

Xenosemiotics. Toward an Alienist Materialism

Original study

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Abstract: Intended as a branch of synthetic biology, xenobiology aims to design and build non-standard life forms, that is to constructively venture into biological otherness. According to this creative and speculative character, it challenges the principles of synthetic biology itself, which is tied to a fundamentally reductionist approach. Xenobiology does not treat life as a closed code, but rather as a field of ontological innovation; in this sense, it evokes a biosemiotic paradigm that accounts for sense-making and non-anthropomorphic interactions.

Xenobiology, however, can also be intended as the “divergent” and most speculative part of astrobiology, namely as a theory of contact with extra-terrestrial life. According to this second meaning, it searches for and speculates on alien biologies. Building on these two meanings, the paper aims to outline a semiotic theory of otherness, or ‘xenosemiotics’, that shifts the focus from communication to morphogenetic information.

Keywords: Biosemiotics, Xenobiology, Speculative biology, Synthetic biology, Astrobiology.

I. XENOBIOLGY: DESIGNING BIOLOGICAL OTHERNESS

I begin by defining xenobiology (from now on ‘XB’) as a discipline that designs and aspires to fabricate life forms that are biologically different from the ones we know. According to this first definition, XB constitutes itself as a branch of synthetic biology. Since the birth of modern biology, life sciences have contemplated the idea of a shift from a descriptive to a prescriptive kind of action, which would lead to harnessing and manipulating nature at its core instead of simply studying its phenomena. In the past few decades, the dream of artificially interpreting life’s constraints has paved the way to ever more precise models of how life works, but it has also allowed the recreation of life’s fundamental elements: engineered chemical compounds, molecules (and especially DNA molecules), cells, tissues, even entire microorganisms (Endy 2005; Cameron et al. 2014). “At the end there awaits artificial life” (Schmidt et al. 2018, 302). During the first decade of our century, the rapid advances in synthetic biology came with great and sometimes disproportionate hopes around its future

applications. In spite of that, the new-born discipline is still quite rudimentary in its approach.

Although it deals with nothing less than life itself, synthetic biology is generally dominated by a reductionist approach. As an essentially engineering and computational discipline, it proceeds by discretization and modularization, making deliberate and programmatic use of operational abstractions that drastically reduce complexity (Nicholson 2012, 2013, 2014; Boudry, Pigiucci 2013). In short, the only way for synthetic biology to extract models from life is by denying its processual continuity. Moreover, this approach is often implemented for strictly practical purposes instead of evolving as an open and free process of research. The engineering of life, which is thus reduced to mere biomatter (Catts, Zurr 2014, 29), has presumably very high costs in terms of knowledge and effectivity; the fact that such approach holds only a heuristic value (Holm 2015) does not change the impression that a different conception could bear much richer fruits.

Within this framework, XB appears as a weird and highly speculative endeavour. While synthetic biology aims to discretize life in order to reproduce and assemble the parts, XB aspires to redesign life's component on a biochemical level and to ultimately shape biological systems based on different biochemistries (Kubyskhin, Budisa 2017; Budisa et al. 2020). XB, hence, does not dispute the approach of synthetic biology, but rather perverts it. To build life forms upon different materials and relations means to start conceiving of life not just as it is, but as it could be, thus going along with life's own power of divergence and creativity. By abandoning the model of earthly life, xenobiologists displace the goal of biological synthesis and radically broaden its perspective – not in the methods, but in the principle. Nowadays, XB can integrate unnatural or extra-terrestrial amino acids into the proteome, create new synthetic pathways, expand the genetic alphabet by adding novel nucleotides to the nucleic acids or creating nucleic acids with different sugar backbones (Schmidt et al. 2018). All this leads to the construction of a new DNA, the XNA (Chaput, Herdewijn 2019), and to significant alterations of the flow of genetic information¹. By aiming to create the new, XB hints at a different conception of life as a plastic and processual domain rather than as a fixed and therefore exploitable set of phenomena.

Through the replacement of life's fundamental components, XB shows that life is not defined by certain materials (or contents), but rather by certain relations (or forms). For now, XB's attempts are focused on making new materials fit into known relations; but even so, the ultimate result could show unforeseeable new properties. This conclusion leads to a productive abstraction of our concept of life, enabling us speculate on what life could be. It does not prove, however, that the relations of which life is made can be isolated, discretized, and codified. The fact is that different materials evoke different relations and different contents entail different forms. Life is characterized by a fundamental sensitivity to contingency within the constraints, which produces unpredictability on both an ontogenetic and a phylogenetic level. The constancy of relations as the contents vary is far from proving the existence of universal biological laws: it just proves that life is extremely plastic. The most profound and relevant message of XB, then, is that biosynthesis should explore life's possibilities rather than mechanically reproduce its apparent results. The only general rule should be life's constant striving towards otherness.

The horizon of XB is the creation of complete xenolife, genetically but not ontologically separated from natural life (a goal which basically has already been accomplished: see e.g., Marliere et al. 2011; Hoesl et al. 2015; Csibra et al. 2020). It is now not hard to imagine entire organisms, taxonomies, and ecosystems endowed with artificial xenolife. But what would an organism built on different chemical bases ever be? The answer is that probably we would not even recognize it (Ferrari 2021, 45–46). Even knowing the materials and having designed their initial interactions, the expression of their combinations might result in something so unfamiliar that we would not perceive nor conceive it as a life form if not specifically trained. More importantly, xenolife forms could develop different ways to elaborate, transmit, and express their fundamental (e.g., genetic) components. Their behaviour could differ at a fundamental level. Given certain basic conditions, life works with what it has, but has also different results according to different materials. By underlining the *materiality* of life's creativity, we state that life is not made of abstract relations but of concrete processes. Therefore, life should not be conceived of on the traditional model of the genetic code, as a pure meta-language that can be analysed in its discrete components and reconstructed. Synthetic biology too must be freed from the deterministic overtones of the metaphor of the code (Atlan 1999). XB has the power to challenge such assumptions exactly because it shifts the focus from replication to creation and from exploitation to free speculation.

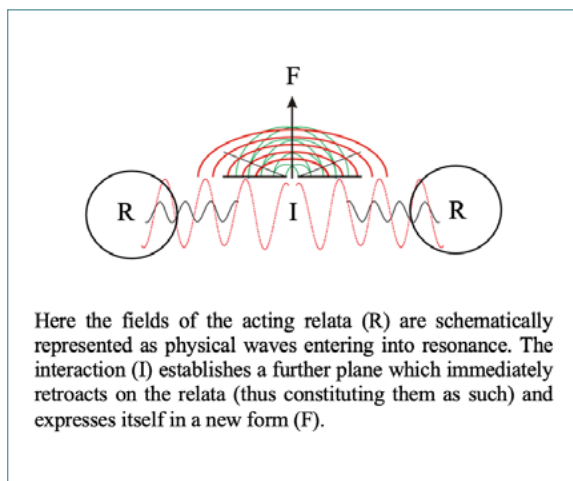
One way to clarify this shift is to accept the metaphor of life as a language or as a code and see what happens if we stop projecting anthropomorphic notions onto life's innermost functioning. Let us tackle these assumptions, then, from a biosemiotic point of view. Biosemiotics is prone to admit that life is made of informative relations, but the notion of information is often subsumed into the idea of sign-based communication (Queiroz et al. 2011). One common instrument for such operation is Peirce's semiotics (El-Hani et al. 2008; Marcos 2011). In a Peircean framework, a sign makes a code virtually possible as a discretized element of information (even though it does not necessarily imply the presence of a code) and relates to a "quasi-mind" that interprets it (even though it does not require the presence of a human interpreter). However formal, a Peircean biosemiotics lies on anthropomorphic assumptions because it looks for codes and interpreters where there aren't any².

1 In particular, a "conversion of the whole flow of genetic information" (Schmidt et al. 2018, 305) is necessitated by the different chemistries of xeno-organisms. In other words, novel chemistries entail novel, unexpected ways of conveying and elaborating information from DNA to RNA to proteins. In this sense Nieto-Dominguez and Nikel (2020, 2556) talk of "neo-metabolisms" as sets of "(novel) biochemical reactions and routes purposely assembled to integrate substrates, intermediates, products and chemical reactions unprecedented (or very rare) in Nature". This last definition includes the XNA. First described by Herdewijn and Marliere (2009), XNA can be defined as a DNA with redesigned constituents: Herdewijn and Marliere, for example, envisioned nucleic acid polymers with different sugar backbones from the natural deoxyribose and ribose sugars that constitute DNA and RNA.

2 Although Peirce tries to avoid anthropomorphic fallacies, his semiotic theory lies (inevitably, one could say)

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In order to apply its logic to nature, the Peircean model needs to be specified in a non-anthropomorphic sense. Let us take the paradigm offered by French philosopher Gilbert Simondon. Simondon (2017, 2020) describes information as the systematization and materialization of a difference between acting entities. In an informative act, two entities in general (for instance two oscillators) establish a field of differential resonance, also defined as a plane of analogy, which determines the spontaneous occurrence of a novel configuration – where ‘novel’ means unforeseeable in its concrete features, but also reminiscent of the original constraints. The result of the interaction is not a sign, but a real form, which exists independently from any recipient. The interaction itself does not consist in an abstract mediation, but is concretely morphogenetic. The semiotic event is made of material contacts (which represent its ‘quantitative’ aspect), the reconstruction of patterns (its ‘qualitative’ aspect), and the activation of affective gradients and thresholds (its ‘intensive’ aspect), but does not entail anything that ‘stands for’ something else. The relata are not the referents of the resulting form: they rather transform into it. The form, hence, does not explicate, develop, or recapitulate the relata on a logical level, since it is the concrete creation that stems from a concrete difference.



From a semiotic viewpoint, we are still dealing with a triadic relation: there is a morphogenetic interaction (I), which connects at least two interacting relata (R) and results in a form (F) that embodies it. The first term (I) is not a semiotic entity (i.e., a discrete and potentially codifiable semiotic element), but a semiotic event (i.e., a dynamic and non-codifiable semiotic element), which replaces Peirce’s notion of Sign. The interaction is not much like a “complementariness” as Prodi (2021, 36) describes it, i.e., as an “interlocking, or key-and-keyhole condition” (an image tainted by physicalist overtones): it is rather a process of analogy by resonance, a differential interlacement. The second term (R) replaces Peirce’s concept of Object. The relata are always two or more individuals that partake in the process. Ontologically, they do not precede the interaction, which is always the primary term: this means that they are what they are only within the interaction that determines them. The third term (F) replaces Peirce’s notion of Interpretant and refers to the expression of the process. Here we can follow Prodi (2021, 37) when he talks of “the formation of a metastable complex between the two terms”: the interaction triggers the formation of a system within the same informative process. The form is the *expression* of the interaction rather than its product. This means that there is ontological correspondence and partial overlapping between I and F: the form’s thirdness is only apparent. In fact, the interpretant (F) is the sign (I). In a hypothetical I-R-F (Interaction-Relata-Form) model, the epistemological side is brought back to the ontological level: there are no signs nor interpretants in absence of human (or human-like) minds, only material interactions and their resulting systems.

Our conclusion that ‘the interpretant is the sign’ (rather than a sign) derives directly from the concept of expression, in which *exprimendum* and expression coincide (Montanari 2015). This point is confirmed by genomic information. Analysing the semiotic dynamics of DNA, one must conclude that the cell does not ‘read’, ‘explain’ or ‘interpret’ the gene, nor is it determined by it: it rather constitutes its ontological expression and the expressive

on anthropomorphic assumptions. In Peircean philosophy, reality is not simply reduced to human semiosis, but depends on it; the inverse, however, is also true (Eco 2000, 2014, 524ff.). According to Eco’s interpretation, for example, this relationship is explained as a potency-act relationship: reality *per se* remains in potency, and human semiosis and cognition have the power to actualize it (Eco 2014, 525). For a Thomist like Eco, the act is the very sense of the potency; thus, human cognition is intended here as the sense of reality. Anthropomorphism, then, is the implicit axiology that makes reality dependent to logics, while only the opposite is true. Another difficult point of Peirce’s conception is the concept of “quasi-mind” (CP 4:551, SS 195). The quasi-mind is not included in the Peircean triad but is, in a sense, the formal guarantor of the whole process. Despite Peirce’s efforts to devoid it of psychological meaning, the quasi-mind basically does what a human mind does. That quasi-minds can also be found “in the work of bees, of crystals, and throughout the purely physical world” (CP 4:551) sounds a merely supplementary observation: something that *acts* as a mind is still needed in the semiotic relationship. Extending the qualities of the human mind to all reality (by saying, for example, that even crystals ‘think’ and exchange signs) is a suggestive, yet insufficient move. A non-anthropomorphic attempt, instead, would start from the assumption that reality does not behave like the human spirit or mind: if something like a reflexive and dialogic determination can be found in nature, it must be taken as a primary fact without giving any kind of priority to the human model.

environment of its transformations³. The cell as a form (F) stems from and as a theatre of relations (I) between the relata (R), i.e., the molecules and their interactions, configurations, and associated biochemical networks. The genes are among the relation's terms, but the "difference which makes a difference", to use Bateson's words (1972, 453), occurs elsewhere, in the system of their resonance. The gain of this view would be a pragmatic understanding of the genome as a set of performing materials rather than as an abstract program separated from the conditions of its realization.

According to the understanding of information as an expressive ontological process, there is no message separated from its effects. In the communication of genetic information, for example, the DNA's directives are not elaborated on an abstract level and then applied (as it is with verbally communicated instructions), they are rather immediately performed. What "makes the difference" are the material contingencies given in the relational environment, which include DNA's folding paths and transformations, chromatin structures, spatial organization at the nuclear level, etc. All the interactions between the relata are of material nature, because they do not need operations of abstraction (which would require some kind of 'mind'). The relata are constituted by their relational environment, which in turn ensures the possibility for them to communicate and simultaneously results from their very interaction. Every communication, regardless of what kind of contact it entails, builds an additional entity, an 'interpreting' system if you will, which however belongs ontologically to the semiotic environment and constitutes a transformation of it.

The I-R-F perspective can also be applied to life on the mesoscopic scale: for every biological population, there is a web of ecological interactions between more or less autonomous relata (the individual elements of a territory) from which other forms emerge, be them behavioural patterns, ecological structures, or other individual entities. This emergence includes not only intra-species variation and inheritance, but also inter-species relations such as symbiosis. In any case, what interests me here is the implications of such semiotic paradigm. Being centred on morphogenetic interactions rather than signifying entities, the I-R-F model describes ontological processes, and is therefore particularly suited to explain the phenomena of life. The I-R-F model is non-humanistic, as it replaces the ambiguous concepts of 'interpretant', 'interpretation', and 'communication' with the notions of form, formation, and material interaction; and it is non-biocentric, as it does not give any a priori privilege to natural over artificial life.

Finally, by focussing on formation rather than interpretation, the I-R-F model provides an open-ended scheme of life's inherent creativity. It is no coincidence,

then, that our reflection started from XB. XB is creative, as it aspires to create new forms of life; it is non-humanistic, as it speculatively overlooks the immediate needs of industry and market; and it is of course non-biocentric, as it deals with artificial life. However far from drawing radical conclusions from its own practice, XB carries on the idea of taking life's power of divergence in itself and systematically venturing in the unknown. In this sense, it directly inspires a non-anthropomorphic biosemiotics based on sense-making and on the priority of formation over meaning.

II. SYNTHESIS, RECOGNITION, TRANSCODING

By designing the impossible and attempting to create the unimaginable, XB does not seek to understand or make a point about a present phenomenon, but looks straight into the abyss of life's creativity. As has been mentioned, life – much like some aspects of human culture – escapes the question on 'what is it' in favour of that on 'how does it present itself'. It follows that a speculation about life must be at least in some way heuristic and divergent, ready to look for ever new forms without a binding definition. Here a more classical semiotic question comes to the fore, the question of recognition: how to look for something that we might not know nor understand? Generally, the physico-chemical and morphological features shared by all livings ensure a fundamental plane of communication between them, so that life as we know can be associated to certain eidetic properties or experiential patterns. When Bateson showed his students a cooked crab and asked them to describe the difference between a living and a nonliving thing, he expected acts of recognition of homological patterns based on a sort of primal empathy (Bateson 1979, 7ff.). When something lives, it shows: life is self-evident.

Of course, these mechanisms can be tricked and played with, as in the famous leitmotiv of the artifact that comes alive (from E.T.A. Hoffmann's tale *The Sandman* to the uncanny valley hypothesis). The automaton, however, is only a borderline case of life's power to recognize and be recognized. XB presents us with a different idea: if built on different bases and emerged from different conditions, life could take forms so different from the ones we know that our attempts to recognize them as alive would fail. Synthetic biology does not have to deal with this issue just yet; but the possible breakdown of fundamental communication patterns is a much more relevant problem for other disciplines, such as exo- and astrobiology. Exo- and astrobiology study the possibility of extraterrestrial life. Life on other planets would be by definition a form of xenolife, namely a foreign, exotic, non-standard life. Until its development as a branch of synthetic biology, XB was in fact the same as astrobiology (Heinlein, Wooster 1961; for

3 One may argue that for Peirce the Interpretant is indeed the productive systematization of the Sign rather than its subsumption into a pre-existing system through equivalence or abstraction, which could lead to what we can call a performative understanding of language.

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the slight semantic distinctions between the terms, see also Wicaksono, Cristy 2021). Thus understood, XB is still a speculative discipline, but apparently not a creative one, as it remains centered on recognition rather than synthesis.

When they search for occurrences of life as we know it, instead of imagining life as it could be, exo- and astrobiology offer examples of convergent rather than divergent speculations. Recognizing extra-terrestrial life when encountered, however, is not a foregone result. Our cognitive biases may prevent us from noticing any life form that diverges from life-as-we-know-it. It follows that, if they want to overcome this unconscious bio-chauvinism (Sagan 1973, 41–50), exo- and astrobiology must engage in speculations upon life as it could be, for example, if it were based on different amino acids, or on exotic liquids, or on silicon rather than carbon, or if it adapted to radically different physical conditions (Dupont 2022). There might even exist organisms that invented different ways of harvesting energy (Schulze-Makuch, Irwin 2018, 65–88). The possibilities are not infinite, but surely exceed the efforts of our imagination.

The problem at stake, then, is not so much of recognition as it is of *transcoding*. For every form xenolife might take, an act of radical translation needs to be carried out in the absence of a meta-code. Communication must be invented, not just performed. Sci-fi literature is full of speculations about alien languages and the semiotics of first extra-terrestrial contacts. Of course, everything is much simpler in the presence of intelligent life; but on a more fundamental level, the alien remains a “hyperphenomenon” and a primordial source of wild alterity that requires an “originary heterology” (Waldenfels 2011, 35–36). Any possible contact with it is already a semiotic event and implies the creation of a common ground of sense, however fragile and provisional. Before constituting itself in a proper meta-language, the form resulting from the interaction can be a new perceptive habit, an emotion, a nightmarish or entrancing image; even sci-fi literature could be considered as a product of an (imaginary) encounter with alien alterity. When our faculties come into resonance with xenolife, the shock – if not excessive – triggers the emergence of a form from the relation.

Following Greimas (1970, 14), I define transcoding as the very act of sense-making. Signification does not tend to and does not come from a “white universe” of meaning, that is a meta-language capable of describing reality from the outside: it is rather something that occurs inside reality itself as the process of its differences, a process that can never really end. We can now go back to the I-R-F hypothesis and state that transcoding, not recognition, is a suited category for I. The generative interaction between relata is always, in a general sense, an alien contact and a first encounter. What results from it (F) is not primarily a common language, but a sign of life, a primary element of communication. We can use the astrobiological notion of “biosignature” (Cavalazzi, Westall 2019) to designate this basic semiotic ground that stems from a sense-making operation. In our view,

a biosignature does not simply correspond to certain characteristics of one term that needs to be recognized (for example, an extra-terrestrial entity that shows biotic traits), but rather to the genetic result of a – at least in principle – symmetric interaction in which two different domains of meaning are put into communication. The ‘signature’ of xenolife is not identifiable in advance, because it always stems from a contingent interaction between particular codes or systems: it is in this sense a proper signature, an idiosyncratic sign. In conclusion, transcoding has much more to do with synthesis (namely with creative construction) than with recognition.

As for the relata, they can be described as two different regimes of signification that exist *as such* in the semiotic event without one imposing itself on the other. Within the interaction, they coexist and coevolve, renouncing logical or ontological priority. They are not bound by a logical relationship (like contradiction or subsumption), nor do they result in a logical synthesis: they rather enter each other’s effectual or existential space and trigger a progressively unstable system, expressing a new metastable form. This result requires a condition of *symmetry* between relata. Among the most general phenomena of life, let us take for example the non-equilibrium interlacement between individual and environment, which is at the base of every energy coupling. An alien encounter could entail the contact between individuals coming from different environments, but also between some individuals and an alien environment, a cohesive set of alien agentive elements like a planet. Intended as interacting relata, individual and environment are symmetric in the sense that they are integrated and ontologically codependent; symmetry here means differential integration rather than logical specularity. Only integration is productive of specific transcoding solutions.

By basing our view on the I-R-F model, we can gain a more comprehensive understanding of alien contact as a primitive semiotic event. We are often tempted to imagine the alien encounter as the meeting of two foreign delegations trying to establish a diplomatic dialogue, a common rational ground, a meta-code for their differences. A first encounter, however, would most likely result in an appearance, a sighting, a finding of the unknown, hence an immediate generation of meaning. The exchange of signs is indeed one of the most anthropomorphic scenes of all. The sign’s fundamental affinity with the human mind goes against the very meaning of the alien, which is a radical alterity that does not bear abstract mediation, only contingent encounters. Communications with the alien are not made through signs, they are always concrete interactions and contacts.

Even in the case of contacts with intelligent xenolife, what tells to us that our semiotic categories (sign-object-interpretant, content and form...) would apply? What if a semiotics of contagion took over, like in the *Alien* saga? If for example some intelligent aliens received the messages we scattered across the universe, like the famous Pioneer plaque, would they be able to recognize

them as artifacted messages, hence as signs of other intelligent actants (Chiurazzi 2021, 24–25)? Our artifacts might be too primitive for them: had their civilization already reached a “postbiological” condition (Dick 2020), the self-evident distinction between an artifact (which is made) and a natural entity (which is born) would have become meaningless for them.

III. MANIFESTO OF XENOSEMIOTICS

I have tried to define XB in relation to biosynthesis and alien semiosis intended as two different examples of dealing with biological information. Both cases – the creation of postbiological xenolife forms and the contact with extra-terrestrial xenolife forms – relate to a common semiotic model that emphasizes sense-making over recognition and interpretation. The model I have suggested sketches the foundations of a semiotic theory of biological otherness, a xenobiosemiotics, which in turn alludes to an even more general *xenosemiotics*. Xenosemiotics (from now on ‘XS’) is of course an open category, a conceptual label that hopefully can inspire more detailed researches and stimulate further reflections, but also connect with already existing theories and approaches (such as Shank 2021).

I shall now summarize its fundamental characters in the form of a manifesto.

1. XS is a process-oriented, non-humanistic nor bio-centric semiotics that accounts for sense-making. In this regard, it entails non-anthropocentric biosemiotics, as well as divergent speculations on natural and artificial biologies, AL and AI.

2. XS is an alienist semiotics that accounts for the encounter with otherness. In this more traditionally semiotic sense, it entails reflections on first contacts and life-as-it-could-be, as well as on the search for life in the universe.

3. XS focuses on material (i.e., concrete) interactions that constitute its own terms and materialize into a new resulting form. The form is not a sign, but the ‘ontological interpretant’ (i.e., the expressive result) of a transcoding process. In general, nothing ‘stands for’ something else, and every mediation is concrete.

4. XS replaces communication with morphogenetic information, signs with material interactions, interpretants with generated forms, codes with sense-making events.

The advantage of this whole operation is that it allows to conceive signs as non-discrete, non-codifiable relational dynamics, and exchanges of signs as transformative processes occurring between anonymous elements that do not necessarily correspond to minds. Still, these processes are semiotic events because they are communication and information, even without being language in a narrow sense. If this sort of ‘hyper-semiotics’ goes beyond the scope of semiotics, then semioticians should not take life as their subject and limit themselves to the study of the human world. Otherwise, they should be prepared to speculate and make strange encounters.

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