

Autopoiesis and enaction: conceptual landscapes in Francisco Varela

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ABSTRACT: This academic essay uses the notion of “conceptual landscape” (Andrade, 2019) as an analytical-epistemological key to contextualize and highlight the intellectual legacy of the Chilean neurobiologist Francisco Varela (1946–2001). The central aim is to investigate Varela's formative-experiential path and his contribution to the construction of the concepts of autopoiesis and enaction, understood here as conceptual landscapes according to the theoretical framework adopted (Andrade, 2019; 2026). The methodology is essayistic and qualitative in nature, structured in three interconnected parts corresponding to a triple temporality: retrospective, constitutive, and prospective. The results show that Varela's intellectual trajectory — marked by his training in Chile, his self-exile in the United States, and his consolidation in Paris — was fundamental to the creation of autopoiesis, which defines life as a process of circular self-creation, and of enaction, which conceives cognition as an embodied and emergent action, overcoming the subject-object dualism and the representationist paradigm. The concluding remarks, presented as a coda, point to the complementarity between the two conceptual landscapes, which, when juxtaposed, reveal layers of reality that would otherwise remain opaque in isolation, offering a heuristic toolkit for analyzing contemporary phenomena such as artificial intelligence and autism, and reaffirming the inseparability of living, knowing, and doing.

Keywords: conceptual landscape; enaction; autopoiesis; education; Artificial Intelligence.

1 INTRODUCTION

The notion of conceptual landscape (Andrade, 2019) is used here as an analytical-epistemological key to contextualize and highlight the intellectual legacy of the Chilean neurobiologist Francisco Varela (1946–2001).

The conceptual landscape, as defined, is a:

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“Term, or linguistic expression, capable of naming, representing, creating, appreciating, and communicating an object of thought for the very subject who expresses it, or for an interlocutor, meaning for both the object itself, or the process by which this object was created, identified, described, named, classified, and appreciated, as a synthesis, along the constructive path of knowledge (Andrade, 2019, p. 184).”

Exploring the heuristic of the metaphor "knowledge is a path", also formulated by Andrade (2018), and its intrinsic relationship with the conceptual landscape, we decided to investigate Francisco Varela's formative-experiential path and his epistemological contribution to the construction of the concepts of autopoiesis (Maturana, Varela, 1980; 2001) and enaction (Varela et al., 1992), which, in our view, are inscribed as conceptual landscapes according to the theoretical framework adopted here (Andrade, 2019; Andrade, 2026).

As highlighted by Andrade (2026), the conceptual landscape emerges as a reflective pause along the constructive path of knowledge. When it emerges, it enables an attentive, analytical, and expanded gaze, in a triple temporality: toward the past, revealing the path taken to reach the epistemological position where the author stands (retrospective); toward the present, exploring the phenomenal and explanatory plots relating to the objects of knowledge observed and analyzed (structural-constitutive); and toward future possibilities (prospective), unveiling countless possibilities, new questions, and new approaches for subsequent steps — its heuristic.

Thus, with this triple gaze — retrospective, constitutive, and prospective — this essay is divided into three interconnected parts, namely: 1) retrospective — the history of Francisco Varela's life and work, highlighting his main interlocutors in experimental research, his readings in the fields of philosophy and cybernetics, and, more importantly, his contribution to the creation of the conceptual landscapes announced here, autopoiesis and enaction; 2) constitutive, a description and analysis of the impact of Varela's work on various fields of knowledge such as cybernetics, immunology, psychology, education, and philosophy; and 3) prospective, exploring the heuristic of the conceptual landscapes formulated in partnership with Humberto Maturana (autopoiesis) and with Evan Thompson and Eleanor Rosch (enaction), regarding problems that are more intensely emerging today and that can be analyzed and interpreted through these conceptual landscapes, such as, for example, autism.

A distinguishing feature of this essay, which is also one of its objectives, is to show the steps, obstacles, and shortcuts of Francisco Varela's formative, experiential, and intellectual journey in constructing these conceptual landscapes: autopoiesis and enaction. For didactic purposes, we will divide the Retrospective into major historical-geographical periods,

beginning with the formative years in Chile in the 1960s, the deepening and broadening of his academic interests in the United States in the mid-1970s, his return to Chile as a professor and researcher until 1973, and his move to Paris in the mid-1980s, where he remained until shortly before his death in 2001.

1.1 Retrospective: Part I — The Formative Years in Chile and the Construction of the Concept of Autopoiesis

Francisco Javier Varela García, or Francisco Varela, as he liked to sign his texts, was born in Chile in 1946. From adolescence he showed a vocation for intellectual work, completing high school in 1963 and subsequently dedicating himself to Medicine (Varela, 2000, p. 421) and Biological Sciences at the Catholic University of Chile, where he was an apprentice to Juan Vidal in his Cell Biology Laboratory (Varela, 2000, p. 422). In addition to his mentor Juan Vidal, he held academic conversations with Luis Izquierdo, Héctor Croxato, and, especially, Joaquín Luco, who awakened in him a passion for Neurobiology (Varela, 2000, p. 422).

In 1965, when Humberto Maturana went to teach at the newly created Faculty of Biological Sciences of the University of Chile, Juan Vidal himself encouraged Varela to go work with Maturana, who was already a renowned researcher. In April 1966, Varela visited Maturana and, when asked what aroused his interest, he answered without hesitation: "The psyche of the universe!" Maturana smiled, and that was the beginning of a great partnership (Varela, 2000, p. 422). Initially, Varela repeated some experiments that led him to investigate vision and perception more deeply — phenomena of great interest to Maturana, and which later became the subject of his doctoral thesis.

The scientific density and intellectual freedom experienced in Maturana's laboratory always attracted brilliant students, such as Letelier, Uribe, Mpodozis, and others, but Varela stood out as a collaborator, especially because he was, together with Maturana, co-creator of the concept of autopoiesis in the 1970s, which brought international recognition to both, extending to the country itself and its capital, referred to as the Santiago School by Fritjof Capra (2006).

An example of this intellectual richness and collaborative synergy was the contact between Francisco Varela and Gabriela Uribe, a physician with a clear epistemological inclination. They problematized the concept of information and representation for understanding the functioning of the nervous system and the behavior of the organism. It should be noted that Humberto Maturana had already reflected on this question since his work on

perception, using the frog as an experimental model (Lettvin et al., 1959), having even begun in the laboratory of the British neurobiologist John Zachary Young (1907–1997), his first advisor. Thus, for the participants of the laboratory in Chile, the concept of information was dispensable for explaining living systems, since, as was intensely discussed, the nervous system would itself be capable of generating its own conditions of self-reference. This general conception brought the Santiago School close to the "experimental epistemology," a term introduced into the literature by McCulloch (Varela, 2000, p. 426), although, as we will see later in this text, with a strongly representationist outlook.

From readings guided by Roberto Torretti at the Center for Humanistic Studies of the School of Engineering, Varela encountered European phenomenology, in authors such as Husserl, Heidegger, and Merleau-Ponty. Reading these authors inspired certain theoretical questions developed later, such as lived experience. Phenomenology was important in that initial context for refining his capacity to approach systemic biological questions with a philosophical bent. Varela was one of those chiefly responsible for connecting biology to phenomenology (Lavarello, 2025). As for his interest in mathematics, we would say it was more instrumental than purely theoretical, that is, mathematics was well used as a language, a way of thinking, and a way of simulating biological systems through automata (Varela, 2000, p. 425, 436).

Broadly speaking, we can affirm that the main theoretical contribution of the Santiago School was, without a doubt, the creation of the concept of autopoiesis, described here as a conceptual landscape. Briefly, we will present the concept and then discuss Francisco Varela's contribution to this construction.

As explained by Maturana himself, the concept of autopoiesis was built through a long reflection triggered by a Chilean student's question: what happened three and a half billion years ago that allows us to call something life? Or put another way: what kind of system is a living being? Or even more directly: what is life? (Maturana; Varela, 2003, p. 11). Recognizing the legitimacy of the question's essence, Maturana admitted that although he had prepared his whole academic life to answer that question, he felt incapable, since biology, at that moment, had no answer for its object — life. The classic answer of biology, at the time, and, we would say, still today, is a list of predicates that can be endless when we consider all of biodiversity. He did not like the list, even if synthetic in its predicates, such as being born, developing, reproducing, evolving, and dying. This approach did not satisfy Maturana, who, on that occasion, answered the student thus: come back next year, and I will dedicate myself to answering your question, and perhaps you will accept my explanation.

Thus, challenged by his student's inquiry, Maturana began a long reflection on what he should present as an explanation for that fundamental question (Maturana; Varela, 2000, p. 11). It was during this long reflective period that the collaborative work between the two authors, Maturana and Varela, began. At first, in a teacher-student relationship, but soon after, as collaborators. For Maturana, what was central to understanding living beings as systems was to refer to their condition as autonomous and relational beings, and therefore the great task of biology as a science would be to explain how both this individual operation of asserting autonomy and the relational phenomenology of the living with the environment arise. This relational phenomenology was soon understood by both authors as cognition — the organism's appropriate conduct in the face of the environment (Maturana; Varela, 2000, p. 14).

According to Varela, the concept of Autopoiesis was initially formulated in Maturana's text *Neurophysiology of Cognition* (Varela, 2000, p. 429), written in 1969 for an international meeting on this theme: "Cognition: A Multiple Approach" (Varela, 2000, p. 429). The text addresses the inadequacy of the concepts of information and representation for understanding biological systems, alluding to the self-referential nature of living beings. Some time later, Humberto Maturana updated the text and began calling it *Biology of Cognition* (Varela, 2000, p. 430).

But what was Varela's contribution to the construction of this concept? Varela describes himself as one of the direct authors of the joint creation of the concept of Autopoiesis, acting as the link connecting philosophical reflection to theoretical biology. With his knowledge of cell biology and computational models, he claimed to have participated in the discussions surrounding the 1969 essay (Varela, 2000, p. 429). It is worth noting that in the published text, Maturana mentions Heinz von Foerster and Francisco Varela.

"Whatever success I may have achieved in this endeavor, I owe to the enriching discussions I had with my friend Heinz von Foerster and my student Francisco Varela." (Maturana, 1969, p. 1)

While Maturana was working on the idea of the "closed" organization of the nervous system and the critique of the representationist paradigm, Varela brought to the debate the need to define the autonomy of the cellular process (Varela, 2000, p. 373). He questioned cellular "self-maintenance," a concept that seemed unclear to him within the molecular biology of the time. His contribution was to propose that the minimal organization of the living is a circular mechanism of identity constitution, in which chemical transformations and physical boundaries mutually define one another (Varela, 2000, p. 373). In May 1971, inspired by a conversation

with José María Bulnes about the Aristotelian distinction between praxis and poiesis, the term autopoiesis (self-creation or self-production) emerged to designate this organization (Varela, 2000, p. 431). According to Varela, the term autopoiesis figured in his notes, but the word only acquired power when associated with the content attributed to it — that is, its resonance went beyond the charm of the neologism itself (Maturana and Varela, 1997, p. 47).

Maturana emphasizes, however, that although Bulnes provided the philosophical basis, it was he who invented and proposed the word, presenting it to Varela the following day (Maturana, Varela, 1997, p. 18). What matters here is not who invented the word, but how the concept was worked out and refined by both authors in the following years. Varela developed what came to be called a minimal case of autopoiesis, consisting of a chemical scheme of two reactions: polymerization for membrane formation and the generation of metabolic units constituting the autopoietic organization (Varela, 2000, p. 432). In collaboration with Ricardo Uribe, he carried out computational model simulations called "Protobio." Varela demonstrated how these models were capable of engendering spontaneous emergences and self-repair of units that self-distinguish within the metadynamics (Varela, 2000, p. 437).

Although they did not use the term "autopoietic machine," the idea of an organized molecular machine was proposed in the early 1970s and expressed in the title of a classic of the period — "Of Machines and Living Beings" (Maturana; Varela, 1973).

Thus, autopoiesis was conceptually defined as:

"... a machine organized as a system of production processes of components linked in such a way that they produce components that: (1) generate the processes (relations) of production that produce them through their continuous interactions and transformations; and (2) constitute the machine as a unity in physical space" (Maturana; Varela, 1973, p. 69, our translation).

This definition, while enunciating a concept, also proposes an explanation for the phenomenology of the living. In other words, it is a concept because it creates an object in language. It is an explanation because it reformulates, in language, a generative mechanism that, once set in operation, generates the phenomenon it seeks to explain — namely, the living being. It is important to note that "the autopoietic unity does not arise in a vacuum, but in a world. It arises as a dynamic, autonomous, recursive unity, in structural coupling with the world, or worlds, understood here as niches, and its existence — organism-niche — is produced in its operation, in living, following both a natural drift (ontogeny) and a natural co-drift (phylogeny)" (Mpodozis, 2022).

For Maturana and Varela (1973), living systems are cognitive systems, and living, as a process, is a process of cognition. That is, knowing and living cannot be separated, insofar as knowing is an effective action that allows the living being to preserve its existence in the world that it itself brings forth by knowing it. It is in this sense that the act of perceiving constitutes the perceived, and that cognition is neither in the body nor in the world, since it arises from the organism-world relation, pointed out by the observer as an appropriate conduct in a context specified by the observer, or community of observers. We habitually think of interaction as a relationship between two formal domains, independent and pre-existing to their relation. Hence cognition is defined, by the traditional paradigm, as representation. The autopoietic organization of the living presents itself as a biology of knowing, which breaks with the representationist notion of cognition, since it is presented as an activity of co-engendering, of self and world, in one and the same generative act. It is this act par excellence of the living that reveals the indissociable character of living, doing, and knowing. That is, the internal modifications inherent to the system's structure enable the organism's forms of interaction with its environment, such that the environment with which it interacts does not pre-exist the organism that knows it. The act of knowing is thus the result of the continuous structural changes of the system that produce, in a double effect, the overall state of the cognitive system and the world correlated to it. Cognition is defined as a function of the interaction of the living with the world — that is, an appropriate conduct (Maturana, Varela, 2001).

1.2 Retrospective: Part II — Military Coup, Self-Exile, and the Search for Opportunities in the United States

Francisco Varela's academic journey in Salvador Allende's Chile — like that of many Latin American intellectuals — was interrupted by the military coup of September 11, 1973, led by General Augusto Pinochet, whose forces bombed and invaded La Moneda Palace. Surrounded, with the palace in flames, Allende delivered his final speech to the country and decided to take his own life (Padrós, 2005, p. 16).

In that scenario of terror, several intellectuals were detained, among them Humberto Maturana, for a brief period. As an intellectual connected to the Allende government, even though not formally affiliated with it, Varela saw his life at immediate risk. His residence and the Faculty of Sciences of the University of Chile were searched by military forces. Faced with this, he was forced to leave the country preventively and was subsequently compulsorily

dismissed from his academic post by decision of the military regime. Given the daily danger, he decided on self-exile in the United States, in search of new paths and opportunities.

In the United States, he furthered his academic training, earning his doctorate at Harvard University in 1970, and shortly thereafter was hired to teach and conduct research at New York University, remaining in the U.S. for about seven years. During this period he explored Buddhism, and later became co-founder of the Mind and Life Institute, with the support of the Dalai Lama.

In Immunology, he received support from Professor Nelson Monteiro Vaz, a Brazilian who at the time headed a unit for the study and treatment of asthma in Denver. When Varela arrived at Nelson Vaz's laboratory, he was not familiar with immunology, but he carried substantial intellectual grounding in systems biology. It was Varela who introduced Vaz to the notion of networks, and the intellectual context was favorable, since Jerne's "idiotypic network theory" had been published a few years earlier and represented a major theoretical advance. However, Varela argued that Jerne's network was incomplete because it lacked the notion of operational "closure," which he considered essential for describing all living systems. From this elaboration, and the short time they spent together, they published an important theoretical article entitled "Self and Nonsense" (Vaz and Varela, 1978). Upon his return to Brazil, Nelson Vaz organized, in 1982, a symposium during the meeting of the Brazilian Society for the Progress of Science (SBPC) in Campinas, where Varela, Maturana, and Antonio Coutinho met in person — an encounter that proved important for the future collaboration between Varela and Coutinho in Paris, France, in the mid-1980s (Andrade, 2021; Vaz, 2021).

1.3 Varela in Paris: The Immune System Integrated with the Cognition of the Organism

Francisco Varela's residential and institutional settling in Paris, from 1986 onward, inaugurated a period of prolific theoretical production in the field of immunology, made possible by a close collaboration with immunologist Antonio Coutinho at the Pasteur Institute. This partnership allowed the principles of autonomy and self-organization from the cellular domain to be transposed to the immune system, integrated with the cognition of the organism, challenging dogmas of traditional medical science (Vaz & Varela, 1978; Varela et al., 1988).

Classical immunology operates under the aegis of a military metaphor, centered on the defense of the organism against antigens. This is an isomorphic transposition of the dominant representationist bias, still present in cognitive neuroscience: antigens, external materials to the

organism, take on the role of informational stimuli (inputs), while the immune response is categorized as an "output," to neutralize this input, generally deleterious.

In contrast to this heteronomic model, the approach of Varela, Coutinho, and Vaz posits that the immune system is fundamentally a system endowed with operational closure, coupled to the organism. This self-referential dynamic is ensured by the reciprocal interactions between lymphocytes and the variable regions (V regions) of immunoglobulins, whose network connectivity confers and sustains the somatic identity of the multicellular organism (Vaz; Andrade, 2017).

Under the enactive lens, defensive capacity against infections is not defined as an ontology of the immune system. Thus, what is called defense emerges from network functioning, developed over the course of biological evolution. The functional core of the system lies in its constitutive activity of interiority, operating as an idiotypic network of continuous, endogenous communication. The immune system is ultimately configured as an important subsystem for the preservation of the molecular and cellular homeostasis of the organism, rather than as mere reactivity oriented against foreign particles from the external antigenic universe (Varela & Coutinho, 1991).

The translation of this epistemological shift into experimental models produced fissures in orthodox immunology. Research led by the Pasteur Institute group demonstrated that the immune system possesses a rich and complex temporal dynamic in the composition and expression of its immunoglobulins (Lundqvist et al., 1989). This systemic and global fluctuation proved to be a crucial analytical marker, allowing differentiation, through patterns of connectivity and tolerance, between the state of physiological homeostasis (normality) and the dynamic disorganization that characterizes autoimmune pathologies (Huetz et al., 1988; Varela et al., 1991).

2 THE CONCEPTUAL LANDSCAPE OF ENACTION: BETWEEN EASTERN PHILOSOPHY AND COGNITIVE SCIENCE

In the early 1980s, during one of his returns to Chile, Varela expanded the mathematical and topological approach to the calculus of self-reference and closed networks, integrating it into a fruitful dialogue with Eastern philosophical tradition, particularly Mahayana Buddhism (Lavarello, 2026). This approach provided the necessary grounding for the author to overcome the reductionist dualisms of classical Western science through three conceptual pillars

(Lavarello, 2026), namely: co-emergent causality, potential identities, and paratemporal space or epoché.

The first — co-emergent causality — arose as an opposition to the classical linear causality (cause and effect) derived from Aristotelian philosophy. Thus, the relationship between the living being and the environment was reframed and theorized as rhizomatic, as proposed by Deleuze and Guattari (1995) — that is, each phenomenon emerges from a multiplicity of determinants within networks of mutual and simultaneous influences.

The second, potential identities, was inspired by the notions of emptiness and impermanence. That is, identity (cellular or systemic) does not possess a fixed or centralized ontological substantiality. The self emerges from decentralized processes of coupling and multiple emergences, and is therefore a potential identity that actualizes itself on the occasion of action.

The third, paratemporal space (epoché), can be understood as a practical methodological tool, a moment of suspension of representationist judgments and preconceptions that enables the practicing subject to touch the vertex of experience at the very instant it emerges — the so-called paratemporal space — the moment at which knowledge and world constitutively emerge in the embodied process of living.

These pillars were complemented when a publisher asked Varela to write about recent advances in neuroscience so that people could read them during their commute on the Paris metro. Faced with this challenge, Varela wrote "fundamental insights" (Varela, 1999) which, in our view, complement what has been said above about enactive cognition:

The first point — Embodiment — affirms that the mind is not "in the head" and that cognition is not the processing of representations of a predetermined world. Instead, cognition is an embodied action, resulting from the practical and recurrent engagement of the organism with its environment. There is a mutual co-determination between the interior (organism) and the exterior (world), where the world is not something given but something brought forth through bodily activity — enaction.

The second point, Emergence, affirms that the mind is not an entity independent of the body, but rather the result of a co-determination between neural and sensorimotor elements and the overall cognitive subject. Varela argues that local processes arising from neuronal arrangements give rise to the whole (the mind), but the whole also delimits and determines its parts. Thus, the cognitive subject emerges from the network of interactions, not being reducible merely to its physical components.

The third point, Intersubjectivity, emphasizes that cognition is generatively enactive, occurring in the co-determination between "self" and "other." Varela suggests that we are born with the capacity to read the emotions and signals of other beings, and that the cognitive process is inherently social and situated, transcending the isolated individual.

The fourth point, Circularity, refers to the ontological co-determination between first-person and third-person descriptions. He proposes a constant dialogue and a mutual constraint between objective scientific analysis (third person) and the disciplined investigation of lived experience (first person). The goal is to create a "circulation" in which scientific knowledge and human experience mutually transform each other.

This theoretical reflection allowed Varela, in the early 1990s, to formulate a forceful critique of nascent connectionist and computational Artificial Intelligence (AI), a field in which one of the giants of cybernetics — Warren McCulloch — was found. It is worth expanding on this context, because this discussion is highly relevant to addressing representationism and the epistemological and political debates surrounding artificial intelligence and its consequences.

It was Warren McCulloch who proposed that neurons communicate through a propositional logic and that the mind would be the result of the material complexity of this same logic. With this, the science of the mind became a science of signs based on binary logic, with clearly defined units of perception and precise rules of formation and transformation for representing mental states. Aiming to overcome the gap between body and mind (matter and form) and the technical gap between man-made things and generated things, neural networks were also used as a foundation for the field of artificial intelligence. In his seminal work "A Logical Calculus of the Ideas Immanent in Nervous Activity," McCulloch and Pitts (1943) proposed a revolutionary approach for the time, one that still commits us today, by arguing that the functioning of the nervous system could be described in terms of a propositional logic, defining neurons as logic gates equivalent to those of digital computers. This proposition provided the theoretical basis for what would become classical representationism in cognitive science, in which neuronal activity is interpreted as symbol processing representing aspects of the external world (Abraham, 2016).

Seen this way, McCulloch's work was fundamental to the consolidation of the computer metaphor as an explanatory model for the mind, transforming neuronal biology into a system of symbolic manipulation governed by logical rules (input-output). This perspective, although it generated significant advances in artificial intelligence and computational neuroscience, established the representationist view of cognition, whereby knowledge came to be understood

as a faithful representation of an objective, pre-existing reality — fundamentally distinct from autopoiesis and enaction.

To counter McCulloch's representationist approach, the enactive theory proposed by Varela, Thompson, and Rosch (1992) emerged as a profound epistemological critique of the classical cognitivist model. While McCulloch conceived the neuron as a logical unit capable of processing representations through neural networks, enaction understands cognition as an embodied and emergent process, resulting from dynamic interactions between organism and environment, where knowledge is not a representation of an external world but the "emergence" of domains of meaning through organic activity (Baum; Kroeff, 2018). This dichotomy between the two approaches reflects a paradigmatic shift in cognitive science: from a "top-down" model, based on symbolic logic and computational processing, to a "bottom-up" model, which values embodiment, biological autonomy, and lived experience. This transition not only questions the fundamental assumptions of McCulloch's representationism but also repositions the role of the body, context, and the phenomenology of lived experience as constitutive elements of cognition. It can thus be said that Varela, Thompson, and Rosch (1992) proposed a significant break with the legacy of the cybernetic thought that McCulloch helped establish at the prestigious Macy Conferences (Oliveira, 2016).

Although artificial neural networks and learning algorithms sought to emulate the autonomy of living beings, Varela warned that such systems operated devoid of an authentic embodied experience, which for him is the core of knowledge. Organic autopoiesis, whether cellular or systemic, imposes a mode of existence and a production of meaning (sense-making) that no purely syntactic database would be capable of accommodating.

It is important to note that the perspectives of both Maturana and Varela belong to the field of the biology of cognition, taking as a basic axiom the inseparability of living, knowing, and doing. The premise of the rootedness of cognition in the living being as a whole means that the investigation of the biological foundations of knowledge does not stop at the nervous system. There is a cognitive dimension of the cell, insofar as it organizes itself as an autopoietic unity within whose absolute autonomy a reality and a world are defined. Every domain of interactions closed in its circular operation configures a reality for itself. From this perspective, the world as it appears to us is the result of alterations internal to the individual structure. Hence the formula: "continuous coincidence of our being, our doing, and our knowing" (Maturana and Varela, 2001, p. 67). Biologists discover in the circular causality of autopoiesis the secret of life. In doing so they reveal their affinity for the circular forms of creation, obsessively explored by the engraver Escher. There is an architecture of the living universe that the Dutch artist's

drawings express through the paradoxical force of the circle: a form that outlines itself. In his vast body of work, the Möbius strip, which shaped several of his engravings, allowed the paradox of artistic creation to be expressed visually: I create a world that is other in relation to myself, within myself. This question, which seemed to obsess the artist, is not far from the idea of "operational closure" that biologists identify in the living system. A one-sided band, twisted such that its outer side is a version of its inner face, seems to reflect the specificity of the living unity, which creates the world from folds of itself. In the 1986 book "The Tree of Knowledge", Maturana and Varela illustrate the text with Escher's engraving "Drawing Hands" (1948). In this drawing, we have a synthesis of the problem that runs through the artist's entire body of work. Here, the draftsman's hands draw themselves, definitively captured by the circularity of creation. Space engenders itself through an interior unfolding. It is not that there is a pre-established world that my mental image represents. On the contrary, the world is contemporaneous with the act of grasping it: "Every act of knowing brings forth a world" and "All doing is knowing, all knowing is doing" (Maturana and Varela, 2001, p. 68).

It is this thesis that Varela emphasizes in insisting on the idea of embodied mind. Merleau-Ponty's concept of the "lived body" (*corps propre*) sets the tone for his engagement with phenomenology. To say that the mind is a phenomenon inscribed in the body leads to important positions in the field of cognitivism, whether in overcoming the body/mind dualism or in affirming a materialist perspective that dismisses any pretension of grounding the spirit in a transcendent dimension. The idealism of Cartesian modernity gives way to a new empiricism reconciled with the ideas of spirit and creation. The fierce debate between Descartes and Hume — between the idealism of "innate ideas" combined with dualism (*res cogitans* and *res extensa*) of the French philosopher, and the empiricism of the "tabula rasa," a mind that derives from the sensible body according to the Scottish philosopher — gave way to the Kantian perspective that sought to reconcile modernity. Kant responds to Hume, thanking him for having awakened him from his dogmatic slumber. Yes, all knowledge comes with experience, but it does not come from experience, as is shown in the "Critique of Pure Reason". There are conditions of possibility of experience that cannot themselves be known. Kant called the domain of the conditions of possibility of knowledge transcendental. The transcendental subject grounds knowledge and has no empirical reality. Kant rejects, at the same time, the transcendent innatism of Cartesian philosophy and the environmentalism of the empiricist perspective. Knowledge has conditions of possibility that are a priori, universal, and inaccessible to scientific investigation.

It is within the thread of modern philosophy, capped off by Kant in the eighteenth century, that twentieth-century cognitive science made its wager, still oscillating between the competing traditions. Let us say that the two perspectives that organize computational cognitivism, from the second half of the twentieth century onward, defend contrasting models to explain the phenomenon of knowing: the hegemonic top-down perspective assumes that knowing is the result of innate information-processing programs (software) that organize the inputs of experience from the top down. The bottom-up perspective of connectionism, in turn, emphasizes learning, whereby cognition emerges from the bottom up — that is, cognitive rules result from experience. Descartes and Hume in dispute once again, whether affirming the transcendence of an innate thinking self, or refuting transcendence only to fall into the danger of the relativism of the contingencies of experience.

Defending the bodily inscription of the spirit reframes the debate by affirming both the distinction and the inseparability between mind and body, wagering on the force of action as the relational plane from which a knowing subject and a known world derive. Action, or doing, constitutes the transcendental plane that is the condition of possibility of knowing. Instantiated, therefore, in action, the transcendental is not separated from the empirical, thus arriving at the formulation of this epistemic ground that characterizes an important wager of contemporary thought, which Gilles Deleuze called "transcendental empiricism" in his testamentary text published in the journal "Philosophie", no. 47, September 1995: "Immanence: A Life".

To characterize the living system as a cybernetic machine defined by its functional properties, such as self-regulation, is insufficient if one admits that the specificity of the living is given by an autopoietic organization or by enaction. A servomechanism modifies its internal states through the feedback movement of information; however, one cannot say that it establishes a domain of interactions that constitutes its own components. Autonomy here is behavioral, not constitutional. On the other hand, the organization of a living organism makes it a history of interactions from which this autopoietic unity alters its structure through internal compensations. We speak of interactions, but by this we should not understand a simple interactionism. The relationship between the autopoietic unity and the environment is a type of interaction that should not be thought of as one between two independent terms. The notion of "structural coupling" defines the interactive domain as specific to an individuality — that is, as proper to the living system. Between the structure of the environment and that of a living entity there must be a compatibility or congruence that ensures that one acts upon the other as mutual sources of state changes. To say that between the living system and the environment there is a "structural congruence" is to affirm that modifications in one provoke modifications in the

other, provided the autopoiesis of the system is preserved. Strictly speaking, one should not speak of two levels of modification, but of a single one, since the "external" perturbations to the organism are merely the occasion for triggering a modification determined by the organism's own structure.

"Thus, we distinguish two structures that will be considered operationally independent of one another: the living being and the environment. Between them there is a necessary structural congruence (or the unity would disappear). In such structural congruence, a perturbation of the environment does not determine what will happen to the living being, since it is the latter's structure that defines what changes will occur in response. It is therefore not an instructive interaction, since it does not determine what its effects will be. That is why we use the expression to 'trigger' an effect. In this way we refer to the fact that the 'changes that result from the interaction between the living being and its environment are triggered by the perturbing agent but determined by the structure of the perturbed system. The same holds for the environment: the living being is a source of perturbations, not of instructions.'" (Maturana and Varela, 2001, p. 131).

Structural coupling thus presupposes a "parallel evolution" between organism and environment, as Deleuze and Guattari (Deleuze and Guattari, 1995, p. 19) used this expression, taken from Rémy Chauvin, to think through the crossed becoming between heterogeneous realities. Between organism and environment there is this effect of double capture, in which each term becomes a component of the other's interactive domain, finding therein the occasion for changes in its own structure. The model of the "sexual" or reproductive relationship between the wasp and the orchid (what botany calls pollination) demonstrates this "parallel evolution" of two beings that maintain their autopoietic autonomy despite being captured within each other's interactive domain. The becoming-wasp of the orchid or the becoming-orchid of the wasp are phenomena that the biology of autopoiesis and enaction render thinkable.

Should one wish to insist on taking cognition as an informational mechanism, this cybernetic structure must be defined as cast into natural drift, modifying its components and its processing rules, transforming its internal states and creating new ones from the interactions established. Organisms are not foreign to the world but form a unity with it, mutually determining each other and being what the interactions specify as possible realities. The wolf-children that Maturana and Varela evoke did not have before them a world that they represented as wild. They became wild in the relationship with that world, which for them was the wolf-world. Faced with a stimulus, the nervous system does not establish a representation, but triggers an internally determined modification. Is there, properly speaking, cognition here?

Does one not fall into a solipsism more than merely methodological by assuming the non-representational character of cognition? Maturana and Varela avoid this danger by maintaining a "clear logical accounting" that avoids the contradiction that might otherwise be pointed out in their theses. One strategy for escaping the contradiction is, according to these authors, to exit the organism/environment opposition. The two traditional solutions to the problem of cognition proposed opposite alternatives that the theories of autopoiesis and enaction seek to reconcile, remaining "on the razor's edge." While the behaviorist tradition in psychology built a theory of the determining role of the environment, without considering the existence of a structure of experience, computational cognitivism (top-down model AI), on the other hand, works with a notion of cognitive structure without taking into account the productive intervention of the environment. These two models — environment without structure, or structure without environment — have in common the fact that they start from the opposition between organism and environment, accepting the pre-existence of the terms of the cognitive relation. This is what Varela, allegorically, calls the chicken-and-egg problem.

The impasse this problem creates is defined by the way the question is posed: which comes first, the egg or the chicken? Resolving it involves less an attempt to answer the riddle than a displacement of the question, exposing the false problem it poses. Between the realist alternative — the world possesses an order that cognition apprehends (the chicken position) — and the idealist-constructivist alternative — cognition creates its own world (the egg position) — there is a "middle way" that affirms that "egg and chicken define each other, they are correlative" (Varela, 1989, p. 104). It would not be correct to say that cognition represents a world existing independently of it, since mental activity responds to internal alterations of the organism's structure, even if these perturbations were triggered by an environmental stimulus. But it is also too much to say that cognition invents reality from internal laws alone, since this neglects the relationship that the organism's interiority maintains with the domain of interactions established over the history of structural couplings. The fact that Maturana and Varela consider the triggering function of environmental stimuli does not bring them close to the ethological neo-Kantianism of someone like K. Lorenz. The middle way between the realist and idealist alternatives affirms the special relationship organisms maintain with the world — a relationship of construction, but also of risk. For what is defined as the reality of the world is guaranteed by an internal modification of the organism — what is exterior also being a form of interiority — without, however, being able to dispense with the interactions maintained with that reality, originally not yet constituted as a world.

The thinking of Maturana and Varela inspired a different way of thinking about AI — as an intelligence that is not limited to representation, but acts and transforms itself in the very act of knowing. Here we find a decisive impulse for thinking, in the face of contemporary challenges, about the effectiveness of generative AI. Many researchers have extended the application of enaction to other areas (social and technological) for the creation of enactive macro-social autopoietic units.

3 CODA: WHAT CAN BE OBSERVED THROUGH THE TWO CONCEPTUAL LANDSCAPES

Unlike a traditional conclusion, understood as a logical closure derived from what has been presented, or a set of general remarks presented as final considerations, we offer here, to close this essay, an invitation to the reader in the form of a coda: to contemplate the world through the two conceptual landscapes proposed here — autopoiesis and enaction. It is worth noting that these two landscapes, juxtaposed or superimposed, reveal layers that each, taken alone, would leave opaque to constructivist readers, since, as we know, what is seen, or can be seen, depends on the biology of the observer and their history and is, therefore, not an objective reality, but, above all, a way of seeing. Considering that this invitation also applies to the authors themselves, upon rereading the text several times, we will point out distinctions, consonances, and dissonances between what has been presented and what we see at the very moment we write this text to be submitted to a journal for publication. Thus, we are aware that what we see today may be modified and refined in the future, based on further readings and networks of conversation maintained with our students.

From this perspective, we would like to begin by emphasizing that the two vantage points from which the two conceptual landscapes emerge are close to one another and arise from the same epistemological matrix, and therefore what can be seen from one or the other may seem, at first glance, distinct, familiar, or complementary.

That said, we will briefly explain what we are now able to announce and articulate as comments, imagining ourselves atop the two vantage points, attentively observing through one conceptual landscape or the other.

Through the autopoietic landscape, we observe recursive vital processes, carried out by operationally closed molecular networks (autopoietic units), self-creative, structurally coupled to the environment, in natural drift and co-drift, exhibiting appropriate conduct in relation to

their surroundings, niche, or environment — conduct that, from our observer's viewpoint, we generically call cognition.

Through the enactive landscape, we observe bodies in action, whose sensorimotor structure brings forth a world of meaning inseparable from their actions. Each movement carves out relevancies, and each relevancy guides new movements — and it is this recursivity that we describe as cognition, that is, a fabric of meanings shared between bodies, historically and recursively co-determined. The mind also emerges as a commentary on the "experi-livings" of these bodies, which feel their own relevancies, anticipate possible trajectories, and modulate their actions from a situated point of view, conferring subjective qualities, prospective memories, and the capacity to be surprised by their respective enacted worlds.

Broadly speaking, commenting on the two landscapes as meta-observers, we can say that the relationship between them is one of complementarity. While the autopoietic landscape answers the question "what is life and how does it sustain itself, in structural coupling with its environment," the enactive landscape answers how cognition and the mind itself emerge from embodied and co-determined actions. Both reject internalist representation and subject-object dualism, placing the observer within the very domain of the description. A good metaphor for understanding this is Escher's picture "Print Gallery", in which the young man observing what can be seen is himself included within the picture. Thus, both the observer standing at the autopoietic vantage point and the one at the enactive vantage point, observing the two respective conceptual landscapes — autopoietic and enactive — are, in both cases, autopoietic-enactive systems capable of distinguishing other autopoietic-enactive systems within the recursions of language. For both landscapes, subjectivity is not interiority but the domain of interactions in which each unit preserves its active identity in the face of environmental perturbations, and objectivity is placed in brackets (*epoché*), since it does not point to a single, transcendent, objective reality, but rather to one among many possible configurations, arising from the different histories of coupling and networks of conversation among observers who, by being observers, are not to be confused with the environment observed.

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