Porous Epistemic Frontiers: An Ontology of Transdisciplinary Research and the Constitution of the Knowledge in the Age of Complexity

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Summary

The increasing complexity of contemporary epistemic challenges demands an ontological reconceptualization of disciplinary boundaries as porous structures that allow the emergence of innovative forms of knowledge. This article develops a philosophy of transdisciplinary research based on Husserl's phenomenology, Heidegger's ontology of being-in-the-world, and Morin's complex epistemology. It is argued that "porous epistemic boundaries" constitute liminal spaces where scientific intersubjectivity generates new modalities of being-knowing that transcend the limitations of modern disciplinary rationality. Through a phenomenological-hermeneutical analysis of paradigmatic cases, it is demonstrated that disruptive innovation emerges from the dialectical synthesis between apparently incommensurable horizons of understanding. A new ontology of scientific knowledge based on relationality, emergence and complexity is proposed as foundations for a post-disciplinary epistemology that responds to the crisis of modern instrumental rationality.

Keywords: *epistemology, ontology, transdisciplinarity, complexity, phenomenology, hermeneutics, being-knowing, epistemic frontiers, post-disciplinary rationality.*

1. The Fundamental Problem: The Crisis of Disciplinary Rationality

The epistemic architecture of modernity, heir to the Cartesian project of mathesis *universalis* (Klein, 1990), was built on the fundamental premise of the separability and reducibility of knowledge. This ontological configuration, which Heidegger (1927) called the "epoch of the image of the world" (*Weltbild*), has been

scientific Dasein *has been structured for centuries* through disciplinary fragmentation. However, the emergence of increasingly complex phenomena — from the climate crisis to the techno-social transformations of the digital age (National Research Council, 2015) — reveals the inherent limitations of this instrumental rationality and demands a radical reconceptualization of the modalities of being-knowing.

This essay is articulated around a fundamental question: How can contemporary philosophy of science think about the conditions of possibility of an epistemology that transcends disciplinary boundaries without falling into epistemic relativism? This interrogation necessarily leads us to the examination of what we will call "porous epistemic frontiers"—liminal spaces where scientific intersubjectivity generates new modalities of knowledge that exceed the determinations of classical disciplinary rationality.

Our analysis is based on a critical synthesis between the Husserlian phenomenology of *Lebenswelt* (world of life), Heidegger's existential analytic of *Sein-in-der-Welt* (being-in-the-world), and the epistemology of complexity developed by Edgar Morin. This three-dimensional perspective allows us to approach transdisciplinarity (Nicolescu, 2010) not as a mere methodological strategy, but as a fundamental ontological

transformation in the very constitution of scientific knowledge.

The central thesis that we will argue is that the "porous epistemic borders" constitute phenomenological spaces where a new modality of *being-knowing* unfolds that transcends the subject/object dichotomy characteristic of modern rationality. In these liminal spaces, disruptive innovation emerges not as a product of the mechanical application of methods, but as a result of the *creative synthesis* between seemingly incommensurable horizons of understanding, generating what Gadamer (1975) called "*horizontverschmelzung*".

2. Phenomenological Foundations of Porous Epistemic Boundaries

To understand the ontological nature of porous epistemic boundaries, we must start from the Husserlian phenomenological reduction that allows us to access the *Lebenswelt*—the world of life as the ultimate horizon of any constitution of meaning. Husserl (1976) teaches us that consciousness is always *consciousness-of-something*, structured by intentionality that transcends the subject/object dichotomy. In the
In the context of transdisciplinary research, this means that scientific knowledge is not a specular representation of an "objective" reality, but an *intersubjective constitution* of horizons of meaning that emerge from the encounter between different disciplinary "natural attitudes".

Heidegger's existential analysis of *Dasein* provides us with the conceptual tools to understand how disciplinary boundaries are originally constituted as modalities of *being-in-the-world*. Scientific *Dasein* does not exist as an isolated substance, but as *Mitsein* (being-with) that unfolds in the *Zuhandenheit* (being-at-hand) of conceptual and methodological instruments. The disciplines, from this perspective, are not ontologically separate entities, but *modes of unconcealment* (*Alétheia*) that reveal specific aspects of the being in its totality.

The porosity of epistemic boundaries must be understood, following Merleau-Ponty (1945), as the *intercorporeality* of scientific knowledge. Just as bodily perception transcends the limits of the individual body to become the *chair* (flesh) of the world, scientific knowledge is constituted in the *epistemic intercorporeality* that allows the dialogue between different ways of *being-knowing*. This intercorporeality is not a mere external aggregation of perspectives, but the transcendental condition that makes possible the emergence of new configurations of meaning.

Edgar Morin (2005) offers us the conceptual framework for thinking about *complexity* as the organizing principle of this new epistemology. Complexity is not simply "complication"—a multiplicity of elements—but *complexus*: that which is woven together, woven into a network of interdependencies that cannot be reduced to its components. Porous epistemic boundaries constitute, in this sense, *complex spaces* where the principles of distinction, conjunction and disjunction operate simultaneously, generating *emergences* that transcend the determinations of their constituent elements.

3. The Dialectic of Emergence: Paradigmatic Cases of Transdisciplinary Synthesis

The history of science offers us paradigmatic examples of how porous epistemic boundaries generate ontological emergences that radically transform our understanding of the world. These cases should not be read simply as "applications" of pre-existing knowledge, but as *events* in the sense of
Heideggerian: events that open up new possibilities of *being-in-the-world* and reconfigure the horizon of the thinkable.

The development of CRISPR-Cas9 is an exemplary case of transdisciplinary synthesis (Doudna & Charpentier, 2014). Initial phenomenological observation of bacterial defense systems by microbiologists revealed an ontological structure that classical microbiology could not fully grasp. It was necessary to *merge horizons* between microbiology, biochemistry, genetic engineering and bioinformatics for a new modality of being-technician to emerge: the ability to edit the genome with molecular precision. From Simondon's (2007) perspective, CRISPR represents a *technical individuation* that transcends disciplinary determinations to constitute a new *technical milieu* where life and technology co-constitute each other.

The application of Einstein's Theory of Relativity to the Global Positioning System (GPS) illustrates how truth (in the Heideggerian sense of *Alétheia*) is unconcealed at the intersection between the most abstract theoretical physics and the most everyday technique. Without relativistic correction, satellite atomic clocks would accumulate significant errors, rendering the system inoperative (Ashby, 2003). This example reveals that the dichotomy between "pure theory" and "technical application" is ontologically untenable: technique is not a mere instrumentalization of theory, but a specific modality of the *unconcealment of being* that co-originates new existential possibilities.

The case of astronomical image processing applied to medical mammography (Starck & Murtagh, 2006) allows us to think of *epistemic transfer* not as a mechanical transfer of methods, but as *transduction* in the Simondon sense: an operation that creates new information structures by establishing correspondences

between apparently heterogeneous domains. The "same" technique of noise filtering unfolds different ontological potentialities according to the phenomenal field in which it is inscribed: in astronomy, it reveals the structure of the cosmos; in medicine, it saves human lives. This ontological multiplicity of the technical shows that disciplinary boundaries are historically contingent constructions that conceal the fundamental unity of human experience of the world.

4. Ontology of Relationality: Facilitators and Obstacles to the Porous Epistemic Constitution

The ontological analysis of the conditions that enable or hinder the emergence of porous epistemic boundaries necessarily leads us to examine the constitutive relationality of scientific *Dasein*. Following Heidegger's analysis, scientific knowledge is not a property of isolated subjects, but a modality of the *In-der-Welt-sein* that always unfolds already in the *Geworfenheit* (thrown condition) of specific institutional, technological and cultural structures.

4.1. Ontological Facilitators: Bridging Languages and Meeting Spaces

"Bridge languages" such as Artificial Intelligence, Machine Learning and Big Data analysis (Kitchin, 2014) are not mere instrumental tools, but *technical mediations* that reconfigure the transcendental conditions of scientific knowledge. In phenomenological terms, these technologies operate as *passive syntheses* that pre-structure the field of appearance of scientific objects, allowing researchers from different disciplines to inhabit a *common world* of shared meanings. AI, from this perspective, does not "solve" disciplinary problems, but opens up new horizons of *co-understanding* that transcend the limitations of specific disciplinary "natural attitudes".

Design Thinking and human-centered approaches (Brown, 2009) are specific modalities of what Gadamer (1975) called *application* (*Anwendung*): the creative updating of understanding in concrete situations. By placing lived experience at the center of the research process, these approaches operate a *phenomenological reduction* that suspends disciplinary presuppositions to access the *Lebenswelt* as the ultimate horizon of meaning. This reduction is not methodological but ontological: it reveals that scientific knowledge finds its ultimate foundation in the pre-theoretical experience of *being-with-others-in-the-world*.

The physical and virtual spaces of convergence—interdisciplinary laboratories, collaborative platforms, academic events (Olson & Olson, 2000)—are not mere "containers" of scientific activity, but what Heidegger called *Räumlichkeit*: existential spatialities that structure the possibilities of encounter (*Begegnung*) between different modes of *being-knowledge*. These spaces operate as *clearings* (*Lichtung*) where authentic scientific *coexistence* (*Mitdasein*) can unfold, transcending the instrumental logic of strategic collaboration towards genuine forms of *epistemic* solicitude (Fürsorge).

4.2. Ontological Obstacles: The Fall into the Disciplinary Self-Impersonal

Institutional silos and rigid academic structures (Aboelela et al., 2017) are not simply "organizational problems," but manifestations of what Heidegger (1977) termed the *Verfallenheit* (fall) of *Dasein* into *the (*se-impersonal) Man. The traditional disciplinary organization represents a specific modality of the *se-dice* (*Gerede*) that normalizes and domesticates the most radical possibilities of knowledge, reducing them to the reproduction of pre-established knowledge. This fall into disciplinary everyday life obstructs access to the *Eigentlichkeit* (authenticity) of *being-knowing*, keeping scientific *Dasein* in the *Uneigentlichkeit* (inauthenticity) of the mere repetition of methodological protocols.

Evaluation metrics and academic career systems operate as specific modalities of *Zuhandenheit* (being-at-hand) that instrumentalize scientific existence, reducing it to the logic of the *Vorhanden* (being-present-before-the-eyes) of manipulable objects. This ontology of presence obstructs the understanding of science as an existential *praxis* that engages the totality of *being-in-the-world*. Publications, citations, and impact indexes become fetishes that conceal the fundamentally *relational* and *temporal* dimension of authentic scientific knowledge, generating cognitive biases that limit epistemic openness (Tversky & Kahneman, 1974).

The terminological and epistemological differences between disciplines (Repko & Szostak, 2017) are not accidental obstacles, but manifestations of what Gadamer called the *historicity* (*Geschichtlichkeit*) constitutive of all understanding. Each discipline carries with it a *specific tradition* (*Überlieferung*) that pre-configures the horizon of the comprehensible. The challenge is not to eliminate these differences—which would be ontologically impossible—but to generate the hermeneutical conditions that allow for authentic *conversation* (*Gespräch*) between traditions, that is, the dialogue that transforms the interlocutors in the very process of mutual understanding.

5. Towards a Post-disciplinary Epistemology: Implications for the Contemporary Philosophy of Science

The constitution of a post-disciplinary epistemology requires a radical transformation in the ontological foundations of the philosophy of science
contemporary. This transformation cannot be limited to methodological or institutional reforms, but demands a *destruction*—in the Heideggerian sense of *Destruktion*—of the metaphysical presuppositions that sustain modern disciplinary rationality. It is a matter of critically dismantling the conceptual sedimentations that hide the most original possibilities of human *being-knowing*.

Post-disciplinary epistemology must be based on what Merleau-Ponty (1964) called *indirect ontology*: a thought that recognizes the primacy of the *relationship* over related terms, of the *between* over the poles it connects. From this perspective, disciplines are not substantial entities that subsequently enter into relationship, but *provisional crystallizations* of more fundamental epistemic flows that cross and constitute them. Scientific knowledge is thus revealed as a *dynamic field* of *differentiation* and *synthesis* that operates according to the logic of *chiasm*: the reversible intertwining between different modes of *being-knowledge*.

Scientific policy must be oriented towards the creation of *devices* – in the Foucauldian sense – that facilitate the emergence of epistemic events. This implies the design of financing structures that privilege *ontological experimentation* over the reproduction of established knowledge, the creation of institutional spaces that operate as *laboratories of difference*, and the development of new forms of evaluation that recognize the specific temporality of the processes of *individuation* epistemic. Scientific excellence must be redefined not in terms of quantifiable productivity, but as the ability to generate ontologically significant differences in the field of knowledge.

Academic training requires a pedagogical transformation that Simondon (2005) would have characterized as a passage from *education* to *technical culture* (Pohl et al., 2017). It is a matter of cultivating in researchers an *ontological sensitivity* that allows them to perceive the *tensions*, *potentials* and *lines of flight* that cross constituted knowledge. This training cannot be based on the transmission of disciplinary content, but on the development of capacities for *listening* – in the Heideggerian sense – to what is announced in the *margins* and *interstices* of established knowledge. The university of the future must be conceived as a *space of resonance* where the different shades of knowledge can enter into creative *composition*.

6. Conclusions: The Need for a New Complex Rationality

The phenomenological-hermeneutical journey that we have undertaken reveals that porous epistemic boundaries do not constitute a contingent methodological innovation, but the manifestation of a fundamental ontological transformation in the constitution of contemporary scientific knowledge. This transformation responds to what Morin (2005) identified as the exhaustion of the *paradigm of simplicity* that dominated Western modernity and the emergence of a new *paradigm of complexity* that recognizes the fundamentally *relational*, *temporal,* and *emergent* nature of all phenomena.

The crisis of disciplinary rationality is not merely epistemological but civilizational. As Husserl (1992) demonstrated in his analysis of *Krisis*, the crisis of European sciences is a symptom of a deeper crisis of *European humanity* that has lost the sense of its original *telos*. The disciplinary fragmentation of knowledge is part of this broader process of *technification* of the world that Heidegger (1954) analyzed as *Gestell* (structure of location): the reduction of all being
—including the human being— to the condition of *Bestand* (available funds) for technical optimization.

The porous epistemic boundaries open up the possibility of another *beginning* (*anderer Anfang*) of the thinking that Heidegger glimpsed in his last writings. This other beginning does not consist in the nostalgic return to a pre-technical past, but in the preparation of an *authentic habitation* (*Wohnen*) in the era of planetary technology. It is a matter of developing forms of knowledge that recognize the *finitude*, *relationality,* and *temporality* constitutive of all human understanding, overcoming both positivist objectivism and relativistic subjectivism.

The new complex rationality that emerges from porous epistemic boundaries is not a dialectical *synthesis* that overcomes previous oppositions, but a rhizomatic composition that multiplies the possible connections between heterogeneous. As Deleuze and Guattari (1980) taught, rhizomatic thinking operates according to principles of *connection*, *heterogeneity*, *multiplicity,* and *asignifying rupture* that transcend the tree-like logic of disciplinary reason. Porous borders constitute *abstract machines* that create new existential territories where science, technology, art and life can enter into new forms of *creative symbiosis*.

The future of scientific research depends on our ability to *poetically inhabit* – in the Hölderlinian sense that Heidegger took up – these liminal spaces where the known and the unknown, the disciplinary and the transdisciplinary, the human and the technical are intertwined in configurations that are always provisional and open.
Only in this way will we be able to respond to the challenges of contemporary complexity, generating forms

of knowledge that are commensurate with the *creative finiteness* of human existence in the world.

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