Science and Mind in Contemporary Process Thought

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Edited by

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FOREWORD

The relationship of mind to matter, and the very understanding of mind, and matter, still eludes understanding, even after millennia of philosophical work and centuries of scientific reflection. Though everyone seems to agree that the general evolutionary scheme is true—i.e. first a simple universe is born that later complexifies, and finally out of this complexity emerges life, mind and consciousness—there are deep conceptual problems with this vision. The present volume attempts to show how a particular philosophical school of thinking—process philosophy—helps us in conceptualizing such problems.

The twelve chapters of this book discuss the relation between process philosophy and natural and psychological scientific research, with a focus on the problems of mind and experience. The three successive sections "zoom in" even stronger on the human mind, to give the full overview of the role that process philosophy might play in providing a consistent, unified language for the description of the physical and mental reality. Each part starts with an introduction, written by a leading expert in their field, that gives the reader a bird's eye view on the articles within a broader context of Whiteheadian philosophy.

"Part I: Toward a Science of Process" demonstrates a close connection between process metaphysics and contemporary science. The four authors of this section argue persuasively not only that basic notions of Whitehead's philosophy can find their application in a narrow scientific research field such as category theory (the chapter by Michael Heather and Nick Rossiter), information theory (Jeroen van Dijk), and cellular automata (Michael Rahnfeld); but also that process metaphysics can fruitfully draw from natural sciences to refresh its own foundations (Lukasz Lamza). All four chapters discuss a process version of philosophy of nature that cannot be reduced to, nor identified with the contemporary science, but one that must keep up with modern scientific developments to stay relevant.

The relation between immediate, unconsciousness experience and mental, self-consciousness experience is the main focus of "Part II: Grasping Experience and the Mind". Each paper within this section attempts to overcome the Cartesian mind-body dualism by introducing a more sophisticated, bipolar notion of experience that does not separate the mind from the nature. This is, in fact, the very idea of Whitehead's original

metaphysical proposition, which identified the elementary process, constituting reality, with an act of experience. Among other detailed topics, the reader will find a discussion of several experiments that reveal the essence of unconsciousness; profoundly investigated and naturalized notions of experience and intentionality that are to be correctly understood solely in the context of the whole nature; and the analysis of experience and reasoning at the meeting point of western (Peirce's) and eastern (Nishida's) philosophies. This second section forms the bridge between general philosophy of nature and more detailed philosophical psychology, which is the focus of the final section.

"Part III: Developing Process Psychology" covers an important field of theoretical and experimental research that makes fine use of Whiteheadian categories in the psychological study of feelings, intentionality, and ego. Each of four papers in this section explores contemporary, relevant issues, ranging from microgenesis and Gestalt experiments to personal identity and the psychology of feeling. There is a strong ambition in contemporary cognitive science to create the most adequate and naturalistic model of the human mind possible. These authors provide significant arguments that it should be attained within of the paradigm of process psychology.

As Editors, we would like to express our gratitude to numerous people who have helped us along the way of producing this volume. We thank Bogdan Ogrodnik, President of Whitehead Metaphysical Society, for his continuing support and mentoring, an inexhaustible kindness, and years of co-operation that, among many other things, have given us the drive to publish. We would like to thank our colleagues Mirosław Patalon, Janusz Mączka SDB, and Kleofas Gródek OFM, the co-organizers of the 9th International Whitehead Conference, for their effort and heart in preparing and coordinating the event, that gave us the original motivation to create this work. We would also like to express our appreciation to the members of the Center for Process Studies and the International Process Network in Claremont, California for their contribution to process philosophy, and numerous forms of assistance that we have benefited from throughout our careers. Special and the most personal thanks go to our wives, Katarzyna and Zuzanna, whose love and support gives us the strength and motivation to aim higher and higher.

Jakub Dziadkowiec & Lukasz Lamza
Lublin-Bedzin, November 11th, 2018

PART I:

TOWARDS A SCIENCE OF PROCESS

INTRODUCTION TO PART I

BOGDAN OGRODNIK

Among the many applications of process metaphysics, process philosophy of nature occupies a special position. The origin of modern science was one of the reasons for the fall of metaphysics. Science (mainly physics) took of the role of the universal knowledge about the world which is both rational and verifiable. Three hundred years later the old scientific paradigms clearly became too narrow to effectively subsume different scientific disciplines. The situation more and more resembled the biblical story about the Tower of Babel, which was in imminent danger of collapse because of the plenitude of languages and lack of a common understanding of the meaning of the construction. The need for such a universal language, which is able to reconstruct the main ideas of different areas of knowledge, is really dire today. Only metaphysics could play such a role and nowadays we have at our hands few philosophical systems which both arose from strong philosophical traditions and took into account the main features of the world discovered by contemporary science.

The most advanced attempt was made by Alfred North Whitehead in the 1920s. Because process philosophy—a theory of the real, experienced world—is a system of hypotheses, it needs to be constantly verified. Verification of metaphysical hypotheses is not only a methodological problem, but mainly a philosophical one. The problem is really delicate, because it is not easy to be convincing in this matter. We can put forth working hypotheses based on the great success of science as a synthesis of two types of knowledge: *a posteriori* (observation, experimentation) and *a priori* (mathematics, logic). If we find an analogical synthesis of metaphysical *a posteriori* (experience as such?) and metaphysical *a priori* (ontology?), then it will be possible to build the bridge between science and metaphysics without any kind of reductionism. Of course such a proposal should be well grounded in suitable metaphysics (see Ogrodnik 2011).

The articles presented in Part I: Towards a Science of Process confront process philosophy with scientific findings, modern theories and methods of modeling a vast range of phenomena, other contemporary philosophies

engaged in modern science or simply—requirements of its internal coherence or external applicability. All of them provide direct evidence that process philosophy has more than just a historical meaning but—quite opposite—is a strong partner of science in its endless quest for the primordial meaning of all things.

Michael Heather and **Nick Rossiter** in their paper "Formal Representation of Space" give a convincing reconstruction of a deep formal structure of an important part of Whitehead's metaphysics. They use a modern and powerful, yet still not so popular tool, i.e. category theory and topos theory. The authors stress that this tool (esp. natural topos theory) was derived from intuitionistic logic inspired by modern physics. It is one of the necessary conditions of adequacy of Whitehead's metaphysics and the tool by means of which the metaphysics is reconstructed. Unfortunately, most analytic philosophers treat logic as something prior to the reconstructed philosophical subject. Then the subject is adapted to the capabilities of a chosen formal structure at the expense of even an essential part of the content and many shades of philosophical meaning. The authors propose a non-reductionist program of research aimed at the formal structure of Whitehead's world-process interpreted as "a recursive system with closure at four levels consisting of three open interfaces". This formula outlines a route for further investigations on the non-Boolean ground of topos.

Lukasz Lamza in his article under an intriguing title "An Inductively Formulated Process Metaphysics" takes an opposite starting point in his investigation of process worldview then most philosophers interested in this subject. He begins with gathering plenty of types of processes from almost all scales of the Universe as described by scientists. Then he organizes this body of knowledge according to how these processes develop through time. The most general ("philosophical") description of natural processes (and its phases) requires the use of metaphors such as: assembly, point of instability, transition, evolution, dissipation. Some of them are more adequate, other less or even inadequate. Some of them sounds more "organically", others less. The Author concludes that from the point of view of a general description of natural processes the terms are useful with varying effectiveness and asks a provocative question: Should we accept a statistical metaphysics, or a metaphysics that "works" only sometimes? Of course in this kind of introductory exposition the Author treats such suggestion merely as a kind of food for thought which allows the philosophers to re-think the connection between process metaphysics and the content of the scientific descriptions of natural processes.

The following paper "The Process-Informativeness of Nature" by **Jeroen B. J. van Dijk** presents a deepened analysis of the full methodological context of the genesis of experimental science, especially physics. He shows a series of dissections of the research process from the perspectives founded on two paradigms: a dominating exophysical-decompositional paradigm and a gradually emerging process-informational paradigm. The first one systematically omits all processes of constitution of a set of basic categories, by means of which we describe (as we believe) the most fundamental features of the world. These processes construct our subjectivity and experience of the world in the "conscious Now". Such a perspective makes a sharp opposition between the objects and the subjects and excludes the latter from the scope of philosophy of science. The second perspective allows one to join experienced objects and experiential (and self-experiential) subjects into one all-embracing process of co-informativeness. The change of paradigm is necessary for the search of a new set of fundamental categories, which much more adequately describe the full process of research where both sides of experience, the objective and the subjective, will be taken into account.

Michael Rahnfeld in his article "Cellular Automata" takes up an ambitious and risky attempt of constructing an isomorphism between the theory of cellular automata and Whitehead's ontology, which may at first glance seem distant. The Author presents the following reasoning: if cellular automata turn out to be a universal model of natural processes and Whitehead's metaphysics is a natural philosophical background (model) of cellular automata, then Whitehead's metaphysics is a natural philosophical background of natural processes. The novelty relies on the explanatory strength possessed by the theory of cellular automata in modeling natural processes and a non-trivial correspondence between the notions and functions which constitutes the theory and a set of categories, principles and obligations which constitute the philosophy of organism. The Author convincingly shows that even such sophisticated notions of Whitehead's metaphysics as the primordial and subsequent natures of God have their counterparts in cellular automata theory. In this way the philosophy of organism, widely regarded (rightly or not) as vague, gains a strong support because its basic intuitions are given greater clarity. And vice versa: the cellular automata theory gains a strong philosophical background which could inspire the scientists to develop its new applications.

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CHAPTER 1

FORMAL REPRESENTATION OF SPACE

MICHAEL HEATHER AND NICK ROSSITER

Abstract

Category theory was not sufficiently developed in his lifetime for Whitehead to apply it to the speculative metaphysics of *Process & Reality* that he created beyond the methods of classical mathematical analysis he had helped to develop. For a more rigorous understanding, his later work needs to be expressed even more formally than his earlier work. Axiomatic-free Topos Theory is now able to conceptualise formally the inherent space-time structure of Whitehead's extensional space. That is only the beginning of his metaphysics. However category theory seems to confirm Whitehead's underlying belief that metaphysics needs to be founded in physics rather than finitary mathematics and promises a possible road for a full formalization of the concepts in *Process & Reality* for the future.

Keywords: Extensional Space, Process, Formal Metaphysics, Topos Theory

1. Background

Alfred North Whitehead was one of few to appreciate "the theory of linear extension"[1] of the eminent philologist Hermann Grassmann (1809-1877) (Grassmann 1844) that was to lead to linear algebra, vector spaces, differential geometry and the mathematics that underpinned much of 20th century science (Penrose 2004, 203ff). Grassmann's studies contained a germ of category theory to be pursued here for in the meantime it has led to mathematical topics like universal algebra, topology and homotopy all of which are subsumed in category theory. In particular Grassmann's insight[2] allows geometry to escape from the metric dimensions of Euclid.

That escape epitomises the natural ("assumption-free") essence of the *topos* in metaphysical category theory, the subject matter of this paper. That now well describes the connectedness that Whitehead outlines for the structure of his "cosmology" but which he was unable to represent formally even as a world-class mathematician of his age.

Whitehead himself pursued Grassmann's ideas with his own *Universal Algebra* (Whitehead 1998) but his early career may be characterized as a somewhat frustrated author of mathematical texts. *Universal Algebra* led to his election as a fellow of the Royal Society of London but disappointed him that the work was not generally understood. His projected second volume was therefore abandoned in favor of a joint treatise with his student Bertrand Russell on the logical basis of mathematics. He and Russell attended the renowned Paris 1900 International Congress of Mathematicians in Paris and felt further inspired by interaction with the likes of Hilbert, Frege and Peano. The outcome was the well known but little read *Principia Mathematica* (Whitehead and Russell 1910-1913).

That work was probably as frustrating to write as it is to read. Part II (at pp. 328-383) of the first volume attempts to define the cardinal numbers 1 and 2 but without success. Volume II on the other hand devotes 724 pages in an unsuccessful attempt to formalize the arithmetic axioms of Peano and fails even to establish the fundamental 1+1=2. The explanation for all this we now know with hindsight is because the natural topos lacks a natural number object[3]. Whitehead's dismay and disappointment with the whole project of the *Principia Mathematica* is understandable. Not surprisingly the fourth volume on geometry was never published even though apparently much of it had been written. Indeed Whitehead did not involve himself with the second edition of 1925-1927 at all. However it appears that in the meantime Whitehead was diverting to a physics approach to geometry that emerges in *Process & Reality* (Whitehead 1929). The fourth volume was turning out therefore to be a nightmare and in some conflicting transitional state. For Russell alludes to this in the preface of (Russell 1914) when commenting on the problem of scientific method in philosophy:

> "I have been made aware of the importance of this problem by my friend and collaborator Dr. Whitehead, to whom are due almost all the differences between the views advocated here and those suggested in *The Problems of Philosophy*. I owe to him the definition of points, the suggestion for the treatment of instants and «things,,, and the whole conception of the world of physics as a construction rather than an inference. What is said on these topics here is, in fact, a rough preliminary account of the more precise results which he is giving in the fourth volume of our *Principia*

Mathematica.„ (Russell 1914, 8)[4]

We are concerned here with the subject matter of the fourth volume so far as it relates to Whitehead's concept of extensional space but not from the viewpoint of the history and sociology of science. Readers interested in that perspective are referred to the studies of Patrick J Hurley[5] who cites Whitehead's displeasure at Russell's disclosure of the fourth volume material in (Russell 1914) expressed in the letter to Russell:

> "I am awfully sorry, but you do not seem to appreciate my point. I don't want my ideas propagated at present either under my name or anybody else's—that is to say, as far as they are at present on paper. The result will be an incomplete misleading exposition which will inevitably queer the pitch for the final exposition when I want to put it out. My ideas and methods grow in a different way to yours and the period of incubation is long and the result attains its intelligible form in the final stage, I do not want you to have my notes which in chapters are lucid, to precipitate them into what I should consider as a series of half truths.„ (Russell 1968, 78)

Whitehead's other writings of his ensuing "period of incubation" (Whitehead 1906, 1914, 1919, 1920, 1922, 1926, 1933, 1934) suggest that Whitehead was for some time confident that his extensional theory of space presented in Paris in 1914 (Russell 1914)[6] and consisting of material intended for the fourth volume could still be expressed mathematically as distinct from Russell's "half truths". Whitehead's alternative 1922 theory of relativity (Whitehead 1922) probably marks the watershed after which he realized that it is a relativistic quantum world we inhabit beyond classical mathematics. A lesser mathematician might have persevered with the tensor mathematics but he clearly appreciated that his earlier logicalism was inadequate to articulate his speculative metaphysics. Indeed Gödel confirmed that in his doctoral thesis (Gödel 1929, 2) by expressly using the axioms of Whitehead's *Principia Mathematica* as the basis to prove that first order predicate logic is complete but only for closed systems. Metaphysics on the other hand is of higher order but amenable to the intuitionistic internal language of the natural topos derived from physics and therefore outside of Gödel's theorems.

Of course this strand from Grassmann was only one of many influences on Whitehead as comes through from the text of *Process & Reality*: it includes Plato, Aristotle, Leibniz, Newton, Kant, Locke, Hume, etc; but beside the general proposition that science progresses better when supported by mathematics there seems little from them of direct relevance to formalizing the geometry of space. There were also contemporaries like Poincaré, James, Bergson, Dewey, Husserl, Einstein, Bohr, etc., who get

little or no mention in *Process & Reality* but who nevertheless were providing a climate of thought operating heavily on Whitehead's mind that it was necessary for him to escape the limitations of classical mathematics but again these seem of little direct relevance here. What at first sight does appear more relevant, but in the foreground rather than background, is the content of Part IV of *Process & Reality* itself and the work of those who have since sought to build on it.

2. Foreground

The extraneous evidence outlined above suggests Part IV of *Process & Reality* entitled simply The Theory of Extension is the material written much earlier as proposed contents for the projected fourth volume of *Principia Mathematica* on geometry that was never published. Certainly it appears as an insert differing markedly from the rest of *Process & Reality* as the only part in any way mathematical. It is geometric in tone but in a very idiosyncratic style reminiscent more of Venn diagrams[7] than Euclidean geometry. On the one hand it does not adhere to the strict logical principles adopted in the first volume of *Principia Mathematica*. It makes assumptions that are beyond self-evident primitives and lists *a priori* definitions that are more than mere labels, as are banned in the introduction to the first volume. On the other hand it is clear from internal evidence of the text that it is much more than an opportunity to get published material already written for another occasion. It incorporates more recent published work of others. For example definitions of Professor T. de Laguna (Whitehead 1978, 287, 295, 297) are fundamental to the main thrust of Part 4 and indicate that the whole subject of the extensional theory of space had been recast in Whitehead's mind. This is also further evidence (as from his letter to Russell cited above) that he was struggling perhaps for nearly twenty years with a formal description for space. Part IV is the then current version of Whitehead still trying his hand at representing connectivity in the reality extension to his world of process.

Some of his observations are very pertinent here. Thus the overlap in the diagrams he makes into "ovate classes". This is a perspective of universal limits in category theory the significance of which was not appreciated until the 1970's. The impossibility of producing adequate diagrams[8] to represent such features also adds weight to the proposition that we need to turn from mathematics to physics for nature produces an abundance of limits and co-limits, indeed everywhere all the time. However the mathematics of Part IV does not really go anywhere and

Whitehead did not take it any further in the remaining twenty years of his life.

However disciples of a genius often with great enthusiasm attempt to take the work way beyond where the master would have gone and subsequent events show that the subject of Whitehead's connectivity has many potential onward paths to pursue. Geometrical connectivity is a relational view of atomicity and raises issues of whole-part relationships. Whitehead has in this context spawned interest in some new disciplines like holism, point free geometry, mereology, and mereotopology. These have generated a considerable literature[9] and attempts to define new formal systems of logic. Examples of these are the work of (Clarke 1981, Simons 1987, Casati and Varzi 1999) but the latter have demonstrated that the formal representation can be reduced to Boolean systems. Boolean logic however is not inherently constructive and does not have the required intuitionistic logic required by physics.

Although the subject matter of that field of work is within the ambit of this paper they will not therefore be examined in detail here as the end result is a "null return". These are now mainly of only historical interest. Although Einstein's relativity and quantum theory were contemporary with his "period of incubation" and a clear catalyst for *Process & Reality* Whitehead made no serious attempt to include any quantum mechanics in his theories. Perhaps his brief abortive incursion into the subject of relativity (Whitehead 1922) dissuaded him. There have been quite a few attempts at describing quantum mechanics in terms of topology and category theory but these all belong to the mathematics of his early period that Whitehead had abandoned and will not therefore be examined here. For topology is based on sets and the categories are restricted to categories of sets even if enriched as in n-categories. This century Michael Epperson has made an "attempted correlation of quantum mechanics and Whitehead's cosmological scheme" (Epperson 2004). That attempt has taken the form of a painstaking recasting of Whitehead's metaphysical categories in a Hilbert space with Dirac notation. This unfortunately seems rather to forget that a Hilbert space is composed of points which are just numbers, even though rather sophisticated numbers, and therefore really ghosts from Whitehead's discarded former life of the period of *Principia Mathematica*.

More recently Epperson has published A Topological Approach to Quantum Mechanics and the Philosophy of Nature (Epperson 2013). The publishers had issued pre-publicity with the title *Foundations of Relational Realism: Quantum Mechanics, Category Theory, and the Philosophy of Alfred North Whitehead* . The substantial change from "category theory"

to “topological approach” perhaps suggests that some original aim to use category theory was not realized. The change is quite significant because it undermines the decoherence thrust of the book. Metaphysical category theory can track the space-time development of the quantum wave function. Application of topology immediately collapses the wavefunction a priori. Sheaf theory is a finitary description of the pullback in full category theory. We have already shown in 2002 how this provides a simpler yet more sophisticated approach to quantum theory (Heather and Rossiter 2002a, 2002b). The significance of quantum decoherence within process is more simply represented as monadic composition in the natural topos.

3. The Significance of Category Theory

Around the time of Whitehead’s death in the 1940’s formal “category theory” emerged to subsume algebra, geometry and topology as a formal metaphysical language that is now able to integrate his natural philosophy and mathematics to culminate in what we might explore here as the implied formal ingredients of *Process & Reality* as it climbs up through two levels from models to metaphysics. A model reduces reality that metaphysics generalizes. Just as a mathematical model is an instantiation of the world so the world is an instantiation of metaphysics. For historical reasons category theory has had to develop from within classical mathematics and current text books deal mainly with the category of sets that resides within Whitehead’s discarded mathematics of his early period and therefore cannot deal adequately with his speculative metaphysics. For as metaphysics generalizes the dynamics of nature, metaphysical language relates to natural process without the need for the arbitrary axioms of mathematics. Fortunately therefore metaphysical category theory is simpler than the category theory of classical mathematics and also greatly simplifies the natural language descriptions that flowed from the pen of the author of *Process & Reality* that are difficult for those of us not endowed with the power of his mind. The formal categories are therefore simpler than the natural language expressions but it is a simplification satisfying his own observation that “the only simplicity to be trusted is the simplicity to be found on the far side of complexity.”

Rather paradoxically mainstream science a century later is still trying to understand our world using the models based on the concepts of his early mathematical period rather than the informal categorical approach enunciated in the 1929 *Process & Reality* of his later philosophical period. The current mainstream position at the turn of the twenty-first century is

probably well summed-up in Penrose's encyclopaedic tome entitled *The Road to Reality. A Complete Guide to the Laws of the Universe*:

> "There have also been other intriguing radical proposals, such as those of Richard Jozsa and of Christopher Isham which employ topos theory. This is a kind of set theory arising from the formalization of «intuitionistic logic„ (see Note 2.6), according to which the validity of the method of «proof by contradiction„ (§2.6, §3.1) is denied! I shall not discuss any of these schemes here, and the interested reader is referred to the literature. Another idea that may someday find an significant role to play in physical theory is category theory and its generalization to n-category theory. The theory of categories, introduced in 1945 by Samuel Eilenberg and Saunders Mac Lane, is an extremely general algebraic formalism (or framework) based on very primitive (but confusing) abstract notions, originally stimulated by ideas of algebraic topology. (Its procedures are often colloquially referred to as «abstract nonsense„.)" (Penrose 2004, 960)[10]

The typo "an significant role" in this short extract suggests that Sir Roger was unhappy with this sentence and had not finished editing it. The reference to Jozsa is to an unpublished thesis he supervised and those to Isham relate to books he edited but none seem to give any adequate treatment of a topos or category theory. Although the book has in its title "A complete guide to the Laws of the Universe" nevertheless on its own admission is confused by the notions of category theory as "a kind of set theory". The "generalization to n-category theory" relies on number and is therefore limited to finitary mathematics and its restrictions. The extract clearly discloses a serious misconception on the significance of intuitionistic logic in constructive mathematics. The single exclamation mark about the validity of proof by contradiction raises a shadow over the whole thousand pages of the book as confined to Boolean logic. This fuels our belief that any scientific theory today is suspect unless it can be validated by category theory. That follows as such validation also tests the correlation of any scientific theory within Whitehead's scheme of speculative metaphysics. For Topos Theory is isomorphic to Whitehead's *organic organism.* It was probably Alexandre Grothendieck of the Bourbaki group in France who was the first to see the depth (or more accurately the "heights") of significance in the topos. Aristotle was of course responsible for promoting the metaphorical connotations of the simple word for "place" in Classical Greek and there is a parallel abstract usage to be found in literary contexts. A major feature in Aristotle that cannot be captured by finitary mathematics is the macrocosm-microcosm relationship where the part has the characteristics of the whole. Whitehead

alludes to this relationship in *Process & Reality* and seems to use the terms interchangeably with "macroscopic and microscopic".

Finitary mathematics is unable to represent the relationship directly because a set cannot be a member of itself in axiomatic set theory and cannot be proved to be consistently defined in naive set theory. Likewise unfortunately the Grothendieck topos does not manage to escape from its Bourbakian roots in Hilbert's finitary methods[11] which also serve to make it unnecessarily complicated.

The same over-complexity may be found in the standard category theory texts of classical mathematics[12]. The approach from physics on the other hand by identifying the arrow of category theory with process in nature greatly simplifies the complexity and enables category theory to act as an Occam's razor and as a very powerful scientific tool. For a parallel view as an alternative natural philosophy, see (Heather and Rossiter 2011) where two texts that have proved seminal are examined to show the limitations in the use of the category of sets to represent the internal structure of the topos as a Cartesian closed category which corresponds to Whitehead's "extensional space".

4. The Topos: Archetype of the Natural World

The archetype of the natural world is the topos, in its early days formally defined as Cartesian closed category with subobject classifiers and informally as a generalized set. Johnstone in his preface to lists thirteen alternative descriptions that have been applied to the topos (Johnstone 2002, viiiff). Many of them like for instance "A topos is a generalized space" still carry hangovers from sets. We would recommend as an informal definition: "The category of categories of categories". To some this may only confirm the Penrose quote of categories as "abstract nonsense" but it is accurate and makes the recursion explicit. The topos sums up all that we have said in this paper. It is the ultimate intension existing as an identity natural transformation in any extension given by the internal categories, subject to the locally Cartesian closed condition with the preorder structure and an intuitionistic logic that is Heyting and which is more general than Boolean. There is a unique arrow from the source of the World to every object in it and a unique limiting arrow directly between any pair of objects as well as repletion of indirect co-limiting arrows between them. These relationships satisfy our empirical perception of "the laws of physics". To satisfy its holistic nature the World must emerge top-down. That is to say no more than that if the Big Bang happened it potentially contained everything that ever existed. However it

is easier to explain bottom-up by treating the role of the arrow as a natural expression of process with an identity arrow as intension and a distinguishable valued arrow for extension. Nevertheless while in naive category theory the simplest identity arrow may be treated as an object, it is convenient to begin with a category of three composing objects as a generalization of any possible category. This is shown in Fig. 1-1 with the next higher identity arrow (the functor) composing extensional arrows between objects. The next higher identity arrow is the locally Cartesian closed natural transformation composing categories with ordinary functors as extensional arrows between categories as also shown in Fig. 1-1. The highest level arrow is also a natural transformation which composes structures of categories and functors. It is this identity natural transformation that constitutes the full Cartesian closed category of a topos as in Fig. 1-1. However, the natural arrow is double-headed to represent as a composition of the adjoint functors but with a parity arising out of the order of the adjointness. Although the manner just explained bottom-up may be easier to understand the diagram because of the way that models are usually built-up, nevertheless process can only exist as a whole which requires it to devolve top-down. The circles with an arrow head represent an identity arrow. The particles in the "standard model" of classical physics would be represented to first order by the smallest identity arrows. However in process physics a particle can't exist in isolation and the minimal identity object is the triangle in the diagram. Each such triangle represents a natural occasion or "actual event" as first introduced by Whitehead (Whitehead 1929).

The whole is just a recursive system with closure at four levels consisting of three open interfaces. Fig. 1-1 shows the three interfaces for composing arrows (ordinary, functor, natural transformation) with the four levels (identity arrow, identity functor/category, higher-order identity functor/category, identity natural transformation/topos). The higher order is an intrinsic component of the topos structure and described as the property of being "locally Cartesian closed". Thus from the top-down perspective of the topos it would be more appropriate to designate the higher-order as lower order. The locally closed Cartesian closed categories are at the level of number and metric space-time. With an arbitrary initial object or "bottom" they are therefore Boolean and explain the approximate success of Euclidean models in physics. Prime examples are Einstein's theories of relativity. These bridge the gap between the measurement of physics and the mathematics of relativity.

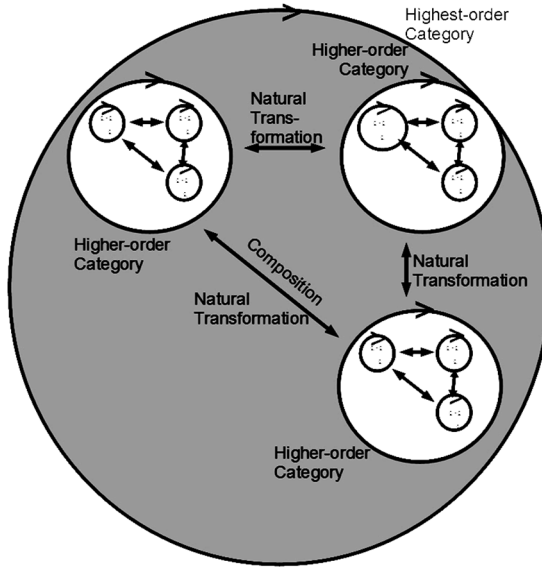

Fig. 1-1: The Topos: Natural transformations of composing functors which in turn compose in the highest possible category

The diagram exhibits the natural recursive nature of the structure. It also demonstrates connectivity from any object to any other object. It is possible therefore to get from any object to any other object directly: or indirectly with possible local variations through any other internal path. This is a natural structure because it is obtained by simple induction applied to the notion of process without any assumptions. It is also "natural" as formally defined in category-theoretic terms.

5. Future Directions

The next step will be to represent formally the entity types of process that populate his reality but there is no space to attempt that here. Only a few "simple" concepts are needed: the World is a topos with monadic objects related by contravariant functors with natural transformations as units of adjunction. These are sufficient to identify formally the Whiteheadian vocabulary encompassing the likes of the ontological principle, actual entities and occasions, eternal objects, concrescence, creative and emotive advance of becoming, public and private, prehensions, nexus, primordial

nature, emergence, etc, together with their other postmodern counterparts. Nevertheless it will be a long road to represent Whitehead's *Process & Reality* formally but until it can be studied in that way his speculative metaphysics can never be fully understood nor expect the impact it deserves.

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Notes

[1] *Die Lineale Ausdehnungslehre, ein neuer Zweig der Mathematik*.
[2] An insight that may very well have come from Grassmann's studies in natural language.
[3] The natural number object can only be concocted by assuming some successor function and that requires an axiom of choice to import some closed world assumption.
[4] The Problems of Philosophy refers to (Russell 1912).
[5] See: www.religion-online.org/showarticle.asp?title=2469.
[6] There is apparently no original English version extant but details of its publication in French with its subsequent translations into English together with a commentary

may be found at the religion-online website given in the footnote above.
[7] In a couple of pages (Whitehead 1978, 295ff).
[8] The diagrams of transition functions between overlap of manifold patches in twistor cohomology, for example fig 33.17 in (Penrose 2004, 988) are perhaps more advanced developments of ovate classes in Whitehead's diagrams.
[9]And vocabulary like gunk for any whole with proper parts.
[10] The Note and § numbers refer to the Penrose book (2004).
[11] Colin McLarty recently claims that "the entire Grothendieck apparatus" is of weaker strength than finite order arithmetic (McLarty 2013).
[12] No attempt will therefore be made here to give a comprehensive list of these texts as they are not directly relevant.

CHAPTER 2

AN INDUCTIVELY FORMULATED PROCESS METAPHYSICS

LUKASZ LAMZA

Abstract

There is a number of ways in which metaphysical systems are created; one model often spoken of, but rarely actually realized in practice, is the creation of philosophies through generalization of scientific knowledge of Nature. The openly inductive character of such a system would lead to many undesirable properties, such as its contingency upon the contemporary state of knowledge or its inherently temporary and unfinished character. Usually, this leads to the creation of more careful programs where only selected scientific results—typically related to quantum physics and/or relativistic cosmology—are used as inspiration and combined with traditional philosophical results and methodologies.

Here, I present a method of recovering the basic ontological structure of natural processes—a method that relies on a careful selection of a large sample of causally related natural processes and analyzing their common properties. 44 large-scale processes are analyzed, spanning from cosmological to astrophysical, geophysical and atmospheric. A unified process framework is suggested, consisting of the following phases: assembly, instability, transition, maturity and dissipation. All phases are illustrated by examples from the abovementioned selection of natural processes and strict physical criteria for the existence and duration of these phases are discussed.

Three general philosophical issues are discussed: the usefulness of the organic metaphor, the similarity of the framework to Whitehead's organic philosophy and the perspectives of promoting a "statistical metaphysics of nature"—i.e. a general description of natural processes that is true (applicable) only sometimes. It is argued that in light of the bewildering complexity of Nature one is faced with a choice: creating only a very vague system that will always work, or creating a detailed system that will

work only sometimes.

Keywords: Astrophysics, Cosmology, Philosophy of Nature, Process Philosophy

1. Introduction

Creating philosophical propositions through the analysis and generalization of scientific results is a model often spoken of, but rarely realized in practice (but see: Spencer 1937, Teilhard de Chardin 1976 or Jantsch 1980). Our growing knowledge of Nature's structure and history makes it both increasingly feasible and important to push the tendency to generalize knowledge further and further. The question arises—is metaphysics of nature simply an end-member of a series of increasingly more general propositions concerning the natural world; or is there an impenetrable barrier between science and metaphysics: one that would render a program of inductively formulated metaphysics of nature futile?

Here, I wish to avoid answering this question directly, providing instead an actual example of an inductively formulated philosophical description of Nature. My thinking is that it is philosophically desirable to discuss grand issues, such as the border between science and metaphysics, based on specific examples rather than *in vacuo*. This article is therefore intended to serve two goals: first, to actually contain certain general observations concerning Nature's structure (especially its dynamic, "processual" side); second, to discuss several general properties of such an inductive "metaphysical" description of Nature.

2. Method

2.1. Induction

The inductive method in its basic form means simply taking a lot of facts and finding a generalization of them. Logically, there exist strict methods of doing this (Holyoak and Morrison 2005), but analysis of actual scientific or philosophical inductions shows that reality is much more complex than logical schemes and structures. Scientists and philosophers don't simply apply elementary schemes of logical derivation in their task of understanding and describing reality. There is a considerable amount of intuition, creativity and educated guessing involved (Hadamard 1945, Fojt 2009). Therefore, in this article the word "induction" will simply denote any method of producing general propositions (here: propositions concerning

nature) that begins with a study of a large number of individual facts and follows therefrom, adhering closely to these facts in a gradual progression from specific to general propositions.

Consider this: there *is* a certain *how-ness* to how galaxies form, live, evolve and dissipate; and there is a certain *how-ness* to how stars, planets, clouds, storms, volcanoes and soils form, live, evolve and dissipate. There is order, and regularity, and a certain "style" in all those processes, and science studies these regularities on low levels of abstraction: generalizing from a thousand clouds of different types, for instance, to derive general propositions concerning cloud formation.

There is no reason why this age-old and quite intuitive method of discovering Nature's ways could not be extended. In principle, an analysis that covers *all* natural objects would lead one to generalizations (if such were to be found) valid for all Nature, i.e. statements true of all natural entities. Wouldn't statements true of all natural entities be metaphysical statements? While the number of natural objects is potentially infinite, the number of natural objects *known to man* isn't, and no sane person—it is to be hoped—would proclaim that propositions of any sort should be based on a sample *larger* than the extent of human knowledge. In other words, any project of inductive metaphysics must, by necessity, limit itself to the contemporary (and temporary) state of knowledge.

2.2. The Science Basis

There are multiple ways of organizing scientific knowledge of the world, but one in particular deserves our attention: through the unity of natural history. (It can be noted in passing that all three thinkers mentioned in the first paragraph—Herbert Spencer, Pierre Teilhard de Chardin and Erich Jantsch—based their theories on an evolutionary, *processual* view of Nature). A generally recognized scenario for the history of the Universe is now largely agreed on and there is a more or less known "phylogeny" of natural entities with a universal common root in the Big Bang, from which sprouts a tree-like divergence of forms and processes. This universal history unites basic physics and cosmology with astrophysics, planetary science and Earth sciences; atomic physics with chemistry and mineralogy; mineralogy and biochemistry with biogeochemistry and soil science; there follows a weak link of the still missing theory of abiogenesis, from which genetics and cell biology should emerge. From that point evolutionary theory leads to multicellular organisms with their physiologies and anatomies, reaching a local (and temporary) conclusion in "human studies" following another weak link, one that is still being

seriously suspected of concealing a true Mystery—the emergence of humanness. The perspective is thus obviously process-centered which steers the whole effort into not simply "a metaphysics of Nature", but to "a processual metaphysics of Nature".

Now, a more manageable program can be defined: to collect data on as large a sample of natural objects known to science as possible and to attempt to derive general properties concerning their formation, properties, patterns of evolution etc.

Here, a modest selection of 44 natural processes is analyzed, which encompass the macroscopic development of Nature from the state of primordial featureless homogeneity to a simple representation of its contemporary richness (the processes and corresponding natural entities are schematically pictured in Fig. 2-1).

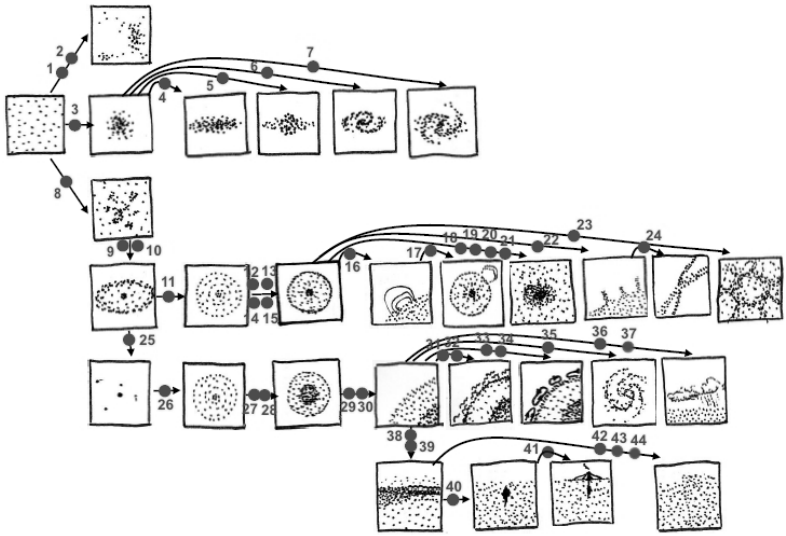

Fig. 2-1: The schematic representation of the natural processes and entities analyzed in the article. More information in text.

The formation and evolution of the following entities is included:

- galaxy clusters (1) and groups (2);
- protogalaxies and galaxies (3) later exhibiting various substructures: disks (4), bulges (5), spiral systems (6) and bars (7);