PROCESS ENVIRONMENTAL PHILOSOPHY

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A process-information approach is examined as a foundation for an environmental philosophy that is dynamic and elastic, with particular emphasis on value, beauty, integrity and stability supporting Aldo Leopold's vision. I challenge one of the basic assumptions of Western philosophy, namely the metaphysical primacy of substance. The classical, medieval and modern metaphysics of substance is presented with particular attention given the paradoxes of substance. Starting from the philosophy of Heraclitus, relatively ignored by the Western tradition of philosophy, a process philosophy is developed as an alternative to standard metaphysical attitudes in philosophy. A possible resolution of Zeno's paradoxes leads to consideration of other paradoxes of substance metaphysics. It is argued that substance metaphysics is incompatible with evidence found in the shifting paradigms of ecology and general science. Process philosophy is explored as a basis for an environmental philosophy, attempting to put the environment back into philosophy.

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CHAPTER 1

INTRODUCTION

Eugene Hargrove stated that "Once environmental ethics or environmental philosophy finishes putting the environment back into philosophy, it will be significantly different from what it is now." [1] I have taken this suggestion to heart. In this paper, I challenge one of the basic assumptions of Western philosophy, that of the metaphysical primacy of substance.

Nicholas Rescher maintains, "The mainstream philosophical tradition of the European West has been characterized by the dominance of a substance ontology that sees the world's particulars as being typically and pragmatically material objects."[2] The classical, medieval, and modern metaphysics of substance is presented with particular attention given to the paradoxes of substance. The problem of the 'one and the many' is examined along with Zeno's paradoxes. The philosophy of Heraclitus, which has been relatively ignored by the Western tradition of philosophy, is followed by an outline of the development of contemporary metaphysical attitudes in philosophy, most particularly in environmental philosophy. As suggested by Hargrove and Attflield,[3] there are problems in trying to adjust and defend environmental philosophy given traditional presuppositions

[1] Eugene C. Hargrove, *Foundations of Environmental Ethics* (Denton: Environmental Ethics Books, 1994) p. 3.
[2] Nicholas Rescher, *Process Metaphysics: An Introduction to Process Philosophy* (New York: SUNY Press, 1996), p. 51.
[3] Robin Attflield, *The Ethics of Environmental Concem*, 2nd ed. (Athens, Ga.: University of Georgia Press, 1994). First edition published 1983.

in Western philosophy. Perhaps these problems are an indication that we should attempt an alternate approach.

Ecology and science have serious metaphysical difficulties. For example, how are evolutionary increases in complexity possible when the concept of entropy suggests that decreases in complexity should take place?[4] This dilemma, which I refer to as the evolution-entropy dilemma, is directly related to Zeno's paradoxes. A number of investigators have worked on this problem including Gregory Chaitin, Steven Wolfram, and Ilya Prigogine. A philosophy similar to that of Alfred North Whitehead and Henri Bergson is developed in this essay. Application of some newer mathematical insights and process metaphysics relating to the notion of information, such as the *central limit theorem* and *Levy flights*, play an essential role process philosophy and lead to an evaluation of the key criticisms of process philosophy. The weakest points of substance metaphysics are also illustrated. The reliance on a concept of substance as the basic component of metaphysics is shown to be incompatible with evidence found in the ecology and science. In general, this investigation offers some justification for the process-relational step going from the discrete to the continuous.

Further, I reveal and explore a metaphysic that is consistent with science and that can serve as a foundation for environmental philosophy. A foundation that is dynamic and elastic, with particular emphasis on value, beauty, integrity, and stability.

[4] Entropy – a measure of disorder or energy within a closed system.

CHAPTER 2

HISTORY OF SUBSTANCE METAPHYSICS

In this chapter I outline the idea of substance in metaphysics as it develops from Ancient to contemporary times. In each section I draw particular attention to the era's view of metaphysics and other traditions of philosophy that expose major issues that advance a thesis of process philosophy. Keep in mind Hartshorne's advice that the history of philosophy has been written primarily by historians who have "taken chiefly an account of those philosophers or those systems of philosophy, that have in fact exerted strong influence upon their contemporaries and successors." Philosophers poorly or simply misunderstood, marginalized or simply ignored, have the potential of offering the most interesting contribution to the advance of philosophy. Hartshorne says it well: "What we want from the history of philosophy is knowledge not merely of influential views and arguments but of possible ones."[5]

Ancient Period

Major commentators on the foundations of philosophical attitudes usually split Ancient philosophers into three major groups: those before Socrates; Socrates, Plato and Aristotle; and those after Aristotle. The 'pre-Socratics' can be further divided into three groups: philosophers of flux, represented mainly by Heraclitus the Ephesian;

[5] Charles Hartshorne, *Insights and Oversights of Great Thinkers: An Evaluation of Western Philosophy* (New York: SUNY Press, 1983), p. 1.

philosophers of stasis, represented by Parmenides, and then the group of Pythagoreans.[6] In general, the primary concern of these early philosophers was with the nature of the world and humankind's place in it, "speculations about the nature of matter and its interactions with mind."[7] "They were Wise Men, who might make astronomical observations for the sake of navigation, try to find out the one primary element of the universe, plan out feats of engineering, etc., and all without making any clear distinction between their various activities."[8]

Philosophers are thought to be lovers of wisdom. Many earlier philosophers became very skeptical of mythological explanations of the world and started to search for different explanations. The pre-Socratic Thales asked "What is the stuff out of which the world is made?"[9] What kind of material substance or matter possibly makes up the world?[10] In response to these questions, philosophers have called this stuff by different names: substance, matter, atom and many more. The meaning shifted wildly from philosopher to philosopher. Some posited air, earth and/or water. It is often stated that Heraclitus suggested 'fire' as a fundamental substance.[11]

The Western philosophical tradition is based on metaphysics that poses and answers this type of question, "What is this stuff?" By asking this type of question, the a priori assumption seems to be that some stuff exists.[12] That some thing is atomic; that there exists a smallest definable unit or essence of things.

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[6] Fredric S.J. Copleston, *A History of Philosophy, Volume 1: Greece and Rome-From the Socratics to Plotinus* (New York: Doubleday, 1993).
[7] Hargrove, *Foundations*, p. 16.
[8] Copleston, *History of Philosophy*, p. 21.
[9] W. T. Jones, *A History of Western Philosophy: The Classical Mind*, 2nd ed. (New York: Harcourt Brace Jovanovith, 1970), p. 14.
[10] Hargrove, *Foundations*, p. 17.
[11] Hartshorne, *Insights*, p. 13.
[12] Fallacy of complex question?

> In spite of the melancholic side of the Greek, his perception of the constant process of change, of transition from life to death and from death to life, helped to lead him, in the person of the Ionian philosophers, to a beginning of philosophy; for these wise men saw that, in spite of all the change and transition, there must be something permanent. Why? Because the change is from something into something else. There must be something which is primary, which persists, which takes various forms and undergoes this process of change.[13]

The tradition, then, is the notion of changing substances. That this tradition has been successful is not denied, but I argue that this metaphysical basis is no longer serving our understanding of the world and is, in fact, impeding our understanding. This misunderstanding should not be surprising since the Ancient period is replete with philosophers struggling with major problems of their own implied metaphysics[14] and the problem of the "one and the many." Has Western philosophy provided a reasonable solution to these problems? W.T. Jones has suggested that "the logical development of Thales' initial premise … gradually led philosophers to a point very far from common sense."[15]

Consider the anti-flux paradoxes offered by Zeno of Elea (ca. 488-439 B.C.). In general, these paradoxes attempted to demonstrate the impossibility of motion.[16] The paradoxes were offered originally in defense of Zeno's teacher Parmenides' (510-450 B.C.)[17] belief in a static and unchanging world. Parmenides asked, "How is it that an object may be permanent but changing? … The Ionian philosophers were profoundly impressed with the fact of change, of birth and growth, decay and death."[18] For Parmenides there is one thing: a substance that endures unchanging. This concept is the

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[13] Copleston, *History of Philosophy*, p. 17.
[14] Hargrove, *Foundations*, p. 19.
[15] Jones, *Classical Mind*, p. 21.
[16] Ibid., pp. 22-24.
[17] Parmenides birth is on record 510 B.C., but he was possibly born as early as 515 B.C. Some fragments from Plato suggest that he met the young Socrates around 450 B.C.
[18] Copleston, *History of Philosophy*, pp. 19-20. By Ionian Copleston is referring primarily to pre-Socratic philosophers.

'doctrine of Parmenides.' Zeno intended to show that fundamental change in the world is an illusion, pushing towards a metaphysic of the 'one'. If the 'doctrine of Parmenides' is accepted, there must then be two worlds: a world as it seems to be with change and flux, and another world as it really is unchanging with basic unchanging substance. Not only does this approach require substantive notion of all things, it also requires a dualistic approach to reality. Thus, Western philosophy mainly draws from an early rejection of a dynamic metaphysics and the acceptance of a static and unchanging one.[19]

The second group of pre-Socratic philosophers, the Pythagoreans, were said to have been founded and lead by Pythagoras of Samos (ca. 580-500 B.C.).[20] They were almost entirely preoccupied with the "harmony of the world" and stressed that "things are numbers," and could be described equally either as a cult or as a school of philosophy.[21] While their main interest was in mathematics, they were practical and operated a brisk trade in solutions to problems, never giving a hint of their methods. Their metaphysical understanding was a combination of the unlimited and limited, creating a philosophy/religion that took the essence of the universe to be harmonious in both the numeric and musical senses. Part of the rationale of the Pythagorean mysticism was the connection they found between the geometric and the numeric in nature. This mystic mixture of numerical interest in nature and religious passion is a result, in part, of Pythagoras' travels to Egypt, Babbylon, and perhaps India.[22] He was probably also exposed to the teachings of Buddha, Lao-Tze, and Confucius since all four were virtually

[19] Hartshorne, *Insights*, pp. 14-15 and Copleston, *History of Philosophy*, pp. 14-19 and p. 59.
[20] Carl B. Boyer and Uta C. Merzabach, *A History of Mathematics*, 2nd ed. (New York: Wiley, 1989), p. 52.
[21] Copleston, *History of Philosophy*, p. 29 and CF., p. 33.
[22] Boyer and Merzbach, *History of Mathematics*, pp. 52, 55-56 and John O'Connor and Edmund Robertson, "Pythagoras," in *The MacTutor History of Mathematics Archive* [University of St. Andrews online cited 16 March 2003] http://www-gap.dcs.st-and.ac.uk/~history/Mathematicians/Pythagoras.html; INETERNET.

contemporaries and Pythagoras made a life long habit of reading and studying laws and ideas from new cultures.[23] Pythagoras helped transform mathematics into a more liberal examination of its principles and theorems resulting in advances in geometry and arithmetic.[24]

Just as Parmenides and his followers had suggested a world as it appears and a world as it should be, the Pythagoreans juxtapose a world of perfection in numbers as it must be and a world as it appears.[25] They "asserted the plurality to practical exclusion of the One – there are many ones" where the doctrine of Parmenides "asserted the One to the exclusion of the many."[26] Both schools, therefore, adopted a dualist viewpoint.[27] Also note that the Pythagoreans "regarded things as being numbers, not merely as being numerable." Thus, a primary problem was the transformation between the limited and the unlimited: essentially the problem of going from thinking in terms of discrete linear to thinking in terms of continuous non-linear.

Does this problem mean that a dualistic approach must be taken and that we must adopt a static metaphysic? Should the focus of metaphysics be on substance when it is the process of change that is most obvious, or at least the most interesting and/or problematic? Jones states, "If experience discloses change, it also discloses permanence."[28] We have a paradox of the world as it appears to be and the theory of the world as is must be. The paradox is based on the starting point that the stuff of the world must be things that have attributes, things that are both permanent but somehow

[23] A Pythagoras-Buddha meeting is thought controversial by some scholars. Some evidence is found in the In *Ma Dutu Gandaraya,* a book about the life of Buddha in Ancient India.
[24] Boyer and Merzbach, *History of Mathematics*, p. 55.
[25] Copleston, *History of Philosophy,* p. 35.
[26] Ibid.
[27] Jones, *Classical Mind*, p. 16.
[28] Ibid.

changing. Copleston writes "The one-sided doctrine of Parmenides was unacceptable, as also was the one-sided doctrine of the Pythagoreans."[29] So, let us consider now the third pre-Socratic position, represented by Heraclitus.

With Heraclitus we find a profoundly different view of metaphysics that is in strict opposition with that of most pre-Socratics. His view is later rejected out of hand by Socrates, Plato, and Aristotle. Heraclitus (544-480 B.C.)[30] was an Ephesian[31] noble whose work we know only from a limited number of fragments. Even though the work of Heraclitus is known only in patches, is suggested that the patchwork apparently does not spoil the intended style of Heraclitus which was similar to that of James Joyce in that Heraclitus attached importance in forcing a reader into actively participating in unraveling the meaning and truth of his work.[32]

Now, recall that Heraclitus is said to have posited fire as the stuff of the world. It is Heraclitus' concept of change that is critical[33] and his thoughts relating to fire are grossly misunderstood in a Western tradition that has rejected his general philosophy since antiquity. Fire is not meant as oneness or as a substantive replacement of substance for Heraclitus.[34] Jones and Copleston criticize Heraclitus for his idea that the world is in flux since such a theory commits him to the idea that "everything changes all the time."[35]

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[29] Copleston, *History of Philosophy*, p. 59.
[30] Dennis Sweet, *Heraclitus: Translation and Analysis* (Lanhan, Md.: University Press of America, 1995), p. xi. All references to fragments of Heraclitus are from Sweet's translation and will be cited in this text as "Heraclitus fragment no."
[31] Ephesus was a Greek city on what is now the coast of Turkey.
[32] Sweet, *Heraclitus*, pp. xii-xiii.
[33] Jones, *Classical Mind*, p. 14.
[34] Copleston, *History of Philosophy*, p. 41.
[35] Jones, *Classical Mind*, p. 16.

Jones writes the pre-Socratics thought that "things endure, says experience."[36] But Heraclitus denied this permanence outright:

> One cannot step into the same river twice … nor can one twice take hold of mortal substance in a stable condition; for by the quickness and swiftness of its alteration it scatters and gathers-at the same time it endures and dissolves, approaches and departs.[37]

This requires a notion of change rather than permanence as basic. Consider Copleston's interpretation of Heraclitus' fire.

> However, if it be maintained that all things are fire, and are consequently in a constant state of flux, it is clear that some explanation must be offered of what appears at least to be the stable nature of things in the world.[38]

It is clear by Copleston's comment that he means to judge Heraclitus not on the merit of Heraclitus' philosophy of the world, but on his [Copleston's] own. Fire, for Heraclitus, is meant as the unifying law or *logo*s. Fire represents an early conception of the notion of general processes.

Consider Heraclitus' use of the words *logos* and *unity*. Unlike most Ancient philosophers, Heraclitus was less inclined to treat the world as a simple place with unity and permanence. He considered the world as a complexity of processes. It is by understanding the nature of change that we are able to grasp the unity and rational order of the cosmos, or the *logos*. Heraclitus suggests a persistence of fundamental regularities. "The primary motive of Heraclitus' metaphysics is the determination of structural unity in a world of apparent diversity and change."[39] By *logos* Heraclitus implies a "universal order of world as well as the mind's capacity to rationally discern this order – a capacity

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[36] Ibid.
[37] Heraclitus fragment no. 91. Notice that most authors like Jones and Copleston quote only the 'river' part of Heraclitus and not the full fragment. This is an injustice against the meaning of the passage.
[38] Copleston, *History of Philosophy*, p. 411.
[39] Ibid.

shared by everyone,[40] but actualized only by those few individuals who possess wisdom."[41] Fire was a transitory idea representing process, the best imagery that Heraclitus could think of in a pre-scientific world. Fire is an example of how we fail to account for the world when we assume that it is based on a notion of static nature. Heraclitus writes that "fire, having come upon them, will distinguish (separate, pick out, choose, decide and/or judge) and seize all things."[42] Fire is the process by which things are changed: "The death of fire is the birth of air, and the death of air is the birth of water."[43] This concept of 'changeable' is understandable, as fire will change many things, even stone to lava. This concept does not support the idea that Heraclitus replaced other substantial descriptions with merely another one called fire. It is probable that our modern Western reading of Heraclitus leads us to understand him as making a distinction between one and the many where no distinction was truly intended by him. "Why not see being as merely an aspect of becoming, which, as Bergson long afterward said, is "reality itself"?[44] Let us turn to Plato for a possible alternative.

Plato (427-347 B.C.) offers the analogy of the divided line and the levels of forms. The doctrine of Parmenides[45] plainly plays an important role in his thinking. For Plato, the 'intelligible' and 'knowable' is achieved by intelligence *nous* and *noesis* or *logos*, as compared to the 'visible' and 'opinable' which consist merely of beliefs and conjectures. The process to enlightenment Plato calls the dialectic; a process of search for understanding that proceeds along the divided line leading to the highest level, The Good.

[40] See Heraclitus, fragment no. 113.
[41] Ibid., p. 58.
[42] Heraclitus fragment no. 66.
[43] Heraclitus fragment no. 76.
[44] Hartshorne, *Insight*, p. 15.
[45] Copleston, *History of Philosophy*, p. 182.

Copleston states that for Plato "To explain the world must at least mean to elucidate the unitary principle behind the seemingly absolute duality of matter and mind."[46] According to Hartshorne, Plato seems to have adopted both substance metaphysics and dualism. Yet, the form of the Good "must operate through some kind of soul, some process of thinking or feeling"[47] and "the forms are essentially internal items in psychical process."[48] We might have an alternate understanding of Plato by looking at his metaphysics in terms of process. Plato's matter is that "which is moved" but this conception involves a confusing dualism, since Plato included both matter and soul as things that can be moved, but with two meanings of motion. Matter can be physically moved and the soul is moved by "deliberation … joy, sorrow, confidence, fear, hatred, love and other primary movements which again receive the secondary movements of corporeal substances and guide all things."[49] He also says that the "self-mover … is the source of change and motion in all things."[50]

> But when the self-moved changes other, and that again other, and thus thousands upon tens of thousands of bodies are set in motion, must not the beginning of all this motion be the change of the self-moving principle?[51]

Plato's comment sounds remarkably like a repetition of Heraclitus. Here, Plato is very close to breaking out of his dualism but, as Hartshorne states, "it's a near miss." The "frustration of purposes arise and was more than Plato could handle."[52] Hartshorne points

[46] Hartshorne, *Insight,* p. 23.
[47] Ibid.
[48] Ibid.
[49] Ibid., p. 26.
[50] Plato, *The Laws,* in Daniel Kolak, *The Philosophy Source: Books on CD-ROM* (Belmont, Calif.: Wadsworth-Thompson Learning, 2002), *10* (896, 897).
[51] Ibid.
[52] Hartshorne, *Insight,* p. 38.

out, "There are many souls, hence many purposes; no one purpose can fully determine events since every purpose is (partly) self-determining."[53]

It is with Aristotle that we get the most profound Ancient analysis of this stuff of the world, that which Aristotle called substance. In the *Categories*[54] and *Metaphysics*,[55] Aristotle introduces a notion of substance, one that has rarely been challenged in the Western tradition. For Aristotle, the fundamental determinants of substance are of quantity, quality, relationship, and place.[56]

> Every uncombined term indicates substance or quantity or quality or relationship to something or place or time or posture or state or doing of something or the undergoing of something.[57]

Marie Louise Gill claims that this Aristotelian-type substance is a compound of form and matter.[58] Matter, states Aristotle, cannot alone be substance since a substance must be separable or of independent existence. "It [matter] owes what individuality it has to the substance it is the matter of."[59] In *Metaphysics*, Aristotle indicates that an entity is "conceptually primary if it is a definable unity, that is, if it is definable simply in terms of itself and without reference to entities that are prior to it."[60] Form also cannot alone be substance, for what would have the form or essence other than some matter?

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[53] Ibid., pp. 38-39.
[54] Aristotle, *Categories*, *In Aristotle's Categories and Propositions (De Interpretatione)*, trans. Hippocrates G. Apostle (Grinnell, Iowa: The Peripatetic Press, 1980).
[55] Aristotle, *Metaphysics* in Daniel Kolak, *The Philosophy Source: Books on CD-ROM* (Belmont, Calif.: Wadsworth-Thompson Learning, 2002).
[56] Aristotle, *Categories*.
[57] Aristotle, in Norman Melchert, *The Great Conversation: A Historical Introduction to Philosophy*, 4th ed. (Boston: McGraw Hill, 2002), p. 161.
[58] Marie Louise Gill, *Aristotle on Substance: The Paradox of Unity* (Princeton, N.J.: Princeton University Press, 1989), p. 5.
[59] Marc Cohen, "Aristotle on Substance, Matter, and Form," in *Philosophy 320: History of Ancient Philosophy* [University of Washington faculty web server online cited 1 March , 2003] http ://faculty.washington.edu/smcohen/320/zeta17.htm; INETERNET.
[60] Gill, *Aristotle on Substance*, p. 4.

Aristotle's conception of substance, and not Plato's, is the one that has pervaded the ages. Hargrove argues that "Aristotelian-style philosophy gradually overshadowed the earlier Platonism."[61] Hargrove[62] and Gill[63] suggest that Aristotle's metaphysics is meant as a solution of Parmenides' problem of change; the issue of the one and the many.

> On one level, change was characterized as the actualization of these potential properties. On another level, it was also characterized as a superficial movement and rearrangement of matter in space. By arguing that matter and form did not themselves change at either level, Aristotle succeeded in producing a credible explanation of change that did not violate Parmenides' arguments that absolute change was impossible.[64]

Gill's exploration of what she calls "the paradox of unity" in Aristotle suggests that a "fresh interpretation" of substance and the "relation between matter and form is possible."[65] The unity of material substances, she states, thus "involves a dynamic relation between resistant materials and directive ends." Perhaps, even Aristotle realized that the idea of stuff was not clearly a demarcation of location or position of an object in space. There is possibly much more to the idea of substance. It is clear that Gill is suggesting that the paradox of unity is concerned with the question, "How do substances survive?" What is the attribute of survival which makes a thing a substance? This question seems to suggest that the concept of substance is an attribute itself. Substance, even in the Ancient Aristotelian sense, is an attribute of something else. Another possibility may be that the question, "What is the stuff of the world?" is fundamentally flawed.

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[61] Hargrove, *Foundation*, p. 34.
[62] Ibid., p. 21.
[63] Gill, *Aristotle on Substance*, p. 7.
[64] Hargrove, *Foundations*, p. 21.
[65] Gill, *Aristotle on Substance*.

Other philosophers asked the wrong question: "What is everything composed of?" Heraclitus asked instead, "What is the law that governs the processes of change?" This question again involves the idea of *logos*, of rationality or law that governs process. Most Ancient philosophers approached natural phenomena with the assumption that the world could be rationally understood in terms of substance. The world could be deduced and knowledge of the world achieved from first principles: the world was simple, it was ordered and man could easily understand its workings.[66] From Thales' commitment to "the idea that objects encountered in the world were made out of some kind of substance or matter" followed a long and loyal progression leading up to the current assumption, that matter or substance is the "element" of our world.[67]

Copleston and Jones' interpretation supports the mainstream idea that while objects may be in a state of flux, they appear and have a property of permanence, because their rate of change is constant. This is the idea of substance in terms of persistence of change. But the basis of this permanence might be incompatible with current thinking, for example, relativity physics. Our perception of objects is relative to the space-time location and the act of perception. Over a long period of time, it is less likely that objects will seem unchanged, while over very short periods of time, ordinary objects seem permanent. The same holds for space. If one were to view objects very closely, perhaps looking at the subatomic level, at the microscale or microcosmic perspective, one would be hard pressed to find permanence as subatomic particles are in continual vibratory motion. From a galactic point of view, from the macroscale or macrocosmic perspective, one would have difficulty trying to find change, at least from a human perspective.

[66] Hargrove, *Foundations*, p. 22.
[67] Ibid., p. 17.

Beyond physics, J. Baird Callicott has suggested that scale and duration hold great promise in bringing dynamism to Aldo Leopold's land ethic and thus are also important to environmental philosophy.[68]

Medieval Period

The Medieval thinkers, mainly St. Thomas of Aquinas and St. Augustine, read and translated Ancient philosophy from the context of the Christian faith and significantly influenced the modern world's view of Aristotle. "The primary task of philosophers in the middle and late Middle ages was the reintroduction and assimilation of Greek philosophy, specifically the writings of Plato and Aristotle, into a fully Christian context."[69] Hartshorne adds, "The Thomistic doctrine of the soul as the only form in a human body is Aristotelian."[70] This embedded Aristotelian-type substance as something on which one can, so to speak, stick an attribute. Judeo-Christian belief placed substance in the context of a mystical world. If a paradox were revealed, religious mysticism could be applied as clarification; thus both essence and substance became confused concepts. Support for this interpretation of Medieval thought can be found in the text of Francis Suárez, a sixteenth-century Jesuit. In *De Essentia Entis Finiti Ut Tale Est Et De Illuis Esse Eorumque Distinctione*, Suárez wrote that substances "continue to perdure [persist], though the actual things which embody them have ceased to exist." Thus, the "Christian viewpoint" strongly delineated objects in terms of substance and essence. St. Thomas Aquinas reaffirmed Aristotle's viewpoint stating that substance is a composite of form and matter, with the stress on terms like soul for form, and body for matter.

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[68] J. Baird Callicott, "From the Balance of Nature to the Flux of Nature: The Land Ethics in a Time of Change," in *Aldo Leopold and the Ecological Conscience*, ed. Richard L. Knight and Suzanne Riedel (New York: Oxford Press, 2002). chap. 6.
[69] Hargrove, *Foundation*, p. 34.
[70] Hartshorne, *Insight*, p. 81.

> Note that what composes composite substances is material and its form (human, for example, contain body and soul), and neither of these by itself can be the thing's essence. This is clear enough for anything's material, because … a thing isn't know by its material … but by the way that material is actualized. But neither can form alone be a composite substance's essence, though some think so. ... Clearly the evidence involves both material and form.[71]

The word *essence* became more fundamental than the word *substance* in the late medieval period. Essence took on the meaning of "that which is substantial" or "that which is of substance" but again, with mystical overtones. In Aquinas, substance and essence are differentiated in that substance seems to be meant as a grouping of essences, as sub-substance. Perhaps this differentiation is an indication that Aquinas and other medieval writers were becoming aware of the problem of getting down to the level of that Aristotelian stuff of the world.[72] Aquinas became concerned with the problem of God's essence in time and eternity: "How can God know … the condition of a being existing in time," unless God is outside the order of eternity.[73] While medieval philosophy was no clearer about the relational structure of the world than the Greeks, medieval thinkers provided later authors, such as Leibniz and Husserl, with clues. For example, "Husserl's doctrine of intentionality is the medieval idea belatedly posing as the essence of knowing or of givenness."[74] Consider the contemporary angst in trying to nail down that Aristotelian stuff given the present understanding in physics. At the beginning of the twentieth century we had atoms, but that progressed to sub-atomic parts, then quarks and now it appears likely that there is some other smaller thing (coming soon at a cyclotron

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[71] St. Thomas Aquinas, in Norman Melchert, *The Great Conversation: A Historical Introduction to Philosophy*, 4th ed. (Boston: McGraw Hill, 2002), p. 275.
[72] Copleston, *History of Philosophy*, p. 166. Copleston's comment on Aquinas and the distinction between essence and the act of existence with the Scholastics suggests the increased attention that the Scholastics paid to the issues and problems of substance. Also see p. 284.
[73] Rescher, *Process Metaphysics*, p. 158. See also p. 190, note 5.
[74] Hartshorne, *Insight*, pp. 83-84.

near you). Have we come much farther in identifying or understanding substance or thing with Aquinas's notions of "the essence of substance?"

Modern And Contemporary Period

In the modern era, the three major schools of philosophy, rationalism, empiricism, and Kantianism, saw incredible shifts in first principles of philosophy, but the primacy of substance remained essentially unchallenged. Rene Descartes serves as a good model for rationalism. As a rationalist, Descartes starts from first principles understood as certain and proceeds to construct knowledge of or about the world through reason alone. Descartes took his cue from Plato and Pythagoras, who were more "distrustful of sensation" than was Aristotle. What is this thing that Descartes doubts? It is some sort of substance for Descartes. How about the wax brought close to a flame? This wax has qualities that seem to be enduring: smell, colour, taste, shape, solidity. When heated and melted, however, these qualities seem to also melt away. "Certainly, it could be nothing at all that I was aware of by way of the senses, since all things that came by way of taste, sight touch and hearing, are changed, and the wax none the less remains."[75] Perhaps Descartes' description of the qualities of the wax actually depicts two instances of reality, separated as instances in time and space. Descartes moves the wax closer to the fire and as time passes the wax "changes." Wax before and wax after, a worm tube[76] of wax realities through time confusing an uncertain mind.

> I observe also in me some other faculties such as that of change of position, the assumption of different figures and such like, which cannot be conceived, any more than can the preceding, apart from some substance to which they are

[75] Descartes, *Meditations,* p. 188.

[76] Think of a worm tube (alternate mathematical term 'level surface') as a sphere propagated in space-time, for each second the sphere moves and occupies a new three dimensional location but over time you get a number of these creating a volume of spheres or a tube. Or think of a special movie effect where the image of a moving person is overlaid with the previous images creating a montage of movement.

> attached, and consequently cannot exist without it; but it is very clear that these faculties, if it be true that they exist, must be attached to some corporeal or extended substance, and not to an intelligent substance, since in the clear and distinct conception of these there is some sort of extension found to be present, but no intellect at all.

This account seems to assume that the wax is one thing, one substance, the mind another type of substance. Such an account also does not move significantly to answer the problems and paradoxes of the Ancient philosophers. If anything, Descartes entrenches the problem into the mind-body dualism that permeates or troubles most philosophy that follows.[77] His system of doubting, while epistemologically intended, had a profound impact on the idea of substance and matter metaphysically. If we can doubt our own existence, we therefore can doubt the existence of matter or substance in general. This result is a main principle of a competing school of thought, the empiricist philosophers.

Empiricists rejected certainty as the basis of their philosophy and looked instead to direct experience. John Locke posited two sources for ideas, sensation and reflection.[78] Locke used his method of understanding, often referred to as an 'idea machine', to trace complex ideas of sensation back to simple, atomic ideas that fill the empty mind.[79] For Aristotle and Aquinas, we use substance as something we know precisely. With Locke, certain distinct and clear ideas simply appear together and we cannot understand them otherwise.

> … that a certain number of these simple ideas go constantly together; which being presumed to belong to one thing … we are apt afterward to talk of and consider as one simple idea, which indeed is a complication of many ideas together: because … not imagining how these simple ideas *can* subsist by themselves, we accustom

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[77] Hargrove, *Foundations*, p. 34. Hargrove suggests the permeation. I suggest, as Hume did, that Cartesian doubt is a disease.

[78] John Locke, in Norman Melchert, *The Great Conversation: A Historical Introduction to Philosophy*, 4th ed. (Boston: McGraw Hill, 2002), p. 379.

[79] *Tabula Raza* or blank slate of the mind, see Locke, *An Essay Concerning Human Understanding* in Daniel Kolak, *The Philosophy Source: Books on CD-ROM* (Belmont, Calif.: Wadsworth-Thompson Learning, 2002).

> ourselves to suppose some *substratum* wherein they do subsist, and from which they do result, which therefore we call substance.… we have no other idea of it at all, but only a supposition of we know not what *support* of such qualities which are capable of producing simple ideas is us.[80]

Thus, for Locke, understanding is based on epistemology, on how it works and what materials it works on. With experience as the source to all our ideas, substance is reduced to the cause of these ideas: sort of a platonic unmoved mover or self-mover. The act of cognition is an active working on these passive materials of experience, an activity which creates the complex ideas, which for Locke, include both mental and material substances,[81] a manufactured (hence, 'idea machine') finished product of higher cognition. This conception of an active mind was also held by Immanuel Kant, who drew on both the rationalists and the empiricists.

Kant specifically rejected the basis of epistemology of both the rationalist and the empiricist who were concerned with how objects in the world could be known by the mind. In other words, how can the objective (the substance) be known by the subject (the mind). Kant started by assuming instead that knowledge "is possible" and then attempted to show "how" it is possible. Kantianism also generally held that something served as the basis for irreducible substance. Kant's response to Hume is to say, "If knowledge is possible," then it looks like this. The resulting idealism generated seems to suggest that the external world exists but the certainty of knowing is transcendental to our knowledge. We can't quite know it.[82] Substance is, for Kant, a category of the human understanding. All it does is organize our knowing: substance as the "thing in itself" is unknowable.

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[80] Locke, in *Great Conversation*, p. 379.
[81] Just like Descartes' move to two substances.
[82] Hargrove suggests that "this lunacy was finally put effectively to rest at the end of the nineteenth century with G.E Moore," but it is possible that the idea is still alive and well. See Hargrove, *Foundations*, p. 37.

Quine's Last Stand: The Fallacy Of Misplaced Concreteness

Substance metaphysics has been held as a paradigm of thinking in Western thought for millennia. World views and paradigms change, but has there been any real paradigm shift in the conception of what is the stuff of the world? For most of us, I think not. Michael Slote's work on essentialism[83] is an example of the overly analytic tradition of the 20th-century based on Aristotelian type substance metaphysics that can lead to grandly erroneous conceptions of 'process.' For example, Slote argues that process is merely an extended property of an object.[84] The misinterpretation of *object* is all too common in what Rescher considers the "revolt against process."[85]

In *Word and Object*,[86] Willard Van Orman Quine elaborates "the standard position among recent writers on ontological subjects,"[87] once again reaffirming an object-oriented viewpoint. Quine's last stand for this object-orientated viewpoint comes from a wonderful analysis of language. The words that give "evidence" to objects are words that help differentiate meaning in reality. "Any realistic theory of evidence must be inseparable from the psychology of stimulus and response, applied to sentences."[88] An outstanding study of abstract complexities of language and object, Quine's treatment of objects nonetheless commits the classical error that Whitehead calls the "fallacy of misplaced concreteness."[89]

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[83] Michael A. Slote, *Metaphysics and Essence* (New York: New York University Press, 1975), p. 3.
[84] Ibid., p. 1.
[85] Nicholas Rescher, *Process Philosophy: A Survey of Basic Issues* (Pittsburgh: University of Pittsburgh Press, 2000), p. 33.
[86] Willard Van Orman Quine, *Word and Object* (New York: Wiley, 1960)
[87] Rescher, *Process Philosophy*, p. 33.
[88] Quine, *Word and Object*, p. 17.
[89] Whitehead, *Science*, pp. 50-51.

An example is the issue of identity using the sign '='. For Quine, "identity is intimately bound up with the dividing of reference."[90] Between things like two rocks, the reference of one object relationally to the other is the determination of the identity between them. Indeed, how can one measure the relationship of what is, in essence, one thing, in one location. The aspect identity of an object, either changed in time or space, can be extended by relaxing the difference between time and space. In terms of Einsteinian space-time, we already have the treatment of time as space and occasionally space as time.[91] But notice that it has been assumed that the object is one: The distance in space-time between 'locations' is based on the thinking that the object is the same. Perhaps, suggests Quine, this type thinking is only an informative treatment of identity in language and not completely adequate for our purposes. He invites us to recall Heraclitus' words, "you cannot step into the same river twice, because of the flowing of the water."[92] Notice that Quine does not complete the quote. Let us complete it here for him:

> One cannot step into the same river twice … nor can one twice take hold of mortal substance in a stable condition; for by the quickness and swiftness of its alteration it scatters and gathers-at the same time it endures and dissolves, approaches and departs.[93]

Quine ignores the full meaning of the quote, i.e., that Heraclitus is not necessarily worried about the "flow" of the river. Quine instead concentrates on the identity of the river(s) as a separation of referenced things.

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[90] Quine, *Word and Object*, p. 115.
[91] Note that physics, especially Prigogine argue that time is unidirectional and flows. This suggests that time is unique from space. But, Feynman and Hawkins both discuss space as possibly unidirectional in the multi-universe sense, which supports the idea that space-time flows. The uniqueness of time is the dimension it describes, and not its properties, per se.
[92] Quine, *Word and Object*, p. 116.
[93] Heraclitus fragment no. 91. Notice that most authors like Jones and Copleston quote only the 'river' part of Heraclitus and not the full fragment and this do injustice to the meaning of the passage.

> This difficulty [confusion of identity] is resolved by looking to the principle of division of reference belonging to the general term 'river'. One's being counted as stepping into the same river both times is typical of precisely what distinguishes river both from river stages and from water divided in substance-conserving ways.[94]

Yet, this question is not the one a process philosopher such as Heraclitus is considering. It is not the act of "stepping into the river" that creates two references to the river. Nor, is it the action of perception or action that creates two references to a thing. What Quine believes is confusion between a sign, the name of the object, and object, the object itself, through references in space-time is actually Quine's own confusion about what language identifies as an object or thing, what is in reality a set of changing references in space-time, i.e., a process. Calling it, this thing, a "process-object" or "process-thing" does little to resolve the issue. Thus Quine and others who reject a process-relational theory[95] explain using the notion of time. Action and activity result from "the idea of paraphrasing tensed sentences into terms of eternal relations of things to time"[96] Quine discounts change using a concept of "process-object" via space-time, but then rejects action and activity as change because these are references of objects located in space but over time.

> Physical objects, conceived thus four-dimensionally in space-time, are not to be distinguished from events or, in the concrete sense of the term, process. Each comprises simply the content, however heterogeneous, of some portion of space-time, however disconnected and gerrymandered. What then distinguishes material substances from other physical objects is a detail: if an object is a substance, there are relatively few atoms that lie partly in it (temporary) and party outside.[97]

From the most common resolutions of Zeno's paradoxes,[98] Quine suggests that since infinitely many periods of time can add up to a finite period of time, some kind of

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[94] Quine, *Word and Object, p. 116.*
[95] Rescher, *Process Philosophy*, p. 35.
[96] Quine as quoted by Rescher, *Process Philosophy*, p. 35.
[97] Quine, *Word and Object*, p. 171.
[98] CF. Zeno's paradoxes in chap. 3.

atomistic period of time is possible. This suggestion misses the point. What Zeno's paradoxes induce is the notion of a unit length of time infinitely portioned into smaller and smaller periods or randomly sized periods. This set of infinite partitions still sums to one unit length of time (or space). As Rescher points out, language references for identity of object substances are a poor approach.[99]

> Once we put the temporal extent of the river on a par with the spatial extent, we see no more difficulty in stepping into the same river at two times than at two places. Furthermore the river's change of substance, at a given place from time to time, comes to be seen as quite on par with the river's difference in substance at a given time from one count than on the other.[100]

Could it not be possible that the river changes both in space and time? Atoms are ever changing in space-time.[101] Is there such a thing as "one unchanged river"? Whitehead would argue, "There is an error; but it is merely the accidental error of mistaking the abstract for the concrete."[102] This concept is called *the fallacy of misplaced concreteness*. The idea of simple location of an object in space-time is confused by Quine. The object of "river" as something that is unchanging is a very abstract notion indeed. It is, in Whitehead's words, among other "entities left corresponding to the entities we talk about, yet these entities are of a high degree of abstraction."[103] To call the river a substance and to "afford the quality" of the abstraction to simple locations in space-time is treating the river as a concrete static object: a questionable abstraction. In Quine, as in others,[104] the fallacy is made more evident when one is asked to make the

[99] Rescher, *Process Philosophy*, p. 38.
[100] Quine, *Word and Object*, p. 171.
[101] The Heisenberg Uncertainty principle denies that one can precisely determine the position and momentum of objects simultaneously, at least at the sub-atomic level or microcosm.
[102] Whitehead, *Science*, p. 51.
[103] Ibid., p. 52.
[104] See Rescher, *Process Philosophy*.

"sophisticated recognition" that 'water' and 'red' are "stuff of the world."[105] There is a sufficient designation in language to separate the concrete from a higher abstraction which even Descartes accepted. Quine misplaces the concreteness of an abstract idea and calls it an object. In language we might call it an object, but we mean an abstraction and not a thing concrete or substantive. An abstraction cannot be a substance and thus his theory of process-objects is not acceptable.

Quine's slighting of process is only the forerunner of many similar slighting by writers on ontological subjects.[106] Ordinary language philosophers Nelson Goodman and P.F. Strawson, according to Rescher, both endorse a paradigm of 'object' that includes the assumptions that 'thing' is the only appropriate paradigm for discussion and that "even persons and agents … are secondary and ontologically posterior to proper … things."[107] 'Change' and 'time' are then "downgraded in ontological consideration to the point where their unimportance is so blatant that such subordination hardly warrants explicit defense." In *Individuals: An Essay in Descriptive Metaphysics*,[108] Strawson particularly rejects what he calls "revisionary" metaphysics. He rejects the idea that the world is more than the thing we see and touch daily, that most contemporary descriptions are overly complex, for what seems to him to be rather simple. Everyday language should match the every day world. Strawson's fundamental thesis of identifiably-dependence "constitutes the appropriate criterion for ontological priority."[109] Thus, we have two errors at the extreme end of possibility: one is that the concept of substance may be too

[105] Quine, *Word and Object*, p. 121.
[106] Rescher, *Process Philosophy*, p. 33.
[107] Ibid., p 34.
[108] P.F. Strawson, *Individuals: An Essay in Descriptive Metaphysics* (London: Routledge Kegan & Paul, 1979).
[109] Rescher, *Process Philosophy*, p. 38.

simple to provide a foundation for an adequate metaphysic, the other is that it leads to an overly complex ontology to support itself.

The criterion for determining ontological priority, according to these ordinary language philosophers, is based on linguistic practices, ignoring all other alternatives. The ontological questions are reduced to asking, "What is the linguistic identification of this thing?" As Rescher points out, description-dependence and explanation-dependence are only two of many alternatives. More importantly, it is possible that "processes are ontologically prior to physical things, since the existence of (given) material objects can be fully accounted for only in terms of the processes that lead to their realization."[110] "Even *identification* is itself a (cognitive) process, and we generally identify existing things by means of *instructions* as to what one is to do to establish contact with the item at issue."[111]

What is common among these ordinary language philosophers, such as Quine, is the need to believe that ontological identity, itself, results in a simple identification. Strawson asks "whether there is reason to suppose that identification of particulars belonging to some categories is in fact dependent on identification of particulars belongings to others, and whether there is any category of particulars which is basic in this respect?"[112] This supposition itself breaks down the properties of the thing being identified as strictly belonging either to a category or not. This breakdown assumes that a categorical is atomically complete. For Strawson, therefore, the thing being identified can be separated from all other things, in space or time, in that it has a property that results in

[110] Ibid., p. 40.
[111] Ibid.
[112] Strawson, *Individuals*, pp. 40-41.

its association with a category.[113] That things might never be separable in relationship to other things is exactly the point that process philosophers want to embrace. So, one alternative to the identity question posed by Strawson must be that one cannot determine ontological priority beyond priorities within relationships. Ontological priority can result in an increase of complexity of description rather than simplification.

We have seen how the idea of substance in metaphysics has developed from Ancient to contemporary times. Next I consider some paradoxes that result from our Western dependence on Aristotelian-type substance and consider the notions of scale and object.

[113] Here, I am using the linguistic distinctions given by Quine and Strawson.

CHAPTER 3

PARADOXES: ZENO, DESCARTES, NEWTON, AND CHAITIN

The purpose of this chapter is to explore the theories of substance metaphysics and process metaphysics. I outline the background to Isaac Newton's discovery of the calculus and its implications, the paradoxes of substance, and Gregory Chaitin's discovery-demonstration of randomness. Zeno's paradoxes may well have a common solution, but they introduce some mathematical issues. The notion that substance cannot be ideal or simply located will be investigated. In addition, it will be determined if metaphysics can account for the broadest issues of infinity and randomness that present as a regular feature of reality. How these two theories of metaphysics measure up will indicate the value of process philosophy and will set the stage for the foundations of an environmental philosophy.

We have asked the question, "What is a thing?" Is substance a representation of atomic things, things indivisible that have attributes? Or is substance just something I am aware of? What is this thing of which I am aware? Qualities? Sensations? Locke demonstrates that we "have no experiential contact with substances as such: we experience only their (putative) effects."[114] In a sense, it seems that we are identifying information about some thing. When I say I am aware of substance, then, I am saying that I am aware of information. I do not mean a mystical *je ne sais quois*, not some type of illusion. Hume identified it as sensation, as what is fundamental in experience but I want

[114] Rescher, *Process Metaphysics*, p. 53.

to suggest a fundamental awareness of knowledge in a much stronger sense. You may doubt information about some thing, but would you think that the information came from within yourself, your mind, or is this information from the world, from the senses, your ears and eyes, of your body? Either way, your self has been changed and is constantly changed by new information.

In fact, in this Cartesian sense, what is this 'thing' you doubt? You doubt information about whether one exists or not, you doubt that this chair or this room exists. These facts are mere information about what you think is the case. Do you doubt that something doubts? No, as Descartes would say, at the very least, we know that something or someone doubts (*Cogito ergo sum).* But this doubt itself has changed the manner of the doubter. As suggested by relativity physics, there is no purely objective observer. Now you have information about the existence of something that certainly doubts. It is information that changed the 'I'. Information seems to serve as a basis for knowledge rather than substance and the paradox is extended. By positing substance as a concreteness and information as an attribute or abstraction of substance, we have become trapped in the Cartesian dualism.

Let us explore still further. I can have some certainty about information. First, I can know that I am either aware of the information or not. I can also determine the proximity of this information via a method or set of standards of verification and testing of the information. At the very least the quality of the information can be affirmed using a probability statement that can be declared within certain boundaries.[115] If one said that he or she had probability knowledge of the existence of substance, this claim is still about

[115] I mean to deny the notion that probabilistic means the same as uncertain. See below comments by Chaitin.

the information of which we are aware. If substance is claimed to be atomic, this notion cannot be applied to it. As Johanna Seibt has argued, "the idea of a substantial object as standardly conceived in the philosophical literature is logically incoherent."[116]

Rescher[117] has very recently suggested that future development in philosophy necessarily entails a shift in our metaphysical paradigm. To resolve the logical incoherencies and/or paradoxes of substance it is necessary to reverse the concrete-abstract relationship between substance and information. Think of metaphysics from the point of view of the process of information, where substance, if anything, is one of many attributes of a thing. Consider a substance before us, say a rock. That this rock thing is a particular 'atomic presence' is only an abstraction. A useful abstraction but it does not imply anything substantive. Not a substance itself, but some quality 'substance'. If anything, these objects are less real than the duration of experience. Rescher defends C.S. Pierce's "synechism" as an appropriate approach to Whitehead's atomism, but I think the approach is mistaken.[118] "A true continuum is something whose possibilities of determination no multitude of individuals can exhaust."[119] This is yet another example of substance language, suggesting that "a true continuum" is an object. Can an infinite representation of discrete individuals result in a continuous representation?[120]

[116] Rescher, *Process Metaphysics*, pp. 64-65.
[117] Ibid.
[118] Ibid., pp. 55-56.
[119] Ibid., pp. 64-65. Note that Rescher is quoting C.S. Pierce here.
[120] No specific type of thing or object is meant here.

Zeno's Many Paradoxes

Zeno of Elea offered a number of paradoxes to show that motion or change cannot occur.[121] These paradoxes can be grouped in terms of *plurality, motion, and place*, but, the common thread in all of these paradoxes relates to mathematical issues of infinite partition and limit.[122] Looking each paradox in turn it is clear they all seem to be related to partition. The *plurality* paradoxes, such as *the argument from denseness,* intend to show that there could not be many things. The claim is that a definite number of things must be a finite number of things. A one-to-one denseness is assumed, meaning that the definite things are automatically assumed to be enumerable or countable, which is a mathematically false idea of the partition of a dense set. The s*ize* and c*omplete divisibility* type paradoxes are also partition related. The *paradox of place* is an very early version *of Russell's paradox*.[123] The *grain of Millet* paradox is again one of partition, but this time finite and discrete with the smallest portion possible being one single grain of millet. Aristotle's reply that not all sounds are audible to us seems sufficient, but we might add that it is not clear why this paradox demonstrates that motion is impossible.[124] The first thee paradoxes of motion, *dichotomy, Achilles, and arrow*, are each obvious paradoxes of infinite partition. The *paradox of the stadium* can also be considered as an infinite

[121] Jones, *Classical Mind*, p. 22-24, Plato, *Parmenides*, in Daneil Kolak, *The Philosophy Source: Books on CD-ROM* (Belmont, Calif.: Wadsworth-Thompson Learning, 2002) and *Stanford Encyclopedia of Philosophy*, "Zeno's Paradoxes" [online database cited 17 March 2003], http : //plato.stanford.edu /entries/paradox-zeno/no. 2.
[122] What some other authors, such as Kenyon below, refer to as Infinite divisibility.
[123] Russell's paradox, set containing as a subset the set of all sets, can be stated as the cardinality comparison of these two sets and solved by infinite partition or by using a theory of types.
[124] It is far too easy to argue that this paradox is a poor example. If the sack was dropped under different conditions, such as on top of a pile of millet (which would make almost no noise), we see that the result differs beyond the scale considered. There is also the automatic atomic of the notion of grain.

partition paradox in that the relative velocity comparison is one that relates partitions to respective velocities of motion.[125]

In his comprehensive work on Zeno's Paradoxes, Wesley Salmon argues that "Zeno's arguments fit into an overall pattern."[126] This pattern is designed to refute the view that space-time is continuous or that space-time lacks continuous structure. This gives justification in simplifying Zeno's paradoxes with a generalized partition paradox (most similar to the first three paradoxes of motion) which I put forward below.

Imagine you are teaching a class to students and wish to demonstrate the idea behind Zeno's paradoxes. You crumple a piece a paper into a ball and throw it at one of you students, perhaps the one sleeping in the back row. You state, "Motion is impossible. I will prove it even thought we see that the student here in class caught the paper ball (on his ear). If the ball is to travel the entire distance, from myself to the student, it must first travel half way. If the ball is to travel half way, it must also travel one quarter of the way, and so on." You now explain that one can break up or partition the pathway between yourself and the student into parts: one half, one quarter, one eighth, one sixteenth, one thirty second and so on.

You |-----|-----|----------|----------|----------| Student

1/8 1/4 1/2

You ask, "How many partitions are possible?" Dutifully, students answer that an infinite or endless number of partitions are possible. Each partition, no matter how small, is measurable. "Fine, no problem," affirm your students. You then ask, "What is the sum

[125] Zeno was completely bewildered about the relative velocities of motion.
[126] Wesley Salmon, *Zeno's Paradoxes* (Indianapolis: Bobbs-Merrill, 1970), p. 12. Also see Ralph E. Kenyon Jr., "Atomism And Infinite Divisibility" (PhD. diss., University of Massachusetts Amherst, 1994), pp. 45-82. In Salmon's text, Adolf Grünbaum's essay "Zeno's Metrical Paradox of Extension" is particularly pertinent, but text as a whole is an indictment of Zeno's paradoxes.

of an infinite number of measurable segments or partitions? Certainly infinite", suggest the class. But some students are beginning to look a little unhappy with the future state of things. They can see the punch line coming. "If the distance is infinite, and the time for the ball to pass is finite, then it is not reasonable to think that the ball can reach the end of the path at all, is it? Motion is impossible – any questions?"

It will be helpful to have a resolution to this paradox in order to advance a process philosophy. Recall that an apparently infinite set of discrete entities was assumed. The proposition is that an infinite sum of an infinite number of partitions of measurable distances is infinite. This is the underlying error in all of the paradoxes.[127] The infinite sum in question can be represented by $\frac{1}{2}?\frac{1}{4}?\frac{1}{8}?\frac{1}{16}?\frac{1}{32}\square$ and is a classic geometric series with a common ratio, r = ½ and first term, a_1 = ½. For values of $0 < r < 1$, it is known that the infinite sum of a geometric series is convergent to $S_? \; ? \frac{a_1}{1?r}$. Therefore the sum is a finite and equal to one, the unit distance between you and the student.

$$\frac{1}{2}?\frac{1}{4}?\frac{1}{8}?\frac{1}{16}?\frac{1}{32}\square \quad ? \frac{1/2}{1?1/2} ? 1$$

The sum represents a distance that matches our expectation at normal world scale (mesoscale). It is almost certain that Newton intuitively knew this. Indeed, Galileo's student Bonaventura Cavalieri was very likely to have known this in 1635 when he published the *Geometria indivisibulus continuorum*.[128]

[127] The error, in general, is that infinite, cardinality, denseness, and measurable are each mathematically distinct and interrelate very odd and usual properties. For example, two real number subsets with different bounds have the same countabilility.

[128] Boyer, *History of Mathematics*, p. 367. Cavalieri calculated the infinite sum rule that Newton would later write as the integral rule for polynomial functions to integer powers.

How can non-mathematicians come to grips with infinitesimal sums? An analogy might be a car running smoothly at speed. The engine motion created by the finite number of cylinders going up and down in a piston engine is discrete but the motion transmitted to the wheels is continuous. The more pistons, or partitions, the smoother the engine will run. Scientists in the modern period understood this and designed many engines of great complexity. In fact, the early attempts at engines used continuity thinking. These early engines, called Wankel Rotary engines, proved unreliable. Contemporary improvements in technology, especially metallurgy, have resulted in engines of similar design, i.e., jet engines. These are some of the best and most powerful engines ever made.

Newton's Physics

Conceptions derived from culture and habit can easily mislead us. Galileo Galilei's (1564-1642) reliance on the doctrine of Parmenides' ideal motion delayed his understanding of gravitational acceleration for many years. Indeed, his theory of the motion of bodies in *De Motu*, around 1590, was mistaken because Gallileo left out the concept time from his equation.[129] He corrected this only after three more years of work![130] Not much later Isaac Newton's contributions were to shine brilliantly.

> Nature and nature's law lay hid in sight:
> God said, "Let Newton be",
> and all was light. (Alexander Pope)

Yet, I am left with some uneasiness given the possibility of serious misconceptions. The science of Newton is based on the conception of irreducible ideal

[129] John O'Connor and Edmund Robertson, "Galileo Galilei," in *The MacTutor History of Mathematics Archive* [University of St. Andrews online cited 1 March 2003] http://www-gap.dcs.st-and.ac.uk/~history/Mathematicians/Galileo.html; INETERNET.
[130] Galileo only published the results 35 years later and never published *De Motu*.

particles or ideal bodies with a particle center of mass; matter in motion: physics grounded in Aristotelian-type substance. The physical understanding of the contemporary world is still based on Newtonian physics.[131] We think of physics primarily as motions of entities in the mesocosm, at the scale of every day life. But, life takes place for stars and starfish[132] beyond the mesocosmic world.

The permanence of an object and the fact that an object changes over time is the paradox of substance metaphysics. Zeno criticized Heraclitus' idea of flux because of the difficulty of thinking of a thing being both one and many. In the passing of time, how can we understand that something is enduring if we say that that something is always changing? Substances are things that have certain attributes and do not change. To accept this view is to accept the dualism of Descartes and all the problems that follow from it.

Strangely enough, Newton is one of the major perpetrators of erroneous thinking concerning substance in physics. Late in the seventeenth-century he had two major contributions to make. One was the introduction of the calculus of infinitesimals and the other was the completion of the work on motion of bodies that Galileo had failed to finish in *De Motu.* But in 1672, Newton needed to solve a problem of the infinitesimal, or of the microcosm (the points) and the macrocosm (infinite partition), in order to complete the development of his calculus.

> In a letter of to Mr. J. Collins … having described a method of tangents [tangential approximation by finite sums of areas under a curve] … I added these words: This in one particular, or rather a Corollary, of a general method, which extends itself, without any troublesome calculation, not only to the drawing of tangents to any curves lines … but also to the resolving of other abstruse kinds of problems ... limited to the equations which are free from surd quantities. The

[131] Peter Farleigh, "Whitehead's Even More Dangerous Idea," Open Discussion Paper from the 2000 Conference of *Concrescence: The Australasian Journal of Process Thought* [online cited 1 March 2003], http://www.alfred.north.whitehead.com/AAPT /discussion_papers/farleigh_01.htm; INTERNET.
[132] See Chap. 6 of this paper.

> method I have interwoven with that other of working in equations by reducing them to infinite series.[133]

Newton had developed a method using infinite sums to represent the exact area over a finite interval.[134] It is not an accident that Newton referred to this method as "the method of fluxions."[135] The method is a process that is only slightly more complicated than the method one would use to add an infinite partitioned sum on an interval, as in the solution of Zeno's paradox.[136] This step, from an infinite set of discrete or separate, individual partitions, to a continuity or unity of a single finite distance is a very difficult intellectual step indeed. An infinite sum is an ordinary but still commonly misunderstood mathematical concept. It had been the curse of Zeno since around 466 B.C. and Newton's treatment of infinite sums in AD 1666 had finally got a small hold on the concept.[137]

Never less, Newton did not fully grasp the difficulties of infinity. It fell on the shoulders of George Cantor to develop a precise understanding of infinity and the properties of real numbers.[138] "No one before 1872 had been able to tell precisely what he was talking about" when using the word 'infinity'. Any calculus student will confirm that the shift from infinite discreteness to finite continuity is not easy. It is the quintessential step in the history of mathematics that describes and solves a mesocosmic problem in language that is both microcosmic and macrocosmic.

So, in 1672 Newton was rapidly developing a method and applying it to problems of greater and greater complexity. But he had already developed a theory of bodies in motion and had the three laws of motion by 1666, before he completed the calculus.

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[133] Isaac Newton, *Principia* in Boyer and Merzbach, *History of Mathematics*, pp. 444-45.
[134] Gottlieb Leibniz would independently discover the calculus a few years later, but published before Newton.
[135] Note the word fluxion is defined as the action of flowing or changing.
[136] See Chap. 5 of this paper.
[137] Boyer and Merzbach, *History of Mathematics*, pp. 437-63.
[138] Ibid., p. 631.

Unfortunately, Newton decided not to rework his physics in the language of the calculus, but instead left it in the more commonly understood language of finite algebra. Why would the brilliant Newton do such a thing? Emilio Sergè suggests that it is the fault of Newton's aberrant personality traits of under-confidence and abhorrence of confrontation.[139] Sergè quotes the authoritative Newton scholar Lord Keynes (around 1936-40): "In vulgar modern terms Newton was profoundly neurotic of a not unfamiliar type, but-I should say from the records-a most extreme example."[140] Newton was neurotic about any type of confrontation. When his first paper on optics was published in 1672, "it was assailed by some members of the [Royal] Society, including [Robert] Hooke [1635-1702]."[141] Newton's response was telling: "I intend to be no farther solicitous about matters of Philosophy: and therefore I hope you will not take it ill if you find me never doing anything more in that kind."[142] It is good that Newton did not stand by his word, although it took some convincing.

When Edmund Halley (1656-1742) came to realize that Newton not only had considered the well known but unanswered problem concerning the "trajectory of a body attracted to a fixed point," but that Newton had worked out a solution and a proof, he began a quest to convince Newton that he should publish this and other works in physics.[143] In eighteen months the result was *Philosophiae Naturalis Principia Mathematica,* Newton's greatest work. Newton had already written much of the text but

[139]Emilio Sergè, *From Falling Bodies To Radio Waves: Classical Physicists and Their Discoveries* (New York: W.H. Freeman and Co., 1984), pp. 48-49.
[140] Ibid., p. 49.
[141] Ibid., p. 57.
[142] Ibid.
[143] Ibid. Newton never paid a pence of his own money for his work to be published. It was always paid by others like Halley.

did not want to publish it for fear of dissention and confrontation. Why not use the calculus, the language in which Newton himself understood the world?

> The book is written in the style of Greek geometry, using geometrical proofs throughout. There is little doubt that many of the results have been obtained otherwise, using analytical methods either known to Newton's contemporaries or invented [the calculus] by him. … He told a friend that "to avoid being bated by little smatters in mathematics {he} designedly made {his} principle abstruse [i.e. algebraic not infinitesimal]; but yet so as to be understood by able mathematicians.[144]

The great work was a simplification from calculus to algebra. While the first account of the calculus is indeed found in Book I of the *Principia*, the concept of the infinite limit lacks depth and accuracy.[145] The physics in Book II and Book III is entirely of geometric and algebraic definition, demonstration and proof.[146] An understandable strategy, since Newton wanted as many people as possible to understand his physics. This would be difficult if calculus were used. More importantly, he wanted to avoid, at all costs, any confrontation that might have resulted from use of the still to be tested and still sketchy mathematics of the infinitesimal.[147] There was even a companion work written by Francesco Algarotti [1712-1764], *Newtonianism for Ladies*, "which became extremely popular."[148] Newton's physics was popularized and over-simplified from the start.

The result is that most scientists, and ultimately the world, learned physics from utilizing a conceptual structure based on discrete things. A view sympathetic to the doctrine of Parmenides, instead of a physics relating to the flux of infinitesimals, changes

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[144] Ibid. Comments in hard brackets mine. Comments in parenthesis are the authors.
[145] It is Newton's notes related to *Principia* that we get the full extension of Newton's conception of the calculus, which is, to say the least, substantially greater that what appeared in *Principia*.
[146] Boyer and Merzbach, *History of Mathematics*, pp. 443-44 and Sergè, *Falling Bodies*, pp. 61-65.
[147] Ibid.
[148] Sergè, *Falling Bodies*, p. 67. I can just imagine the oversimplification of a theory already simplified from calculus to algebra.

or processes.[149] A purely discrete, numerically singular or atomistic description of physics may be gravely mistaken about the ultimate nature of reality. But Newton was more afraid that his physics in a language of flux would be challenged. Most would not be up to the task of learning both a new physics and a new mathematics. The connection between the calculus and physics was tenuous at best and the calculus was still imperfect. Newton stressed that his substance was matter with the attribute of ideal existence, perhaps understood by the concept of inertia. By underscoring and using this idea of substance in his physics, Newton unwittingly launched his successors into a metaphysical dead end.

The ideal simple location that Newton assumed is not possible; as Einstein demonstrated, position is relativistic. Quantum mechanics goes much farther. There is a difficulty in even demonstrating the position or velocity of a particle and some major question as to what exactly is the ultimate 'stuff'. Thus, we had atoms, then sub-atomic particles such as neutrons, protons, and electrons, then smaller parts to these such as quarks and leptons.

> So, what then is the true nature of the atom? It certainly isn't a solid little piece of matter like the tiniest bit of something that you can get hold of. So, where do we lose the concept of solid matter at what point does it disappear?
>
> When you reach out and touch something that you can see[,] you perceive the presence of what are supposedly millions of tiny atoms. But if we dissect any substance down to the smallest particle we can see or feel it is true that we are still nowhere near experiencing a single atom. Ordinary optical microscopes still leave us dealing with millions of these tiny particles and it is somewhere near this point that the solidity of the material universe begins to disappear.[150]

[149] This view is also close to that of Leibniz.

[150] Roland Cichowski, "The Atom," in *Presence*, [Secret of The Atom online cited 11 March 2003], http://users.senet.com.au /~presence/SitePages/SecretsOnWheel/CelestialWheel /StructureAtHub/atomgate/theatom.html; INTERNET.

Contemporary physics is far beyond understanding 'stuff' in terms of substance. In addition, the tradition of science had and still holds the idea that primary qualities are objective.[151] Einstein's point about relativity, in addition to results from Quantum Mechanics, suggests that there might be problems with a strictly ideal or objective idea of measurement. The subject determining the substance is having an effect on that substance by merely considering it. Hargrove suggests that most scientists have maintained a belief that science is purely objective. [152] This belief may result in a problem with the compatibility of facts and value in nature and must certainly have an impact on environmental philosophy. In addition, I am suggesting that our attitude about our world in terms of substance is incompatible with both fact and value. This suggests that, as philosophers, we should (1) recognize that substance is not ideal or simply located and (2) reconsider substance as a basic component of our metaphysics. We should therefore begin to consider a metaphysics that is not dependent directly on substance as a starting point: we need to wean ourselves from the attitude that substance is a primary concept of metaphysics. But the worst metaphysical problem has yet to be acknowledged: randomness.

Incompleteness, Uncomputability, And Randomness In The Logic Of Arithmetic

Information theorist Gregory Chaitin has very recently made the claim that randomness is a characteristic of arithmetic.[153] In this section I outline this claim and show that if the claim is correct, it suggests that process-information metaphysics can offer some solutions to contemporary problems.

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[151] Hargrove, *Foundations*, p. 41.
[152] Ibid.
[153] Gregory Chaitin, "The Decline and Fall of Reductionism in Pure Mathematics," in *The Limits of Mathematics* (Singapore: Springer-Verlag, 1998).

In Paris, 1900, David Hilbert, addressing the International Congress of Mathematicians, outlined twenty-three problems that remained to be adequately addressed by mathematicians.[154] He threw down the gauntlet to the congress and urged them to fix mathematics truly and finally.

> I should say first of all, this: that it shall be possible to establish the correctness of the solution by means of a finite number of steps based upon a finite number of hypothesis which are implied in the statement of the problem and which must always be exactly formulated. This requirement of logical deduction by mean of a finite number of processes is simply the requirement of rigor in reasoning.[155]

Within the text of the second problem, "The Compatibility of the Arithmetical Axioms," Hilbert states the common faith of mathematicians and scientists at the beginning of the twentieth century; a faith that has not, to a large extent, diminished in the one hundred years since his address.

> I am convinced that it must be possible to find a direct proof for the compatibility of the arithmetical axioms, by means of a careful study and suitable modification of the known methods of reasoning in the theory of irrational numbers.[156]

According to Hilbert, a systematic search for meaningful statements in mathematics (or "well formed formulae and their proofs") is a pursuit that is both possible and realistic. "The first step in the construction of an absolute proof [of mathematical statements], as Hilbert conceived the matter, is the *complete formalization* of a deduction system."[157] Recall that in a study of any formal axiomatic system, arithmetic for example, one is first concerned with logical consistency and the completeness of the axiomatic system. Consistent means that a well formed formula and

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[154] David Hilbert, "Mathematical Problems," trans. Mary Winton Newson, *American Mathematical Society* 8 (1902): 437-79. Lecture delivered before the International Congress of Mathematicians at Paris in 1900.
[155] Ibid., p. 439. I am quoting from a text version of the paper and page numbering will vary slightly.
[156] Ibid., p. 443.
[157] Ernest Nagel and James R. Newman, *Gödel's Proof,* rev. ed. (New York: New York University Press, 2001), p. 25.

its negation both cannot be proved from the system's axioms. Thus, no contradictory statements within the formal system are possible, i.e., one cannot generate falsity or F_o. Why is this important? The existence of F_o would mean that any statement, any well formed formula, could be proven, for any well formed formula P, since $F_o \nvdash P$ is always true.[158]

Completeness is also an important logical device. Completeness means that for all well formed formulas that can be stated with in the logic, each one can either be proved or disproved. A proved formula we shall call a theorem.[159] In the logic of arithmetic, the logic that Hilbert was most interested in, this means any arithmetic theorem can be proved or disproved based on the axioms of arithmetic using the formal rules of inference of the system. Consequently, Hilbert's problem can be stated simply as a search for all possible well formed formulae and checking each one to see if they are provable. The properties of completeness and consistency are verified along the way.

As Chaitin notes in his paper *Randomness in Arithmetic and the Decline and Fall of Reductionism in Pure Mathematics*, "David Hilbert was not a twit."[160] Hilbert's search can be stated as a "simple" algorithm that can be processed by a computer program. This algorithmic program would first generate all possible proofs of well formed formulae. By running through the algorithm that generates all possible proofs based on the axiom set

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[158] $F_o \nvdash P$, is really $F \nvdash (T \vee F)$? T , i.e., true for P or not P.

[159] Theorems '=' tautologous formulas. Usually, the only formulas examined in a system are theorems of the system. It is often assumed by formulas is meant "tautologous" formulas and that completeness could be defined as when "all formula are true and proved." As we need to consider all possible well formed formulas and then test them, this would include not just the tautologous ones, but also all the non-tautologous ones within the system. For example, p and ~p are both well formed formulas that can be stated, but both could not be true in the same system. Since we consider all well formed formulas we need to define completeness as the property of being able to either prove or disprove all formulas. See either Irving M. Copi, *Symbolic Logic*, 5th ed. (New York: Macmillan Publishing, 1979), pp.165-67 or Ernest Nagel and James R. Newman, *Gödel's Proof*, rev. ed., ed. Douglas R. Hofstadter (New York: New York University Press, 2001), pp. 55-56.

[160] Chaitin, *Limits of Math.*

and check for the occurrence of A and not A, one is checking for consistency. Since the program automatically evolved formulae that have proofs, completeness should not be an issue. Either A or not A is a provable generated well formed formula. In the early 1900s, this approach would have been practically unworkable as the problem is rather large, especially when Hilbert had the whole of mathematics in mind.[161]

The goal of Hilbert's problem progressed instead with Russell and Whitehead's effort to show that mathematics is reducible to logic, the positivist program.[162] Russell and Whitehead started with the axioms of arithmetic and attempted to generate, through deductive and pedantic proof, all of mathematical theory. Using a particular set of axioms of arithmetic that seemed promising, commonly labeled as Peano's axioms of arithmetic, Russell and Whitehead proceeded to construct set theory and number theory. The result was *Principia Mathematica,*[163] a monumental three-volume tome spanning thousands of pages of small print. Never in doubt was the assumption that such a system would necessarily be consistent and that one would, in due course, prove everything known in mathematics. It was a smug, stiff, and arrogant self-assurance set fully in the tradition of Laplace's assumption.[164] It was also dead wrong!

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[161] Henri Poincaré was famous for attempting calculations at this scale and for his diagrams and calculations of what is now called attractors. The meanings of his results only became apparent in the 1970s when computer permitted large scale replications of his work. Note that Poincaré also provided much of the mathematic basis for *General Relativity*.

[162] The school of thought that assumes that one could reduce all of mathematics to logic is referred to, as positivism, logical positivism or logicism. See Marc Corbeil, *Mathematics and Logic*, (master's paper, Concordia University Montréal, 1997) [Papers Marc Corbeil online cited 11 March 2003], http://www.mcorbeil.com/papers; INTERNET.

[163] Bertrand Russell and Alfred North Whitehead, *Principia Mathematica* (Cambridge: Cambridge University Press, 1989). Text develops mathematical theory from base axioms. A forth volume on geometry was planned but never completed.

[164] The great mathematician Pierre-Simon Laplace (1749-1827) stated that given all the information relating to one particle at any moment in time, he could calculate the past history and full future of that particle. One result of chaos theory is the demonstration that Laplace's assumption is false, i.e., such a calculation is theoretically impossible.

Thirty-one years after Hilbert's speech in Paris, Russell and Whitehead were desperately working on the fourth volume of *Principia Mathematica*. Kurt Gödel's *On Formally Undecidable Propositions of Principia Mathematica and Related Systems*[165] appeared out of the school of logical positivism at the University of Vienna, refuting the possibility that a consistent axiomatic system can also be complete. Hilbert's conviction was wrong; no program can be consistent and complete. Russell and Whitehead never completed the fourth volume and parted company soon after.

Incompleteness is only part of the problem-it gets much worse. Recall the approach suggested by Hilbert's challenge in terms of the analogy of the algorithmic program as stated by Chaitin. Alan Turing in 1934 stated this exact problem to address some bothersome snags in number theory. Turing asked the question, "Can we truly show that arithmetic is both consistent and complete?" But he asked in the question in the formulation of Hilbert's 1900 problem, an algorithmic search for *information* about the well formed formulae. The requirement of consistency and completeness is approachable by what Hilbert called the *Entscheidungproblem* or the decision problem.

> Solving the decision problem for a formal axiomatic system is giving an algorithm that enables you to decide whether any given meaningful assertion is a theorem or not. A solution to the problem is called a decision procedure.[166]

Hilbert's program would require a result in the decision problem, information. In other words, if you put the algorithm to the test and you ran through all the well formed formulae, a decision on a statement's provability necessarily results. You learn if the well formed formula is a theorem. In other words, you gain information about the well formed

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[165] Kurt Gödel, *Uber formal unentscheidbare Sätze der Principia Mathematica und verdwandter Systeme* [On Formally Undecidable Propositions of Principia Mathematica and Related Systems-1931], trans. B. Meltzer (New York: Dover Publications, 1992).
[166] Chaitin, *Decline and Fall*, pp. 3-4.

formula. Gödel assumed that the system was consistent, but incomplete. With Turing's decision algorithm, we can assume a consistent system that is incomplete, but still attempt to use the decision algorithm to check for theorems. Even after Gödel there was some hope to that the methods and work of Russell and Whitehead could result in a successful Hilbert program. In principle, this could work but the size of the problem was far too large to be practical.

Not surprisingly, in 1936, Turing showed that "there could be no decision procedure."[167] Turing proved that a decision procedure for a theorem cannot be the case for all theorems.[168] Inexorably, some theorems are undecidable. This is a stronger result than Gödel's. Not only is such a system incomplete, but Hilbert's whole scheme must fail.[169]

The question hangs on the idea of computability. A computable algorithm is one for which there is a method to calculate or compute the algorithm to a result, to the point where information results. The assumption for computability is that the algorithms *halts* or completes itself and the algorithmic program ends. Consider a computer program that will list all possible algorithms, i.e., a program that will list all possible proofs of well formed formulae.[170] If the program halts, the problem is computable, or, alternatively, the process is said to be denumerable or countable. Using a Cantor diagonal argument, one can check to see if the problem is always denumerable, i.e., if the well formed formulas

[167] Ibid., p. 6.
[168] Alan M. Turing, "On Computable Numbers with an Application to the Entscheidungsproblem," *Proceedings of the London Mathematical Society* 42 (1936): 230-65.
[169] Chaitin, *Decline and Fall*, p. 7.
[170] The machine that does this is called a Turing Machine and s the inspiration that lead to the first real computer in 1943, called Colossus, and then to the modern computer.

can always be counted.[171] The question is "Does the program work?" What happens if the program fails to print a line or fails to compute a result? What if the program fails to stop or halt?

Turing proved that there is no algorithm, no mechanical procedure, which will decide if the nth computer program ever outputs an nth result.[172] There is no guarantee the program will halt. Anyone who has experience programming recognizes this is an infinite looping problem, like trying to get an algorithm to divide by zero. The program gets caught up within the algorithm and can't escape the loop. Such a programming situation is said to be uncomputable.

Now enter Chaitin's interesting discovery, which has even more far reaching implications that those of Gödel and Turing. Chaitin argues that the algorithm to find and check all well formed formulae in the logic of arithmetic, will fail to halt. The system of arithmetic is therefore uncomputable. In addition, by using a coded set of instructions of set theory in the programming language LISP, a low level or machine-language program similar to Assembler, Chaitin claims that his result leads to randomness in number theory,[173] the basic theory of addition and subtraction of numbers. Chaitin shows that his halting probability is an uncomputable real between zero and one and one cannot reduce or compress the information contained in such an expression. The information is

[171] Although possibility infinite. By countable here we mean that a one-to-one correspondence with the set of natural numbers is possible. The set of rational numbers, all the natural numbers and fractions, anything that is writable as p/q, where p, q are both integers and g not zero: this set is countable by Cantor's argument. (Cantor's Diagonalization Theorem). The real number set is the union of the set of rational numbers with the set of irrational numbers like Pi, square root of 2, non-repeating, non-terminating decimal representations. The real numbers fail the Diagonalization Theorem and are not countable. Thus, there are at least two types of numerical infinity: countable and uncountable. Finite sets, by the way, are countable by definition.

[172] Chaitin describes this in terms of a numerical process and translates the algorithmic issue as a numerical process. The output is the nth digit.

[173] This is worse than randomness in arithmetic.

irreducible. In addition, if you were to examine a particular digit within this information you would find that the probability of the digit being particularly a 1 or 2 or 3 … or 9, would be 10%. But this is the same probability of any of these digits chosen randomly![174] If you flipped a coin to decide a particular digit, you would do as well as trying to compute the digit using an algorithmic program.[175] This means that the digit is purely random. Thus, randomness can be found in elementary number theory. But this is not all Chaitin has to suggest.

> Consciousness does not seem to be material, and information is certainly immaterial, so perhaps consciousness, and even the soul, is sculpted in information, not matter.… The conventional view is that matter is primary, and that information, if it exists, emerges from matter. But what if information is primary, and matter is the secondary phenomenon![176]

Chaitin is suggesting that information should be primary rather than substance and this information will have some kind of randomness property related to it.

Let us recap. Hilbert suggested a problem, that all theorems in arithmetic are provable using an axiomatic system that is consistent and complete. Gödel proved the system could be consistent but could not be complete. Turing proved Hibert's original algorithmic search program could be represented, but is uncomputable, and therefore also incomplete. Chaitin's demonstrated that the halting program can be expressed as a well known *Borel real number* (which is characteristically random). This means that Hilbert's search program results in some kind of randomness in number theory. Randomness is a feature of reality and randomness is a feature found in the structure of mathematics. In addition, Chaitin suggests that since information serves as the vital characteristic that

[174] Chaitin, *Fall and Decline*, pp. 14-15.
[175] Ibid., p. 16.
[176] Gregory Chaitin, *Unknowable* (Singapore: Springer-Verlag, 1999), p. 106.

leads to randomness, then information must figure centrally in any understanding of reality.

Conclusion

What conclusion can we now reach about Newton's implications, paradoxes of substance, and Chaitin's discovery-demonstration of randomness? Zeno's paradoxes have a solution: substance cannot be ideal or simply located, and metaphysics has to consider the broadest issues of infinity and randomness. Chaitin admitted that he could not *increase* randomness in a numerical string. The level of randomness is constant.[177] This is a problem that can be used to challenge the theory of substance metaphysics.

If a method could be found that would allow an increase in randomness in an information string relating to the natural world, in the DNA molecule for example, then the process-information theory can explain a very complex problem of physical reality that substance theory cannot. In the following chapters, I show this demonstration is possible.

[177] That a level of randomness can be referred to as constant implies different levels or types of randomness. This similar to George Cantor's different types of infinity.

CHAPTER 4

PROCESS-INFORMATION METAPHYSICS

> "Imagine a chess board set up between us. Now the human who plays is an expert on a set of rules and strategies based on that set. However, the Drac who plays the human will win, because the Drac is an expert on standing outside a fixed set of rules. The Drac's first move would be to sweep its opponent's pieces off the board"
> "And, Mitzak, the Timan player? What would his first move be?"
> "The Timan's first move would be to switch games."[178]

We are, in the words of science fiction writer Barry Longyear, rule-bound to our attitudes of substance. We need to think like a Timan chess player; that is, to step outside the game. The alternative I am suggesting is stepping outside the game of substance metaphysics into process philosophy, an attitude focused on change and interconnectedness in the universe. In this chapter I develop a process-information philosophy similar to those of Whitehead and Bergson. A dissimilarity will be a focus on notions of information. This philosophy leads to the concluding criticism of process philosophy, relating to the step from the discrete to the continuous.

Remember that Heraclitus, perhaps the first process philosopher on record, was concerned with change and disagreed with both Parmenides' and the Pythagorean's conceptions of the world. He could not fully explain how things can change and yet be the same and therefore rejected the idea of 'the one'. The final alternative was to consider

[178] Barry B. Longyear, *The Tomorrow Testament*, a full novel in volume set *The Enemy Papers* (Clarkston, Ga.: White Wolf Publishing, 1998), pp. 369-70, *The Tomorrow Testament* was firs published as an independent novel in 1983 by Berkeley/Putnam.

relationship and process. Particularly, to look at the natural world and accurately see what there is to been seen.

Looking out at the world, I observe some thing. "There it is, I have it in my sight." What is meant by this observation? Recall the classic question "Does a tree falling alone in the forest make any noise?" Does existence require an observer? As a solution, Bishop Berkeley, not unlike Descartes, offered the argument that God was the ultimate observer and the objection was resolved thus:

> There once was a man who said, "God
> Must think it exceedingly odd
> If he finds that this tree
> Continues to be
> When there's no one about in the Quad."
>
> "Dear Sir:
> Your astonishment's odd:
> I am always about in the Quad
> And that's why the tree
> Will continue to be,
> Since observed by,
> Yours faithfully,
> God." [179]

I don't think this answer is good enough. To observe a thing, I direct my conscious focus on that thing. In Whitehead's terminology, I *apprehend* this thing. This relationship of process among entities, as Chaitin[180] and Wolfram[181] suggest, concerns information about those entities. It should also be recognized that we have information about other entities peripheral to our main focus. Whitehead's concept of *prehension* suggests that all entities *prehend* each other. When I look specifically at you it may be said that I apprehend you. If I redirect my attention, perhaps I look away, then I am no

[179] "God in the Quad a précis of Berkeley," attributed to Ronald Knox.
[180] Chaitin, *Unknowable.*
[181] Wolfram, *Science.*

longer directly aware of you. But, I still have some limited awareness of you. Other things, far and near, I also prehend; the radio in the background, the cars outside, the stove and wax over there in the corner, and the tree, in extension, falling in the forest. We are at no time independent of one another. This is true especially of the relationship between human and biotic communities:

> No neo-Gleasonian ecological theory of which I am aware asserts that organisms are entirely independent of one another. However individualistic and self-seeking each organism may be, consumers cannot exist without producers and producers cannot exist without decomposers.[182]

No entity can exist without prehensive qualities of other entities. By entity here, I would accept any thing sentient or non-sentient. There are connections between all entities that force a relational understanding when even considering or directly focusing on a single one.

Our existence and our reality do not allow us a complete or absolute objectivism, as Heraclitus hinted. In 1905, Einstein rejected the idea of absolute location and replaced it with location relative to an observer.[183] Einstein and Poincaré, and then Schrödinger, Heisenberg, and Dirac in the 1920s, together offer a contemporary basis to physics: relativity and quantum mechanics. In contemporary physics the idea that one could hold the same thing in at any time or place, even instantaneously, is illusionary: a Laplacian illusion. One cannot, even in principle, measure any particular property of a thing precisely.[184] The best that quantum physics can provide, even instantaneously, is a subjective observation over duration of experience.

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[182] Callicott, "Flux of Nature," p. 96.
[183] Hawking, Stephen, *A Brief History of Time: From The Big Bang to Black Holes* (New York: Bantam Books, 1988), pp. 23-25.
[184] Ibid., p. 55.

Essence or substance must be a characteristic that is relative to some scale; it is relativistic even beyond the Einsteinian sense. Rather than an absolute substance, we might abstract a relative substance in relation to duration in space-time. Does the object considered in the microcosm, the mesocosm, or the macrocosm, bear properties related to space-time?

As Callicott suggests, the dynamism of stability and integrity of an ecosystem largely depend on assumptions of scale.[185] But let us extend this further. When we take a snapshot of apprehension of some thing, perhaps, as argued by Chaitin,[186] we are making an attempt to locate information rather than material. Whitehead's idea of space-time interrelations is transformed into one of information, where information is "said to be here in space and here in time."

This is no easy step. Space-time is very unlikely to be limited to anything resembling the three dimensions we humans normally understand. A four dimensional space-time concept limits both physics and metaphysics to our scale of reality, and, more importantly, gives a faulty description when we leave the mesocosm. The microcosmic world requires a more complicated space-time. And, even in the mesocosm, I count a minimum of five dimensions: we have three dimensions for space (human imposed length, width, height), one uni-directional dimension for time, and at least another perhaps for probability (sorry Dr. Einstein). Superstring theory and theoretical physics advocate nine p-branes or dimensions. Super-gravity theory, another type of physics, advocates seven to eleven dimensions, and the Sierpinski Gasket, a fractal object, has a

[185] Callicott, "Flux of Nature."
[186] Chaitin, *Unknowable*, pp. 106-07.

'dimension' that can be calculated to approximately 1.58![187] Truly, God only knows the brand of dice with which Stephen Hawking plays when he says space-time is either ten or twenty-six dimensional.[188]

Herni Bergson affirmed that we never really experience a bit of information. Rather, prehension (for him, intuition) must be a process over duration. Seeing, touching, measuring, all are verbs of action in time. The Aristotelian substance doesn't even make sense as a single event, since an event takes some duration of time.

> The duration wherein we see ourselves acting, and in which it is useful that we should see ourselves, is a duration whose elements are dissociated and juxtaposed. The duration wherein we act is a duration wherein our states melt into each other.[189]

This is the idea of information process as the primary characteristic in perception.[190]

> Thus concrete fact is process. Its primary analysis is into underlying activity of prehension, and into realized prehensive events. Each event is an individual matter of fact issuing from an individualism of the substrate activity.… An entity of which we become aware in sense perception is the terminus of our act of perception.[191]

The prehension event, an event of interconnectedness, is the key to how Whitehead understood process. However, if we left substance located in the space-time continuum, there would be a problem of extending these discrete facts to a continuum, the continuum of our seemingly continuous perception of these events. That which is prehended, the entity that "we become aware of in sense perception," I would argue is information. Prehension, then, is an operator or transformation function on information resulting in more or new information. Reality is not *substantive* but *informative* through process.

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[187] Robert L. Devany, *An Introduction to Chaotic Dynamical Systems*, 2nd ed. (Redwood, Calif.: Addison-Wesley, 1989).
[188] Hawking, *History of Time.* See chap. 10 particularly.
[189] Henri Bergson, *Matter and Memory* (New York: Zone Books, 1991), p. 186.
[190] Rescher, *Process Metaphysics*, p. 45.
[191] Whitehead, *Science*, p .70.

Every event results, essentially, in new events that again are perceived and operated on as an *iterative process*. Cognition over duration of time is an iterative process of discrete information events. [192] This is important if we want to adequately describe reality.

We may think we focus on the one thing, but that is the illusions of the doctrine of Parmenides. We may think that things can be separated out into a very small or atomic unit, in the Ancient sense, as did Leucipuss and Democritus when they first conceived a theory of atomism. For them, a thing can be an indestructible and internally changeless particle, "so small as to escape sensation."[193]

Looking out at the world, I locate some thing. "There it is, I have it in my grasp." As I am saying this remark, a little phrase, usually conspicuously missing from translations of fragment no. 91 of Heraclitus, comes again to mind:

> … Nor can one twice take hold of mortal substance in a stable condition; for by the quickness and swiftness of its alteration it scatters and gathers-at the same time it endures[194]

Can I truly have the same item in my grasp that I had only a minute ago, or even a second ago? Where is this thing located? Tradition suggests that the thing is located at some point in space, namely in my hand. But is this specific enough? To hold the doctrine of Parmenides despite this evidence is to commit what Paul Weiss calls the "fallacy of essential completeness."[195]

> It supposes that the individual entity is "in a single moment of time and merely inwardly points beyond that moment," so that "it will vanish, as so point, with the passage of that moment. Pointing does not enable an object to persist …."[196]

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[192] Bergson and duration of time.
[193] J. Baird Callicott, "Traditional American Indian and Western European Attitudes Toward Nature: An Overview," in *Foundations of Environmental Philosophy: A Text with Readings*, ed. Frederick A. Kaufman (New York: McGraw-Hill, 2003).
[194] Heraclitus, fragment no. 91.
[195] Paul Weiss, *Reality* (Princeton, Princeton University Press, 1938), p. 208.
[196] Weiss as quoted in Reck, "Substance," p. 766.

Whitehead defined simple location as "one major characteristic which refers equally both to space and to time, and other minor characteristics which are diverse as between space and time,"[197] thus, an Einsteinian space-time. But just saying space-time is not merely to describe a combination of space at some time in the traditional metaphysical sense.

It is enough to understand that the concept of location is merely of information, and one characteristic of this information, at a certain scale of space-time, *appears* to us as substantive. We have the feeling that it is substantive, but our analysis demonstrates that this is not so. It is worthwhile to treat thing as substance, in the same sense that it is worthwhile to apply Newton's laws of motion to a falling object in the Earth's gravitational field. But, in much larger or smaller scales, Newton's laws fail.

Additional information other than location is also possible. Our analysis of things, our apprehension, is a directed perception (or direction prehension) of this information. Often this information lacks relational location, as might a timeless triangle, or the view of the edge of a square where one sees only a line. Characteristics such as color again, from this point of view, are simply bits of information. Aristotelian-type substance is information about matter and form. Substance, as either Aristotle or Descartes might hold, is a projection of information, a mere subset of the actual. Again we see how the concept of substance, at its best, serves us poorly as a basis for metaphysics which in turn is a basis to our physics.

Whitehead, the heavyweight of the process philosophers, clearly opposed "substance-attribute metaphysics" and a "subject-predicate logic. … Instead he urges that

[197]Whitehead, *Science*, p. 49.

philosophy should be based on a logic which gives the primacy to relations or structure and not to the terms or subjects."[198]

I must point out that process philosophy does not suggest process as a replacement for substance in metaphysics. To do so would be too casual an error. Such a metaphysic would make itself open to all the paradoxes of substance by the mere substitution of a single word.[199] It would be circular to remove the 'substance thing' and replace it by "a collection of events occurring in it," seeing that the 'it' must refer to the thing at issue. Process philosophy entirely denies that a thing is simply located or that "an existing thing which [is one] which requires nothing but itself in order to exist."[200] This Cartesian image of things must be completely rejected. But how do we avoid "throwing out the machine along with the ghost?"[201] This is accomplished by going from substance-thinking to event-thinking.

Fallacy Of Misplaced Concreteness

A primary criticism of process philosophy, or event-thinking, concerns the paradox of unity, as suggested by Gill,[202] the question of how substances survive. Andrew J. Reck claims that "process philosophies that repudiate substance are untenable, and in fact to press the claim that substance in the sense of unitary, continuant, and independent individuals … must undo the possibility of process, since our awareness of process as well as its reality would be thereby impugned."[203] In anticipation, Whitehead carefully incised substance from the foundations of metaphysics by replacing the concept

[198] D. Bidney, "The Problem of Substance in Spinoza and Whitehead," *The Philosophical Review* 45, no. 6 (November, 1936): 574-592, p. 583.
[199] Mario Bunge as quoted in Rescher, *Process Metaphysics*, p. 33.
[200] Farleigh, "Whitehead's Even More Dangerous Idea," p. 1.
[201] Ibid.
[202] Gill, "Paradox of Unity." See chap. 2.
[203] Andrew J. Reck, "Substance, Process and Nature," *The Journal of Philosophy*, Vol. 55, no. 18 (August, 1958): 762-772, p. 767.

of substance with "matter without attribute," what he called a 'subject-superject'.[204] In *Process and Reality,* Whitehead writes, "It is fundamental to the metaphysical doctrine of the philosophy of organism [process], that the notion of an actual entity as the unchanging subject of change is completely abandoned."[205] This is clearly a call for a rejection of substance as a basis for metaphysics.

In defense of substance metaphysics, Reck states that "the event is not merely a matrix of qualities and relations excluding substance; it is a center of activity, or energy expenditure, or creativity." Here, Reck demonstrates the common confusion of an event with the attribute of the event, what he thought of as substance. Hume recognized this issue, stating that objects "have a constant union with each other … we commonly regard the compound which they form as ONE thing, and as continuing the SAME under very considerable alterations."[206] Reck claims that an event "must have an atomic moment which it spans, so that the entities that are perpetually becoming and perishing in Whitehead's system are in some fundamental sense of being for a while." As in Quine above, Reck is confusing substance and abstraction. The idea of an atomic moment is inconsistent with the idea of a span of the event or duration of experience. Whitehead identifies this idea as the fallacy of misplaced concreteness.

> This simple location of instantaneous material configuration is what Bergson has protested against, so far as it concerns time and so far as it is taken to be the fundamental fact of concrete nature. He calls it a distortion of nature due to the intellectual 'spatialisation' of things. …There is an error; but it is merely the accidental error of mistaking the abstract for the concrete. ...This fallacy is the occasion of great confusion in philosophy.[207]

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[204] Alfred North Whitehead, *Process and Reality*, corrected ed. (New York: The Free Press, 1978), p. 29.
[205] Ibid., p. 29.
[206] David Hume, *A Treatise of Human Nature*, ed. L.A. Selby-Bigge (London: Oxford University Press, 1955), p. 219.
[207] Whitehead, *Science and The Modern World* (New York: Free Press, 1925), pp. 50-51.

To think of an event as simply located or an entity as substantive in the Aristotelian sense is to fall into the trap of the fallacy of misplaced concreteness. Rather, the idea of event-thinking is essential to process:

> The ordinary logical account of 'propositions' expresses only a restricted aspect of the role in the universe, namely when they are the data of feeling whose subjective form are those of judgments.[208]

You doubt information about whether one exists or not; you doubt that this chair or this room exists. You reach out and touch the chair and declare, "That seems solid to me." But, what you feel is not truly momentary, for no sensation is atomic or instantaneous as an event. Apart from an abstraction of the moment, your experience is of duration of the event. The substantive quality is exactly that, a quality of the event, not the subject of the event: an abstraction of process.

Do you doubt that something doubts? No, this is where Descartes would say, at the very least, something or someone is doubting. But this doubt itself has changed the manner of the doubter.[209] You have information about the existence of something that certainly doubts. What allowed Descartes to go from a doubter to a thing, a mental substance that doubts? It was a fundamental assumption of substance. It we abandon substance, then information becomes pivotal.

Consider Holmes Rolston's suggestion that the dynamism of life that we should respect is based on information contained within the history of a species, including the information found on the DNA.

> What humans ought to respect are dynamic life forms preserved in historical lines, vital informational processes that persist genetically over million of years,

[208] Whitehead, *Process*, p. 25.
[209] Ibid., p. 77.

> overleaping short-lived individuals. It is not *form* (species) as mere morphology, but the *formative* (speciating) process that humans ought to preserve."[210]

Positing information as a basis rather than substance helps with the paradox of determining what a thing is, and also helps with the paradox of mind-body.

Information prehended, in error or not, seems to travel the mind-body gap without a problem; the very idea of a gap may no longer be problematic. What doubts, in the Cartesian sense, is the collection of information, perhaps with some guiding structure, process, which needs to be something that limits the pathways of this information. Doubting adds information to this complexity of information. But this complexity of information is similar to a community or an ecosystem in that the boundary of being in or out is uncertain. What is this pain I feel? The pain is merely information and the question of mind-body is mute since you cannot properly determine that information is of the mind or body. It is information, data and not substance, which we need to consider in processes. To coin a phrase, *Cogito datum ergo data sum*.

Ushenko claims that it was Whitehead who convinced Russell "to abandon Newtonian absolute time and space, and also particles of matter, substituting systems of events" in 1914.[211] Russell looked to space-time perception and recognized that substance seemed "unperceivable."[212] Bradie also suggested that "the events in this latter space [of substances] are also assumed to by Russell to be spatio-temporally connected"[213] and interrelated to other events in the perceptual [other] space. Russell became trapped in a dualism of perceptual and unperceived space "making inferences from percepts to events

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[210] Homes Rolston III, *Environmental Ethics: Duties to and Values in The Natural World* (Philadelphia: Temple University Press, 1988), p. 137.
[211] A.P. Ushenko, "Einstein's Influence on Philosophy," in *Albert Einstein: Philosopher-Scientist*, ed. Paul A. Schilpp (La Salle, Ill.: Open Court Publishing, 1949).
[212] Michael P. Bradie, "The Development of Russell's' Structural Postulates," *Philosophy of Science* 44 (1977): 441-63, p. 444.
[213] Ibid.

which no one perceives."[214] The dualism forced Russell to claim that "in spite of such interferences, we do manage to be aware of the effects of distinct physical objects."[215] "What Russell seems to be saying here is that as perceivers we are constantly being bombarded by casual influences or causal chains of events [in Whiteheads words, prehensions]. These events interfere with one another to a certain extent much as fog obscures our vision or static interferes with our listening to the radio."[216] As Bradie points out, this is one the most surprising positions that one would expect Russell to defend. Indeed, Russell may have completely adopted Whiteheads process viewpoint later in life (1954-1960!).[217]

> One of Russell's major contributions to modern philosophy was to provide a theory of relations which made them [relational propositions] as respectable, if not more so, than substances and attributes.
>
> He discovered to his chagrin and discomfiture, that the revolution of which he was a prime mover [the overthrow of metaphysical views which he destroyed] had been too thorough; philosophers, having seen the old metaphysics destroyed [and replaced by substance metaphysics of the analytic school], and had no desire to replace them by anything. Thus, a general neglect of Russell's later philosophy by the professional community.[218]

Russell was well known for an unforgiving analytical viewpoint of metaphysics. Nevertheless, he conceded the metaphysical battle to his "lesser contributor" Alfred North Whitehead, also a former positivist. It is notable that two of the greatest analytic Aristotle-style substance metaphysicians, Whitehead and Russell, both seem to have abandoned *substance*.

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[214] Ibid.
[215] Ibid., p. 446.
[216] Ibid., pp. 445-46.
[217] Ibid., p. 441.
[218] Ibid., p. 441-42.

Non-Linear Reality

One of the most important issues that process philosophers face concerns the non-linear properties of reality. Chaos theory, or non-linear dynamical systems, is a mathematical research area that has caused a great deal of interest and raised some fundamental questions. In terms of process philosophy, per se, the linear non-linear issue can be reduced to the problem of stepping from the discrete to the continuous. This is exactly Reck's and Bidney's second criticism of the removal of substance from the foundation of metaphysics.

Reck states that "Unless the series of particulars [discrete bits] can be compressed into a unity, the thing is pulverized into an indefinite, perhaps infinite set of inconsistent properties."[219] The illusion or abstraction in reality is the idea of moment and not the idea of duration. I can easily point to duration, but, it seems unlikely that I will be able to truly point to a simple moment. Albert William Levi writes that "time and spatial extensions are reflexively definable because they are quantities, continuous and divisible."[220] Definable because they are divisible; A little circular in terms of metaphysics, I think. Magnitude, movement, and time are all continuous only because the succession of now which defines the cutting edge of time is assimilated to a Euclidean imagery of points which defines the infinite divisibility of space. Process reality offers a description of entities in process and relations in a flowing world: Heraclitus' world of flux. Western tradition, as remarked above, requires that we start with a singular substantive object or substance. If entities are not illusions, then the

[219] Reck, *Substance*, p. 768.
[220] Albert William Levi, "Substance, Process, Being," *Journal of Philosophy* 55, no. 18 (August 1958): 749-61, p. 752.

metaphysical issue of discrete objects compared to experience of a reality that seems to be continuous must be addressed. We have a feeling of duration that is continuous.

> But, in man, the thinking being, the free act may be termed a synthesis of feelings and ideas and the evolution which leads to it a reasonable evolution. The artifice of this method simply consists, in short, in distinguishing the point of view customary or useful knowledge from that of true knowledge. The duration *wherein we see ourselves acting*, and in which it is useful that we should see ourselves, is a duration whose elements are dissociated and juxtaposed. The duration *wherein we act* is a duration wherein our states melt into each other. [221]

Bergson suggests that our experience is actually a "succession of phenomena" which is separately distinguishable by scale. We prehend minutia of discrete information; yet we seem to experience reality as a continuity. How can we extricate ourselves from this discrete-continuity problem? Are we any better off than we were with the problem of mind-body?

[221] Henri Bergson, *Matter and Memory*, trans. N.M. Paul and W.S. Palmer (New York: Zone Books, 1991), p. 186.

CHAPTER 5

DISCRETE VERSUS CONTINUOUS

The previous chapter outlined process philosophy but terminated with the criticism of the discrete-continuity gap. In this chapter, exploration of elements of mathematics will assist in answering this criticism. I claim that the evolution-entropy dilemma is related directly to Zeno's paradoxes. Chaitin identified the difficulty in explaining how evolution is possible when the concept of entropy suggests that species on the planet should have become less complex rather than more complex. An extension of the resolution to Zeno's paradoxes, namely chaos theory and process-information philosophy, may offer a satisfactory solution to the evolution-entropy dilemma.[222] Further, I demonstrate a metaphysic that is consistent with science and may serve as a foundation for environmental philosophy that will put "the environment back into philosophy"[223]

Recall Reck's second criticism of process metaphysics: "Unless the series of particulars [discrete bits] can be compressed into a unity, the thing is pulverized into an indefinite, perhaps infinite set of inconsistent properties."[224] If we accept that Zeno's paradoxes have a solution, then we understand that one *can* compress a "series of particulars into a unity." As Reck suggested, this necessitates a conception of the infinite which is more than acceptable and consistent with a process reality. In fact, the point to

[222] L.c.., p. 5. Entropy suggests that species on the planet should have become less complex rather than more complex.
[223] Hargrove, *Foundations*, p. 3.
[224] Reck, *Substance*, p. 768.

process is treating relationships and interrelationships as actual. At worst it treats "the one" as the illusion.

Reck seems unaware of contemporary resolutions of Zeno's paradoxes and have problems with the infinitesimal.[225] Reck suggests that process philosophy necessarily needs to depend on "fuzzy logic" or Bergson's "fuzzy character of the real.… The process philosopher has replaced a horror vacui with a horror separationis, being impelled by the paradoxes of Zeno into the conviction that once reality falls apart into disjointed discreteness, not all the king's horses and all the king's men can get it together again."[226] Even Rescher, a staunch process philosopher, states that "Zeno's classical paradox demonstrates the incapacity of stable concepts to characterize the fluidities of an ever-changing reality."[227] D. Bidney's criticism of duration demonstrates the crux of this issue:

> Movement is not the series of static positions of a thing. It is essentially a certain duration of flux. This duration can be analyzed for the purposes of action into a series of stages or positions, but motion cannot be reconstructed through a series of static positions. When one attempts to do so he becomes involved in all the paradoxes of Zeno.[228]

Bidney's criticism is even more specific than Reck's. It is this call to the infinite that Zeno identified as the problem, but from the point of view of process metaphysics, this is favorable. Once again witness the fallacy of misplaced concreteness; the abstraction of a *duration* into touchable singular or atomic "oneness" is fallacious. Bergson had it right when he said "one cannot touch the instant."

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[225] For example, see Rescher, "Process Metaphysics," p. 15.
[226] Ibid., p. 40.
[227] Rescher, "Process Metaphysics," p. 15.
[228] D. Bidney, "The Problem of Substance in Spinoza and Whitehead," *The Philosophical Review* 45, no. 6 (November, 1936): 574-92, p. 578.

> But the real, concrete, live present – that of which I speak when I speak of my present perception – that present necessarily occupies a duration. Where then is this duration placed? It is on the nearer or on the further side of the mathematical point which I determine ideally [in abstraction, relating also the idea of instant as an abstraction!] when I think of the present instant? … Sensations and movements being localized [prehended and then apprehended] at determined point of this extended body, there can only be, at a given moment a single system of movements and sensations.[229]

Can an extension of process really get us from the discrete to the continuous? It can if we apply the central limit theorem. In addition, applying this theorem to a *Levy flight* will make the important correlation to chaos theory, relating the concept of process-information to the concepts of complexity and stability.

Levy Flights

Steve Wolfram, in *A New Kind of Science*,[230] illustrates how such an extension is possible through the process of random discreteness of very large sets of discrete entities. Consider a discrete set of information and use the analogy that information represents behavior. What is the outcome of arranging the such information? Discrete elements usually result in complex arrangements of discrete behavior. But, in nature we seem to encounter some kind of continuity. Either we are mistaken in the idea that this results from discrete information, or we are mistaken overall in our metaphysics, and the information is continuous.

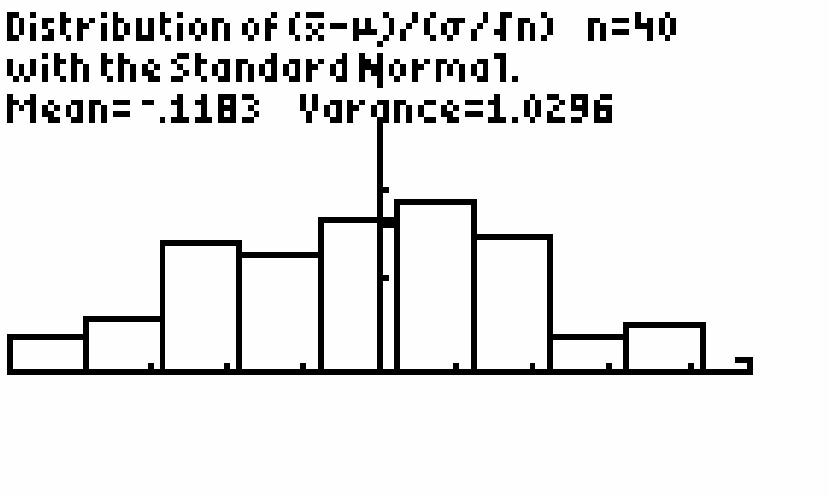
> To explain our actual experience of the natural world, we need to consider not only how phenomena are produced in nature, but also how we perceive and analyze these phenomena.[231]

If we accept that the individual components of reality are primarily made up of process-information, rather than substance, then even in large systems, discrete

[229] Bergson, *Matter and Memory*, pp. 137-38.
[230] Steven Wolfram, *A New Kind Of Science*, (Champlain, Ill.: Wolfram Media, 2002).
[231] Ibid., p. 547.

information should be characterized by discrete descriptions. But, with *really large* systems of complex information, for example an ecological system or even a human brain, individual information seems to get damped out and these "systems with discrete components" produce "behavior that is smooth and continuous."[232] Rescher also recognizes that large populations contribute to a truer understanding of the whole.[233] This does not mean that discontinuity is fundamental, rather it may suggest that discontinuity is abstract or simply illusionary.

Wolfram describes large population behavior using the notion of a *Levy Flight*. If we take a discrete particle and then apply a random operator to it, for example a random movement of the particle to the left or right, a distribution of the particle results. This distribution is called a 'random walk'. Applying such an operator to a large group of discrete particles, and looking at the distribution of each particle, results again in a discrete description. Analysis of discrete data should result in a discrete distribution resembling the binomial distribution represented below by a binomial probability histogram



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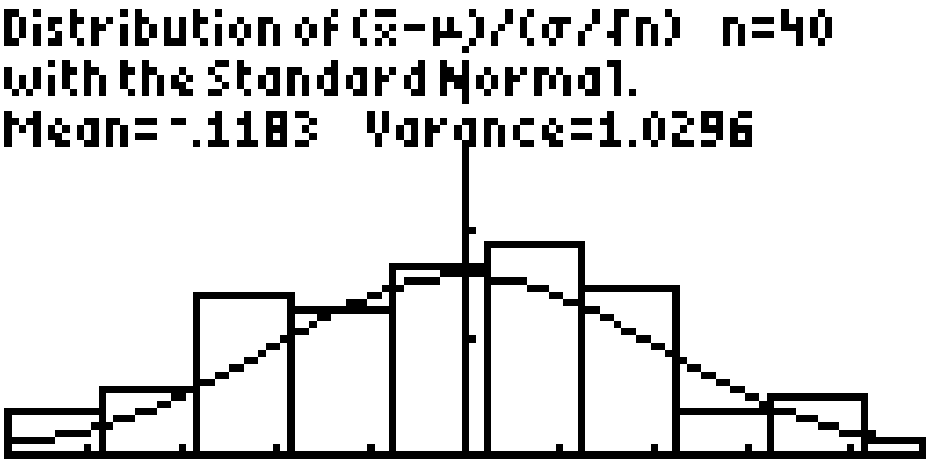
[232] Ibid., p. 327.
[233] Rescher, "Process Metaphysics," p. 22.

"But what happens if one looks not at the position of each individual particle, but rather at the overall distribution [using descriptive probability] of all particles?"[235] If the number of particles and the number of iterations of the operator is large numerically,[236] the resulting distribution starts to look smooth. These special random walks are referred to as *Levy Flights.* If the diffusion of the distribution gets very large a continuous distribution results. Mathematically, the assumption is that any physical quantity has a Gaussian, or continuous, distribution of probabilities when the iterations are very large. This is stated in following theorem:

> THEOREM (Central Limit Theorem)
> *For very large n a discrete distribution converges to a normal or continuous distribution.*

This theorem provides part of the step from discrete to continuous. As an example, consider the diagram below of a continuous distribution (over laid on top of the orginal discrete distribution):



[234] These images produced by the author using a TI-86 calculator and TI graph link software.
[235] Wolfram, *New Science*, p. 327.
[236] In terms of biological systems this might still be quite small.

As n becomes large, the smooth curve approximates the discrete distribution. As n gets very large it is almost impossible to distinguish the two distributions. If n goes to infinity, the curves will match exactly, i.e., the discrete curve will converge to the continuous curve. The upshot is that Levy flights and the *central limit theorem* allow one to go from discrete to continuous in a definitive manner. This is not an illusion or the appearance of continuity but a convergence relating to an iterative process. This argument is similar to the transformation going from discrete to continuous in the calculus of Newton-Leibniz, what is called the Riemann sum of infinitesimal areas under the curve added up over an infinity of very small partitions of x giving a total finite sum (a convergence of the infinitesimal sum) or area under the curve.[237] It is also similar to the convergence of an infinitesimal sum as in Zeno's paradox. In addition, the iterative process demonstrates the properties of self-similarity and sensitivity to initial conditions characteristic of chaotic dynamical systems. Perhaps this may suggest alternative notions of 'stability' and 'integrity' of such systems.

The Evolution-Entropy Dilemma

I have suggested throughout this paper than a resolution exists to the evolution-entropy dilemma, as I call it. Before going into depth, some clarification of terms is necessary. There are clearly two distinct meanings of entropy: thermodynamic and logical. The second law of thermodynamics states that a closed system must deteriorate in available energy and complexity. Energy tends to flow and spread: more *entropy* results in less energy for doing work. The term entropy here is being used synonymously with the second law of thermodynamics. This is acceptable as long as entropy is defined as unavailable energy. But a different meaning of entropy, called logical entropy, refers to

[237] The integral.

disorganization or disorder in general. Physicist Richard Feynman defines (thermodynamic) entropy in units joules per degree and (logical) entropy in another section as distribution of order, without units or equations.[238]

Often entropy becomes the focus of criticism of evolutionary theory. This theory seems to violate the second law of thermodynamics since more energy seems to be available as time passes, rather than less as entropy suggests should be the case. The response usually is that the sun, and the earth's core, both provide energy for the planet. The earth is not closed in terms of energy. This explains how energy is still available to do work for eons upon eons. But the entropy issue in evolution is not a thermodynamic one; instead it is logical entropy or complexity that is at issue. Life increases in complexity and this seems to defy explanation.

I am considering logical entropy and the unexplained appearance of complexity.[239] John A. Jungerman gives the following exposition of the problem:

> Countervailing the general tendency of the universe toward increased entropy, as specified by the second law of thermodynamics, is the order and decreased entropy produced by complex systems. These systems exhibit spontaneous creativity and unpredictable behavior accompanied by *interconnections* among trillions of atoms. These are all concepts that are tenets of process thought.[240]

Although Jungerman states "specified by the second law," he is obviously referring to the complexity and order issue in this statement and not energy of a closed system, i.e., logical entropy and not the second law at all. He is asking, "How do things in the world in general become self-organizing toward complexity?" Why is there life at all? If we are

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[238] Richard p. Feynman, *The Feynman Lectures on Physics* 1 (Reading, Mass.: Addison-Wesley, 1963). Thermodynamic: sect. 44-6 and Logical: sect. p. 46-8.

[239] It is not clear from Feynman, Robert Penrose or Ilya Prigogine exactly what is the relationship between the two types of entropy.

[240] John A. Jungerman, *World in Process: Creativity and Interconnection in the New Physics* (New York: SUNY Press, 2000), p. 135.

to accept that life and nature have increased in complexity over the eons as facts, then this planet certainly seems driven towards complexity and self-organization. The evidence is fairly plain, but how can we possibly give a rationale for this?

> It seems that most biological mechanisms of action show that life involves far-from-equilibrium conditions beyond the stability of the threshold of the thermodynamic branch. It is therefore very tempting to suggest that the origin of life may be related to successive instabilities somewhat analogous to the successive bifurcations that have lead to a state of matter increasing coherence.[241]

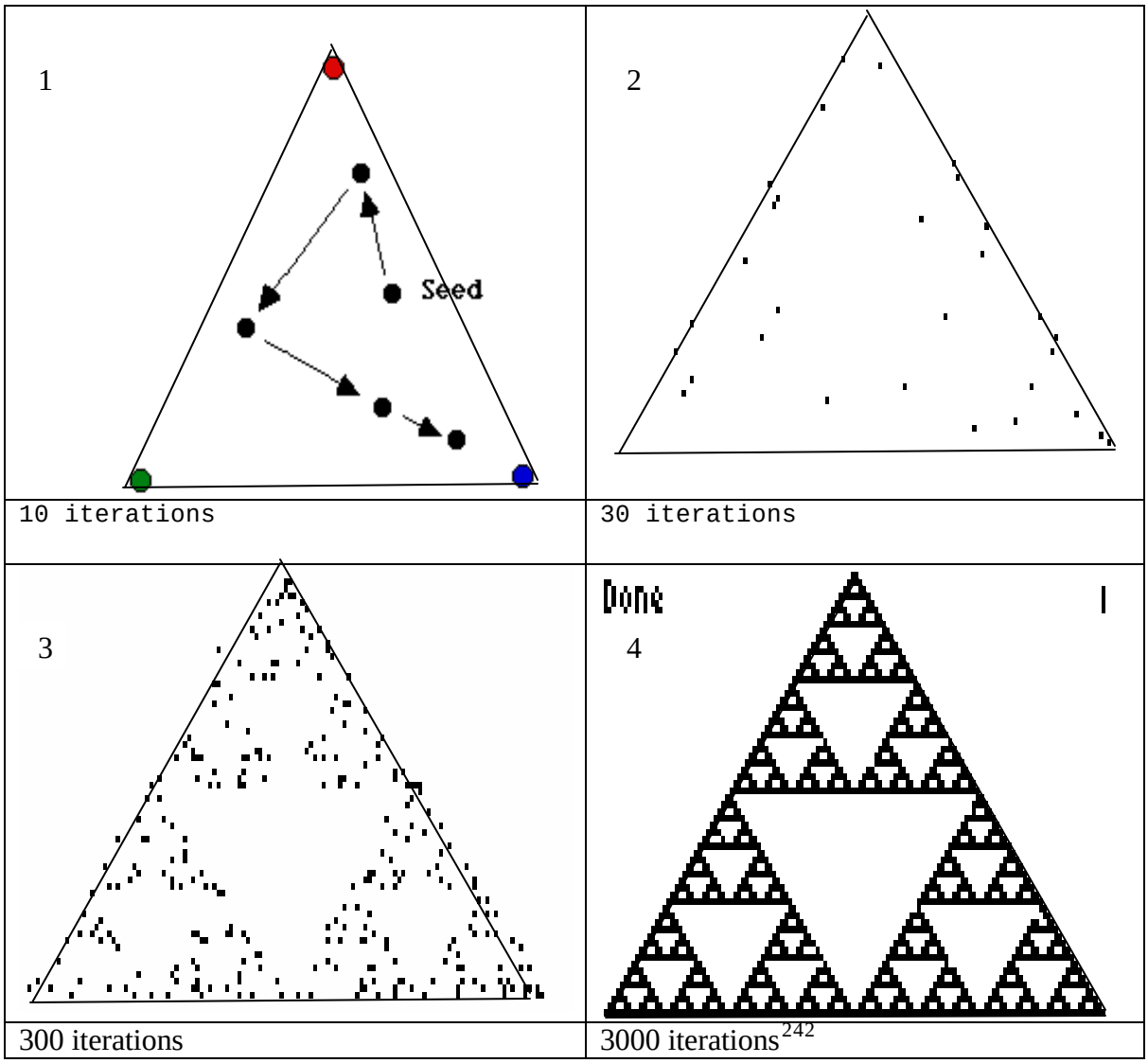
Substance metaphysics is simply going to fail to explain a reversal of logical entropy. The processes of life via a study of the information contained in life forms, iterated information related to *Levy flights* for example, seem to have characteristics of self-similarity and sensitivity to initial conditions. We know that ecological systems have these qualities, and we know that this sort of information certainly can take discrete probabilistic iterations and quickly generate these patterns. This behavior is surprisingly easy to demonstrate. Process-information metaphysics provides a way.

The Chaos Game

The chaos game, like most approaches to chaos theory, starts simply enough. Take out a pencil and your ruler. If you don't have one, just reach over to the nearest mathematician, and take his or hers from that pocket protector they are supposed to always have. Start by drawing any triangle and label the three vertices as 1-2, 3-4 and 5-6. Randomly draw a point inside the triangle, a seed value. Roll a normal, six-sided, game die and note the number rolled. Place the ruler so that the edge passes through both the seed value and the vertex labeled by the number rolled. Place a point halfway along this line going from the seed value to the vertex that matches the roll of the die. This is the first iteration. Roll again. This time place a new point halfway from the last point plotted

[241] Ilya Prigogine, *From Being to Becoming* (New York: W.H. Freeman, 1980), p. 123.

and the vertex that matches this second roll. This is the second iteration. Continue the game for a very long time, for a great number of iterations. Below, is an approximation of the game using a programmable calculator.



[242] These images are produced by the author using a TI-86 calculator and TI graph link software. Two programs were used, one in TI Basic and the second was written in Assembler, using Assembler studio. The 'discrete look' is a result of using a machine with relatively very large pixilation. If one had an infinite depth to pixels and let the program run for a very long time it would produce a continuous image. The demonstration of this can be found by taking a very large magnification of any portion of the triangle, say a million, and the same identical image will appear to the same limitations of the pixilation. In other words, by definition, any accuracy wanted can be achieved in the image. Discreteness is only an illusion of limited pixilation ability of the device used to display the image. An alternative algorithm to create the triangle is available at http://ejad.best.vwh.net/java/fractals/sierpinski.shtml.

The Sierpinski Triangle will appear irrespective of the seed value; pattern emerges out of randomness. Certainly, if information is what is operated on in evolution, i.e., information found in DNA and other living structures dependent on it, and if some randomness is mixed with a numerically large iterative process, perhaps illustrated by the notions of chance survival and millions of species and billions of living things, then pattern as a product of this process is understandable, even expected. Evolution is possible and relativity simple to demonstrate if process-information is the basic concept of metaphysics.

Conclusion

Biological or ecological questions are like evolution. For example, in environmental philosophy, problems of complicated environmental systems often will fail to yield results if descriptions are limited to simplistic discrete explanations. Looking at 'things' alone, rather than at relationships and interrelationships, will surely mean that we will fail to understand and, thus, we will fail in environmental philosophy.

CHAPER 6

ENVIRONMENTAL PHILOSOPHY

> No important change in ethics was ever accomplished without an internal change in our intellectual emphasis, loyalties, affections, and convictions. The proof that conservation has not yet touched these foundations of conduct lies in the fact that philosophy and religion have not yet heard of it. [243]

Paradigms Of Ecology

Ecology is not an old science; the term 'oecology' first appeared in 1886 in a paper by the German disciple of Darwin, Ernst Haeckel.[244] The origin of ecology coincided with the end of the period dominated by the Newtonian paradigm, itself governed by substance metaphysics. This coincidence is ironic since revolutionary concepts in physics were rapidly developing a new paradigm. Even though ecology did not lag behind very long, it is not surprising that ecology started with a general focus on objects in the management of the environment and then quickly developed into a study of relationships of processes. The rapid progression has resulted in a duality in ecological thinking: ecological science based on dynamic processes and justification of ethics of the environment dependent on issues of balance, stability, and integrity, concepts from traditional substance metaphysics.

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[243] Aldo Leopold, "The Land Ethic," in *A Sand County Almanac: With Essays on Conservation From Round River* (New York: Ballantine Books, 1966), p. 246.
[244] David Worster, *Nature's Economy: A History of Ecological Ideas*, 2nd ed. (New York: Cambridge University Press, 1997), p. 192.

More evidence of duality in the structure of ecology is at hand. There is a metaphysics that wants to handle objects or things in the environment, sere, climax or ecosystem. Conversely, there is an understanding of nature as a study of relationships or dynamic processes. Philosophical justifications based on substance metaphysics are incompatible with process-relational ecology and environmental issues. Process-information philosophy may help over come dualities and paradoxes. In this chapter, I extend process-information philosophy to bridge the gap between the environment and metaphysics, bringing the environment back into philosophy. In addition, support for the dynamism of Leopold's vision is offered.

In *Nature's Economy: A History of Ecological Ideas*,[245] David Worster considers the three major paradigms that he believes ecology has followed from the eighteenth through late nineteenth century: the Arcadian, the Imperial, and the Darwinian.[246] The Arcadian or naturalist paradigm of ecology, represented by Worster using the words of Henry David Thoreau (nineteenth century quasi romantic), is one in which "the world was no mere system of mechanical order but a flux of energy capable of welding all things into an animated kosmos."[247] Thus, the first paradigm started as a rejection of the mechanical model of Descartes and Newton. The Imperial paradigm, however, regressed toward mechanical models and developed an ecology of individuals. This viewpoint progressed into an ecology of community and/or organism, concepts more in tune with substance metaphysics. Although Imperial ecologists were either reductive (individualistic) or holistic (ecosystems), they were nevertheless focused on entities.

[245] Worster, *Nature's Economy*.
[246] Ibid., p. xii.
[247] Ibid., p. 81.

Early theory was conceived mostly in Newtonian terms, individuals rather than relationships. In addition, since this theory attended to the question of what created the individual entities and how they fit within the scheme of other separate entities rather than with interrelational issues, it relies mostly on substance metaphysics. In the last few decades, Darwinism shifted towards process and demarcation of atomic individuals became blurred.

In the early twentieth century, ecology became increasingly reliant on the notion of process. For example, in the 1910s Frederic Clement brought out the idea of succession,[248] "a processional change." In 1927 we have Charles Elton's food pyramids,[249] in 1970 Likens et al.'s nutrient budgets,[250] and finally White and Picket's disturbance regimes and patch dynamics in 1985.[251] The concepts of ecosystem and organism are also related to process relational thinking. As ecological theories change and paradigms shift, successive movement towards a process-relational position is evident. Ecologists today most often think of the environment in terms of a "shifting mosaic,"[252] a "non-equilibrium paradigm [that] emphasizes process,"[253] or simply as a dynamic process. "We define the parts and explanatory principles of ecosystem as

[248] Frederic E. Clements, "Nature and Structure of the Climax," *The Journal of Ecology* 24 (1936):252-84 in *Foundations of Ecology: Classic Papers with Commentaries*, ed. by L.A. Real and J.H. Brown (Chicago: University of Chicago Press, 1991), pp. 59-97.
[249] Charles S. Elton, *Animal Ecology* (Chicago, Ill., Chicago University Press, 2001). This is a reprint of the original publication by Methuen Publishers in 1927.
[250] Gene E. Likens, F. Herbert Borman, Noye M. Johnson, D.W. Fisher, and Robert S. Pierce, "Effects of Forest Cutting and Herbicide Treatment on Nutrient Budgets in the Hubbard Brook Watershed-Ecosystem," *Ecological Monographs* 40 (1970): 23-47, in *Foundations of Ecology: Classic Papers with Commentaries*, edited by L.A. Real and J.H. Brown (Chicago: University of Chicago Press, 1991), pp. 880-904.
[251] P.S. White and S.T.A. Pickett, *The Ecology of Natural Disturbance and Patch Dynamics* (San Diego: Academic Press, 1985), pp. 5-6.
[252] Ibid., pp. 65-89.
[253] Ibid.

pathways of processes and fluxes between organisms and their environment."[254] Environmental management does not seem to have followed this development.

The early focus of environmental management was on objects. The Clementian successions or Eltonian food pyramids, especially as they apply to populations, are about processes relating directly to objects. In addition, management was characteristically population studies of individuals and strongly emulated physics. The physics envy gleamed in the theories, and eyes, of ecologists, and corresponded to the over-mathematization of ecology and the adoption of a dualistic view: process with substances. Add to this the fact that traditional philosophical training is in substance metaphysics, not process metaphysics. Thus, today, environmental philosophers tend to think in terms of substance metaphysics while ecologists tend think in terms of process-relational thought. What, then, is good for the environment?

In a *Sand County Almanac*, Aldo Leopold (1887-1948) offers an assessment of what serves as good for the environment.

> A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise.[255]

Further, Leopold tenders this evaluation as a supplemental ethic to be amended to human ethics: meaning that environmental philosophy does not replace human ethics but is a supplement to it. "The land ethic simply enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively: the land."[256] Thus, we might consider the human ethic and the "land ethic" related as one circle within the other.

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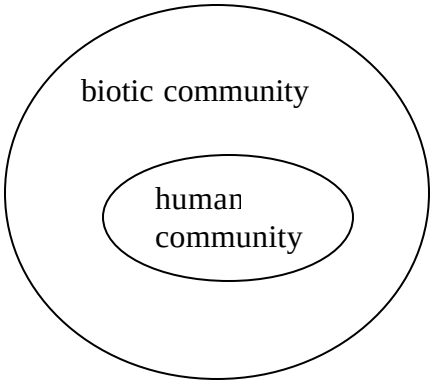
[254] T.F. Allen and T.W. Hoekstra, "The Ecosystem Criterion," in *Toward a Unified Ecology* (New York: Columbia University Press, 1993), p. 90.
[255] Leopold, "Land Ethic," p. 262.
[256] Ibid., p. 239.



If we are to extend human ethics to the land, it requires recognition of both the interrelationship between the human and the biota, along with an idea of scale. Natural can be defined in terms of occurrences in normal scale of space-time. Forest and species tend, for example, to endure in time scales of millennia. Hunting a species to extinction in a relatively short time period is unnatural since it happens at a faster pace than expected in the scale of normal space-time. In fact, this fast pace is what makes much human activity unnatural. "Evolutionary changes, however, are usually slow and local. Man's invention of tools has enabled him to make changes of unprecedented violence, rapidity, and scope."[257] Humans can change the environment at a rapid rate in either space or time, especially compared to nonhuman beings. For example, the extinction of a species can be natural if it occurs within a relatively normal scale of space-time. But, rapid and multiple extinctions occurring in one season cannot be natural.

If ecology is process-relational and not about things at all, then what ever can be meant by an environmental philosophy that holds that human action "is right when it

[257] Ibid., p. 254.

tends to preserve the integrity, stability, and beauty of the biotic community?"[258] We have been led to understand that integrity, stability and beauty are words that seem to apply to things in the biotic community. The fall back position for the justification of an environmental philosophy is what is being supplemented, and this position is an ethic that has evolved from the Western tradition, i.e., substance metaphysics. We have an ecological understanding of the environment that is in conflict with this tradition, an understanding of dynamic processes, hence, the claim of dualism. Moreover, it is the worse kind of dualism, since it justifies an environmental philosophy using a metaphysics that is in conflict with our understanding.

It is no wonder that Michael E. Soulé states that environmentalism (conservation biology) is a "crisis discipline."[259] Although the crisis Soulé is referring to is holocaust extinction and not a crisis in the discipline of metaphysics, I believe the crisis is representative of an overall crisis in the discipline, a crisis that is the result of a mismatch between environmental philosophy and underlying metaphysics.

Leopold makes it clear in "Thinking like a Mountain" that a personal transition had to take place to get him to "see" the environment from a different time scale, in this case that of a mountain.[260] Perhaps transitional crisis is also an endemic conflict between management practitioners and their philosophical beliefs. The way out is perhaps thinking of, for example, a series of forests set in regimes of disturbance, rather than one forest heading toward a Clementsian climax. As suggested by White and Pickett,[261] each

[258] Ibid., p. 262.
[259] Michael E. Soulé, "What Is Conservation Biology: A New Synthetic Discipline Addresses The Dynamics And Problems Of Perturbed Species, Communities, And Ecosystems," *Bioscience* 35, no. 11 (December 1985): 727-34.
[260] Aldo Leopold, "Thinking like a Mountain," *A Sand County Almanac: With Essays on Conservation From Round River* (New York: Balentine Books, 1966), pp. 137-41.
[261] White and Pickett, *Patch Dynamics.*

forest itself is not really a single organismic entity, but a highly dynamic set of individual trees.[262] A basis for a metaphysics should be compatible with ecology and contemporary science.

The ontological question is, "How can we conserve a biota that is dynamic, ever changing, when the very words "conserve" and "preserve" … connote arresting change?"[263] The transition going from thing to substance automatically situates an ontological given of human scale of both time and space: to assume a mesoscale viewpoint is simply to commit the fallacy of division. To say a thing is a substance is to assume an understanding in one single space-time scale only. The alternative conception to single space-time conceptualization, i.e. the idea of a substance over different scales, leads to different ontological priorities and identities.

A table is a thing that seems solid in the mesoscale, but in the microscale it is a multitude of things with parts that are fuzzy. What holds for the table in one scale does not hold for table in another scale. The division of the whole into parts leads to a failure of understanding and ontology if we take substance metaphysics as a starting point. Perhaps the relationship of things can be expanded through scale of space-time. The effect of an alternative foundation can make the difference.

The Star Fish As A Wolf Pack Hunter

I want you to imagine a seascape of star fish meandering on the bottom living their slow and solitary lives along the edge of a living reef. If you track one along the sea floor for an extended period of time, it appears that the star fish just manages to achieve a life of almost passive subsistence at best. We would hardly think of a group of star fish as

[262] Individual trees, but not treated as entities or things as they are separated from the system and have recognizable subparts.
[263] Callicott, "Flux of Nature," p. 100.

a menace. A scientist could study the species for years and be convinced that the star fish lack any resemblance to a wolf pack. Of course, this perception is false.

> Biologist John Pearse has been studying echinoderms along the rugged coast of northern California for forty years. He long believed echinoderms were capable of basic behavior, but he didn't think they were capable of complex social interactions. They don't posses seemingly necessary hardware, like a brain. But after seeing underwater photographer Don Wobber's time-lapse films of sea stars [also called "star fish"], Pearse changed his mind. Wobber's footage showed sea stars wrestling with one another to dominate their food supplies on the ocean floor. These animals were certainly leading active lives.[264]

The time-lapse films of interacting star fish is an incredible vision of what Wobber describes as "wolf pack behavior." The ability of the star fish to communicate, locate prey, and hunt down prey as a pack is obvious once you shift yourself to their time frame.[265] These creatures are so long living that they do not seem to die naturally. The longevity of star fish should be no surprise given what appears to be an existence in a different time scale.[266] I use this example to demonstrate the weakness and fallibility of conclusions about our reality made at a certain limited level of perception; the perception of everyday sized and timed objects in the mesocosm.[267]

"Taking our clue from Holling, we might measure appropriate temporal mesoscales for norms of ecological restoration."[268] Pearse, a lifetime expert, was dead wrong about the basic behavior of star fish because he applied a simplified mesocosmic viewpoint to his early study, i.e., he chose an inappropriate time scale. We see simple benign behavior, but the wolf pack is in full hunt.

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[264] John Pearse and Don Wobber, "Ultimate Animal - Digesting Mussels in the Shell: Documenting Echinoderm Behavior," in *The Shape of Life* (Monterrey, Calif.: Sea Studio Foundation for National Geographic Television and Film Sea Studio, 2002). Series aired on PBS April 2, 2002.
[265] Obvious if you film time lapse at around 24 hours for 24 minutes, or 1 hour to 1 minute.
[266] Consider that many of the extant Galapagos turtles, hundreds of years old, are personal witnesses to the first time humans ever set foot on the islands. If only they could talk.
[267] Pete A.Y. Gunter, personal conversation. Also resembles spatial scales of Callicott.
[268] J. Baird Callicott, "Choosing appropriate temporal and spatial scales for ecological restoration," *Journal of Bioscience* 27, no. 4, Suppl. 2 (July 2002): 409-420, p. 414.

The star fish as a wolf pack highlights what Callicott has identified as the importance of temporal-spatial scale in determination of what constitutes an ecosystem. Callicott calls for a dynamism of Leopold's "land ethic."[269] Process-information metaphysics provides the necessary foundation. We now know that the process-information dynamics of ecology is complex enough to suggest an emergence of order; a worthwhile task of analysis. Since the ecology paradigm shift is toward dynamics, why not make a corresponding shift in ethics? "The land ethic" can be dynamized, without loss of its essential claims.

Value Through Interrelated Scale

The most difficult and most important issue of environmental philosophy is value. What is it that environmentalists value? Gunter points out that "the philosophy which best fits the conceptual needs and the long-term telos of environmentalism is process-relational."[270] And, we have seen how process is important to ecological understanding, as well as the importance of scale. But where is value?

Environmental value can either be intrinsic (innate) or instrumental value (granted). Some organisms can feel, are sentient, and have value such that we ought not cause them pain and harm.[271] Value in this case is intrinsic to these organisms. Valuing trees for the potential wood products or simply the warmth they provide us when burned are examples of instrumental value.

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[269] Callicott, *Flux in nature*, pp. 99-103.
[270] Pete A. Y. Gunter, "Process-Relational Philosophy and Environmentalism A Case of Pre-established Harmony," Open Discussion Paper from the 2001 Conference of *Concrescence: The Australasian Journal of Process Thought* [online cited 1 March 2003], http://www.alfred.north.whitehead.com/AAPT/discussion_papers/2001_Gunter01.pdf; INTERNET.
[271] Mary Anne Warren, "The Rights of the Nonhuman World," in *The Animal Rights/Environmental Ethics Debate: The Environmental Perspective*, ed. Eugene C. Hargrove (Albany, N.Y.: SUNY Press, 1992).

The prehensive quality of relationships extends value to all objects of the world. In this way, the value of a biotic community is intrinsic to us (and also to the biotic community), rather than simply instrumental to us, since we are so closely connected process-information-wise to the biotic community. Beauty can be argued to be intrinsic, since that which is valued, is valued simply for what it is.[272] The necessity of interrelationships extends intrinsic value to all things. By abusing or damaging the biotic community, we are damaging what is part of ourselves, not just what would be effectively worthwhile to us or an instrument to our happiness or survival.[273] I do not mean to ascribe (as does the "deep ecologist") equal value to all species and to all things. A gradation of value is necessary and hard to avoid. Birch[274] and Warren[275] have both suggested that richness of experience and level of sentience should be considered in comparing value and rights between humans and various levels of nonhuman, but sentient beings.

Prehension implies community. A community of values of which humans and nonhumans take part. "Homo sapiens is a part of nature, a plain member and citizen" of the "land community.""[276] "It is easy to show that in the long run sustaining the integrity of these communities [the land community, the swamp, forest, prairie, and farm] is good for man."[277] From the vantage point of process relational philosophy, it is also possible to

[272] Gunter, "Process-Relational Philosophy," pp. 3-4.
[273] Karen J. Warren's Eco-feminism seems to be similar in that we become one with the environment as the climber is move effective when she is one with the rock. I did not have space to expand on this here. See Warren, "The Power and Promise of Ecological Feminism," in *Environmental Ethics: Divergence and Convergence*, 2nd ed., ed. by Richard G. Botzler and Susan J. Armstrong (New York: McGraw-Hill, 1998), pp. 471-480.
[274] Birch, "Environmental Ethics," p. 5.
[275] Warren, "Rights of the Nonhuman World," pp. 91-93.
[276] Callicott, "From the Balance of Nature," p. 101.
[277] Gunter, "Process-Relational Philosophy," sec. 5, par. 4.

show that each of the organisms sustained in natural communities has life, an experience, and a value of its own.

The relationship between process philosophy and chaos theory is clear. Process-information inherits the characteristics of dynamical systems: iterations, complexity, sensitivity to initial conditions, perturbations, self-similarity, and mathematical predictability (stability) including attractors (and basins of attraction).[278] The dynamic aspect of process-information serves as an adequate mathematical model for both ecology and environmental philosophy.

For example, consider the concept of stability. The ecologist's idea of a system's stability can be qualified 0-by the concepts of attractors or basins of attraction. The same concept of stability can be applied to the environmental philosopher's conception of stable biota. Stability to be conserved (or preserved) is the dynamic stability of a biota in a complex but mathematically describable flux. The value of a biotic system can be found both in the stability of the system and, as Rolston suggested, in the information contained in the system. This information is not only the DNA, but, also the process-information relating to interrelationships within the system.

Scale is also important to both the ecologist and the environmental philosopher. The concept of self-similarity is one of scale. Look back at our Sierpinski Triangle. Notice the detail in any third of the triangle. You can find a miniature of the entire triangle within any sub part of the object. This property is referred to as self-similarity over scale. Just as the triangle really has no definition of spatial criteria, neither does an

[278] See Marc Corbeil, *Environmental Ethics and Chaos Theory* [Marc Corbeil papers online cited 11 March 2003], http://www.mcorbeil.com/papers; INTERNET. Basins of attraction are higher dimensional versions of attractors

ecosystem.[279] But, some features absolutely require reference to scale, just like the notion of natural. It is no surprise that scale has been called for as an essential characteristic of ethical theory.[280]

Conclusion

Why should we change our basic assumptions is now clearer. We use our understanding of the world via an ecology of process-information to examine the world, to determine an ethics of the environment. The classical, medieval, modern, and contemporary metaphysics of substance has been shown to be essentially unsuited to the paradigms of twenty-first century science. Process thought has been shown advantageous in solving a number of paradoxes and is potentially a foundation of environmental philosophy. An interesting relationship of process philosophy and mathematics has been demonstrated and should be explored further. For example, for evolution to even be possible, randomness must be a feature of nature's structure, not a feature of the mathematical theory of numbers, not a feature of the search for a halting program but a feature of information. Embracing process thought could be a defining step in the future of philosophy and particularly applied environmental ethics. Ecology and science suggest that characteristic dynamics is needed, and process thought provides an alternative for an environmental philosophy that is both dynamic and elastic.

[279] Callicott, "From the Balance of Nature," p. 101.
[280] Ibid. Also see Callicott, "Choosing Appropriate Scales."

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