MIND IN NATURE

by George A. Riggan

Mind in Nature: Essays on the Interface of Science and Philosophy, edited by John B. Cobb, Jr., and David Ray Griffin (Washington, D.C.: University Press of America, 1978), is a sympsoium of multidisciiplinary essays from a conference sponsored by the Center for Process Studies with support from the Rockefeller Foundation. The avowed purpose of the conference was to consider whether and how process thought, especially Alfred North Whitehead's philosophy of organism, might facilitate nonreductionistic interpretations of biological processes.

The broad subject of the title is made manageable by organizing the symposium in four parts. In part 1, "The Evolution of Mind," the papers treat of the emergence of human self-conscious, purposive action out of a matrix in which, until the rise of quantum physics, Western thought customarily perceived no grounds for that emergence. W. H. Thorpe, L. Charles Birch, and the late Theodosius Dobzhansky are major contributors to this section. They concur that life, human consciousness, and purposive action must have been among the potentialities of the primordial cosmic substratum. Further, they agree that their emergence was subject to the same evolutionary principles operative in the emergence of novel anatomical and physiological characteristics. Dobzhansky differs, however, in that he will not speak of "the seeds of self-consciousness as present in all living creatures—from virus and bacterium upwards" (Thorpe), nor yet of "a germ of subjectivity in atoms before there were brains" (Birch). Dobzhansky insists that evolution consists in the development of novelties "which began to appear at some time and were not at all present earlier." He notes, among other biological illustrations of his point, that "animals evolved quite different kinds of organs of respiration—lungs, gills, tracheae, etc. The ancestral unicellular and primitive multicellular organism respire through the entire body surface. It is gratuitous to ascribe to them proto-lungs, proto-

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[*Zygon*, vol. 16, no. 1 (March 1981).]
 0044-5614/81/1601-0002$01.30

gills, and proto-tracheae." Thus he rejects protopsychism and panpsychism.

Perception of Essential Order

Part 2 of the symposium argues in effect that developments in quantum physics and in evolutionary theory require the transformation of our perception of essential order in the universe. David Bohm proposes the hologram, instead of the usual esoteric mathematical descriptions of order in quantum physics, as an imaginative analogue for better understanding what he terms the "implicate" or "enfolded" order of reality at the microphysical level. The language intends a contrast with an "explicate" or "unfolded" order manifest in the mechanical motion of bodies through space. Precise mathematical descriptions of those macrophysical motions, made possible by René Descartes's invention of coordinates, rest upon the assumption that the world is constituted of points. This world view, dominant in the sciences since the Copernican revolution, is reinforced by the optical lens, which provides a point-for-point correspondence between an object and its image on a photographic plate.

Quantum physics, Bohm points out, confronts us with a universe comprising quanta of mass energy behaving indeed somewhat like particles moving through space, although the order implicit in the particle model is not applicable to the behavior of these quanta, and behaving as fields of energy, although the order implicit in the continuous field model is not applicable either. He presents the hologram rather than the lens as the key to the order of this deep level.

In producing a hologram, that half of a split laser beam which is reflected back upon the object produces interference patterns in the light striking the photographic plate. If later a section of the developed plate is illuminated by a laser beam, light waves emerging through the seemingly random patterns on the film will be similar to those coming from the object as it was photographed. To an eye intercepting those waves, the original object appears to be seen three-dimensionally, as if through a pinhole. Bohm stresses not that the image is three dimensional but that in some sense the image of the whole object is enfolded in each section or part of the hologram.

Bohm infers from developments in quantum physics that at the microphysical level the universe may be seen as a single holomovement, analogous to the holomovement of light in the production of a hologram. He concludes that we ourselves, our bodies with their brains and nervous systems, along with electrons, protons, rocks, planets, galaxies, etc., are but relatively stable forms in the universal process. On the assumption that our thoughts, feelings, urges, will, and desires are inseparable from the functions of our brains and

nervous systems, he further concludes that what is generally called "mind," along with all matter, is grounded in the implicate order of the cosmic holomovement. Thus he sees the explicate order charted along Cartesian coordinates not as invalidated but as an abstraction from the implicate order—a special case, "having no independence or substantiality of existence." An impressive argument! But does he mean that every distinct entity from atom to galaxy, from paramecium to man, is equally a holograph of the cosmos? And what does he make of the sequential appearance of the relatively stable entitites that constitute the cosmic holomovement in the successive phases of its evolution?

Francis Zucker advances three counterstrategies to reductionism in the sciences. His strategies are directed against ontological reductions, which he defines, following H. Jonas, as the position that the universe "consists of the basic entities disclosed by physics, which are, in their diverse arrangements, all there 'really is' in the world—all else, including the subject himself and his perceptions, being reduced to the derivative status of 'epiphenomena.'"

Zucker's first strategy is to employ the enterprise of physics itself to repudiate what he perceives as the misplaced ontological unity of physical reductionism. He suggests, following C. F. von Weizaecker, "that the axioms of unitary physics are precisely the formal expression of the preconditions of [scientifically verifiable] experience, hence that the subject as knower is an integral factor in the science of physics." He concludes therefore that if matter is what obeys the laws of the enterprise, matter becomes an aspect of all that exists in the universe. He argues in other words that matter is not juxtaposed to life and mind but "is a *mode* of experiencing both."

Bohm's position can sustain the inference that brain states and mental states are aspects of a single indivisible process, which in turn is a lately manifest and relatively stable form in an all-inclusive cosmic flux. Zucker's first strategy, by contrast, leads to the inference that mountains, oceans, and galaxies are precisely aspects of life and mind. This inference is incompatible with his earlier argument that scientific analysis leads to truth the objective correlates of which can be no mere "thought economies" (Ernst Mach) or "tools for manipulating nature" (instrumentalism) but which in some sense must be "real." Zucker has made a case for no more than this, namely, that the experiences of mountains and galaxies are aspects of life and mind. He ignores the crucial question whether the scientific enterprise, lately manifest in evolutionary time, is implicit in every phase of the cosmic process.

Zucker's second strategy for countering reductionism and reconstructing an ontology of nature proposes that interested scientists "cultivate the simples specifically appropriate to their respective dis-

ciplines." By way of illustration he compares two sets of color simples in color theory—one set being the spectral colors that Isaac Newton discovered by decomposing a beam of sunlight through a prism, and the other, entirely different set being the so-called edge colors that Johann Wolfgang von Goethe discovered by a contrasted use of the prism. The Newtonian color simples cannot be resolved further into constituent hues by passage through another prism; they stand in a one-to-one correspondence with a specific angle of refraction; and each corresponds one-to-one to a wavelength. Hence they are subject to invariant quantification. All other colors correspond to a set of possible color distributions. This would seem to imply that Goethe's edge colors are derivative, not primary as he claimed. Zucker reports experiments demonstrating that the Newtonian spectral colors can be obtained through the series combination of complementary pairs of edge colors, thus showing that they are in fact compound in terms of Goethe's simples. However, since conversely the edge colors can be resolved into Newtonian spectra, Zucker concludes that there is no reason, other than ontological prejudice, for calling one set of color simples more fundamental than the other. He next gives a mathematical demonstration that in color theory the metric of physical space is a special case of a projective measure that is descriptive not of phenomena in an independently existing physical space but of phenomena in a space of sense experience. On this showing, the mind cannot know a physical universe of which it is not an integral constituent.

Zucker's third strategy against reductionism in the sciences is the pursuit of developments arising out of quantum mechanics pointing to the possibility of a direct mathematical description of the growth and of the metamorphosis of forms in space and time. In this connection he mentions again the greatly enriched projective geometry of Bohm's paradigm, the Hilbert space implicate order. He also calls attention to the work of R. Thom in theoretical biology as a more immediate step toward a mathematics that eventually may bridge understanding of the micro- and macrorealms.

Milic Capek's contribution is an essay in the history of ideas as to the character and interrelationships of temporal and spatial orders. Its function in part 2 is to challenge post-Einsteinian interpretations that portray the mind's experience of temporal succession and/or becoming as epiphenomenal.

Capek reminds us that when the astronomical revolution of the sixteenth century challenged the view that the rotation of the sphere of the fixed stars accurately measured the objective flow of time, philosophers and physicists of the period perceived only two ways of reconstructing the concept of time. Either retain the relation of time

to physical movements through space, and hold with Giordano Bruno that "there are as many times as there are stars," or dissociate time from physical motion altogether. Newton chose the latter alternative, holding that time is a uniformly flowing metaphysical stream invisibly measured by the mind of God. Pierre Simon Laplace held to a determinism in which time is but the fourth dimension of space, as static as the other three dimensions, its incompleteness illusory, being for him, as Henri Bergson noted, merely "the infirmity of a mind that cannot know everything at once."

Early on, Hermann Minkowski's four-dimensional continuum, derived from the theory of relativity, was sometimes perceived not as a dynamic four-dimensional process, essentially incomplete, but rather as what Capek calls a sort of hyperspace, in which the temporal dimension exists already fully completed. Capek points out that this misinterpretation of Minkowski's work has been effectively criticized both by eminent philosophers, Whitehead among others he names, and by numerous physicists, including Albert Einstein and Arthur S. Eddington. Yet he notes that this misconception of Minkowski's space-time continuum recently was revived by Costa de Beauregard, Adolf Gruenbaum, and J. J. Smart and apparently accepted by W. Quine. Having already demonstrated the absurd consequences of the tendency, prevalent in pre-Einsteinian Western thought, to spatialize temporal relations, he then addresses this post-Einsteinian revival of the beguiling misconception.

This modern argument for a static interpretation of space-time, according to Capek, usually runs as follows: "If there is no objective *Now* unambiguously separating past from future throughout the universe, if in other words what is simultaneous in one frame of reference is not so in another, is it still meaningful to uphold the objectivity of succession and the reality of becoming?" Against Quine, Capek answers, yes! Thus he affirms a central assumption in process thought. He points out that the relativization of simultaneity and succession pertains only to events in different places. Since, however, no two events occupy precisely the same space, this means that every event is metrically simultaneous only with itself. This conclusion is far from trivial, Capek argues, for since in a relativistic universe no body can move faster than the speed of light, the simultaneity of every isotopic event with itself, and only with itself, effectively rules out a Wellsian trip into one's past and a return to one's present.

The theory of relativity excludes the concept of simultaneous events coexisting in an instantaneous cross section of points in three-dimensional space; but it does not exclude Newton's concept of time as incomplete, Capek argues, and neither does it weaken the objective status of becoming. He holds that it can be rigorously proved, on the

basis of Minkowski's formula, that no event which is still in my causal future can be included in the causal past of any possible observer, in any frame of reference whatsoever. Since such future events are intrinsically unobservable, he holds that it is entirely superfluous to postulate their existence.

Relativity and quantum theories challenge the tendency to hypostasize points, either in space or in time. Hence Capek argues that auditory models serve better than visual models and geometric diagrams to convey the dynamic reality of space-time: "The fact that a melody does not exist at an instant does not make it unreal; on the contrary it shows the fictitious character of durationless instants." The impossibility of instantaneous cuts through points in space is entirely compatible with the cobecoming of innumerable, spatially discrete series of events or "world lines," according to Capek. He compares the mix of contemporary world lines to the different melodies existing contemporaneously within the sounding interval of a polyphonic pattern.

Finally Capek turns to the unresolved epistemological difficulties arising from Gruenbaum's view that although becoming and succession cannot be denied, they belong to the purely subjective realm. Capek responds: To suppose that what I experience as a new present event existed prior to and independently of my deceptive temporal experience tenselessly (i.e., timelessly) in the becomingless physical world is to propose a dualism more extreme than that of Descartes, for in Cartesian dualism, mind and matter shared a general temporal character despite their heterogeneity. Indeed, he adds, the physicalist leanings of Smart, Quine, and Gruenbaum would seem to render even the subjective experience of succession absurd, "for if the subjective realm itself is part of the becomingless physical reality, we should not have even the *illusion* of becoming." Hence Capek concludes: "Briefly, the static interpretation of physical reality is nothing but a relapse into a strange Eleatic myth with all its oddities and contradictions, not only completely divorced from our immediate experience, but incompatible with contemporary physical science properly interpreted."

Under the title "Free-will in a Hierarchic Context," Arthur Koestler portrays nature, the context within which mind appears, as a multileveled hierarchy of dynamically stable, semiautonomous subsystems, "holons," which display the quasi-autonomous properties of wholes and the dependent properties of parts in relation to more inclusive systems. He advances this hierarchic model with a twofold intention. On the one hand it replaces the panpsychist's continuously ascending curve from protoplasmic (indeed from microphysical) mentality to human mentality by a series of discrete steps, each higher

stratum of which involves a distinctively more complex organization of behavior. On the other hand it replaces the single Cartesian discontinuity by a series of transitions, none of which is absolute.

At the human level in this model the categorical distinction between mental and bodily behavior gives way to a hierarchy of holons ranging from "mechanical" to "mindful" behavior. Human consciousness is described negatively "as that special attribute of an activity *which decreases in direct proportion to habit formation*." In crises, or in unexpected situations for which habits have not been formed, control is switched from semiautomatic to a higher level of more conscious performance. According to Koestler, "it would seem that this sudden transfer of control of behavior from a lower to a higher level of the hierarchy—analogous to a quantum jump—is the essence of conscious decision-making and of the subjective experience of free will."

By explicitly rejecting Andrew Cochran's view that the quantum-mechanical wave properties of electrons reflect a rudimentary consciousness of matter, Koestler takes a position closer to that of Dobzhansky than most of the contributors to this symposium.

In response to Koestler's paper, Bernhard Rensch approves Koestler's hierarchical model, but he argues that even voluntary thinking can be regarded as a determined process. These opposed understandings of freedom and determinism would seem to arise from a difference in point of view. In any case, within the context of this symposium Rensch's rejoinder calls for further discussion of the meaning of free will in relation to the interchanges between genetic endowment and past environments as they affect internalized goals and behavioral responses in situations calling for decision.

Primacy of Mind

Two biologists, Rensch and Sewall Wright, and one philosopher, Charles Hartshorne, contribute the substantive papers in part 3, the capstone of the symposium. The editors have entitled this section "The Primacy of Mind," and one of them, Griffin, concludes it by summarizing the agreements and differences among the three contributors as well as between them and Whitehead. The primacy of mind in nature intended in the title is first of all epistemic. All agree that subjective knowledge of each of his/her own experience is primary and that all scientific knowledge by comparison is derivative and inferential. But in each of the papers the epistemic primacy attributed to mind in nature tends to become also ontologic primacy. Here the arguments are for me less than fully convincing.

Rensch argues for what he calls "panpsychistic identism," which means, first, that psychological states (including sensation, emotions, memory, consciousness, etc.) and physiological states are identical. He

cites eight grounds to support the hypothesis of this identification. Among the more forceful ones is that the formation of long-term memory traces, based on structural changes which (unlike short-term memory) cannot be extinguished by electric shock, can be prevented by the injection of compounds which inhibit the formation of proteins.

Second, panpsychistic identism means, according to Rensch, that every individual entity, including microphysical particles, as opposed to mere aggregates of such entities, is either protopsychic or psychic in nature, for, despite the claimed identity of physiological and psychological processes, Rensch cannot conceive of mind as having evolved from nonmental mass energy. Given protopsychic atoms, however, he finds no difficulty in conceiving of an evolving series of ever more complex systems in which psychic characteristics finally attain the level of the full-blown human mind. He explains the vast difference between the protopsychism of an atom and human psychological characteristics by the analogy of atoms becoming molecules with "absolutely new chemical and physical characteristics arising out of new systemic relations." He instances the combination of sodium, a light metal, and chlorine, a gas, giving rise to salt, with characteristics totally different from those of its component atoms. The logic of his argument suggests absurdly that sodium and chlorine (as also the stellar hydrogen from which through many steps they have evolved) cannot produce common salt if they are not already protosaline in character. The net result of his argument in reference to the evolutionary origins of mind is a covert dualism of mind and body, despite his first premise that physiological processes and psychological processes are identical.

The statement of that first premise itself requires reformulation to fit the evidence adduced by Rensch in its support. The evidence and even more strongly the pioneering studies of the brain by R. W. Sperry, Michael Gazzaniga, and José M. R. Delgado, curiously neglected in this symposium on mind in nature, suggest the hypothesis that our knowledge of physiological states of the human nervous system and our knowledge of our respective mental states reflect two aspects of a single underlying process. Although a single process can be hypothecated, its physiological and psychological aspects are surely by no means identical. Neither, as Dobzhansky notes earlier in the symposium, is it necessary to resort to the hypothesis of microphysical protopsychism to account for the evolutionary origins of mind.

In an article on panpsychism and science, Wright (adverting to information concerning the origin of nucleotides and amino acids and their possible polymerization into nucleic acid and protein, respectively, under certain conditions of a lifeless earth) proposes that the origin of living organisms from lifeless matter is a reasonable

hypothesis. Despite this tentative concession to prevalent scientific opinion, he labels as a resort to sheer magic the hypothesis that mind arose from no mind at all: ". . . mind must already have been there when life arose and indeed must be a universal aspect of existence—still assuming that mind cannot arise from nothing."

Wright adopts a monistic panpsychism, "according to which mind and matter are merely two aspects of the *same* reality: as it *is* to itself and as it *seems* to other minds with which it interacts" (italics added). The stark implication of this position is spelled out in Hartshorne's words in the next article: "The greatest geneticist I have known (Sewall Wright) believes with me that there is nothing in all nature except mind on various levels."

Both men make the tacit and unexamined assumption that knowledge constitutes reality. For Wright there are two kinds of knowledge. Primary knowledge is the internal, private, subjective stream of consciousness, with its awareness of choice. Derivative knowledge reflects the external behavior of minds other than one's own. Science, a special case of secondary knowledge, "is restricted to [publicly] verifiable knowledge and thus must exclude the knowledge of our streams of consciousness, because it is unverifiable by anyone else. We must [as scientists] continue to accept a *rigorous determinism* as far as possible, and supplement this by probability distributions where necessary, even though we interpret the determinism philosophically as the *external aspect of choices throughout the hierarchy of existence* and make use of this philosophical interpretation in choosing topics for research" (italics added). Wright summarizes in this brief statement his own understanding of process thought and its proper relation to the scientific enterprise. He seeks to resolve these seemingly contradictory aspects of choice and determinism by reference to numerous switch or trigger mechanisms, briefly illustrated. He concedes that the use by scientists of some subjective terms may be warranted in describing the behavior of humans and perhaps of higher animals to obviate ponderous circumlocutions. He holds, however, that such terms should be avoided in attempting the most precise scientific formulations.

In "Physics and Psychics: The Place of Mind in Nature" Hartshorne takes as the criteria of mind, or of the psychic, activity, individual unity, initiative, and purpose—in extended meanings of those terms. He finds evidence of mind everywhere in nature, from microphysical entities to human beings—excluding only mere aggregates of individuals such as chairs or rocks. He argues, against Dobzhansky, that mind is the most general form of reality. He concedes that animal mind and human mind in particular are indeed special forms of reality: "But as the psychialist uses the words, mind, or the psychical, is an infinite variable, coextensive in range with 'active singulars,'" and what is not an active singular he takes to be an aggregate of singulars

or else an abstraction therefrom. To the objection that such an extension of the term "mind" invalidates the concept by removing all contrast, he replies, following Gottfried Wilhelm Leibniz, that two contrasts remain: "That between active singulars and groups of these, only the former of which literally feel; and that between low and high levels or degrees of feeling, or minding."

As does Wright, Hartshorne regards mind or the psychical as the fundamental reality and holds that the physical is the psychical viewed from without as behavior: "But *mind is the substance*, and mere behavior, in the sense of spatio-termporal change, is the shadow, the skeletal outline only, the causal geometry of nature."

Whitehead's Philosophy of Organism

Papers in part 4 of the symposium, "Mind and Organism," with one exception deal with Whitehead's thought and its implications for a philosophy of the sciences. The exception is C. H. Waddington's discussion of the influence of Whitehead's philosophy upon his own work as a biologist.

In the first of these concluding essays Ivor Leclerc treats of the transformations of seventeenth-century conceptions of matter and mind consequent upon developments in microphysics, with particular reference to those transformations wrought in Whitehead's philosophical system.

In the second essay Ann Plamondon sketches the outlines of a philosophy of science based specifically upon Whitehead's understanding of process. She sets forth her proposal in contrast with the tenets of logical empiricism, in the tradition of positivism, and with those of historical relativism, of which she takes Thomas S. Kuhn's position as the radical example. Fundamental to her project are two Whiteheadian concepts, namely, organism and environment. She shows that by organism Whitehead intends not only biological entities but microphysical entities as well and that by environment he intends not the whole universe but that portion of it with which a particular entity has a significant systemic interrelationship. On this foundation she builds a case for a Whiteheadian process view of the logic of law, induction, explanation, and conceptual change.

In her discussion of four criteria frequently adduced to differentiate invariant correlations (laws) from accidental correlations, Plamondon concludes that from a process view (1) laws are conceived as statements of dominant orders of particular environments; (2) since particular environments are bounded by other environments having different dominant orders, laws are restricted and not universal; (3) the disorder characteristic of every environment renders laws essentially statistical; (4) since environments change through time,

laws are capable of evolving, and hence they are not grounded in logical necessity.

Parenthetically, I wonder how in view of her discussion Plamondon would respond to the proposal that the operation of natural selection might be stated as a universal law: All mutant organisms (microphysical or biological) are selected for survival by reciprocal interchanges with their respective evolving environments.

My tentative proposal raises of course two problems concerning induction to which Plamondon turns next: the much disputed role of induction in theory formation and the dilemma perceived by formalist philosophers in any attempt to validate a philosophical principle of induction. According to the argument, empirical justification of the principle confronts the infinite regress of possible invalidation by the next case. A metaphysical validation based on a priori categories on the other hand involves triviality or circularity. On formalist views, reasonably accurate prediction does not resolve the theoretical dilemma; rather such prediction pragmatically by-passes theoretical concerns.

Plamondon takes seriously the theoretical dilemma as to the possibility of a philosophical validation of induction. She grants also that Whitehead's metaphysical flights from experience suggest circularity rather than resolution of the dilemma. I infer, however, that she regards Whitehead's metaphysical categories of organism and environment as extrapolations from solid scientific evidence, whatever their basis also in the structure of the knowing mind. Indeed she argues that the process view can resolve the "new riddle of induction" on the basis of Whitehead's statement: "Thus the basis of all probability and induction is the fact of analogy between an environment presupposed and an environment directly experienced" (*Process and Reality* [New York: Macmillan Co., 1929], p. 314).

Following a reconsideration of the internal relationships between organism and environment, Plamondon argues that a positive analogy between organisms of two different environments provides both a warrant for an inference as to analogy between the dominant orders of the two environments and a context for inferring predictions as to the behavior of organisms, in the environment to which reference has been shifted, other than those explicitly considered in the original analogy. Thus she rejects the temptation to justify inference as such—inference in general as to the behavior of unspecified entities in unspecified environments. Rather she outlines and schematizes a procedure for making inductive inferences about a specified organism-environment complex exhibiting positive analogy with another such complex better known. She holds that this procedure demonstrably explicates not only the role of induction in prediction

but also a role for induction in theory formation. It appears therefore that she seeks to include pragmatic considerations in her philosophical justification of a particular class of inductive processes.

Plamondon rejects the formalist account of explanation because on that view (1) the explanans must contain at least one universal law, the existence of which is denied on her understanding of the process view, and (2) the explanandum must be deductively derivable from the explanans. She proposes instead a metaphorical view according to which explanation consists in a metaphorical redescription of the explanandum on the basis of positive analogy with the explanans. Thus, if I understand her, the essence of explanation for her is not deduction but a "synoptic vision" gained by abstracting generic categories from a particular complex of fact or laws on the basis of positive analogies with other, better-known complexes. She defines a theory as essentially an abstraction of analogies between systems: "Theories in science abstract analogies between more special systems; metaphysical theories abstract analogies between more general systems, e.g., the sciences themselves."

Plamondon advances a process view of conceptual change in sharp contrast with the view of selected formalist philosophers. According to her account formalists hold that observational language is prior to and independent of theoretical language and that the terms of observational language are invariant in their meaning. Thus they regard conceptual change as restricted to theoretical language and interpret an earlier theory to be deducible as a particular case within its successor theory. They hold that the meanings of observational terms in both theories remain constant, or else the deduction of the earlier theory from the latter cannot be performed.

In the contrasting process view precise meaning is environmentally dependent and varies with changes in the relevant environment. It follows that the meaning of observational terms becomes dependent on theoretical meaning. Thus on Plamondon's view scientific theories constitute a specialized environment within which concepts relative to data derived from controlled observation take their meaning. Taking as demonstrated that explanatory categories in science are to be conceived as metaphors, Plamondon argues, as I understand her, that in successive modifications of theory the metaphorical concepts based upon observed analogies are stretched yet maintain an essential continuity because derived from the same observed order. This argument would seem to hold for ordinary developments in scientific theory.

It strikes me, however, that Plamondon too hastily dismisses Kuhn's argument that revolutionary conceptual changes have occurred from time to time in the history of the sciences. After all, the order per-

ceived by scientists and the order they observe are by no means identical. Occasionally the familiar gestalt apparent to synoptic vision suddenly disappears. A strangely novel configuration confronts us in the same complex, and the perceived characteristics of its components undergo radical change. (In the case of sense experience, recall the sketch, in profile, of the ancient crone in textbooks of gestalt psychology. [See the illustration in Holmes Rolston III's "Methods in Scientific and Religious Inquiry," in this issue.] In a gestalt switch her face dissolves; her eye becomes an ear; her nose the cheek, chin, and jaw; her mouth the necklace upon the throat of a young woman of fashion. The same lines and blots of ink on white paper are thus perceived in radically different ways.)

To take a similar example from the realm of ideas, consider the concept of the atom in two contrasting gestalts. In the first gestalt, physical and biological species appear to be fixed forever. In the second, species appear to be subject to mutation consequent upon changes in their environments. Irrespective of what the actual atom may be, the term in the first gestalt denotes what appears to be an indivisible, irreducible, indestructible constituent of all physical objects, having external relations only with other such constituents, acted upon but initiating no action. In the gestalt of quantum physics the term "atom" denotes what appears to have both internal and external relations and to be capable both of fission and fusion, with a consequent loss of mass and a release of energy in proportions stated in Einstein's equation. This gestalt switch requires a succession of subsidiary changes as to the conceived nature of the atom and necessitates the development of quite novel technologies and tools for handling the actual atom. There is in this and similar cases some conceptual continuity, but discontinuity is the more striking. If Plamondon deems the discontinuities just discussed to be less than revolutionary, her difference with Kuhn would seem to be at least in part semantic.

Griffin presents, as the third paper in part 4, "Whitehead's Philosophy and Some General Notions of Physics and Biology," the most adequate, the most lucid introduction in short compass to Whitehead's thought from the perspective of his interest in the sciences known to me. (A summary of it that would be useful to those unfamiliar with Whitehead's thought would extend this review unduly.)

One of the central concepts in Whitehead's metaphysical system, the actual entity (= actual occasion), calls for attention even in so brief a reference to Griffin's article. According to Whitehead actual entities are "the final real things of which the world is made up. There is no going behind them to find anything more real" (*Process and Reality*, pp. 27, 29). As inferred objects of human experience they are the

"more ultimate entities dimly discerned in the behavior of quanta of energy" (ibid., p. 139). As inferred subjects actively participant in events they "are drops of experience, complex and interdependent" (ibid., p. 28). Whitehead acknowledges that in the interest of brief statement he often applies the term "actual entity," or "actual occasion," to what in more careful usage should be called a society of actual entities, defined as a nexus of organically interrelated and systemically unified actual entities in the precise meaning of the term (ibid., pp.140-41). Thus on occasion he can speak of an electron, a proton, a living cell, a worm, a jellyfish, an insect, a human being, even God, as an actual entity, meaning rather a society of actual entities.

Every individual actual entity, according to Whitehead, originates and perishes within an infinitesimal time span, receiving its content selectively from actual entities perishing in its vicinity at the moment of its origin and yielding its content to other actual occasions originating at the moment of its perishing. Curiously he assumes that an individual actual entity never moves through spaces (ibid., pp. 113, 119, 124). Societies of actual entities at both the microphysical and macrophysical level—likewise random aggregates of such societies as rocks, liquids, and gases—are capable of spatial movement, but actual entities as such, never. He perceives a molecule (or photon), for example, not as an actual occasion but as a "historic route of temporal succession of interrelated occasions, propagated through successively overlapping spaces" (ibid., pp. 113-14, 124). The wave particulate entities of quantum physics, by contrast, do move through space, and many of them exhibit extended duration through time. Moreover, the one universal in the relativistic Einsteinian universe, the speed of light, is irrelevant to Whitehead's conception of the actual entity—the basic constitutent of his metaphysics. His system might be more compatible with developments in quantum physics had he at least tentatively adopted the photon as one manifestation of the ultimate metaphysical entity. As it is, his notion of an unmoving actual occasion, inferred as dimly perceived in the behavior of a quantum of energy, is somewhat tainted by what he himself calls the fallacy of misplaced conreteness, that is, the reification of a conceptual abstraction.

However, if once we grant to Whitehead's actual occasion the attribute of movement through space and possible, if limited, endurance through time, the metaphorical attributes he ascribes to every actual occasion then begin to make sense in terms of the observed behaviors upon which quantum physics is based. He speaks of the subjective aim of the actual occasion—an inference, I take it, from the principle of uncertainty. He attributes to each actual occasion both a mental and a

physical pole. The metaphors of subjectivity and mentation call to mind the behavior of a population of photons admitted singly, or in very small numbers, into an interferometer. The trajectories of the whole population within the interferometer and the eventual distribution of the photons as they collapse on the photosensitive screen are statistically predictable. But the trajectory of the individual photon and its target area are unpredictable. To continue the metaphor of subjectivity, each individual photon can be shown to behave as if it existed in a multiplicity of trajectories along one of which it moves unpredictably, as if by its own decision.

Another attribute of the Whiteheadian actual occasion is appetition. When I questioned a physicist about this metaphorical attribution, he smiled and replied, "You could say that the hydrogen atom has a voracious appetite for most anything in its vicinity." Consider as another illustration the encounter of a photon with a molecule of amine in a living green leaf, an encounter in which both the photon and the amine molecule cease to exist as such and are transformed into a molecule of thiamine—a new creation, an instance of photosynthesis, the general process that provides the several kinds of building blocks for the construction of almost all living organisms. An analysis of that encounter and consequent transformation can exemplify the Whiteheadian meaning of process, perishing, and becoming. Further, such an analysis can illustrate the derivation from quantum physics of such Whiteheadian metaphors as prehension, physical and conceptual data, adversion, aversion, emotion, valuation, purpose, eternal object, etc., as applied by Whitehead to the functions of actual entities. Unhappily such an analysis is beyond the scope of this review.

Whitehead keeps us mindful, however, that these concepts, derived from the most complex experiences of human beings, are metaphors stretched to signify crudely analogous functions of infinitely simpler systems "dimly discerned in the behavior of quanta of energy." His use of analogy conveys his conviction that the riches of human aesthetic, intellectual, moral, and interpersonal experience are thoroughly indigenous to actual developments in the course of cosmic evolution, his confidence that mind and nature are integrally related processes. Unlike his former colleague Bertrand Russell, he does not view human life as a bit of flotsam cast up on an ocean of sterile matter. Finally the metaphors of Whitehead's metaphysical poetry express the hope that human beings can achieve a heritage of mind and spirit that will be immortalized in the processes of creative evolution long after our species may have perished.

I find nothing in Whitehead's work that challenges the view, expressed in Dobzhansky's essay and held by a majority of evolutionary theorists, that, despite crude analogies between early and more re-

cently evolved systems, evolution consists in the development of novelties "which began to appear at some time and were not at all present earlier." It is startling therefore to discover that in a few of the essays, one or two of them by scientists, the analogies of mind in nature at the microphysical and microbiological level are treated as homologies, and the subtleties of Whiteheadian metaphors are overwhelmed by literalistic interpretation. Taken as a whole, however, this symposium is a fascinating and most welcome challenge to the view that mind characterizes mankind alone and that by virtue of possessing it our species is set over against nature to exploit it with impunity as may be at the moment pleasing to us.

STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION
(Required by 39 U.S.C. 3685)

1. Title of publication: *ZYGON: Journal of Religion and Science*
2. Date of filing: October 1, 1981
3. Frequency of issue: Quarterly
   No. of issues published annually: 4
   Annual subscription price: $18.00
4. Location of known office of publication: Rollins College, Winter Park, Florida 32789
5. Location of the headquarters or general business offices of the publishers: Council on the Study of Religion, Wilfrid Laurier University, Waterloo, Ontario, Canada N2L 3C5
6. Names and addresses of publisher, editor, and managing editor:
   Publisher: Joint Publication Board of *Zygon*, Rollins College, Winter Park, Florida 32789
   Editor: Karl E. Peters, Rollins College, Winter Park, Florida 32789
   Managing Editor: None
7. Owner: Joint Publication Board of *Zygon*, Rollins College, Winter Park, Florida 32789
8. Known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages or other securities: None
9. The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes have not changed during preceding 12 months
10. Extent and nature of circulation:

	Average No. Copies Each Issue during Preceding 12 Months	Single Issue Nearest to Filing Date
Total number copies printed	3,208	3,500
Paid circulation:		
Sales through dealers and carriers, street vendors and counter sales	none	none
Mail subscriptions	2,018	2,093
Total paid circulation	2,018	2,093
Free distribution: samples, complimentary, and other free copies	77	77
Total distribution	2,095	2,170
Copies not distributed:		
Office use, leftover, unaccounted, spoiled after printing	1,113	1,330
Returns from news agents	none	none
Total	3,208	3,500

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