

Editorial

This Special Issue of the journal is dedicated to the memory of Dr. Susan Noble, wife of one of the chief Editors, Denis Noble. Susan passed away while the final editing of the issue was being completed. She was a mathematical biologist herself, and a co-discoverer (Brown, DiFrancesco, Noble, 1979) of the channel that became the target for the successful angina drug, ivabradine (Servier).

Preparing this ambitious Special Issue has challenged everyone involved: authors, reviewers, and guest editors. The editors solicited contributions from many leading figures in a broad array of scientific and philosophical disciplines, with emphasis on phenomenological approaches to philosophy (Section I). The motivating force was the conviction that if we could find a viable bridge for the gap between the “two cultures”¹ of science and philosophy, fundamental problems in each camp could be addressed more fruitfully than ever before, and a new kind of science be born. We believe the unprecedented cross-fertilization of ideas from this initiative may furnish seeds from which that new, better integrated, and more effective approach to science may arise.

This Special Issue consists of forty papers. For each one, multiple reviewers were solicited, with at least one reviewer from each “culture” (a scientist and a philosopher). In many cases, several rounds of revision were carried out. Needless to say, this required great patience and dedication of all participants. The editors gratefully acknowledge the contributions of our authors, and of our anonymous reviewers, who worked long and hard on the papers we sent them with no compensation for their efforts. We also wish to thank the Elsevier editorial and production team for the support they gave us in bringing this project to fruition. We hope the reader will find this effort to marry science and philosophy both meaningful and enjoyable.

We would now like to offer a synoptic overview of the Special Issue, section by section and paper by paper.

I. INTRODUCTION

1. **Stuart A. Kauffman and Arran Gare**

Beyond Descartes and Newton: Recovering Life and Humanity

The first contribution functions as a prologue. It provides the historical background and rationale for efforts to naturalize phenomenology, including a brief history of phenomenology, and also, of parallel developments in science. This history justifies the inclusion under this label of the work of philosophers who were not part of Edmund Husserl’s school of Phenomenology. While the influential phenomenologist Maurice Merleau-Ponty embraced the work of Schelling and those he directly or indirectly influenced, including A.N. Whitehead, here it is shown why the semiotics of C.S. Peirce (who characterized himself as “a Schellingian of some stripe”) and the work of Michael Polanyi and the hierarchy theorists should also be included. It then shows how with the development of endoscience, which assumes that we are part of the world we are striving to understand, science converged with naturalized phenomenology. With this convergence, we have recovered our consciousness and our minds. The far-reaching consequences of these developments are explored. They provide the basis for rethinking the nature of mathematics and its role in science, a new interpretation of quantum mechanics that both advances quantum mechanics and

¹ Snow, C. P. 1959. *Two Cultures and the Scientific Revolution*. Cambridge: Cambridge University Press.

illuminates the nature of consciousness, and the basis for a major rethinking of biology. The notion of “function” in biology is defended, but nobody can prestate the emerging new biological functions that constitute the phase space of evolution. No laws “entail” evolution. Consequently, we cannot mathematize the detailed becoming of the biosphere. In its place, a post-entailing law explanatory framework is proposed. Here, *Actuals* arise in evolution to constitute new boundary conditions that are enabling constraints. These create new, typically unprestatable, *Adjacent Possibles*, opportunities for further evolution. The concept of functional closure of an organism making a living in an interconnected world becomes central. The implications of these innovations are shown for the historical reconstruction of evolutionary patterns, for the establishment of statistical laws about extinction events, and for the reintroduction of formal cause laws rather than efficient cause ones.

2. Jonathan Singer

“Menaced Rationality”: Husserl and Merleau-Ponty on the Crisis and Promise of Science

This article explores natural science from the standpoint of phenomenological philosophy. The author argues that while formal mathematical and scientific truths appear to Enlightenment rationalism as more basic than the lived empirical reality that they describe, they always already depend upon this reality for their meaning and being. The author notes the implicit conflict within traditional science between its rationalist hope of achieving an absolute knowledge that transcends the contingencies of the concrete world, on the one hand, and its profession of openness to the falsification of its ideas that makes it answerable to that world, on the other. But Singer goes further than contending that science must rely on empirical reality merely as a way of confirming its independent insights. He claims that the abstract truths of science are in fact “*rooted* in the empirical world itself.” In supporting this claim, Singer introduces Husserl’s and Merleau-Ponty’s phenomenological critiques of science, and he suggests that these can actually help science keep its commitment to openness. He further intimates that science has long been plagued by a polarization of subject and object that phenomenological philosophy can help overcome.

3. Steven M. Rosen

Why Natural Science Needs Phenomenological Philosophy

In the third introductory paper, Steven M. Rosen suggests that developments in physics, science’s premier discipline, point unmistakably to science’s need for a new philosophical foundation. By following the historical trajectory of the two main branches of modern theoretical physics—relativity theory and quantum mechanics—Rosen demonstrates that, in the end, neither field of research can successfully deal with the fundamental problem of discontinuity that is common to them. These fields in fact converge in confronting the ultimate challenge of bringing unity to physics by solving the riddle of quantum gravity, but this is precisely where discontinuity becomes wholly unmanageable. Rosen argues that the discontinuity plaguing theoretical physics is essentially symptomatic of the merging of subject and object, anathema to the Cartesian philosophy in which conventional physics is rooted. He introduces an alternative philosophical foundation, well suited to the non-Cartesian phenomena of contemporary physics: *phenomenological philosophy*. This approach is elaborated through Maurice Merleau-Ponty’s concept of *depth*, and then brought into focus for use in theoretical physics via qualitative work with topology and hypercomplex numbers.

II. PHYSICS

4. Plamen L. Simeonov

Yet another time about time – Part I: An Essay on the Phenomenology of Physical Time

The section on physics begins with the essay of Plamen L. Simeonov, a personal reflection on the concept of time in physics from multiple physical, mathematical and phenomenological perspectives. It seeks to extract the essential tenets from the diverse, often hidden or arguable assumptions underlying a number of hypotheses and theories about time in physics. It continues the argument of papers in our introductory section, in particular Steven M. Rosen's, while focusing on the problem of time in our understanding of the fabric of the Universe. By contrasting some of the major theories and hypotheses in physics, the paper emphasizes the interpretation of time phenomena, and paradoxes associated with the *different sorts and levels of logic* used for addressing the same issues in natural sciences, mathematics and philosophy, as well as physics itself. As in visual illumination at different frequency levels, different images result. Simeonov believes that the *systatic*² application of creative queries from all these domains, in the fashion of Laplace, Poincaré, Einstein and Tesla can push physics out of its current stasis by asking *new questions* related to its foundations. This integrative and mutually enriching process between science and philosophy could initiate a fruitful development and coalescence of both. A major conclusion reached in Simeonov's survey is that most claims about the nature of time in both physics and philosophy appear tractable within their own domains and reasoning frameworks, but hard when bringing together (for instance) quantum theory and relativity. Paradoxes and logical incompatibilities between the different conceptions involve i) experimentally validated facts, or ii) implicit "second-order" logics in a particular field, inapplicable elsewhere. Therefore, one way to resolve such differences and conflicts is to make these explicit, and test them in a broader context. The corresponding frames of reference, their possible interfaces and the remaining gaps of knowledge need to be identified and realized in an integrated representation of time. The failure of physics (so far) to overcome the dichotomy between relativity and quantum mechanics has led to an enduring crisis. To remain a foundational discipline, it will have to transcend its own boundaries and prepare for thorough revision and expansion. This goal may be achieved through intensifying the exchange between natural sciences, mathematics and philosophy, unified under the new thought of a growing research community, gathered for a fourth time since 2010 and a third in this journal: Integral Biomathics. We believe that if physicists, and scientists in general, become aware of other modalities which this focused issue on phenomenological philosophy tries to reflect, this will help them find wider perspectives and new ways to look at their own challenges. Perhaps exploring the problem of time, which is central for all these disciplines, can trigger an accelerated exchange and groundbreaking discoveries in all of them that will eclipse the scientific revolutions of the Twentieth Century.

² i.e. related to a combination or synthesis

5. **Alex Hankey**

A Complexity Basis for Phenomenology: how information states at criticality offer a new approach to understanding experience of self, being and time

This paper presents a new analysis of the criticality at the heart of the regulation of complex biological systems. It shows that a system at criticality constitutes a perfectly self-observing system, which reduces its own quantum wave packets, and provides the basis for a completely new kind of information, different from digital information. The key properties of the new information states include an internal loop of information flow, and high, long-range coherence. The former property has several consequences: it accounts for the sense of 'self', for Husserl's internal sense of time passing, and for Heidegger's 'being in time'. The latter property, long-range coherence means that the new information states constitute an integrated information theory based on *gestalts*. Such states support all aspects of the cognizance of *experience*.

6. **Susie Vrobel**

A New Kind of Relativity: Compensated Delays as Phenomenal Blind Spots

An phenomenological approach to science is presented by Susie Vrobel in this article about relativity in first-person descriptions of the Universe. It introduces the novel concept of an *obserpant* (observer-participant), which differs from the present objective tradition of third-person descriptions of the world. The author suggests an entity not *having*, but *being* a model of the world, which entails the existence of a phenomenal blind spot. This blind spot consists of compensated, i.e. anticipated, delays and is described as a time cone with two temporal dimensions: Δt_{length} and Δt_{depth} – succession and simultaneity. These temporal dimensions are created and measured in compensated and uncompensated delays. What is compensated by one *obserpant* may remain uncompensated by another. This discrepancy can be modelled as fractal time cones exhibiting a new kind of relativity that arises from the *obserpant*'s inability to spot the systemic blindness in the shape of anticipated delays. Future research is required to tackle the question of multiple *obserpants*.

7. **Koichiro Matsuno**

On the Physics of the Emergence of Sensorimotor Control in the Absence of the Brain

Koichiro Matsuno's paper calls attention to the durability of *now* as a foundational basis of phenomenology. The durable now that started from the origins of life has been operative ever since, and is instrumental in upholding the cohesion of the phenomenological domain. A key factor for this durable cohesion is found in those atoms and molecules carrying the path-dependent histories beginning at the origins and surviving to the present moment of now. Matsuno suggests that the durable now is to biology what tenseless time is to physics.

8. Gordon Globus

Heideggerian Dynamics and the Monadological Role of the 'Between': A Crossing with Quantum Brain Dynamics

In the article presented by Gordon Globus, two far-flung fields of research are intriguingly brought together: quantum brain theory and the philosophical thought of Martin Heidegger. The author introduces the Heideggerian notion of *Ereignis*, the pre-spatiotemporal dynamic activity that ultimately gives rise to our existential sense of being situated in the world. This is linked to Globus's rendition of quantum brain dynamics, which entails processes of attunement akin to those found in Heidegger's account of being-in-the-world. The author adds a further twist by dissenting from the Heideggerian view of human beings as dwelling together in a shared world. Globus deconstructs this world, insisting that it is but a projection arising from an underlying reality in which we are actually "windowless monads." The author's monadology is applied to the problem of measurement in physics.

9. Paavo Pylkkänen

The quantum epoché

This paper considers the interpretation of quantum theory, focusing on whether it is possible to provide quantum ontology of particles in motion in the same way as in classical physics, or whether we have to adopt a more limited view of quantum systems in terms of complementary, but mutually exclusive phenomena. He describes the situation in phenomenological terms by saying that according to the usual (Bohr's) interpretation of quantum theory, quantum phenomena call for a kind of *epoché*, i.e. a suspension of assumptions about reality at the quantum level. Bohm seems to re-establish the possibility of a mind-independent ontology at the quantum level, but Pylkkänen emphasizes that even this interpretation contains novel, non-classical features that require it to give a special role to "phenomena" or "appearances", implying the need for a kind of *epoché*. He suggests that while different from the *epoché* connected to phenomenological description, the "quantum *epoché*" nevertheless points to a potentially interesting parallel between phenomenology and quantum philosophy.

We turn next to papers that focus on mathematics (Section III). This section serves to bridge Section II, on physics, with Section IV, on biology. Whereas the physical sciences have relied heavily on mathematics and have developed it in highly refined ways, the life sciences still need further development of mathematical analysis and expression that do justice to the phenomena they seek to understand. What we are proposing in general is that physics, mathematics and biology alike stand to gain by taking into account the perspective of phenomenological philosophy.

III. MATHEMATICS

10. Shaun Gallagher

Doing the math: Calculating the role of evolution and enculturation in the origins of geometrical and mathematical reasoning

Section III opens with Shaun Gallagher's contribution. Whether or not mathematics reflects timeless universal truths, Gallagher traces its origins to practical engagement with the world. His approach is enactive: cognitive structures arise from the dynamic interplay of organisms and their environment, with organisms playing an active role in the process. Mathematical activity is no exception to this, as Gallagher shows in examining Husserl's phenomenological work on the origins of geometry, and describing more recent research along these lines. Throughout his paper, he calls attention to the cultural, developmental, and evolutionary influences on enactive cognition, mathematical and otherwise. In sorting out the various determinants of cognition, Gallagher introduces the notion of *affordance space*, defined by the range of "possibilities for action that depend on both body and environment."

11. Andrée C. Ehresmann & Jaime Gomez-Ramirez

Conciliating neuroscience and phenomenology via category theory

The authors of this article take on the central problem of correlating neural and mental processes for cognitive abilities such as memory or spatial representation and allowing the emergence of higher cognitive processes up to embodied cognition, consciousness and creativity. The paper presents the Memory Evolutive Neural System (MENS) mathematical methodology of Ehresmann and Vanbremeersch³, which encompasses neural and mental systems and analyzes their dynamics in the process of "becoming". Based on a dynamic category theory, MENS describes the generation of mental objects through the iterated binding of synchronous neuronal assemblies (modeled by the categorical notion of colimit); it leads to a theory of mind that overcomes the dualistic debate between classicism and connectionism, and to the development of a naturalized phenomenological approach made possible by the many-to-one correspondences between the neural and the mental.

12. Inês Hipólito

Proof phenomenon as a function of the phenomenology of proving

The paper presented by Inês Hipólito discusses the application of phenomenology to mathematical proving. By introducing a conceptual distinction between proving (the act) and proof (the outcome), Hipólito suggests that the proving process is an individual's phenomenological act of conscious experience (a first-person adventure), and that the proof is the objective result (a third-person description) of that process. In fact, the subjectivity of the phenomenological act gives birth to a formalized language with shareable (second- and then third-person) meaning, that we call a mathematical proof.

³ Ehresmann, A. C., Vanbremeersch, J. P. 2007. *Memory Evolutive Systems; Hierarchy, Emergence, Cognition*. Elsevier Science. ISBN-10: 0444522441; ISBN-13: 978-0444522443.

13. Bruno Marchal

The Universal Numbers. From Biology to Physics

In his article, Bruno Marchal presents the main results of his research in a field he terms *machine theology*⁴. It is a sequel to his contribution⁵ for the 2013 JPBMB special issue on Integral Biomathics, “Can Biology Create a Profoundly New Mathematics and Computation?” (Vol. 113, Issue 1). Like the mystics, he tells us that the story that Reality – let’s call it God, Universe, or Nature – is located “in our heads”. The author shows that the ideally correct machine (such as a Turing automation), possesses a theology quite similar to those of Plato, of the mystics, and most certainly of the neoplatonists (who are open to both mysticism and rationalism). However, unlike most mystics, Marchal substantiates his point by using computer science logic and a small portion of elementary computationalist cognitive science. He claims that if we, human beings, are machines (mechanisms of some sort), then the reality we experience, including the laws of physics, is in the heads of all arithmetically sound universal machines. This makes Marchal’s hypothesis of mechanism testable: we only need to compare the “physics in the head” of the machine with what we observe outside in the world, since such sorts of phenomenological machine theologies include physics as a sub-branch. Marchal demonstrates that such an approach matches well a logically consistent proof (explained in his Universal Dovetailing Argument), which turns machine theology into a “new kind of science”, something that has not so far been disproved. His approach naturalizes consciousness and matter, but also arithmetizes Nature itself, thus coming closer to Digital Philosophy, pioneered by Leibniz and Zuse and advocated also by Alan Turing, Emil Post, Edward Fredkin, Seth Lloyd, Gregory Chaitin, John Case, Stephen Cole Kleene and Judson C. Webb. In this way, Nature is explained through a machine’s self-referential statistics on its possible computational experiences in arithmetic, which is interesting also in relation to the articles of Kauffman/Ul-Haq and Hipólito in this section.

14. Louis H. Kauffman

Self-Reference, Biologic and the Structure of Reproduction

This contribution concentrates on the relationships of formal systems with biology. In particular, it is a study of different forms and formalisms for replication. The author concentrates on formal systems not only to show there is a fundamental mathematical structure to biology, but also to consider philosophical and phenomenological points of view in relation to natural science and mathematics. Kauffman’s original point of departure is cybernetic epistemology. It turns out that this discipline has much to say about the relation of the self to structures that may harbor a self. Also, it has much to say about the interlacement of selves and organisms. The paper can be regarded as an initial exploration of this theme of mathematics, formalities, selves and organisms - presented primarily from the point of view of cybernetic epistemology, but with the intent that these points of view should be of interest to phenomenologists.

⁴ in the Greek sense of the word, where any a priori unifying truth that we human beings are searching for is related to God.

⁵ Marchal, B. 2013. The computationalist reformulation of the mind-body problem. *J. Prog. Biophys Mol Bio*, 113 (1): 127-140.

15. **Bruce J. MacLennan**

Living Science: Science as an Activity of Living Beings

The paper begins with the uncontroversial premise that scientists are human beings that are part of a global ecosystem on which they depend. From this MacLennan draws a number of conclusions about the proper nature of science, both the range of its subject matter and its means of investigation. These suggest increased use of phenomenological methods, recognition of the role of situated embodiment in cognition, expanded notions of causality, and cultivation of aesthetics, emotion, intuition, imagination, and the unconscious faculties of our minds. The author argues that in this way science will enhance the flourishing of the global ecosystem.

16. **Ted Goranson, Beth Cardier and Keith Devlin**

Pragmatic Phenomenological Types

Goranson, Cardier and Devlin approach the disjuncture of science and phenomenology from both a theoretical and a practical perspective, asking how novel philosophical and logical foundations can be harnessed in applied science. Their example is the domain of computer reasoning over multiple contexts, and their approach addresses the difficulty in reasoning about overlapping multi-level, multi-causal biosystems. There is an emerging trend to develop phenome ontologies and explore the interaction between introspective narrative and brain activity. The paper assumes that next generation models require next generation abstractions, proposing a system that reasons about interactions among contexts (as situations) as well as facts. This supplementation of current approaches requires basic work in type theory. Phenomenological constructs are employed in addressing a type theory for the overlapping domains. This paper is a sequel to a previous contribution⁶ for the 2013 JPBMB special issue on Integral Biomathics, “Can Biology Create a Profoundly New Mathematics and Computation?” (Vol. 113, Issue 1).

17. **Fernando Zalamea**

Peirce's Cenopythagorean Categories, Merleau-Ponty's Chiasmatic Entrelacs, and Grothendieck's Résumé

This presentation offers a new reading of Grothendieck's “Résumé de la théorie métrique des produits tensoriels topologiques” (São Paulo, 1956), using phenomenological, semiotic and cultural perspectives derived from Peirce and Merleau-Ponty. Grothendieck's unbounded inventiveness is highlighted through an analysis of the innovations of the “Résumé”: diagrammatic notations (syntactic dimension), injective/projective structures (semantic dimension), and three-sorted order/topology/algebra characterization theorems for the new tensor norms (pragmatic dimension). Going further, Zalamea explores the emergence of Grothendieck's category-theoretic thinking in the “Résumé”, and he shows how Merleau-Ponty's concept of *flesh* can help to elucidate the natural category-theoretic dialectics between concrete and abstract categories. The author compares Peirce's cenopythagorean categories with Merleau-Ponty's entrelacs and chiasma, showing connections and counterparts in their respective phenomenologies and examining their use in understanding the natural duality between mathematical and artistic creativity.

⁶ Goranson, H. T., Cardier, B. 2013. A Two-sorted Logic for Structurally Modeling Systems. *J. Prog. Biophys Mol Bio*, 113 (1): 141-178

18. Ralph Abraham

Mathematics and Mysticism

The author gives his personal view on the reality of mathematical ideas and on the role of meditation, psychedelics, and divination in mathematical discovery. This article takes the reader on an anthropological journey to the edge of mind and matter, delving into the roots of modern day mathematics, philosophy and science.

19. Louis H. Kauffman & Rukhsan-Ul-Haq

The Mysterious Connection between Mathematics and Physics

This essay takes the form of a dialogue⁷ between two scholars, whose names are "Lou" and "Rukhsan". Lou is a mathematician with an intense interest in physics, working on physical ideas and concepts from the side of mathematical thinking. Rukhsan is a condensed matter physicist fascinated by the nature of mathematics. This essay is inspired by a dream of the physicist John Wheeler that the deepest reach of the physical world would be something like Boolean logic. He expressed this dream in the phrase "It from Bit". The reader is asked to be patient, as the dream is like the Cheshire cat⁸ and it is sometimes only possible to see its smile. Lou and Rukhsan address the question: "Does physics simply wear mathematics like a costume, or is mathematics a fundamental part of physical reality?" They illustrate that no matter how carefully we attempt to create a language (and mathematics) that exists only at the limits of the world, that language inevitably is also related, if only in our fiction, to the world itself. This essay provides a springboard for further discussion of Marchal's paper earlier in this section.

IV. BIOLOGY

20. Howard Pattee

Cell Phenomenology: The First Phenomenon

Howard Pattee's contribution reflects his long-term interest in the origins of life. In physical terms, the first organisms require detection or sensing of functional information; he calls what is detected the *first phenomena*. The classical mind-body problem posed by human beings is a more complex counterpart of these simpler distinctions carried out by living systems. The earliest memory-based self-replicating unit, like a cell, is the most primitive case in which an *epistemic cut* is made between the *subject* and *object*. Such cuts are the *first phenomena*. Since all detected information is in the form of symbols, i.e., *arbitrary* molecular signals, Pattee calls this the *symbol-matter* problem. In his view it is only because of such primitive individual phenomena that population distributions can evolve by natural selection.

⁷ following the pattern of Galileo's *Il Dialogo*: Galilei, G. 1624/1630. *Il Dialogo sopra i due massimi sistemi del mondo*. also as: Galilei G. 2001. *Dialogue Concerning the Two Chief World Systems: Ptolemaic and Copernican*, Modern Library, ISBN-10: 037575766X; ISBN-13: 978-0375757662; Dialog über die beiden hauptsächlichsten Weltsysteme, das Ptolemäische und das Kopernikanische. German translation by Emil Strauss, Leipzig, 1891. <https://archive.org/details/dialogberdiebe00galiuoft>.

⁸ in Lewis Carroll's "*Alice's Adventures in Wonderland*" (1865): Carroll, L. 2015. *Alice's Adventures in Wonderland and Through the Looking-Glass: 150th-Anniversary Edition* Penguin Classics, ISBN-10: 0143107623; ISBN-13: 978-0143107620.

21. **Pedro Marijuan, Jorge Navarro and Raquel del Moral**

How the Living is in the World: An Inquiry into the Informational Choreographies of Life

Marijuan, Navarro and del Moral discuss how the latest developments in intra- and intercellular signaling have changed the way biological science can be understood philosophically today, in particular how it has become more amenable to phenomenology. In support of their thesis, the authors draw on some key ideas from the Spanish phenomenologist Ortega y Gasset, and his themes of perspectivism, limitation, vitalism, and his ongoing critique of what he believed was an increasingly narrow disciplinary specialization in the practice of technology and science. The central thesis of this article is that the ascending complexity of life is always information-based and recapitulates level after level, a successful “informational formula” for Heidegger’s notion of *being in the world (Dasein)*. Thus, bio-molecular information flows, being indispensable constituents of living beings, can be seen as complex, but traceable in a continuously sensitive, self-adjusting embodied way. The functioning organism, the authors contend, when studied in action, exhibits a bio-informational and bio-computational structure; in their words, “the mixing assimilation of the different information flows takes place inside a ‘wetware’ all along the *scala naturae* of life.” Their view conceives of the whole living structure as permeable and connected to the introjected information it receives constantly from the environment within which it is embedded. The authors regard information flows not just as being processed, but as *acquiring* a changing embodiment as they circulate through the processing structure and are ultimately entered into the life cycle of the entity. This requires new, more adequate computation paradigms for modeling biology, paradigms that internalize this phenomenology, such as those pursued within the Integral Biomathics framework. The authors discuss in depth the dynamic intertwining between self-production and communication characterizing life at cellular, organismic, and social levels of organization, and they argue that it is the creation, transmission and reception of signals which, in all instances, provides guidance and orientation to the inner self-production activities of the living agent and connects it with the world. They conclude that transitions to new levels of organization are marked by the emergence of new forms of communication, embedded in the correspondingly augmented life cycles of the more complex entities.

22. **Luis E. Bruni & Franco Giorgi**

Towards a heterarchical approach to biology and cognition

The authors criticize what they argue is the over-emphasis in science on hierarchical organization in biological and cognitive systems. This focus on hierarchies has been fruitful; but it has so dominated thinking that the heterarchical nature of communication processes in a range of disciplines has been ignored. The authors advance a more complex framework that recognizes the heterarchical embeddedness of different layers of physiological, behavioral, affective, cognitive, technological and socio-cultural levels implicit in networks of interacting minds. From this perspective, the dynamic complementarity of bottom-up and top-down causal links can be seen. The authors illustrate the dialectical nature of these processes by addressing the simultaneity and circularity of cognition and volition, and they show how such dialectics can be present in primitive instances of proto-cognition and proto-volition. On this basis they claim that subjectivity and semiotic freedom are scalar properties.

They conclude by reflecting on the emergence of pathological conditions in multi-level semiotic systems.

23. Maxine Sheets-Johnstone

Phenomenology and the Life Sciences: Clarifications and Complementarities

The article begins with clarifications of phenomenology and phenomenological methodology. Drawing on the writings of Edmund Husserl as well as her own writings, Sheets-Johnstone demonstrates phenomenology's abiding concern with Nature and with the experienced dynamic realities of life itself. Following these detailed clarifications, she goes on to specify conceptual complementarities between phenomenology and the life sciences, complementarities that include the practice of verifying the research findings of others. In the context of specifying complementarities, she furthermore pinpoints basic relationships such as that between primal animation and what dynamic systems theorists term "intrinsic dynamics", and that between mind and motion. In the process of pinpointing such complementarities, she brings to the fore the dynamic nature of animate forms of life.

24. Patrick Whitehead

Overcoming Parallelism: Naturalizing Phenomenology with Goldstein and Merleau-Ponty

Whitehead's paper is motivated by the aim of promoting collaboration between biological science and phenomenological philosophy. For Whitehead, the obstacle to such interdisciplinary cooperation lies in the fact that while life science and phenomenology both focus on the body, two different and apparently conflicting forms of embodiment are investigated. "Biology examines the corporeal or living body (*Körper*)," says Whitehead, whereas "phenomenology examines the body of lived experience (*Leib*)." But Whitehead proposes that these seemingly disparate modes of embodiment are actually only different aspects of one and the same body. The author draws on the research of neurologist Kurt Goldstein and the writings of philosopher Maurice Merleau-Ponty to make his case. In so doing, he points the way toward a rapprochement between natural science and phenomenological philosophy.

25. Alicia Juarrero

What does the closure of context-sensitive constraints mean for determinism, autonomy, self-determination, and agency?

Advancing the tradition of hierarchy theory, a different perspective is provided by the paper of Alicia Juarrero. Complexity theorists have developed the concept of complex adaptive systems, but only recently begun to examine systematically the role of context-sensitive constraints – first as enablers of complexification, and subsequently as regulators that maintain the integrity of self-organized, coherent wholes. Conceptualizing these in terms of far-from-equilibrium processes allows us to rethink how parts-to-whole and whole-to-parts relationships are constituted, and offers a renewed understanding of recursive feedback and the role of context-dependence in generating the boundary conditions and the internal organization of complex adaptive systems. This allows us to redescribe formal and final causation to provide a meaningful grip on heretofore seemingly intractable philosophical problems. Autonomy, self-determination, and agency are the most important of these.

While not solving the hard problem of consciousness, granting a place to subjective experience becomes intelligible within this framework.

26. Roland Cazalis

From creativity to perception: The conditions of possibility for a true biology

In his paper, Roland Cazalis argues that a true phenomenology of the living being and a true biology converge towards the same reality. The author suggests that such a reality could be attained *inter alia* from Renaud Barbaras' phenomenological insights that stress as *originary*⁹ the notion of *desire for otherness*, which is intrinsic to the living as a form of dissatisfaction opened at the heart of the world, one that becomes manifested as movement. Nevertheless, for Barbaras' proposal to be applied to the world of life in its heterogeneity and unity, it has to be interpreted within the Whiteheadian framework of creativity. Indeed, Barbaras' living being becomes less speculative if its most basic level is understood as a confluence of local creative work that reaches a critical point to form a proto-plateau from which the following levels¹⁰ are built. The Whiteheadian notion of creativity does precisely this. By the same token, the latter concept grants this approach scale and thermodynamic features characterizing a living system and a full notion of movement integrating the entire world of living, including plants, in a unique realm. Cazalis shows that, supplemented in this way, Barbaras' proposal can be orchestrated in a consistent manner using the concept of adjunction from category theory. In this frame, the living being appears as a rhythmic to-and-fro pulsation fluctuating between aspects of qualia and quanta, as it fluctuates between the originary and the manifest. This paper provides an interesting starting point for further discussion related to the work of Longo, Montévil and Kauffman¹¹ (2012) on extending criticality and symmetry breakings, as well as that of Hankey on self-organized criticality, presented in his paper on information states at criticality in the physics section of this special issue.

27. Marcin J. Schroeder and Jordi Valverde

Situated Phenomenology and Biological Systems: Eastern and Western Synthesis

While phenomenology emerged from the works of Husserl and his scholars to impact mainly philosophy and the humanities, the actual attempts to develop a scientific discipline about the *self* and to carry out research on cognition and consciousness were always based on the methods of traditional science in which elimination of the subjective has been a primary tenet. Thus, the methodology of this research required a regression to traditional forms of objectification in terms of physically defined entities. For instance, research on consciousness was mainly limited to finding the *neural correlates of consciousness* (NCC¹²), and hence of phenomenal experience (e.g., Crick and Koch¹³). Schroeder and Valverde here attempt to initiate

⁹ "Originary" is a typical term in French phenomenology and means "what is primordial, radically irreplaceable, and remains beyond our calculation or control": Renaud Barbaras, 2006. *Desire and Distance: Introduction to a Phenomenology of Perception* translated by Paul B Milan, Stanford, Stanford University Press, p. 115.)

¹⁰ as far as a living being or an organism is a hierarchical multi-scalar system, and the lower level n is used as basis for the subsequent upper levels $n+1$, $n+2$, etc.

¹¹ Longo, G., Montévil, M., Kauffman, S. 2012. No entailing laws, but enablement in the evolution of the biosphere. *arXiv*: 1201.2069 [q-bio.OT]. <http://arxiv.org/abs/1201.2069>

¹² the minimal set of neuronal events and mechanisms sufficient for a specific conscious *percept* (Koch, C. 2004. *The quest for consciousness: a neurobiological approach*. Englewood, US-CO: Roberts & Company Publishers. ISBN 0-9747077-0-8, p. 304.

¹³ Crick F., Koch C. 1990. *Towards a neurobiological theory of consciousness*. Seminars in the Neurosciences. Vol. 2, 263–275. <http://profiles.nlm.nih.gov/ps/access/SCBCFD.pdf>.

an extension and revision of phenomenological methodology to issues of modern technology and science, by integrating disciplines ranging from information science and studies of computation, up to cultural psychology and the studies of philosophical traditions of the East. Their approach is based on concepts related to information and computation, which provide a general conceptual framework for phenomenology free from the limitations of particular languages and of linguistic analysis.

28. Otto E. Rössler

Is it Ethical to heal a young white Elephant from his physiological Autism?

No one knows the exact difference between human beings and animals. A proposal for identifying it as a sort of “invoked presumptive benevolence”, the *suspicion* that the other wants you to be happy, was made by the author of this paper 40 years ago. The idea of treating autism in human beings with an acoustically made bonding sound (“acoustic smile”) whenever oneself is happy in the interaction is certainly worth studying. Carrying it further to create an intelligent non-human ethical advisor could be an interesting alternative approach to solving the complex problems of modern society. In his paper, Otto E. Rössler illustrates his case vividly, with a therapy for deep autism in mind, on a white-elephant cub: to feed the imagination and perhaps even save humankind from pursuing a disastrous course of which an example is mentioned in passing.

29. Katherine Peil-Kauffman

Emotional Sentience and the Nature of Phenomenal Experience

Katherine Peil-Kauffman’s article suggests that emotion functions as an ancient “self-regulatory sense”. It can shed new light upon the origins of evaluative perception in complex adaptive systems, upon the physics of genuine free will, and even upon the mystery of phenomenal experience itself. Given the key role of “the self” in this new kind of science (in immune functioning, emotional stimulus, and all higher level sociocultural identity components), this offering examines the construct of a subjective, sentient, or otherwise experiencing self, arguing that it is emergent in living systems from the interaction of two ongoing physical processes: a “classically embodied mind” and a more fundamental “quantum consciousness” — ultimately perhaps a unified Self-as-observer within which all relative subjective selves creatively self-actualize. The author weaves this missing strand of physical subjectivity together with various philosophical themes, mathematical devices, quantum mechanical interpretations, and psychological phenomena, aiming to evoke new intuitions about the ontological nature of the subjective self, to gesture toward crisper, biologically grounded language for such constructs as mind and soul, and to reexamine the nature of being, creativity, purpose and value through a panpsychic lens. Ultimately, a paradigmatic shift toward a sentient, co-creative, and participatory universe is seen to move the human species toward optimal accountability for our creative constructions in a shared biosphere and cooperative humanitarian ethics in the now global village.

V. BIOSEMIOTICS

While ‘phenomenology’ is usually associated with Husserl and those he inspired, C.S. Peirce also developed a form of phenomenology that then provided the basis for a new form of semiotics. In the introductory papers here, Jonathan Singer and Steven Rosen argued that phenomenology is needed to provide foundations for science able to do justice both to recent developments in science and to the reality of experience and consciousness within nature: biosemioticians have been making similar claims for Peircian semiotics. The first paper in this section on biosemiotics bridges these claims by simultaneously defending the naturalizing of phenomenology while arguing that Peirce’s philosophy of science is required to defend it, an argument strongly supported by Søren Brier in the next article. This synthesis is further developed by Don Favareau, who relates it to the notion of constraints defended by hierarchy theorists and to Stuart Kauffman’s concept of the Adjacent Possible.

30. Maurita Harney

Naturalizing Phenomenology – A Philosophical Imperative

The first paper in the section on biosemiotics, by Maurita Harney, simultaneously defends the naturalization of phenomenology and the need to go beyond the Husserlian tradition of phenomenology. Phenomenology initially had a problematic relation to science, engendering in many cases a form of anti-science rather than a critique of existing science. As phenomenology developed and granted a central place to embodiment and then nature more generally, it revealed the limitations of mainstream science in a way that suggested how science could and should be transformed. This, in essence, is the message of those who are attempting to naturalize phenomenology. Harney argues that Peircian semiotics and its development by biosemioticians is a necessary contribution to naturalized phenomenology if the development of this more adequate form of science is to be justified. It needs to embrace C.S. Peirce’s philosophy of science to show that a naturalized phenomenology is indispensable not only to the human sciences, but also to the natural sciences.

31. Søren Brier (on biosemiotics)

Can biosemiotics be a “science” if its purpose is to be a bridge between the natural, social and human sciences?

Søren Brier’s article discusses the necessity for biosemiotics to use a broader framework than the received view of ‘science’ to get a grip on the quality of the phenomenon of life. The author defends the radicalism of Peirce’s non-mechanistic metaphysics and semiotics against efforts to uphold mechanistic explanations while simply adding Peircian semiotics to them. Brier targets in particular the work of Marcello Barbieri, who has developed a form of semiotics based on the notion of codes, which he claims, do not necessarily involve meaning. Meaning then becomes an extra, to be added to his account of signs. Brier points out that this strategy is based on maintaining that “scientific knowledge is obtained by building pre-Gödelian machine-like models of what we observe in nature.” This is what Peirce challenges with his triadic pragmatist semiotics when grasping the phenomenological (experiential and interpretational) aspects of life, and in doing so, is really calling for a very fundamental change in what we take to be science in order to develop his

theory of semiotics. Barbieri's strategy is inconsistent not only with Peirce's philosophy, but his semiotics. Brier argues that Barbieri's code-biology is unable to consistently integrate a theory of meaning and interpretation with the rest of our scientific knowledge. It is therefore not a real alternative to Peircean transdisciplinary semiotic foundation, although it is still an important improvement of the received view of biology as a science without biosemiotics. Finally, Brier notes that so far not even cognitive science has been willing to model living systems as cognitive and communicative systems based on meaning and signification. However, to do justice to such systems, science will have to follow Peirce's call for a more fundamental transformation of science than cognitive scientists have been prepared to contemplate, recognizing that signification and meaning are indissociable.

32. Don Favareau

Creation of the Relevant Next: How Living Systems Capture the Power of the Adjacent Possible through Sign Use

Don Favareau's paper is a work of synthesis that brings the Special Issue back to a collection of ideas put forth in the introductory paper by Kaufmann and Gare. He shows how Stuart Kauffman's revolutionary notion of the Adjacent Possible is congruent with the biosemiotic understanding (inherited from Peirce) of the universe as an ever-unfolding 'process ontology' of possibility space brought about through the recursive interaction of genuine possibility, transiently actualized order, and emergent (but never fully deterministic) lawfulness. In particular, Favareau argues that Kauffman's central insight is explicated even further by biosemiotics' hybrid Peircean/Uexküllian "sign" concept, by which living systems — both as individuals and in the aggregate (i.e., as co-actors, communities and lineages) — "capture" relevant aspects of their relations with the immediately given Adjacent Possible and preserve those recipes for future interaction possibilities as biologically instantiated *signs*. On this view, living systems move into the Adjacent Possible by "collapsing the wave function" of immediate-next possibility, not just probabilistically, but guided instead by system-internal *values* based on previously captured sign relations, and which are biologically instantiated as replicable system biases and generative constraints. In so acting, not only are "successful survival strategies" within a given possibility space captured (as in traditional accounts of Natural Selection), but captured as well within those sign relations are the entire complement of previously untaken but still veridical real-world possibility spaces that are inseparably 'entangled' with that sign, and just awaiting exploration by the organism. Drawing out the implications of this synthesis, Favareau argues that while all action in the universe is both current context dependent and next context creating, the emergence of ever-more complex semiotic capabilities in organisms has expanded the possibility space of immediate-next-action in the world exponentially, and has brought into being not a pre-given, singly end-directed ordered world, but an emergent, many ends-directed world of promiscuous, unforeseeable and interacting *telos*.

33. Eliseo Fernandez

Signs, Dispositions and Semiotic Scaffolding

Eliseo Fernandez argues that organismal purposefulness springs from the intrinsic, constitutive kind of finality that is the hallmark of all semiotic transactions. He develops a dispositionalist account of organismal causation based on a distinction between two kinds of causal dispositions: fixed (*efficient*) dispositions and *traveling* dispositions. Fixed dispositions are rigidly attached to physical structures and

processes. These are the dispositions regularly invoked in current discussions of causal explanation. Traveling dispositions, by contrast, are able to move freely from one location to another by becoming embodied in suitable supporting media. This notion is used to articulate a view of semiosis that is ideally suited to the life sciences in which signs are conceived of as traveling dispositions. By capitalizing on the heuristic virtues of Nancy Cartwright's model of a "nomological machine" and combining this with the notion of travelling dispositions, Fernandez formulates a compelling view of the interactions between physical and semiotic causation at play in semiotic scaffolding.

34. Jesper Hoffmeyer

Semiotic Individuation and Ernst Cassirer's challenge

In this paper, Jesper Hoffmeyer sets out to rescue the concept of individuation from Jungian psychology and nominalist philosophy, conceiving it as a process; and in particular, as a series of stages (morphological and/or cognitive) that an organism passes through during its lifespan. While in most organisms, this individuation ends at an early stage of its life, in human beings it is a life-long, open-ended process. It is based on learning, which always builds on prior learning dependent to some extent on chance, concrete events. That is, it is an historical process. This explains why systems biology, as established by Ludwig van Bertalanffy, has not been capable of meeting the hope of bridging the XIXth century mechanist-vitalist gap in biology. Instead, a semiotic approach is called for. Developing this argument, Hoffmeyer argues that human individuation is special in a very important sense: language use implies that humans from earliest childhood inescapably become entangled in an "as-if-world", a virtual reality, a story about who we are and how our life "here and now" belongs within our own life-history, as well as within the greater pattern of the world around us. Human individuation is thus a double-tracked process, consisting in an incessant reconciliation or negotiation between the virtual "game" reality that we have constructed in our minds and the mind-independent reality, as it impresses itself upon our lives. Human life cannot therefore be defined by its uniqueness as a particular genetic combination, but must be instead defined by its uniqueness as a temporal outcome of semiotic individuation.

35. Kalevi Kull

Semiosis stems from logical incompatibility in organic nature: Why biophysics does not see meaning, while biosemiotics does

In his contribution to this section on biosemiotics, Kalevi Kull presents an intriguing and profound argument. He shows that the method of formalization used in physics requires that logical conflicts cannot be part of the model. However, it is precisely such logical conflicts that are required for meaning making. These logical conflicts also assume a *specious present*. Once free of the strictures of the biophysical goal of formalization, it is possible to provide a physiological description of systems in which such a specious present allows for making decisions in situations involving logical conflict. This understanding of organisms' decision-making and bodily learning may have applications in medicine and therapy. Logical conflict, the author argues, is the mechanism of intentionality. Meaning-making is assured through the production scaffolding through choices, decision-making or interpretation. Kull claims that this is a model of semiosis that allows us to naturally connect physiology and phenomenology, or physics and semiotics.

36. Søren Brier (on information)

Finding an information concept suited for a universal theory of information?

The essence of the second article by Søren Brier in this section is the search for a transdisciplinary scientific framework that can integrate phenomenology, cognition, communication and information through a combination of the phaneroscopically based semiotics of C.S. Peirce — where logic is semiotically founded — and Luhmann's triple autopoietic and cybernetic systems theory, where communication is seen as involving self-organizing closed systems of which information is only one aspect. This is not only a natural science, but rather a *Wissenschaft*. The framework is therefore called *Cybersemiotics*. A book under the same name is seven years old now and represents Brier's core field of research.

37. Toshiyuki Nakajima

Biologically inspired information theory: Adaptation through construction of external reality models by living

This paper explores a new integral theory of information. Nakajima begins with a phenomenological hypothesis, in which the self creates a reality model developed through a mental process for internalizing phenomena. Then the author formalizes Wheeler's *it-from-bit* concept by means of a simple mathematical model using symbols referring to the external reality, called the inverse causality. Finally, Nakajima develops a cognizers system model to describe the self as one of the many entities interacting as selves in the material world. On top of this model, the author proposes a conceptual framework for a new information theory incorporating both qualitative (semantic) and quantitative aspects of information involved in biological processes, in order to understand the ability of living systems to manage uncertainty of the environment and maintain their internal order.

38. Theresa Schilhab

Re-live and learn – Interlocutor-induced elicitation of phenomenal experiences in learning offline

This article defends the stance that advanced knowledge acquisition is a product of both biologically controlled susceptibility to the environment, and social and cultural reinforcement of phenomenal experiences through human interactivity. While acknowledging the achievements of conventional neuroscience in explaining the development of concepts and language as re-enactments of simulations of sensory-motor experiences, Schilhab argues that this bottom-up explanation must be complemented by a top-down explanation of language and cognitive development associated with the inter-subjectivity of language. Re-enactment, she argues, can involve the mechanism of derived embodiment. Basing her work on contemporary neuroscience, Schilhab examines how both bottom-up and top-down activity is a precondition of advanced language acquisition.

39. Mogens Kilstrup

Naturalizing Phenomenology: The triadic sign of Charles Sanders Peirce is a systems property

A further defense of Peirce's work and its potential is given in the contribution of Mogens Kistrup. However, he argues that because Peirce's characterization of a sign as a triadic relationship is so complex, and this complexity has not been fully appreciated, the true potential of his theory of semiosis has not been fully realized. Kilsrup offers a reconstruction of Peirce's sign model that enables him to justify this claim. This reconstruction involves a three dimensional linkage space between the Object, the Representamen and the Interpretant. It was initially developed for use in biosemiotics as an exploratory frame, for mapping the evolutionary establishment of sign links that logically must have preceded the fixation of any regulatory processes in molecular biological systems. However, it became clear that the model could clarify many of the difficult explanations offered by Peirce about his sign model. Much of this paper is devoted to demystifying Peirce's complex explanations through this reconstructed model to reveal the power of Peirce's ideas. They are shown to illuminate not only the nature of evolutionary memory, but the nature of memory in general, showing why there can be no sign without some memory function. The power of this reconstructed model is further demonstrated by clarifying more subtle features of Peirce's philosophy. For instance, it explains why Peirce only allowed ten of the twenty-seven sign classes that his theory identified. The forbidden sign classes, which are characterized by various types of illogical over-signification, are argued to be operative in some areas of systems biology. This suggests that a semiotic analysis of the signs presently deployed in biology could reveal which branches of research have defective foundations.

VI. SUPPLEMENT

One of the most immediate aspects of experience that has always been acknowledged by radical empiricists and phenomenologists of all kinds is the privileged status of 'Now', and the sense of being free in a world in which the future is radically different from the past and is to some extent open. A regulative principle of mainstream science is that there is nothing special about the present. The future is determined by the past, even if it is not predictable, and this sense of freedom and openness of the future is an illusion. There is no point on which phenomenology and mainstream science are more conflict than over this issue. For this reason we have included a long supplement to this edition in which Felix Hong, an eminent scientist who formerly embraced these assumptions of mainstream science, carefully interrogates and offers a searching critique of a range of assumptions and developments in science to reveal the questionability of these assumptions to consider whether there is a place for real freedom.

40. Felix T. Hong

Free will: A case study in reconciling phenomenologist philosophy with reductionist sciences

Felix T. Hong's exposition presents extensive arguments to demonstrate that absolute physical determinism, Einstein's dream, cannot be strictly true because it contradicts macroscopic irreversibility — an indisputable fundamental fact. In other words, contrary to explanations given in standard physics textbooks, microscopic

reversibility cannot logically lead to macroscopic irreversibility. The fundamental incompatibility between Newtonian mechanics and Boltzmann's statistical mechanics is rooted deeply in the logic by which these two theories handle the probability of occurrences before and after the occurrence of an event. In particular, by considering discrete physical events in a continuous distribution, time-reversal symmetry is preserved in the former, but it is broken, even at the microscopic level, in the latter¹⁴. The author presents empirical evidence showing that biological determinism is also invalid. Furthermore, Hong uses the example of creativity to demonstrate that the cherished tenet of objectivity does not guarantee sound psychological theories. He recommends a naturalization of phenomenology by replacing objectivity with universality as the main criterion for scientific rigor and by invoking visual thinking — Einstein's and Tesla's favorite thinking mode — to ensure overall consistency. The author points out direct empirical evidence in support of the existence of downward causation: mental efforts to effectuate physical changes in brain states that result in unequivocal and publicly observable outcomes. However, he found no evidence of downward causation's ability to shield off low-level physical forces. Nevertheless, he identifies an intriguing example of high-level causation made possible by biological organization — the phenomenological force, arising from collective motion (diffusion) of ions or molecules down their respective concentration gradient. But the phenomenon is not beyond physics' realm since it is readily explained in terms of Boltzmann's kinetic theory. The author considers the origin of free will as an unsettled problem.

41. Plamen L. Simeonov and Ron Cottam

This final paper recapitulates the state of the art in Integral Biomathics in 2015 and defines the new key themes for research in the field, which have been identified in the course of the JPBMB special issue publication activities in 2013 and 2015. They are going to be explored in a new project under the title SALVE, Support Action for Living Vitruvian Evolution.

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Assembling this special issue has been an exceptional experience for all of us. Working with the many generous and enthusiastic contributors who helped to make it happen has been a delight.

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¹⁴ This and other issues related to problems associated with *different sorts and levels of logic* used in physics, mathematics and other sciences are also discussed in Simeonov's paper on time in the physics section.