

SEIZING AN ALTERNATIVE

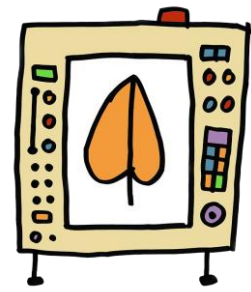
Toward an Ecological Civilization

June 4-7, 2015

**Section IV: Reenvisioning Nature;
Reenvisioning Science**

Track 2: Intuition in Mathematics and Physics

Timothy E. Eastman, summary



Summing Up

John Cobb, a prophet of modern times, describes how there is little hope that we will find an adequate and “healthy response to our global crisis in secularism and the institutions it has generated...modern philosophy, modern science, the modern university, and economism. I see them all as cutting themselves off from the broader stream of human experience and the wisdom it has generated” (Cobb, 2014, 297). In this conference, we have heard many examples in which materialist orthodoxies and secularism have tended to dominate, encouraging cultural mores and worldviews that undermine any sense of self --- transcending meaning and value.

In my undergraduate philosophy of science class (mid---1960s, University of Minnesota), Herbert Feigl (in 1924, a founder of the Vienna Circle of Logical Positivism) summarized how there are two primary types of philosophy, “philosophies of the something more, and philosophies of the nothing but.” During one lecture, he emphasized the “overwhelming” evidence in support of the “nothing but” approach; however, during the very next lecture, he began with how he was still reveling in the sheer joy of listening the previous night to Beethoven’s 6th Symphony, an exquisite musical evocation of the Vienna woods where he had often walked in his younger years. How ironic --- such mindful expression of great feeling and affirmation of value--- talk by a founder of the Vienna circle, known for its “nothing but” philosophers!

In his Plenary presentation for this Section IV on “Re---Invisioning Nature, Re--- Invisioning Science,” Phil Clayton called attention to the “Mind vs. Matter” debate, and recent progress in the relevant basic science, with important advances in

understanding the underlying biophysics, complexity and emergence. As a common strategy in analytic philosophy, one might say that “aesthetic, moral, and mental properties supervene upon physical properties” (i.e., that there is some unique one-to-one mapping from macroscopic properties to microscopic properties),^a roughly an update to Feigl’s model of psycho-physiological parallelism, albeit without the appearance of some magical alignment of events across two very different categories, which undermined the coherence of both Feigl’s and, indeed, Descartes’ more extreme mind-body dualism.

However, the new reductionisms that most frequently deploy “supervenience” tend to presuppose the following:

(1) that the microphysical (indeed, ultimately, the underlying physics) supports the kind of substance-talk or “substance-predicate” language most often ascribed to ultimate particles,

(2) that, ultimately, causal relations are exclusively materialistic “efficient causal” relations and, finally,

(3) that all ‘meaningful’ propositions can be reduced to “nothing but” scientific propositions; i.e., “scientism” or a “scientistic metaphysics.”

For those of us attending the several Tracks of Section IV in the past few days, although such presuppositions can be helpful for certain focused questions within certain limited domains of investigation, we have witnessed a wealth of arguments and specific examples of why all three of these key presuppositions fail overall in light of the best of contemporary science and philosophy.

Let me take these briefly, one-by-one.

(1) **On Substance-talk:** George Shields documents how Johanna Seibt, under Nicholas Rescher’s guidance at the University of Pittsburgh, “produced a protracted case for the logical incoherence of standard substance ontologies”^b (Shields, 2002, 10). As well, an in-depth philosophical analysis of the concept of “substance” is provided by Lorenz Puntel who states that “The root problem [of substance-talk] can now be

formulated as the problem posed by predication on the level of first-order predicate language...in which...the value of the bound variable x is simply and absolutely presupposed. The vital problem is then this: such a presupposed entity is not intelligible...If all the attributes (properties and relations) and whatever else this presupposed entity may be involved in or within are taken away...nothing determinate remains...Such an entity is not intelligible and therefore must be rejected...Attempts to rescue the idea of such a subject have been unsuccessful...[due to] infinite regress [and other problems]" (Puntel, 2008, 194). Another rescue strategy has been the common presumption of "grammar as a guide to ontology" (McHenry, 2015, 33), which is arguably coherent within the confines of western languages [Greek, Latin, French, English being from the same linguistic family and sharing the same substance-predicate structure] but then seriously fails when applied to some Asian languages such as Chinese in which the notion of process is more fundamental.^c

As Peter Hare has argued, Whitehead's "movement to the recognition of being as process rather than substance was as profound a development in metaphysics as his work with Russell had been in math and logic" (Hare, 1995, 909).^d That Whitehead, with his exceptional **rational intuition**, came to this insight early in the 20th century is no accident, as pointed out by Leemon McHenry (2015, 61); he was a student in the 1880s at Cambridge with prime expositors of Maxwell's new electromagnetic field theory (1861---2), namely W.D. Niven, in addition to Edward Routh and J. J. Thomson (Desmet, 2010, Ch. III). Indeed, Maxwell's new field theory was the focus of Whitehead's PhD dissertation at Cambridge. In a detailed analysis of the concepts of 'substance' versus 'event', Leemon McHenry demonstrates "not only that [an event ontology] makes sense but that modern physics requires it." (McHenry, 2015, 55). Such a consequence is not surprising given that contemporary physics is fundamentally built on field theory (quantum field theory, relativistic field theories, etc.). What may be surprising is that it has taken more than a century to (just partly) shake off the presumption of substance---talk as more fundamental than process and relations, whereby substance---talk continues its hold through our default "world view of perceptual objects" and subject--predicate linguistic traps. On this issue, as with many other fundamental interpretive issues in modern physics "There is...no escape from philosophy in the same way that there is no

escape from some conceptual framework [or other] by which we interpret our experience” (McHenry, 2015, 213). One scientist who tried to escape philosophy was the famous quantum theorist, Richard Feynman. At one point, he called attention to how high-energy physics could be equally well called “wave physics” or “particle physics.” Although the latter term has “stuck”, the choice is inevitably, in part, a philosophical question – indeed, such questions are part of the growing and active field of philosophy of physics. For a recent example of a noted philosopher-physicist collaboration that calls attention to both the importance of philosophy, and both becoming (process) and being, I recommend the new work by Roberto Unger and Lee Smolin on *The Singular Universe and the Reality of Time*.

(2) **On relations as exclusively ‘efficient causal’**: As shown extensively by recent works in ecology, complexity, and emergence, essentially all natural systems are open and dynamic, rather than closed and static. “The creative advance manifests itself in two distinct ways: 1) internally, as an *individuating* process of self-integration, and 2) externally, as an *efficient* causal process whereby *individuated*, self-integrating structures determine or condition the self-integrating activity of successive individuals or structures” (Rose, 2005, 12). The “individuating process of self-integration,” especially relevant to the goals of this conference, is revealed in at least four ways: (1st way) Through detailed **analyses of human experiencing**, as done by psychologist and philosopher Williams James, and many philosophers in the phenomenology tradition. In his concept of ‘prehension,’ such self-integrative experience was hypothesized by Whitehead as an appropriate model for ‘experiencing’ more generally.^e In her classic monograph, *Thinking with Whitehead* (2011), Isabelle Stengers invites us all to wonder “what happened to Whitehead in April, 1925” upon his key creative **intuition** leading to the concept of prehension, heralded by Hartshorne as “an unprecedented theory of creativity.”

(2nd way) Building on the works of meeting participant, Stuart Kaufmann, among others, Mirko di Bernardo recently summarized some key themes in **complex system dynamics** as follows: “In a complex system...the generation of new information is intrinsic to the dynamics of the process...the system continuously redefines the space

of the alternatives...the centuries---old contraposition between *reductionism* and *naïve holism* today has been definitively surpassed by a new systemic vision according to which life appears as a transactional *phenomenon* resulting from a series of continuous arrangements constituting and unexpectedly modifying the parts of the game itself...[and] meaning reveals itself with time” (di Bernardo, 2015).

(3rd way) Recent research has revealed close mappings of phases of the **quantum history of events** (comprising all actualities at multiple levels) to Whitehead’s analysis of actual entities. Such is found both in detailed analyses of contemporary relativistic quantum field theory, as in Verlinde’s emergent gravity model (Bettinger, 2015), and in recent advances in solving the quantum measurement problem in which explicit use is made of both efficient causal and ‘logical’ causal structures (Epperson and Zafiris, 2013). Using the well---tested elements that are core to quantum physics, Michael Epperson earlier demonstrated an exceptionally close mapping between Whitehead’s analysis of actual entities and the fundamental structure of quantum events (Epperson, 2004). Returning now to the new results by Epperson and Zafiris, I propose that their outstanding work substantially advances our understanding of the **quantum measurement** issue, viz. (1) by highlighting the importance of the distinction of (ontological) possibility and actuality within the ‘real’ (also see George Shields, 2015); (2) by emphasizing the logical distinction, arising from category theoretic analyses of fundamental topological constraints, of local (Boolean algebra) and the (non---Boolean) global; (3) through recognizing histories of quantum events as truly fundamental; (4) by affirming the need for a logical causality (demonstrating that the ‘efficient causal’ description alone is intrinsically incomplete for science); (5) and showing how the analysis of “possibility” requires careful philosophical analysis, adding to those critical factors (e.g., causality, temporality, values/choice) that are presupposed by both scientific practice and normal human experience.

(4th way) Through the Conway and Kochen **Free---Will Theorem**, which reflects the self---integrative character of fundamental events by showing that the presupposed possibility of “choice” by an experimenter necessarily maps to some element of “choice” at the quantum level, however rudimentary. Thus, some elementary selection among

alternative possibility (“decision”) is inevitably involved in quantum events.^f

Such ‘selection’ need not be associated with a panpsychist view; however, it is consistent with what David Griffin has described as “pan---experientialism” in which the fundamental succession of events involves both prehension (active integration of past fields, particles and other input into a unity) and concrescence (particular actualization of that new unity, the “actual entity”).⁹

In addition to the above features of the Conway---Kochen Free---Will Theorem, it also demonstrates "that there can be no correct relativistic deterministic theory of nature. In particular, no relativistic version of a hidden variable theory such as Bohm's well---known theory can exist" (Conway and Kochen, 2009, 231); in a complementary way, and independently, the logician and philosopher George Shields demonstrates that the absolute determinism presumed in most interpretations of Bohm is logically inconsistent and incoherent; as stated by Conway and Kochen (2009, 230) 'compatibilism' is a "now unnecessary attempt to allow for human free will in a deterministic world."

3) On the third key presupposition of "scientism" (indeed, of many framings of "physicalism"), I now address the common presumption that all ‘meaningful’ propositions can be reduced to scientific propositions; i.e., a “scientific metaphysics:

In addition to the inevitable philosophical issues raised above, some variant of “absolute determinism” is often presupposed in such ‘scientific’ narratives, most often referred to simply as “determinism” Of course, as a principle of order, its opposite “indeterminism” can be similarly incoherent. As I have just noted, the incoherence of strong “determinism” has been clearly argued by Shields. He accomplishes this by using only the “conservative” assumption, based on Charles Sanders Peirce’s work of the “logical basicity of implication or logical inclusion as asymmetrical and contingent, combined with a ‘weak’ form of the Principle of Sufficient Reason for which one assumes that “all states of affairs must have sufficient reason” (Shields, 2015).

In my view, some framings of naturalism or materialism, the “cosmic creation story,” and even big history are too limited; too often these approaches are undercut by some conversion of a sound methodological principle into an implicit metaphysical claim (often represented as simply a “scientific” proposition) (e.g., methodological reduction to reductionism; high levels of determination in physical relationships (“laws”) to strong determinism; extending the application of “proof” in some limited areas of logic and mathematical physics to claims that all “rigorous” science is deductive – in contrast, Farzad Mahootian and I have shown how Big Data and new observational-inductive approaches are rapidly becoming very effective strategies for contemporary science and technology (Mahootian and Eastman, 2009).

As a stark example of the appeal of ‘deductivism’ in model development, Max Tegmark in his recent book *The Mathematical Universe* states that “our physical world not only is *described* by mathematics, but that it *is* mathematics, making us self---aware parts of a giant mathematical object” (Tegmark, 6, 2015). George Ellis roundly criticizes Tegmark’s speculations on his multiverse speculations, built on standard Big Bang cosmology and some mathematical wizardry, in which “all possible mathematical structures are realized in some unobservable physical reality” (Ellis, 2015).

With presentations earlier in this Track, by Ron Phipps and Gary Herstein, I’m reminded of my own misgivings about the standard Big Bang cosmology rendition of the “cosmic creation story.” By all means, as emphasized in Track 1 “Telling the Story,” stories are important, whether Big History, cosmological or other. Indeed, for that we should focus on key themes important for this conference on *Seizing an Alternative*; e.g., evolution, emergence, history, systems and context, creativity and temporality. Consistent with such key themes, however, Phipps and Herstein provide a useful reminder that the contingencies of scientific thought remain very unclear and unsettled in physical cosmology. Along with several hundred other scientists who are part of the Alternative Cosmology Group (cosmology.info), my evaluation of this “cousin” to my own specialty of space plasma physics has led me to a cosmic “agnosticism” (Eastman, 657---665, 2010). A number of recent observational and theoretical developments are suggesting alternative routes towards new cosmological models. For example, new

results in quantum field theory suggest an emergent gravity model (Bettinger, 67, 2015) that could eventually displace top-down theoretical approaches, exemplified by Einstein's current standard. The difficulty of obtaining adequate observations relevant to cosmology is exacerbated by the model-dependence of all observational parameters and how, to date, the number of model parameters has always exceeded the number of observational constraints (Disney, 2007). Recent observations based on two distinct test methods, the Alcock-Paczynski (AP) test (Melia and M. Lopez-Corredoira, 2015) and the Tolman test (Lerner, 2014) are inconsistent with the curved metric assumed in the standard BB model but appear consistent with a flat metric; more such clear tests between models are needed. Within the past month, new observations have revealed exceptional alignment of a galactic quasar quartet that, in my opinion, strongly implies physical association with a host galaxy. Over his illustrious observational career, Halton Arp documented hundreds of such quasar-host galaxy connections, essentially all with different, yet well-correlated redshifts (usually assumed to be a reliable measure of galactic distance). The *Astronomy Magazine* coverage of this announcement makes no reference to non-BB explanations, as is typical, even though this quasar quartet could be readily explained by Arp's model (*Astronomy Magazine*, 2015). Statistical physicist Chris Fulton, along with Arp (now deceased), have completed two papers (Fulton and Arp, 2012) clearly demonstrating that such quasar-galaxy connections are real and not just chance alignments in every case (as required for the standard BB model). As a result, Dr. Fulton and many others are calling for more attention to careful tests between alternative cosmological models instead of the current typical practice of focusing on model confirmation under the assumption that the Big Bang cosmology framework is beyond question.

Although skeptical of any and all "-isms", I find Arran Gare's call for a new "speculative naturalism" as helpful because it tentatively meets most of the criteria that I see as needed for a new integration – well-based in philosophy and the history of thought, inclusive, and incorporating the best of science and both epistemology and metaphysics. Unfortunately, Quine's 'naturalistic turn' may have, as Gare comments, represented "a capitulation of philosophy to mainstream reductionist science" (Gare, 2014). Similarly, Richard Rorty's 'linguistic turn' may represent a capitulation to anti-

realist anthropo---morphism. However, I would like to think that there remains a worthy component of the analytic tradition (including the best of Quine's own works, with limited metaphysical commitments) that maintains a focus on sound methodology and philosophical analysis. Intersections of the analytic tradition with process thought have been reviewed extensively by George Lucas in his work *The Rehabilitation of Whitehead* and in George Shields' edited volume *Process and Analysis*. Building on the best of the analytic tradition, it appears to me that a fully inclusive "speculative philosophy" could draw primarily on the following three complementary areas; analytic philosophy, the process tradition, and science; indeed, one leading philosopher who embodies all three is Nicholas Rescher (University of Pittsburgh, emeritus) who has written extensively on all aspects of this complementary set of perspectives. Of course, there are many important elements of continental philosophy that would be beneficial as well, exemplified especially by the works of Gilles Deleuze and Bruno Latour, among others. Another important source for complementary perspectives would be the works of leading thinkers in other cultural traditions such as Chinese or Indian. If he could have lived to witness these new developments, I suggest that my Professor Feigl would have likely worked to forward such an integration as well, yielding then a real "something more" philosophy!

The above new developments and constraints substantially support **Whitehead's hypothesis of prehension**, designed to avoid anthropocentrism (albeit inspired by the model of human perception), which refers "to a *mode of taking account of other things that could be either sensory or nonsensory.*" (Griffin, p. 34) Overall, Whitehead's is a "prehensive doctrine of perception" (Griffin, 35) Our most fundamental mode of perception is that of causal efficacy; "sensory perception...presupposes this more fundamental, nonsensory mode of perception or grasping things" (Griffin, 35).

Whitehead's **concept of prehension** overcomes the following problematic assumptions (samples based on 16 in Hartshorne, 1979):

1. Subject---predicate logic and the neglect of relative predicates;
2. Thing---structure vs. event---structure of reality;

3. Ordinary language philosophies committing a fallacy of the perfect dictionary --- see detailed philosophical analyses by White and Puntel.
4. Fascination with symmetry [contradicting fundamentality of asymmetry in physics as shown by physicist Joe Rosen];
5. Determinism: the symmetrical view of causal necessity --- demonstrated as incoherent by Hartshorne, Shields, and White/Puntel;
6. Continuous becoming, denial of quanta --- contradicting results of well-tested quantum physics and quantum field theory;
7. Truth as "timeless" --- contradicting the reality of 'potentiality' and denies the importance of 'quantum histories of events';

Prehension, the fundamental succession implied in quantum histories, and an event---oriented analysis of fundamental process together point to the importance and relevance of Whitehead's metaphysical analysis of actual entities, and other key elements of Whitehead's *Process and Reality*.

If you have any doubts about the potential relevance of Whitehead's framework, check out the stunning mappings of its key elements to results of contemporary fundamental physics as shown in detail by Michael Epperson (2004) and Jesse Bettinger (2015).

Considering that Whitehead formulated his admittedly "speculative metaphysics" nearly a century ago, concurrent with the early stages of field theory, relativity and quantum physics, the closeness of these mappings suggest to me that, in spite of its errors and limitations, Whitehead's highly self---critical evolution of thought, combined with profound logical, mathematical, physical and 'metaphysical' **intuition**, enabled the creation of a philosophical/metaphysical research program that is now bearing fruit around the world and in almost every field of research.

REFERENCES

- Astronomy Magazine, "Astronomers baffled by discovery of rare quasar quartet," May 18, 2015.
- Mirko di Bernardo, "Complexity and the Emergence of Meaning in the Natural Sciences and Philosophy," *Theology and Science*, Vol. 13, No. 2, 250, May 2015.
- Jesse Bettinger, *The Founding of an Event---Ontology: Verlinde's Emergent Gravity and Whitehead's Actual Entities*, Ph.D. Thesis, Claremont Graduate University, 2015.
- John Cobb, *Theological Reminiscences*, Process Century Press, 2014.
- Murray Code, *Order & Organism*, State University of New York (SUNY) Press, 1985.
- Murray Code, *Myths of Reason: Vagueness, Rationality, and the Lure of Logic*, Humanities Press, 1995.
- John Conway and Simon Kochen, The Strong Free Will Theorem, *Notices of the AMS*, Vol. 56, No. 2, 226---232, Feb. 2009.
- Gilles Deleuze and Felix Guattari, *What is Philosophy?*, Columbia Univ. Pr., 1996.
- Ronny Desmet, "III. Whitehead's Cambridge Training," in *Whitehead: The Algebra of Metaphysics*, Applied Process Metaphysics Summer Institute Memorandum, Les Editions Chromatika, 2010.
- Michael Disney, Modern Cosmology: Science or Folktale?," *American Scientist*, 383---385, Sept---Oct 2007.
- Physics and Whitehead: Quantum, Process and Experience*, eds. Timothy Eastman and Hank Keeton, SUNY, 2004, 2009.
- Resource Guide for Physics and Whitehead*, eds. Timothy Eastman and Hank Keeton, *Process Studies Supplements*, Issue 6, 2004. (online at <http://www.ctr4process.org/publications/ProcessStudies/PSS/>)
- Eastman, "Cosmic Agnosticism, Revisited," *Journal of Cosmology*, Vol. 4, 2010.
- George F. R. Ellis, review of J. Leslie and R. Kuhn, eds., *The Mystery of Existence: Why is There Anything At All?*," *Theology and Science*, Vol. 13, No. 2, 261, 2015.
- Michael Epperson, *Quantum Mechanics and the Philosophy of Alfred North Whitehead*, Fordham University Press, 2004, 2012.
- Michael Epperson and Elias Zafiris, *Foundations of Relational Realism*, Lexington Books, 2013.
- Lawrence Fagg, *The Becoming of Time: Integrating Physical and Religious Time*, Duke Univ. Pr., 2002.
- Lewis Ford, *The Emergence of Whitehead's Metaphysics 1925---1929*, SUNY, 1985.
- C. C. Fulton and H. C. Arp, "The 2dF Redshift Survey. I. Physical Association and Periodicity in Quasar Families," *Astrophys. J.* 754: 134, Aug. 1, 2012; paper 2 under review.
- Arran Gare, "Speculative Naturalism," *Cosmos and History*, Vol. 10, No. 2, 300, 2014; available online at cosmosandhistory.org.
- David Ray Griffin, *Whitehead's Radically Different Postmodern Philosophy: An Argument for Its Contemporary Relevance*, SUNY, 2008.
- Peter Hare, "Whitehead," in *The Oxford Companion to Philosophy*, ed. Ted Honderich, Oxford

University Press, 1995.

Charles Hartshorne, *Creative Synthesis and Philosophic Method*, Open Court, 1970.

Hartshorne, "Whitehead's Revolutionary Concept of Prehension," *International Philosophical Quarterly*, Vol. XIX, No. 3, Issue 75, Sept. 1979.

E. Lerner, R. Falomo, and R. Scarpa, UV surface brightness of galaxies from the local universe to $z \sim 5$," *Int'l J. Mod. Phys. D*, Vol. 23, Issue D6, May 2014.

George R. Lucas, *The Rehabilitation of Whitehead: An Analytic and Historical Assessment of Process Philosophy*, SUNY, 1990.

Farzad Mahootian and Timothy Eastman, "Complementary Frameworks of Scientific Inquiry," *World Futures*, Vol. 65, 61---75, 2009.

Farzad Mahootian and Tara---Marie Linné, "Jung and Whitehead: An Interplay of Psychological and Philosophical Perspectives on Rationality and Intuition," Chapter 17 in *Rational Intuition: Philosophical Roots, Scientific Investigations*, eds. Lisa Osbeck and Barbara Held, Cambridge, 2014.

Leemon B. McHenry, *The Event Universe: The Revisionary Metaphysics of Alfred North Whitehead*, Edinburgh at the University Press, 2015.

F. Melia and M. Lopez---Corredoira, "Alcock---Paczynski Test with Model---Independent BAO Data," *arXiv* 1503.05052, March 2015.

Joseph Needham, *Science and Civilization in China, Vol. 2 History of Scientific Thought*, Cambridge Press, 1956.

Lorenz Puntel, *Structure and Being: A Theoretical Framework for a Systematic Philosophy*, Penn. State Univ. Press, 2008.

Philip Rose, "Relational Creativity and the Symmetry of Freedom and Nature," *Cosmos and History*, Vol. 1, No. 1, 12, 2005.

George Shields, *Process and Analysis: Whitehead, Hartshorne, and the Analytic Tradition*, SUNY, 2003.

George Shields, "A Logical Analysis of Relational Realism," Chapter 5 of *Physics and Speculative Philosophy*, eds. Eastman, Epperson, and Griffin, deGruyter---Ontos, in press, 2015.

Isabelle Stenger, *Thinking with Whitehead*, Harvard University Press, 2011. Max Tegmark, *The Mathematical Universe*, Vintage, page 6, 2015.

Roberto Unger and Lee Smolin, *The Singular Universe and the Reality of Time*, Cambridge University Press, 2014.

Alan White, *Toward a Philosophical Theory of Everything: Contributions to the Structural---Systematic Philosophy*, Bloomsbury, 2014 (in part, an introduction to Lorenz Puntel's work). Alfred North Whitehead, *Process and Reality: Gifford Lectures 1927---1928, Corrected Edition*, eds. Griffin and Sherburne, The Free Press, 1979.

^a see "supervenience" entry in the *Stanford Encyclopedia of Philosophy*.

^b Described by George Shields in his "Introduction" of the book *Process and Analysis*, George Shields, ed., SUNY, 2003, p. 10; FN 21 on Johanna Seibt "Towards an Ontology of Process," PhD Dissertation, 1990.

^c see Joseph Needham (1956) for both this issue of linguistic comparison, and for substantial notes on the relevance of Whitehead's philosophy.

^d quote taken from paper by Peter Harris written in honor of philosopher James Bradley, (Peter Harris, "Creative Order: The Case for Speculative Metaphysics," *Analecta Hermeneutica*, Vol. 4, 2012, page 5.

^e see Kraus, *The Metaphysics of Experience: A Companion to Whitehead's Process and Reality*, Fordham University Press, 1998.

^f on the Free--Will Theorem, see

http://www.informationphilosopher.com/freedom/free_will_theorem.html

^g see Nobo's essay "Whitehead and Quantum Experience," in *Physics and Whitehead*, eds. Eastman and Keeton, SUNY, 2004.

