of biosemiotics, the "interpretation" of sign vehicles. Deacon's approach aligns closely with the enactive approach to autopoiesis and adaptivity — living is sense-making at its core and from its very start (Ivi, 1).

The author shows how Deacon uses a narrow form of naturalism while not explaining the qualitative shift from a "non-normative" to a "normative" condition. The problem noted is how to create a model sensitive to a normativity that is not derived but intrinsic to the system. The question posed by Froese, and not resolved by Deacon, is: how did normativity originate in nature? According to Froese, the precondition is that the origin of life consists not only in an increase in the complexity of chemical organization but in the emergence of a biological normativity that performs a function on the planet.

However, neither of the authors notes that when one thinks of this initial activity, it is taken for granted that an inert form exists beforehand. But this shouldn't be taken for granted at all, and it would be questionable if before any activity of self-repair and reproduction there was absolute staticity. In fact, one of the hypotheses to be inserted between the two articles is to imagine an *immanent dormant elasticity* of the constituent elements. One would have to speculatively assume that matter could be endowed with a type of *intrinsic agency that is activated the moment it can find spaces of freedom or composition*[14]. In short, a type of dormant significance that waits for its sign to reveal itself (like von Uexküll's tick that waits for the mammal's butyric acid and then activates).

It is the idea of "rupture"[15] as a response that can lead us to rethink the meaning of the emerging world in our hypothesis. Any material object is determined and constituted by radical instability (according to varying degrees). And "instability" is what might characterize *matter as an active agent*. In other words, at the moment there is an energy and a force that maintains the stability of an object, where there is a certain kind of entropy, matter can be understood as active. Such activity holds in its origin a virtual sign that is dormant until it comes to light. These virtual signs (Deely 2001) emerge only when they find a correspondence, in a kind of "natural co-evolutionary affordance". This is a differential topology based on correspondence.

4. SEMIOTIC CORRESPONDENCES

Through a semiotic analysis of matter, Giorgio Prodi (2021 [1977]) has indicated a new plane of interpretation of correspondences between natural elements. For there to be a specific fit between material objects, according to him, there needs to be a code within which two objects can "interlock". There are things that fit together better than others because they are useful for maintaining their structure, while others intersect in a random

12 The question of freedom will serve us to introduce the idea that if there is freedom, there is selectivity.

13 Although it has been pointed out that constraint on the physical and chemical level is not relevant for the process of semiosis. As is clear from our position, we do not agree with this statement. However, for lack of space we have to leave this statement aside. See (Zámečník, Krbec 2019).

14 An interesting theory approaching this point of view, concerning the emergence of semiotic freedom in the field of geology and physiosemiotics, was constructed by (Coletta 2016).

15 Reference is made to Pattee's "frozen accident" in (Kull, Pattee 2009).

and secondary way. Starting from Prodi's analysis, we can point to a new theoretical theorization based on correspondence:

1. There must be material objects interacting, i.e. coming into contact with each other. Physics shows that every material object is in reciprocal constitutive relationship with its surroundings.

2. Objects must be transformable by contact. Resistances in this sense must yield to the encounter, because if we imagine something that resists infinitely and independently from the surroundings, we're making bad metaphysics. Everything is concatenated.

3. Change occurs if the two objects correspond to each other. As we have mentioned, more things correspond, in a primary way for the maintenance of their own structure, and in a secondary way, as the use of an encounter to form an event of complementarity.

4. The specificity of correspondence is found in space, in adaptation, through an interlocking or "key condition".

Correspondence, from the semiotic point of view, is a mutual conformation of the objects that meet. This correspondence leads to a kind of "order" of the structure that manifests itself in the encounter. "The 'meaning' resides precisely in this process: from an indefinite causality to an ordered situation, interpretable also in terms of the theory of information and of the theory of communication. It is matter of a 'channeling' of the semantic entities into the definite pathway of the syntactic rules" (Prodi 2010, 331). What emerges is independent of the terms that composed it, because it is unstable and it is in the process of being formed. The instability given by the encounter is due to a simple fact: there are some things that fit together, while for others this is not naturally possible (for example, water and oil do not mix due to their polarity).

In this regard, Prodi states that in order to verify a science of signs it is necessary to eliminate every linguistic perspective and every intentional premise. For this reason, *correspondence, understood as a selection of material interlocking, can also be read as a semiotic process*. In an open debate with Umberto Eco, Prodi stated that the condition of elementary sign is a *dual* (and not triadic) physical state whereby a structure has a meaning in relation to another structure to the extent that it selectively interferes with it (Prodi 1976). While for Eco, there is a lower threshold below which semiosis processes do not occur, only a concatenation of stimuli and blind responses. According to Eco, moreover, the notion of interlocking belongs to a blind chain of complementarity, like a child's construction game (Eco 1976)[16]. He speaks of the genetic code as a metaphor to describe a process of action and reaction, stimulus, and response.

However, the debate between Eco and Prodi is difficult to resolve because they start from very different premises (Cimatti 2019). In our proposal, we choose to follow the path traced by Prodi because it is more closely related to our working hypothesis. The latter argues that the elements of two systems in contact display an unpredictable "disposition to meet". It is a matter of understanding the form as a kind of "complementarity towards" the object. In this way, relationships of choices, selections, siftings are established between objects that expel or accommodate complementarities. In other words, the correlations, the joints, but also the reactions are not taken for granted but emerge in a field of unlimited possibilities since they are always physically indeterminate objectively and a priori. There is no transcendent or immanent law that necessarily prescribes that everything that has reacted in one way will react in the same way at a given time. The elementary sign condition is a physical state whereby one structure is significant with respect to another structure insofar as it interferes with it selectively (Prodi 1976, 70).

Prodi illuminates the research with several elements of signification in the context of natural physical chaining. A thing is never an impersonal sign for any reader, but it is a sign for a determinate structure insofar as this has adapted itself to him in evolution. The sign therefore has these two characteristics: to be a thing (a material state, a possibility of interference, a process, a section of the world), that is, to have a physical presence in reality, and to be a sign for a structure. There cannot be an objective and absolute sign but only a readable sign, and this reading is particular. The relationship between the thing as material presence and the thing as sign is therefore only this: that the thing is such that in certain respects it can be deciphered as a sign by a structure. Both (*thing-sign* and *thing-structure*) are material presences in the sphere of the world, and one is formed on the other and interferes with the other. It follows that the "quality" by which a thing is known to an interpreter is nothing other than being a sign for it (Prodi 1976, 71).

16 "In *Kant and the Platypus*, Umberto Eco defines the concept of 'primary iconism' in explicit reference to Prodi, mentioning the semiotic domain of complementarity— 'the icon is the natural willingness of something to correspond to something else'—and finds in it the ground for 'superior cultural phenomena'. […] . However, Eco does not seem to have moved on from his previous stance (as, e.g. in Eco 1976) since he still sets this dyadic iconism apart from 'triadic processes of interpretation'. Conversely, the radicality of Prodi's proposal lies precisely in its questioning of such a separation, considering all semiotic phenomena intrinsically dyadic (reducible to chains of dyadic links)" (Cimatti 2018, note 2).

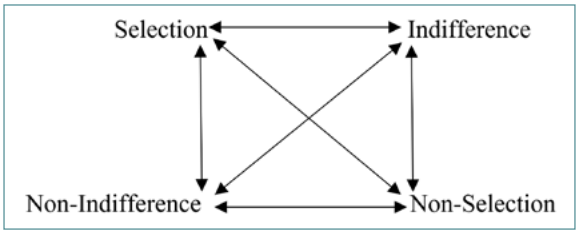
4.1. SELECTIVITY BETWEEN PHYSICS AND METAPHOR

On this planet nothing is passive, everything is caught within an incessant and constant movement. Bruno Latour (2015, 150) also gives an example to understand the extent of non-human agency. He says: if A modifies B, C, D, and X for the benefit of its survival, it is equally true that B, C, D, and X modify A in turn. Let's consider, for example, the action of decomposition of inorganic matter by fungi. They take energy from the oxidation of inorganic materials. Fungi associated with photosynthetic partners are very important for the biosphere. They improve plant nutrition through the solubilization of essential metals and phosphate from soil minerals. In fact, there are not only processes of decomposition of inorganic materials[17], but also of composition in a chain of meanings.

The relationship between the thing as material presence and the thing as sign is that the thing is such because *it can be deciphered as a sign by a structure in some respect or capacity*. That is, there is an interpretive contact that gives the possibility of entering into a reciprocal relationship. There is no reason to think that, if this is the basic material situation, it changes qualitatively with the complication of the biological level. In other words, semiosis as a material relation made of correspondences, joints and selection helps us to understand the *origin of semiosis not as a gap but as a continuity*[18], a process, an evolution, a constant translation (Lotman 1985). In the theory of evolution, in fact, there are no ontological and qualitative leaps, but rather diversification and emergence of complexity. Setting thresholds to indicate separation and not crossing them hinders the understanding of the origin of semiosis, setting the debate on a merely arbitrary and biocentric perspective (Nöth 2000). As Prodi already argued in his 1976 article: "There could be complications and interdependences such and so obscure as to force a simplification of the issue into existence through the assumption of qualitative jumps, but that which we cover when we move from a progressive seriation of complexity and interdependencies to the admission of radically different types of contact with the real is only our ignorance" (Ivi, 72)[19].

For Prodi, there is a sort of "feeling the complementarity". Complementarity fulfills functions of recognition. This idea was brought into the semiotic debate through an essential metaphorical narrative. Umberto Eco (2018, 348) knew this well. "Yet Prodi's problem was exactly that of the dynamic of such a process of waste and choice, absolutely blind, in which, however, some situations, brute in themselves, are established at a certain point as optimal for something that is able to recognize them, or "read" them as preferential". However, Prodi understood that in every physical relationship one of the terms "feels" whether the adaptation and interlocking can or cannot happen.

If the terms of the encounter are not very complex, this may be less apparent. For example, many encounters do not belong to the stage of interlocking because they are indifferent to the other term. Indifference is the other side of the selection. It is a material condition.



For this reason, we can say that everything that exists in the environment belongs to an activity of reading and selection. When things are not indifferent to us then there is a material process of *semiotic selection*, which is a process of selection, reading and interpretation of the surroundings. Re-reading on the contrary von Uexküll (1913, 68), who distinguished inanimate matter from the organism by the possession of a functional plane, we can hypothesize that: every inanimate mass possesses a functional plane, i.e., *all its individual parts are coordinated in such a way that its performances correlates with each other in a programmed way so as to allow an overall performance*. From this selectivity a semiotic correspondence of interpretation is established. But already before the selection there is at the basis a material reading of a virtual sign (Deely 2001). Here we use "reading" in the way Prodi uses it. To put it in Eco's words, which are very strong but also correct:

> Undoubtedly, "reading" is a metaphor, and it is a metaphor to say that "the world is made of things that become signs for the suitable readers (for the categories able to read it)" (Prodi 1988, 41). But Prodi's issue was not to say that in those cases something like our "reading" by cultured individuals would occur: his problem was the question whether, by any chance, our ability to read would already be foreshadowed in that blind dialogue that happened between things. Prodi's problem was not finding signs in nature but identifying nature

17 Biomineralization is the process mediated by microorganisms that leads to the formation of different minerals (calcite, vaterite, fluorite, kaolinite, etc.). The formation of different forms of minerals, however, depends on the composition and structure of the substrate with which the bacteria interact. Studying the role of fungi in biomineralization, it was discovered that fungi deposit minerals with the help of an organic matrix, such as a protein, which provides a nucleation site for the growth of biominerals (Gadd 2021).

18 The same perspective on continuity, in an attempt to overcome all dualism, is also offered by Peirce's *synechism*.

19 Translated into the article (Eco 2018).

as the prehistory of the sign: going back in time and in phylogenesis and asking about the emergence of the sign as a natural fact. Therefore, Prodi's problem was a quest for finding the elementary sign, those processes that certainly are not yet signs, but that are presented as the beginning of a dynamic of interpretation, as the dawn of thirdness not yet emerged, but already prefigured (Eco 2018, 348).

4.2. ITERATION VS. TELEOLOGISM

Offering a theory of complementarity at the physical and emergent level, giving an account of complexity theories, we immediately realize that transformations of indifferent things into signs can arise from repeated attempts at interlocking. If we think that inorganic matter gave rise to organic life through simple chemical elements, we can think of matter as something teleologically oriented, *but not necessarily*. We can think of it as a very long iteration of interlocking attempts that occur *randomly*. Only when, after many attempts, more inorganic elements fit together and stabilize, they produce advantages[20].

The initial random composition, determined by the repeated combination of failed attempts, produce mechanisms of differentiation, complicating a possible linear reading, widening the reading space, increasing the entities that become signs. In order not to reiterate the fallacious compositions, every complementarity needs a selection of favorable results. As in the case of Lovelock's Gaia theory, the description that appears in finalistic terms is only chosen metaphorically and linguistically. In fact, all the processes described are the product of trial and errors, of random variations and successful assortments. It is a kind of "open evolvability". In his theory, Lovelock makes it clear that the planet and its components are interconnected in a balanced, but not teleological way. Correspondence is the key that opens the door to the possibility of combination. Without the correspondence determined by the qualities of matter, as a constraint already given at the beginning, no work of combination is possible.

Combination and correspondences lead to a certain order of things that fit according to a complex planning that is both contextual and interpretive. The structural configuration achieved through trial and error and selection cannot initially be separated from reiteration over large numbers. When a sufficient degree of stability and order emerges, a certain type of selective directionality[21] activated through increasingly complex instruments also emerges[22]; an effect of the composition of simple elements that had been independent so far.

> Thus *displaced affordance* (in which the information-bearing medium is segregated from the constrained dynamical medium) is made possible by the way that coupled *isomorphic* (*similarity*) and *correlative* (*contiguous*) affordances can mediate the displacement of constraints from one physical substrate to another. This provides a bridge that maintains continuity of information despite discontinuity of substrate. Since this change in substrate provides new isomorphic and correlational affordances, interpretive processes that take advantage of these properties simultaneously reinterpret the lower order interpretive processes. This enables what can be described as *interpretive recursion*, making it possible to evolve level upon level of interpretive complexity (Deacon 2021, 19).

4.3. COMPENETRATION AND STRATIFICATION

To conclude, we propose below some terms constructing reading loaves to interrogate physiosemiotic processes and which lead us to open up biosemiotic research to an understanding of the mixture of organic and inorganic matter, life and non-life. This is intended as a theoretical proposal towards a semiotic theorization of inanimate matter. The first term, concerning organic matter, we can define it through the notion of *existential compenetration*. For inorganic matter, on the other hand, we propose the notion of *existential stratification*. Their relationship will be a *stratified compenetration of Lyfe*.

1. Existential compenetration is the result of compenetration between different materials. This process

20 We use this argument in order to get rid of the problem of teleologism, i.e., of having to orientate the event as a predetermined aim.

21 Reference is made to the "problem of chirality". Organic molecules can be formed in a levorotatory or dextrorotatory form. However, after the emergence of life all the amino acids of life have organized themselves in a levorotatory way, while all sugars are dextrorotatory. The question is about the emergence of these directed forms in the primordial soup. In other words, there seems to have been some sort of organizational selection of inorganic matter from certain organic elements.

22 As Kauffman (1993, 285) stated: "In the theory of origin life, it is not necessary any molecule reproduce itself. Rather, a collection of molecules has the property that the last step in the formation of each molecule is catalyzed by some molecule in the system. The phase transition occurs when some critical complexity level of molecular diversity is surpassed. At that critical level, the ratio of reactions among the polymers to the number of polymers in the system passes a critical value, and a connected web of catalyzed reactions linking the polymers arises and spans the molecular species in the system. This web constitutes the crystallization of catalytic closure such that the system of polymers becomes collectively self-reproducing. […] Life began whole and integrated, not disconnected and disorganized".

is due to a life-growing activity around and within things. The interpenetration is never just active or passive but it indicates how the two terms (among which one is necessarily organic) allow the interpenetration and modify each other. Furthermore, the process is a physical phenomenon that is determined by the energy expressed by life on a homogeneous or heterogeneous element. The effect of this growth is that of penetration, mutual interfusion. Existential compenetration can be grasped as a factor that is not exclusively physical, since it can also occur on an emotional and mental level as a deep participation between complex systems. An empathic action by a mammal toward an animal, a plant, or an object (e.g., a puppet), as well as the curb-breaking action by plant life, participate in the notion of existential compenetration. The latter underlies an activity of *mixture*.[23]

2. Existential stratification refers to the process of stratification of inorganic matter. The notion emphasizes the horizontality of the process that expresses a sedimentation and accumulation of material phenomena. As in the process of composition and decomposition of inorganic matter. In stratification the process is not linear but it is directed by a process of selectivity: correspondence, complementarity, contact, impact "significant for". Stratification occurs with a relationship of structural superposition according to certain criteria. By structure we mean a material state interpreted by another material state. Inorganic and organic matter can activate a stratigraphic relationship when there is a slow accumulation of remains of organisms that fix mineral salts in their skeletons or shells. Stratification also includes the composition of the molecular structure of matter, that is, the way atoms are aggregated together, determining their properties. Suffice it to say that diamond and graphite, both formed only from carbon, i.e., with the same chemical composition[24], have opposite properties. It is an activity of grouping and *layering*.[25]

3. "Lyfe" is a term coined by Stuart Bartlett and Michael Wong (2020). With this concept, the two authors seek to expand the concept of life according to novel structures that we fail to recognize due to a narrow definition of what life is and what is not. The term is very technical about the definition of new categories derived from chemical processes capable of including a wider variety of life forms. However, the notion claims a change not only structural in the field of life and non-life, but also cultural about the existential continuity that living beings have with the matter that surrounds them. In this sense, the stratified compenetration certainly stands on a base of horizontal plateaus, but it can grow in verticality and in an ongoing process of interpenetration from one layer to another. The present notion then leads us to think of the emergence of life from inorganic

23 This beech shows how a smaller branch and a thicker one, after constant attachment, have interpenetrated each other, probably to compensate for energy expenditure. (Photo by author)

24 Their difference depends on the fact that graphite has carbon atoms arranged in hexagonal meshes in planes linked by weak forces, whereas diamond has a compact structure with intense attractive forces between the atoms. In addition, their properties depend on the environment in which they are formed: graphite originates at shallow depths where temperature and pressure are low; diamond forms at great depths under very high temperatures and pressures. In all cases, this is polymorphism.

25 These photos represent the layering that has taken place between shells, corals, and stones colonized by algae. Stratification is the mixing and correspondence of heterogeneous elements across time. (Photo by the author)

matter as a transversal process without division, but only thresholds of contact and continuity from one state to another. Any state implies four notions that the authors define as fundamental features that stand on the relationality of matter: dissipation, autocatalysis, homeostasis, and learning. With these four activities, an attempt was made to generalize the concept of life as a process among things. The activity of stratified compenetration of Lyfe privileges *continuity*, *recycling*, and *complementarity* as mutual reading and interpretation.

Being in the world means, for a human as for a stone, first of all, to be captured by a relationship of mutual complementarity. Every existence is an interaction, every influence is a compenetration. Moreover, since the relationship can only occur between heterogeneous objects, the Earth itself is nothing but an object that is composed through a constant stratified compenetration of its elements. Thus *Gaia is a semiosphere* not centered in the bios, but in the semiotic composition of its constituent parts.

CONCLUSION

In conclusion, we started from the advances of biosemiotics in understanding plant life within its field of study, challenging the idea that semiosis requires mind and intentionality. Complexity theories integrated with biosemiotics have led to the study of whole ecosystems and their parts as a composition of semiotic actors that bring forth new meanings. The problem of determining what life is and what is not, and the problem of understanding the biosphere as a complex system, has led us to interpret inorganic matter into a possible semiogenesis. This resulted from the fact that we are trying to step away from what is called "mechanism" as a point of view that interprets inorganic matter as an essentially empty gear. Going to the root of the problem, we have addressed the origin of life and semiosis along a threshold that is very blurred. This threshold, perhaps undecidable, has led us to contemplate a matter that is inherently semiotic as a working hypothesis. We have used physiosemiotics to read the mixture between organic and inorganic, trying to blur the edges more and more.

The research proposal, which is still in its germinal stage, is to rethink semiogenesis as a process coming from inanimate matter in an endless continuity. The Gaia hypothesis can be useful for a different approach to the vision of the planet as a dead body composed of inanimate rocks, oceans, and atmosphere. In the sketched proposal, semiotics should be a geological, chemical, *earthling semiotics* in a broad sense. And biosemiotics should open its field of study also to the inorganic, detaching itself from a certain biocentrism that is not part of a real systemic theory. If this speculative research brings results, semiotics will succeed in interpreting the laws of nature in a new approach. This new approach not only broadens the thresholds of semiotics, but also seeks to redefine the very notion of life itself more broadly, recognizing in physical organization a process that carries with it unpredictable natural meanings.

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