



Editorial

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“Western Science is approaching a paradigm shift of unprecedented proportions, one that will change our concepts of reality and of human nature, bridge the gap between ancient wisdom and modern science, and reconcile the differences between Eastern spirituality and Western pragmatism.”

Stan Grof from 'Beyond the Brain'

The idea about this special issue came from a paper published as an updated and upridged version of an older memorial lecture given by Brian D. Josephson and Michael Conrad at the Gujarat Vidyapith University in Ahmedabad, India on March 2, 1984. The title of this paper was “Uniting Eastern Philosophy and Western Science” (1992). We thought that this topic deserves to be revisited after 25 years to demonstrate to the scientific community which new insights and achievements were attained in this fairly broad field during this period. This edition also serves to remember and honour two outstanding female scientists, Maryam Mirzakhani (1977–2017) and Mae-Wan Ho (1941–2016). Mirzakhani's work as a mathematician and Ho's work as a theoretical biologist, each embracing both Western and Eastern traditions of thought, illustrate how such influences can

open new horizons and result in major advances in knowledge, just as different cultural influences had stimulated the work of Hypatia, the brilliant Greek mathematician and philosopher of the ancient world. This edition is dedicated to their memory.

It is not the first time that such comparative East-West studies are being carried out. From Leibniz to Nietzsche to modern times, such reviews are documented on a regular base. It is well known that prominent physicists like Einstein, Bohm and Pauli were in touch with Indian philosophers like Tagore and Krishnamurti, and the 14th Dalai Lama is having regular meetings with scientists around the world (1991, 2012). Denis Noble, one of the editors of this journal, has also reported interesting advances in the field (2009, 2010, 2015).

The link of biology to Eastern thought from antiquity to present days is a subtle one (Needham, 1956; Ho and Saunders, 1979). It overarches cultures that have been separated from each other for centuries. The common denominator has been the human mind (Partridge and Gabriel, 2003), which, since the Stone Age, has been occupied with observing and reflecting upon its home in the Universe (Kauffman, 1996). So, our attempt in this special issue does not stand alone. The intention of this volume is to reinforce and renew the foundations on which science has evolved in both East and West throughout the ages. The most remarkable part of this effort is that it follows the “silk road”, on which civilizations were learning from each other in a peaceful manner over millennia. It is time now for Western science to naturalize and internalize the overarching concepts of the East that will bring it back to its forgotten and suppressed roots and advance forth towards new horizons. This is the essence of the Integral Biomathics approach, which aims at expanding the

[?] Assembling this special issue was both an exceptional challenge and motivating experience for us all. Working with the many talented and enthusiastic contributors and reviewers who helped to prepare it has been a delight.

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boundaries of knowledge in the natural sciences, and particularly in biology, along three dimensions, pursued in special editions of this journal (2013, 2015, 2017) with the generous support of Professor Denis Noble, FRS.

What makes such work imperative at present is that what appeared to be major advances in Western science, and particularly biology, has cemented in place assumptions that effectively deny any reality to life. This was evident to the great physicists of the past. Einstein concluded that the existence of living beings reveals how primitive physics still is (Rosen, 2000, 34), a view that largely concurred with Niels Bohr's and Erwin Schrödinger's views. In expressing this view they were echoing Immanuel Kant's conclusion almost 150 years earlier where he concluded that Newtonian physics cannot be portraying the world as it is in itself since it could give no place to life or consciousness. Things have barely changed. This is not merely a deficiency in the theories of modern science, however. Science has been dominated by a commitment to objectivity that has been understood as building a world that 'is foreign to consciousness and in which consciousness is obliterated' (Rosen, 2000, 82). That is, it has been dominated by philosophical assumptions that virtually preclude the possibility of even acknowledging the reality of sentient life.

This is not merely a scientific issue, but a philosophical issue, requiring a bridging of the gap between science and philosophy. While at the end of the Nineteenth and early Twentieth Centuries, philosophers such as Charles Sanders Peirce, William James, Henri Bergson and Alfred North Whitehead had followed Immanuel Kant and, more importantly, Friedrich Schelling, and proposed radical changes to alter not only the direction of science but also how science should be conceived, these philosophers were eclipsed by positivists who defend mainstream science, along with behaviourism. Their belated recent return to grapple with the 'hard problem of consciousness' as David Chalmers put it, is unlikely to make any progress because in the meantime they have excluded from philosophy the methods of questioning deep assumptions and offering radically new ways of thinking required to make any contribution to this question. It is for this reason that simply invoking philosophy by itself is not enough either. It is necessary to develop a much broader perspective to grapple with the predicament we are in, a perspective that only engagement with the whole history of Western science and philosophy and non-European traditions of thought can hope to provide. For instance, in his 1993 book Stanley N. Salthe indicated the necessity to develop a logic of *vagueness*, still missing in the Western discourse, which goes beyond the technical one of fuzziness (Zadeh, 1975, 2004). Another, more recent example of how a recapitulation of science from the Eastern perspective can be realized in the case of contemporary biology was given in (Noble, 2015). In this article Denis Noble discusses a little known text by the Korean Buddhist Master, Won Hyo (617–686), found in the *Kumgang Sammaegyong ron*. This writing explores the relationship between the seed and the fruit of a plant using Nagarjuna's four-cornered (actually in this particular case eight-cornered) logic. It could stand as a statement of the principle of *biological relativity*, which is at the base of Robert Rosen's relational biology and the following works of Aloisius Louie, Andree C. Ehresmann and John J. Kineman, the former and current contributors to Integral Biomathics. Denis Noble assumes that Hyo's aim was to illuminate the concept of emergence or being/non-being, an aspect that was sensed by quantum physicists as potentiality/reality.

In the paper by Josephson and Conrad referred to above, the authors postulated a fundamental hypothesis for the natural sciences, that nature is *alive*. They regard the phenomena of classical physics as "the grosser, macroscopic aspects of the life process" and understand the quantum level, as described by the wave function, as "a

'thought plasma' of codes for bringing the classical level into being" (p. 8). This idea suggests a research method analogous to Feynman's requirement for an automation, which is "not a Turing machine, but a machine of a different kind" capable to investigate quantum phenomena (Feynman, 1982, p. 474, ff.), the quantum computer. It internalizes Michael Conrad's contributions to the wave function, vacuum and the new ways of thinking about cross-scale information processing (Conrad, 1996; Fogel et al., 2001) that are well inside the scope of this special issue and dovetails with the postface by Tozzi et al. entitled "Heidegger's being and quantum vacuum" pinpointing another link between Eastern and Western philosophy (Ma, 2008).. The smooth integration of the object of investigation with its subject, the scientist and his/her way of thinking and comprehending the world is characteristic both for Western phenomenological philosophy (Simeonov et al., 2015) and the Eastern tradition advocated by Integral Biomathics. Therefore, we conclude this special issue with a fictional dialog about Existence, confronting the phenomenological and the physical stances. The "thought plasma" of Brian Josephson and Michael Conrad acquires a deeper meaning in this thought-provoking discussion between the characters of Richard Feynman (Richie) and Martin Heidegger (Martin), promoting a more contemplative, introspective approach to science.

Furthermore, Josephson and Conrad argued that progress in theoretical discovery, our particular objective, follows a three-step pattern:

- (i) specification of a new theory starting from basic concepts that deal with change: movement, collision, binding/fusion, dissolution, etc.;
- (ii) reinterpretation of various a priori known phenomena "in an enlightening way" in the new picture of reality;
- (iii) development of new concepts that provide deeper explanation of nature, where new phenomena became amenable to the theory, leading to its eventual general acceptance.

The key question is, however, how does modern science deal with the object and process of observation and with the related apparent dichotomy between mind and matter at the cross point of biology? We have tried to address this question from three different perspectives in the past three special issues on Integral Biomathics. In this recent one, we seem to have come much closer to the essence of the process of scientific inquiry, which connects the researcher with the real world via the interface of our ability to abstract, reflect and model the external world using modern computational tools, in particular in the fields of data analytics and visualization. Two of the articles in the mathematics and computing section (Cardier et al.; Simeonov and Ehresmann) have demonstrated in detail how a smooth integration of the object of exploration with the scientific methodology associated to it can be achieved. In this way a creative discovery "flow" of solutions to problems can be realized as continuous process following the above three-steps pattern to unite Eastern philosophy and insight with modern (Western) science. The presumptions about the nature of life processes, which Brian D. Josephson and Michael Conrad identified in their paper 25 years ago are still holding:

1. Life is associated with continuous and progressive changes in the form-function of a system, which advance its overall state to a *better one*, understood as *robustness*, *resilience* and *health*, often modelled in terms of holding liveness and safety boundary conditions imposed by the external environment which allows the system to occupy a niche and develop within it partially stable conditions in a very specific way. The overall "healthy" condition/state of the system invokes at a certain stage of development another type/level of progression of a rather different kind, that of "adapt-

tive development” or learning, which is a process of change that makes some part of the system gradually more sophisticated, cognitive and introspective and at the same time more intelligible to the external observer who tries to understand the goals/purpose of the system. In other words, this higher level of progression enables the system to become more effective at performing a specific action. This process of secondary change involves the acquisition of knowledge (manipulating complex data structures and optimal ways for storing and retrieving them at need) relevant to a specific task.

2. Life processes are maintained through the continuous exchange of energy and information, which is mediated through the agency of subsystems acting as signals or codes (e.g. DNA or enzymes) between the individual parts of the system. Codes themselves are part of the recursive improvement of the system into yet another level of organization.
3. The Darwinian principle of survival and fitness of the “best” (i.e. most adapted) dictates that living systems implementing codes that optimally correspond to internal and external processes in the environment, improve their chances for survival. This ensures the development of highly sophisticated skills, perpetually modified and optimized across the generations.
4. Mental processing is directly associated with the use of codes. The latter are generally distinct from the systems they refer to, thus demonstrating “two levels of reality”. Mind and matter are on an equal footing in biological systems. Mental function is present in some form in most life forms. In higher forms adaptive development leads to higher competence in code manipulation. The highest development is the ability to utilize modal logic, i.e. dealing with possibilities.
5. Other functions, such as observation and decision, support code manipulation. Observation provides the information on which to base decision.

The papers in this special issue demonstrate the practical applicability of these principles in diverse fields. We followed the proven and tested practice of the previous two special issues and organized this one also like a monograph. It consists of five thematic sections dedicated to the relation between Western science and philosophy, and the Eastern tradition, and a supplement, concluding “experience” section, all embraced by an external frame of this editorial, a preface, a postface and an epilogue. Motivated by the topic of this special issue, the first and the last thematic sections are reviewing the philosophy of science in two specific aspects: the advancement and the confluence/perspectives of Western science with the Eastern tradition, thus shaping a second, internal frame of the volume. It is interesting to note that the contributions to the physics section this time are not as many as we expected, perhaps because most physicists are either too sensitive/careful with the topic of this special issue or they simply do not distinguish between East and West in science today.

The compilation and the review of this volume was a real challenge for all of us. It has been by far the most difficult of all three special issues in *Integral Biomathics* to this moment. Therefore we wish to thank all contributors, peer reviewers and editors, and, in particular those who remained “behind the curtain” to this moment: Lakshmi Chandan, Divya M. Pillai, Valerie M. Teng-Broug from Elsevier, Michael Dix, Glenn McLaren, Pidi Siregar and Jocelyn Dunphy-Blomfield.

In the following we offer a synoptic overview of the Special Issue, proceeding section by section and paper by paper. We hope that the reader will find this attempt to explore the nature of mind and life as a necessary conjunction between Western and Eastern thought traditions both meaningful and enjoyable.

Preface: Towards a global understanding of development and evolution

Robert Ulanowicz

Robert Ulanowicz in his preface to this edition pinpoints the problem faced by theoretical biology; the consensus among leading physicists is that “All causality is from below, and there is nothing down there but the [force] laws of physics.” Something is missing, and a tacit assumption of physics, that the force laws of physics can only be mapped onto homogeneous sets, precludes physics from even acknowledging what is missing - the heterogeneity of living processes. This missing dimension has been revealed most clearly in ecology, Ulanowicz argues, the maverick science in which new ways of thinking are being developed that have more in common with Eastern than Western thought. Ecology gives a place to autocatalysis or indirect mutualism whereby processes benefit one another in cyclical fashion, resulting in development in a non-random, but indeterminate fashion in which, as revealed by process networks, ecosystems evolve towards a balance between constraint and reliability. Instead of a uniform progression towards maximum efficiency, there is a Heraclitean dialectic between order and decay. Such thinking is not only a challenge to physics, it is transforming it. It offers some hope of understanding the evolution of the universe, including the emergence of the forces and constants that have preoccupied past physicists. We are moving towards a physics according to which, as Mark Bickhardt and Donald Campbell put it, “quantum field processes have no existence independent of configuration or process ... it is patterns of process all the way down, and all the way up.” A new narrative is emerging, more inclusive than the physics only perspective on reality. It rests on Milesian Greek and Eastern *I Ching* as well as the principles of the Western Enlightenment. It is the creation of the whole of humanity.

1. Philosophy part A: Advancing Western science through Eastern philosophical traditions

1.1. Linking the Tao, biomathics and information through the language of energy

Joseph Brenner

Noting that knowledge in the West and the East are both incomplete in different ways, Brenner, in the first of three papers engaging with Chinese thought, argues that a non-standard, non-truth-functional logic of energy based on the work of Stéphane Lupasco could provide the means to link Western and Eastern approaches to knowledge. What is blocking the advance of Western knowledge, he argues, are forms of logic and categorial distinctions that are incapable of dealing with qualitative change, while qualitative change was the focus of the work of Chinese philosophers. Lupasco's logic, grounded in physics, can still describe qualitative changes. Its application is illustrated by intra- and inter-cellular processes as well as processes at higher levels of organization. Brenner concludes by arguing that this synthesis is a moral imperative for both Eastern and Western society.

1.2. Quantum gravity and Taoist cosmology: exploring the ancient origins of phenomenological string theory

Steven Rosen

Rosen shows in his contribution how a Chinese number archetype central to Taoist cosmology mirrors the ideas developed in his own work expounded in an earlier contribution to this journal on phenomenological string theory based on qualitative topology and hyper-complex numbers. They each express the psychophysical (phenomenological) action pattern at the heart of microphysics. Tackling the

question of quantum gravity requires a whole family of topological dimensions, and in engaging with these, Rosen has found a related family of Taoist forebears that, in concert with their successors, provide a blueprint for cosmic evolution. Whereas conventional string theory accounts for the generation of nature's fundamental forces via a notion of symmetry breaking that is static and therefore unable to explain cosmogony successfully, phenomenological/Taoist string theory entails the dialectical interplay of symmetry and asymmetry to produce a dynamic theory of cosmic change. A detailed analysis of cosmogony is offered, first in terms of the theory of dimensional development and its Taoist (yin-yang) counterpart, then in terms of the evolution of the elemental force particles through cycles of expansion and contraction in a spiralling universe.

1.3. *Chreods, homeorhesis and biofields: finding the right path for science through Taoism*

Arran Gare

'Chreod', (or 'necessary path'), 'homeorhesis', (or 'tendency of a process to return to its path after deflection'), and 'morphogenetic field', the core concepts developed by the theoretical biologist C.H. Waddington, emerged from his work in embryology. Despite their success and potential for application in other domains, these concepts have not had the impact they should have had. It is argued that this is because, being influenced by the philosophy of Alfred North Whitehead, these concepts were rooted in Chinese traditions of thought incompatible with deep assumptions dominating Western civilization. It is shown that even in physics, the concept of field has been subordinated to the concept of particle for this reason. To overcome the marginalization of all such ideas, it will be necessary to acknowledge that these deep assumptions of Western civilization are fundamentally defective and are now hindering the advance of all science. The need for a major scientific revolution equivalent to that which occurred in the Seventeenth Century should be fully embraced, and science should be consistently founded on a Taoist cosmology able to integrate the best of Eastern and Western thought. Supplementing Mae-Wan Ho's work in theoretical biology through a combination of quantum field theory, hierarchy theory and Rosen's work on anticipatory systems, it is shown how this synthesis of Eastern and Western thought provides the basis not only for defending and further advancing Waddington's concepts, but (complementing Brenner's claims) for overcoming the fundamentally flawed culture of modernity and finding the path to a better civilization.

1.4. *Peircian cosmogony's symbolic agapistic self-organization as example of eastern philosophical influence on western thinking*

Søren Brier

Noting the parallels between the radical challenge to Western mechanistic thought posed by C.S. Peirce's process philosophy of a non-theistic agapistic evolution from nothingness, and Advaitism (non-dual Vedic philosophy) and Buddhism, Brier points out that Peirce was inspired by German *Naturphilosophie*, Indian philosophy and Western spiritual mysticism as viewed by the Concordia transcendentalists. These schools of thought provided a cosmology combining spiritual traditions with rationalism and science. Extending Peirce's project, it is shown how his non-mechanical process view can include quantum field theory in an overall pragmatist triadic semiotic theory. Peirce's cosmogony, based on a view of the development of the universe as a reasoning process from pure potentiality to the fully ordered rational *summum bonum*, is compared favourably to J. A. Wheeler's more recently developed "It from bit" cosmogony

based on quantum philosophy and information science leading into the info-computational view of the nature, mind and culture. As opposed to Peirce's view of the universe as a very vague growing symbolic argument, mainstream Western science exemplified by Wheeler still sees the evolution of the universe as the development of dead mechanical matter driven by energy and computational information and lacks a phenomenological foundation.

1.5. *Foundations of anticipatory logic in biology and physics*

Jesse Bettinger and Timothy Eastman

Noting that living systems oppose the law of entropy that governs the macrocosm, Bettinger and Eastman examine top-down effects and anticipatory systems through which, by active modeling and inference, anticipated effects are projected onto potential causes. A broad landscape of anticipatory systems is extrapolated on this basis. These ideas are developed through counterfactual reasoning in probability space, correlating Eastern and Western thought through Alfred North Whitehead's process philosophy.

1.6. *An extended framework to science*

Roland Cazalis

Cazalis notes that after the Axial Age that generated the civilizations that are still with us, each civilization developed along different paths. Their encounter in the present has revealed each to be lacking in different ways, and this renewed encounter provides the basis for developing an extended framework for the future development of science. This entails access to knowledge with a different state of mind that enlarges the horizon of science. In its traditional way of functioning, the latter is frequently cluttered with paradoxes, duality, incompatibility and other aporias. Case studies in biology and physics give a view of the framework's possibilities.

2. Physics and Eastern thought

The contrast between Eastern and Western thought becomes most acute once the place of measurement is acknowledged as a foundational problem of the physical sciences. Measurement is a very strange beast in being definite in retrospect while being definitively indeterminate in prospect. Classical mechanics as a paradigmatic example of the classical sciences simply assumes without justification that measurement should be both definite in retrospect and determinate in prospect, thus dismissing from the start the troublesome issue of measurement altogether. It fails in admitting, despite this assumption, the intrinsic irreversibility latent in the act of measurement. Quantum mechanics in coming on the scene rectified this situation. However, what quantum mechanics has revealed to us so far is a far more problematic situation latent in the issue of measurement. The confrontation between definiteness in retrospect and indetermination in prospect could easily jeopardize the perspicuity of the intended descriptive enterprise because of the incompatibility between definiteness and indetermination at the same moment. Facing this serious malaise, John Bell, one of the most ardent proponents of European sciences, proclaimed "On this list of bad words from good books, the worst of all is 'measurement'. ... In fact the word has had such a damaging effect on the discussion that I think it should now be banned altogether in quantum mechanics" (Bell, 1990). In contrast, the thinkers sympathetic to Eastern traditions, by virtue of their environmental origins, have dared to live with all the incompatibilities associated with measurement, without ostentatiously offending those folks sympathetic to the Western tradition.

2.1. From quantum measurement to biology via retrocausality

Koichiro Matsuno

In his paper on measurement and retrocausality, Matsuno tries to figure out a pathway through which the role of measurement could properly be appreciated, even in the Western scheme of thought, while facing up to all its incompatible aspects. Measurement in retrospect can set us free from any incompatibles, Matsuno argues, by undoing the incompatible quantum coherences through accepting retrocausality, riding on quantum development as specified by Schrödinger's equation of motion, but proceeding backwards in time. Those quantum coherences to be wiped out would remain unidentifiable. The surviving quantum coherence proceeding forwards in time, on the other hand, is the one that could succeed in recruiting the necessary quantum resources for the measurement underlying the implementation of the identifiable coherence, even to the physicist sitting outside the measurement process. Above all, biology can take full advantage of this trimming of irrelevant quantum coherences for the sake of configuring and maintaining its own organizations in the material world.

2.2. Cellular gauge symmetry and the Li organization principle: general considerations

Arturo Tozzi, James F. Peters, Jorge Navarro, Kun Wu, Bi Lin, Pedro C Marijuan

Measurement is resource-sensitive in detecting and utilizing a material means for the sake of its own operation. One possibility for coping with an irreconcilable discontinuity between before and after the act of measurement must be to make an appeal to something that can remain continuous even while crossing the discontinuity. One practical example demonstrating the continuity of such a transformation Tozzi et al. examine in their paper is second messengers underlying the cellular biomolecular pathways. A nice thing about the present enterprise upon a continuous transformation is that the likelihood of cellular homeostasis with use of the second messengers may be associated with the gauge invariance of the supporting cellular organization. It thus turns out that the robustness of the gauge invariance could be guaranteed in the presence of symmetry-preserving gauge field even if some degrees of freedom being changed are physically measurable.

2.3. Cellular gauge symmetry and the Li organization principle: a mathematical addendum. Quantifying energetic dynamics in physical and biological systems through a simple geometric tool and geodesic curves

Alexander Yurkin, Arturo Tozzi, James F. Peters, Pedro C Marijuan

The idea of gauge invariance is mathematical in general or geometrical in particular in its origin, while it can be quite versatile in its interpretation. One pedagogical example is that there is a likelihood of a continuous map from a pair of opposite points that is antipodal, on the three-dimensional sphere onto a circumference in a two-dimensional plane. In other words, a single feature standing for symmetry-breaking in a lower dimension can be restored in one-step higher dimension. Yurkin et al. in their paper explore the use of topology in assessing the role of symmetry-restoring forces embodied in the form of gauge field met in the organization of various signaling pathways ubiquitous in the biological realm. One advantage of referring to topology as a vehicle to approach biology is to restore a symmetry

property as an index pointing to the extent of an organization as moving up toward a higher dimension through a continuous transformation.

2.4. The path to timelessness: insight, assignment conditions and strong anticipation

Susanne Vrobel

One more strategy for coping with the discontinuity intrinsic to the gap between before and after the act of measurement is to directly face the underlying discontinuous transformation. Vrobel in her paper basically addresses the issue of an eternal Now as reminding us that the transformation of the tense may occur exclusively in Now. Tenses alone cannot change their own tenses. The agential capacity latent in Now is about the tense-less simultaneity, which can tolerate some extent of conflicts and incompatibles internally, thus dismissing the distinction between inside and outside. Comprehending an indivisible reality of the Now serves as the cornerstone for approaching something implicit permeating nonlocally everywhere and upholding something explicit locally.

2.5. The role of Eastern approaches in Bohm's scientific-philosophical odyssea

Paavo Pylkkanen

The strenuous contrast between inside and outside is also an issue taken up by the quantum physicist David Bohm and the Buddhist philosopher Jiddu Krishnamurti, as detailed by Pylkkanen in his paper. Although the local realism remains incompatible with Bohmian hidden-variable theory of quantum mechanics as John Bell aptly proved, the idea of nonlocality can still survive. The quantum potential is certainly nonlocal. One advantage of Bohmian mechanics lies within emphasizing the idea of the definite trajectory of the quantum particle without being bothered by the shifty split between what is measuring and what measured. Nonetheless, the notion of time as a parameter instead of being an operator still survives in the original Bohmian scheme. If time as a parameter is adopted as following the standard practice of doing physics, the Bohmian scheme would come to stage a two-front war. One front is how to make it Lorentz-invariant, the other is how to save the idea of an eternal Now. The future fate of the two-front war remains to be seen.

3. Mathematics, computation and Eastern thought

3.1. Marriages of mathematics and physics: a challenge for biology

Giuseppe Longo, Arezoo Islami

Islami and Longo review the evolution of geometries from the antique to the Algebraic Geometry of the 20th century. In particular, the authors emphasize the mediating role of Persian/Arabic algebra in this historical and geographic perspective and the Western response to this symbolic development. In this context, they also discuss the changes in the ontological attitudes towards the different branches of mathematics and their applications. Islami and Longo conclude that the encounter of geometric and algebraic perspectives enriched the mathematical practices and their foundations. In their opinion however, the collapse of Euclidean certitudes more than 2300 years ago, and the crisis in the mathematical analysis of the 19th century, led to the exclusion of "geometric judgments" from the foundations of mathematics. Today, the limits of the logico-formal analysis and the necessity to broaden the foundational tools and re-examine the interactions with natural sciences are realized by contemporary mathe-

maticians. Islami and Longo examine the way in which geometric and algebraic approaches organize knowledge in terms of a cross-disciplinary and cross-cultural East-West subject in the context of Mathematical Physics and Biology. They also discuss how the current notions of mathematical (phase) “space” needs to be revisited for the purposes of life sciences.

3.2. *Some resonances between Eastern thought and Integral Biomathics in the framework of the WLIMES formalism for modeling living systems*

Plamen L. Simeonov, Andrée C. Ehresmann

Forty-two years ago, Fritjof Capra published “The Tao of Physics” dedicated to the twentieth century physics which has “... necessitated a radical revision of many of our basic concepts” and that, unlike ‘classical’ physics, shows remarkable resonances with Eastern philosophies and “leads us to a view of the world which is very similar to the views held by mystics of all ages and traditions.” Simeonov and Ehresmann stress an analogous situation in biology with respect to a new field in theoretical research Integral Biomathics (IB), the findings of which also exhibit surprising resonances with Eastern thought. Stepping on earlier research in cybernetics and theoretical biology, IB has been developed since 2011 (INBIOSA program) by over 100 scientists from a number of disciplines who have been exploring a substantial set of theoretical frameworks departing from the traditional frame of “objective” science. From that effort, the need for a robust core model utilizing advanced mathematics and computation adequate for understanding the behavior of organisms as dynamic wholes was identified.

In this context Simeonov and Ehresmann have proposed a formal biomathematical and biocomputational research framework *WLIMES*, based on the complementary synergy between i) a *non-axiomatic* “rigid but flexible” situation and context aware spatiotemporal logic, *Wandering Logic Intelligence (WLI)*, and ii) a mathematical formalism, *Memory Evolutive Systems (MES)*, based on a dynamic category theory for multi-level, multi-agents and multi-temporality complex living systems. It represents a sophisticated hybrid design methodology rooted both in mathematics and computation for model conceptualization. *WLIMES* is nearly perfectly suited for an all-embracing investigation of complex system behaviors. Through its capability to integrate other fields of mathematics, it can handle almost every particular problem at its specificity. A previous publication (2012) has revealed the synergies and differences of both techniques unified under the roof of a common formalism. Now, the *WLIMES* principles are explained in this article with respect to their relation to Eastern philosophy and teachings.

3.3. *Design and katachi: modeling emergent systems*

Beth Cardier, Ted Goranson, Niccolo Casas, Patric Lundberg, Ryuji Takaki, Dénes Nagy, Alessio Erioli

Cardier, Goranson et al. elaborate on an approach introduced in the previous two special issues on Integral Biomathics, which addressed the INBIOSA agenda (www.inbiosa.eu). The approach introduces a new tier of information to formal biological modeling: systems-level abstractions, using and extended version of situation theory. The strength of this method is a two-sorted logic where one sort is logic that supports the common reductionist paradigm, and another ‘reasons’ about systems and situations that can include implicit and intangible elements. The advance from Cardier and Goranson’s group is to apply category theory to this second sort in a similar general fashion to others (notably, Simeonov and Ehresmann). They extend

their approach using a range of examples, including some from artistic disciplines (design, katachi and narrative), to shape the relevant categorical dynamics.

The authors have discussed the development of this approach in two previous special issues on Integral Biomathics. The first one (2013) focused on the example of olfactory neural regeneration, in which neurons are influenced by memories of events constructed as ‘narratives’. Some formal elements of the approach are described, as a foundation. In the following special issue (2015), the authors focused on the formal problems of a type system for the second sort, leveraging insights from many contributors in the INBIOSA community. It explores and extends philosophical phenomenology while focussing on practicalities of coding, existing ontological frameworks and a challenging application: multi-system neurophysiological modeling.

The contribution of Cardier and Goranson’s group to the current special issue (2017) extends the specific phenomenological approach to include the peak of the emergent process, in which a system’s structure becomes self-referential. The example this time is the process whereby a herpes virus hijacks the human sensory nervous system to send a spoofed signal to the brainstem, by which it modifies the immune system response. This transitory human/alien neural system is impossible to model by ordinary means. A structured five-stage metaphor of emergent order is identified to better characterize this process, and is described in terms of principles of design, the Japanese notion of *katachi*, and tactile surfaces.

3.4. *Sheaf theoretic formulation for consciousness and qualia and relationship to the idealism of non-dual philosophies*

Menas Kafatos, Goro Kato

Questions about the nature of reality, such as whether Consciousness is the fundamental reality in the universe, and what is Consciousness itself, cannot be answered in closed systems that postulate the existence of an external reality independent of inner world of the observer. The ontological foundation of such explanatory systems, which are common for contemporary science, is the absolute division of subject and object or mind and body.

In his paper, Kafatos and Kato advocate an approach that is in agreement with the foundation of quantum reality based on Rāmānuja’s version of Vedanta philosophy and non-dual Kashmir Śaivism. They claim that quantum mechanics opened the door to understanding consciousness, but it cannot account for consciousness itself. Indeed, the quantum measurement problem implies that we cannot remove subjective experience and philosophical phenomenology as seen by Husserl, Heidegger and Merleau-Ponty from the practice of science, a topic that was extensively discussed in the previous special issue on Integral Biomathics in 2015. With this motive in mind, Kafatos and Kato depart to seek mathematical formalisms for the workings of consciousness that do not rely on specific interpretations of quantum mechanics. They reckon that temporal topos provides such a framework. In this theory, the difference between a subject and an object involves the direction of a morphism in a category. In a dual category, the direction of the morphism (mapping) is in the opposite direction compared with the original direction of the original category. The resulting mathematical formalism provides powerful means to address consciousness and qualia, beyond those attempts to account for consciousness through physical theories. Kafatos and Kato also discuss the implications of the mathematics presented in their paper for the ongoing convergence of science with the non-dualist philosophies of the East and West, which leads to an emerging

Science of Consciousness that may bring out the cherished unity of physics, life and mind.

3.5. *The East, the West and the universal machine*

Bruno Marchal

In his preceding contributions to this special issues row in Integral Biomathics (2013 and 2015), Marchal summed up his research at the intersection of mathematical logic, physics, cognitive science and theology (in the sense of Plato, where God is defined implicitly by the Fundamental Truth that human beings search). He departed from the mechanist hypothesis in cognitive science, or in the “philosophy of mind”, and shows it to be epistemologically incompatible with Aristotle's main theological hypothesis: the existence of some *primary* matter and/or what we call today physicalism. This is an important distinction because of the widespread opinion in science and philosophy that materialism and mechanism are compatible if not identical. Thus, Marchal claims that computer science forces us to backtrack on Plato in the fundamental domain, which leads to a precise (testable) form of Pythagorean Theology. He concludes that the fundamental reality is given by any Turing Universal Realm. According to Gödel, Turing and Kleene it happens that the Arithmetical Reality is already such a Church-Turing universal realm, so that we don't have to assume more than the succession of the natural numbers, and the addition and multiplication laws, to explain where both consciousness and the physical laws come from. These premises give us a form of neutral monism, which is theologically very close to Neoplatonism and Neopythagoreanism.

The East, like the West, has always been oscillating between certain forms of materialism and immaterialism. The tremendous difference between the Platonic and the Aristotelian conceptions of Reality is reflected in the writings of the Chinese Taoists, the Hindu schools of philosophy and religion and in the Buddhists' writings. In the present paper, Marchal recalls a part of the universal digital machine's or number's theology, and uses it to analyze the gap between the intuitive thought and the analytical thought, and their confusion or identification in reasoning or in communicating reports of mystical insights or experiences, in both the Eastern and Western cultures. Eventually, he is not quite convinced that there is a bigger difference between the East and the West thought than between Plato and Aristotle. In both places, some researchers appear to introspect themselves more accurately than others when compared to the (mathematically precise) digital machines or to the numbers introspection. The author agrees that this should not be used to decide who is right or wrong, but allows that the empirical confirmation or refutation of the theology of numbers, which contains the laws of physics entirely, might provide us with some special insights. Up to now, the theory of Marchal is confirmed by the empirical quantum discovery (the superposition principle, quantum logic, quantum formalism/theory) and its similarity with how the sound, self-referentially correct, (Löbian) machine solves the mind-body problem.

3.6. *Mysticism in the history of mathematics*

Ralph Abraham

In an earlier paper (Mathematics and Mysticism, published in the second Special Issue on Integral Biomathics in the journal Progress in Biophysics and Molecular Biology, December 2015) Abraham argued for a role of mysticism in mathematical creativity, especially in the creation of new branches of mathematics. In the present special issue he presents evidence for this hypothesis in the form of detailed

case studies from the history of mathematics of ancient, medieval, and modern times.

4. **Biology, mind and Eastern thought**

This section starts from the papers discussing biological systems and their evolution in the context of Western and Eastern thought (B.J. Ford, J.S. Torday and W.B. Miller Jr., T. Nakajima), then continues with the papers on consciousness (Y.-P. Gunji et al.), on identification of Eastern and Western types of human reflexion (V.A. Lefebvre), on the dynamics of social systems (A.U. Igamberdiev) and its modeling (K. Sawa and A.U. Igamberdiev). In the last paper in the section, Z. Hu et al. analyze hexagrams of the famous ancient Chinese book I Ching and their correspondence to the structure of the genetic code.

4.1. *Cellular intelligence: microphenomenology and the realities of being*

Brian J. Ford

The section begins with the essay of Brian J. Ford. He refers to the traditions of Eastern thought that conceptualised life in a holistic sense while Western science is founded on a reductionist quest for ultimate realities resulting in modeling of living organisms by a digital computer system. The author argues that the essential processes of cognition, response and decision-making inherent in living cells transcends conventional modeling. He takes as examples the shell-building amoebae and rhodophyte algae and demonstrates that these organisms reveal a level of cellular intelligence that is unrecognised by science and is not amenable to computer analysis.

4.2. *The resolution of ambiguity as the basis for life: a cellular bridge between Western reductionism and Eastern holism*

John S. Torday, William B. Miller Jr.

The authors identify what they call “First Principles of Physiology” and refer to the boundary conditions that enable cellular life through negentropy, chemiosmosis, and homeostasis. The most important consequence of the establishment of boundary conditions of living state is the self-referential awareness that arises from this organized state to sustain its homeostasis. The latter is dependent on the information transfer and communication. The imprecision of sources of information and of their dissemination in living entities results in the innate state of ambiguity. Cellular life and evolutionary development are viewed as a self-organizing cellular response to uncertainty in the basal initiating parameters of living processes. This view makes possible a unification between Western rational reductionism and Eastern holism.

4.3. *Ecological extension of the theory of evolution by natural selection from the perspective of the scientific dependent-arising principle*

Toshiyuki Nakajima

The author puts forth the following questions: What generates selective environment? What generates new types? How and why does a certain type replace others, and in what case do they coexist? He considers the necessity of integration of causes and conditions into a universal principle of causality, which is called in Buddhist philosophy “pratitya-samutpada” (translated as “dependent-arising”). This principle of causality asserts that mental, biological and physical phenomena and entities exist only in relation to each other. The author

applies the “pratitya-samutpada” principle for analyzing the process of adaptive evolution, in which a higher-level contains the processes that determine conditions operating at the lower level. In this framework, ecosystem generates selective environments through ecosystem dynamics and new genetic types through lateral gene transfer, hybridization, and symbiogenesis. These processes result in replacement of an old type by a new one, or in coexistence between them.

4.4. Free will in Bayesian and inverse Bayesian inference-driven endo-consciousness

Yukio-Pegio Gunji, Mai Minoura, Kei Kojima, Yoichi Horry

The paper of Y.-P. Gunji et al. links the challenging issues related to consciousness and qualia with natural science from the framework of endo-perspective. In this framework, the external cannot be perceived directly, it can be summoned outside of the perspective within a causation-reversal pair. Causation logically proceeds from the cause to the effect, while a reversal from the effect to the cause is non-logical and is expressed by a metaphorical structure. A causation-reversal pair is described using a pair of Bayesian upward (from premise to consequence) and inverse Bayesian downward (from consequence to premise) inference. Endo-consciousness appears as an agent equipped with Bayesian and inverse Bayesian inference. This yields both highly efficient computations through Bayesian interference and robust computations through inverse Bayesian inference. The suggested framework explains free will as a regression of the controllability of voluntary action. In fact, the authors suggest a powerful concept of free will and consciousness in which the externality is summoned via the operation of causation and its reversal.

4.5. Theoretical modeling of the subject: Western and Eastern types of human reflexion

Vladimir A. Lefebvre

In this paper the author, following his earlier breakthrough ideas on human reflexive processes, introduces a model of the subject with reflexion and capable for meditation. A mathematical model of the psychological process of bipolar choice has been constructed and tested, in which the Western and eastern types of reflexion are distinguished. The process of reflexion is presented in the further development of this model as the sequence of heat engines in which each subsequent engine compensates for the imperfectness of the preceding engine by performing work equal to the lost available work of the preceding one. A chain of the subject’s mental images of the self appears in the model as the sequence of heat engines. The two types of reflexive meditation include the dissolution in nothingness and union with the Absolute.

4.6. Evolutionary transition from biological to social systems via generation of reflexive models of externality

Abir U. Igamberdiev

The paper of A. U. Igamberdiev introduces a wide-ranging concept of evolutionary transition from biological to social systems. It is suggested that the appearance of social systems corresponds to the emergence of the structure of subject that incorporates the internal image of external world. This structure, modelled in reflexive psychology using the algebra of simple relations, is established on the basis of referral of the subject (self) to its symbolic image. It acquires a potential to rationally describe the external world. A substantial opposition of the two basic complementary types of reflexion defined

by V.A. Lefebvre as Western and Eastern generates the opposite models of behavior and opposite organizations of societies. This opposition exists not only between the societies but also within one society underlying its homeostasis and dynamics. Invention of new ideas and implementation of new technologies shift the probability pattern of reflexive choices and direct changes in the preference of reflexive types. The dynamics of societies and of interactions between societies is based on the interference of opposite reflexive structures and on the establishment of different patterns during such interference. At different times of the history of human civilization these evolving patterns led to major social changes including the formation and splitting of large empires, the development and spreading of new technologies, and the consecutive periods of wellness and decline.

4.7. The dynamics of interaction of reflexive subjects operating with the two-valued versus many-valued logic

Koji Sawa, Abir U. Igamberdiev

This manuscript presents a model of interacting subjects with the opposite types of reflexion that belong to the Western and Eastern reflexive modes according to Vladimir Lefebvre. It expands the Double Homunculus model previously developed by the authors that describes reflexive agents as holding “the image of the self in the image of the self”. The two homunculus agents estimate their own reflexion in the opposite ways generating the two-valued versus many-valued logic. The model describes intercommunication of reflexive agents in the social environment as well as interactions between the entire social systems of different types.

4.8. I-Ching, dyadic groups of binary numbers and the geno-logic coding in living bodies

Zhengbing Hu, Sergey V. Petoukhov, Elena S. Petukhova

Z. Hu, S.V. Petoukhov and E.S. Petukhova analyze the famous ancient Chinese book *I Ching* and its system of symbols Yin and Yang as the equivalents of 0 and 1. *I Ching* introduces the dyadic groups of binary numbers represented by the sets of four bigrams, eight trigrams and sixty four hexagrams. The genetic code has the same structure: it uses four nitrogenous bases, sixteen doublets, and sixty four triplets. The authors not only emphasize the similarities between the *I Ching* hexagrams and the genetic code but also introduce the bio-mathematical doctrine of the geno-logic code. This higher level code encodes the inherited algorithmic processes using the logical holography and the spectral logic of systems of genetic Boolean functions.

4.9. Experience information as the basis of mind: evidence from human decision making

K. Sankaran and Alex Hankey

K. Sankaran and A. Hankey in their paper discuss a new kind of statistical distribution classified according to the Herfindahl-Hirschman index. The authors claim that this distribution, characterized by fractal properties, derives from creative processes of the human mind. These processes are controlled at critical instabilities and maintain an information structure that is radically different from digital information: it carries an internal information loop, while external information is encoded as ‘forms’ or gestalts. Observations that products of human decision-making are distributed in accordance with the Herfindahl-Hirschman index support the criticality-based theory of mind.

5. Philosophy part B: New horizons opened by the confluence of Eastern and Western thought

5.1. How Peircian semiotic philosophy connects Western science with Eastern emptiness ontology

Søren Brier

In his previous work, Brier has argued that neither traditional mechanist nor the more recent infocomputationalist models of science can serve to build a transdisciplinary science able to bridge Snow's two cultures. There seems to be no path proceeding from mechanistic physicalism to views that encompass phenomenological theories of experiential consciousness and meaning-based cognition and communication. As an alternative, Brier proposed a cybersemiotic framework's integrating Peirce's semiotics and Luhmann's autopoietic systems theory. In this essay he considers in greater depth the ontological developments necessary to make this possible. He shows how Peirce avoided both materialism and German idealism through his building on a concept of emptiness similar to modern quantum field theory, positing an indeterminist objective chance feeding into an evolutionary philosophy of knowing based on pure mathematics and phenomenology that is itself combined with empirically executed fallibilism. Furthermore, he created a new metaphysics in the form of a philosophical synechist triadic process philosophy. To clarify what was involved in developing this ontology, Brier shows how this philosophy was integrated into a transcendentalist view of science and spirituality as developed by Emerson, while featuring a metaphysics of emptiness and spontaneity (tychism) that aligned it with the Eastern philosophies of Buddhism and Vedanta.

5.2. Neo-semiotics: introducing Zeroness into the Peircian semiotics may bridge the knowable and the unknowable

Sungchul Ji

Examining Peirce's classification of signs into nine groups and ten classes, Sungchul Ji observes an omission in Peirce's treatment of signs. While Peirce discussed the 'interpretant-less' and the 'object-less' signs, he omitted, without any justification, the 'representamen-less' sign. This motivated Ji to propose such a sign, called the 'signless' or 'nilsign', belonging to the category of 'Zeroness'. While Peirce did not introduce the symbol '0' into semiotics, Ji observes that he did consider the concept of zero under the rubric 'Pure Zero'. This, Ji suggests, is comparable to the introduction of zero into algebra, quantum mechanics and astrophysics, opening a new field of what he calls 'neo-semiotics'.

5.3. A causal framework for integrating contemporary and Vedic holism

John J. Kineman

While in the Twentieth Century science and philosophy were pre-eminently concerned with the problem of achieving certainty, the current Century appears to be focussing on the search for deeper explanations of complexity as a property of whole systems. Advances in Relational Biology and Category Theory, based on the foundational work of mathematical biologist Robert Rosen, suggest an elegant way forward. A recent synthesis called "R-theory", which Kineman is involved in developing, preserves the essence of holism and explains "life itself" in terms of cyclical causation without violating mechanistic laws. Kineman shows that this theory may also be congruent with ancient Vedic non-duality (*advaita*). This warrants an in-depth explo-

ration of that relationship to reveal where such ideas may have been further developed and tested in practice, and to combine essential aspects of Eastern and Western thinking, particularly at the foundations of mathematics. The relationship between R-theory holon analysis and likely precedents in ancient civilization suggested in literature and archaeology is then explored. The unifying principle in R-theory is a four-faceted (four-cause) universal order, possibly known in ancient times by the Rig Vedic name "Rta". A corresponding meta-theory of cyclical causation is proposed as a foundation for developing more holistic science.

5.4. Brains, language and the argumentative mind in Western and Eastern societies, the fertile difference between Western-eastern argumentative traditions

Jordi Vallverdu

While the contemporary scientific approach to biology is considered universal, the historical study of different cultural and symbolic approaches to reality and life reveals this approach to be the product of Western reductionist traditions. Recognizing this suggests that the assumed universality of contemporary science could be spurious, and it is argued that its reductionist approach needs to be supplemented by and to integrate holistic ideas about life developed in Eastern traditions of thought. This is not just a matter of characterizing life, but of augmenting science with new epistemological and ontological insights, which could facilitate the development of more powerful and insightful ways to understand life.

5.5. Mind-life continuity: a qualitative study of conscious experience

Inês Hipólito and Jorge Martins

Hipólito and Martins note that there are two fundamental approaches to understanding the phenomenon of life, the computational models based on the paradigm of symbolic thinking, and those based on the model of the biological organism. Both are currently characterized by the use of reductionistic methods and tools that hide the phenomenological aspects of existence behind yes/no responses (behavioural tests) or brain 'pictures' (imaging techniques). Recognizing this fact raises the question of how to overcome these methodological difficulties to achieve a non-reductionistic investigation of conscious experience. The authors set out to show that cooperation between Eastern and Western thought traditions might shed new light on how to achieve such a non-reductionistic way to study the nature of life and mind. They suggest to use qualitative analysis to pre-inform quantitative measurements. *Jhana* meditation, and its qualitative assessment, provided experiential profiles based upon subjects' evaluations of their own conscious experiences. This is the first of two papers, with this paper focussing on qualitative evaluation of subjective experience, which will be compared with molecular measurements in the second paper. By breaking new ground in providing comparative analysis of qualitative subjective experience and quantitative measurements of protein networks, the authors hope to contribute to enhancing the autopoiesis paradigm, layed down at the basement of Integral Biomathics.

5.6. Comparative approximations of criticality in a neural and quantum regime

Jesse Bettinger

Bettenger reviews developments in complexity theory on criticality and efforts to relate this work to the functioning of the brain. This is the neural criticality hypothesis, according to which "the brain op-

erates in a critical state because the associated optimal computational capabilities should be evolutionarily selected for.” Bettinger then examines another inroad to criticality via stochastic quantum field theory and dissipative dynamics. Both neural and quantum criticality hypotheses propose specific mechanisms. This suggests that understanding the quantum approach could help shed further light on brain-based modeling, and Bettinger attempts to integrate these two forms of criticality. In the third part, he turns to Whitehead’s actual entities and modes of perception, notions that Whitehead himself acknowledged are more akin to Asian than to Western traditions of thought, to demonstrate a concomitant logic underwriting both models.

6. Supplement

6.1. Lessons from culturally contrasted alternative methods of inquiry and styles of comprehension for the new foundations in the study of life

Jordi Vallverdu and Marcin Schroeder

The philosophical differences between Western and Eastern philosophies rely not only on general cultural ideas about reality, Vallverdu and Schroeder argue, but they are also methodological, ontological and cognitive-driven. There is not a single way to connect biology and culture, but at least we need to admit that brains allow the existence of minds and these create languages, which also organize the world symbolically following a long set of (sometimes interconnected) heuristics. Throughout the paper the authors show how fundamental cultural perspectives, geographically located, have affected reasoning strategies and discourses, determining the main Western and Eastern traditions of philosophy. They conclude that different perspectives allow more diversity for knowledge acquisition.

6.2. East-West paths to Unconventional Computing

Andrew Adamatzky, Selim Akl, Mark Burgin, Cristian S. Calude, José Félix Costa, Mohammad Mahdi Dehshibi, Yukio-Pegio Gunji, Zoran Konkoli, Bruce MacLennan, Bruno Marchal, Maurice Margenstern, Genaro J. Martínez, Richard Mayne, Kenichi Morita, Andrew Schumann, Yaroslav D. Sergeev, Georgios Ch. Sirakoulis, Susan Stepney, Karl Svozil, Hector Zenil

This paper is a kaleidoscope of unusual personal journeys through the spiritual lives and scientific discoveries of 20 prominent researchers in future and emergent computing. Their stories illustrate the concept of idea exchange between East and West in the field of Unconventional Computing, the field outside any mainstream science or engineering that never stops developing.

Postface: Heidegger’s being and quantum vacuum

Arturo Tozzi, James F. Peters, Raquel del Moral, Pedro C. Marijuán

One of the most profound critics of Western thought from Plato onwards was the Twentieth Century German philosopher, Martin Heidegger. Influenced by Japanese and Chinese thought, Heidegger argued that Western metaphysics had focused exclusively on the being of entities and forgotten the question of Being. It had obliterated any appreciation of Being as the condition for the being of entities, or of human existence whereby Being is revealed. Through an imaginary dialog between Heidegger and Feynman, the authors of the postface to this edition show that the “Void”, the vacuum field in quantum field theory is not merely equivalent to Heidegger’s notion of Being, but can be identified with it. It is the source of entities, and of human subjects open to being. This convergence of Heidegger’s philosophy, largely inspired by Eastern thought, and advanced theoretical

physics, one of the greatest achievements of Western thought, heralds a new synthesis transcending the limitations of both Western and Eastern thought.

Epilogue: Western science, reductionism and Eastern perspectives

Arran Gare

In the epilogue, Arran Gare takes up and further examines the themes raised by Ulanowicz in the Preface, most importantly, the problematic notion of reductionism. There can be no doubt that Western science has been dominated by reductionism, and in its extreme form this reductionism has involved denying the reality of life and consciousness. From this perspective, as Ulanowicz pointed out, there are only the forces postulated by physics determining everything. Yet reductionism has led to great successes, and rejecting reductionism as such invites dismissal as abandoning science. Gare shows that the problem is in the diverse meanings of the term reductionism. Epistemological reductionism, promoted by logical positivists as the basis for defining scientific progress as the subsumption of limited theories by broader theories, led to the virtual identification of epistemological reductionism, methodological reductionism and a form of ontological reductionism that privileged physics over all other sciences. It was a false view of science, Gare argues, and when this is appreciated, the value of methodological reductionism, which is essentially analysis, can be acknowledged, although it is also necessary to acknowledge its limitations, and ontological reductionism accepted. Ontological reductionism, the commitment to explaining every aspect of reality through a coherent conception of being, is what defines science, but this does not require the form of reductionism that privileges current physics. This is only one form of ontological reductionism. An ontology must be tested first of all by its capacity to explain the reality of life and the reality of conscious beings who conduct science. As Schelling argued in 1799, if physics implies the impossibility of life and consciousness, the condition for there being science, it is incoherent and should be replaced. The same conclusion was reached by Robert Rosen, who argued that life itself should be the reference point for evaluating an ontology. This justifies Ulanowicz’s conclusion that new ways of thinking being developed in ecology could provide a new metaphysics (that is, a new ontology) and an extended framework for science in which, in alignment with Eastern thought, patterns of processes are recognized all the way down and all the way up, with nature seen as essentially creative.

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