

Retrospective

ALFRED NORTH WHITEHEAD

by *Dean R. Fowler*

In describing the essence of her husband's genius, Evelyn Whitehead once said: "His thinking is a prism. It must be seen not from one side alone, but from all sides, then from underneath and overhead. So seen, as one moves around it, the prism is full of changing lights and colours. To have seen it from one side only is not to have seen it."¹ The spectrum of Alfred North Whitehead's thought is indeed colored by numerous concerns: mathematics, physics, biology, philosophy of nature, education, history, culture, aesthetics, philosophy, and religion. While multifaceted, the diverse aspects of his thinking are but refracted patterns issuing from a unified stream of thought. In this essay I cannot describe all the vibrant colors displayed throughout the pages of his published works. Instead, I will limit my investigation to those aspects of his thought which delineate his approach to the integration of science and religion.

Many expositors see the uniqueness of Whitehead's thought in his novel insights into the nature of religion and, accordingly, would see his approach to the integration of science and religion from this perspective. A more accurate analysis, however, is to understand Whitehead's approach as grounded in his reevaluation of the foundations of science. In this retrospective essay I will defend this thesis by tracing the development of this reevaluation through the three periods of Whitehead's career. The essay is divided into four sections. The first three sections examine Whitehead's published works. The final section examines the thought of some contemporary scientists who are drawn to Whitehead's vision as they wrestle with the problem of science and values.

Whitehead's works fall into three fairly distinct periods paralleling the three localities of his professorships. In Cambridge (England), both as a student and as a professor at Trinity College (1880-1910), his courses and publications focused on applied mathematics and logic but show his interest in fundamental philosophical problems.² In London (1910-24) his work focused on the philosophy of nature. During this period he challenged the

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tradition of materialistic mechanism which had dominated the history of science since Newton, and he developed an alternative view of nature which he felt was more appropriate to the technical and philosophical revolutions inspired by the advances in contemporary science. In Cambridge (Massachusetts, 1924–47) the previous years of critical reflection blossomed into a series of truly philosophical works, most notably *Process and Reality*. In the final period his views on the integration of science and religion reached fruition. Consequently, the stages in his career may be marked off in terms of the topics addressed; however, the continuity of development is readily apparent.

The historical development of Whitehead's thought should be understood as the ever-advancing penetration of a wider circle of interests. Each period is built upon a reevaluation of the foundations of human thinking: first in mathematics, second in science, and finally in philosophy.³ Although Whitehead's significance for the science-religion dialogue lies primarily in his final period, it is important to examine his early works as preparatory to the final synthesis.

1

Whitehead's first major publication, *A Treatise on Universal Algebra* (1898), was the culmination of many years of work initiated by his investigation of the mathematical foundations of electromagnetism. In fact, his fellowship dissertation (not extant) concerned Clerk Maxwell's *Treatise on Electricity and Magnetism*.⁴ Like Maxwell, Whitehead was concerned with the relationship between matter and space, a concern persisting throughout Whitehead's career. For Whitehead this relationship is answered in terms of the relationship between physics and geometry.

While the *Treatise* appears entirely mathematical, it has characteristics anticipating the philosophical themes emerging in Whitehead's later publications. In particular the seeds of his famous "fallacy of misplaced concreteness" are present, as they are in all of the works of the first period.⁵ For example, Whitehead opposes the use of mathematics as an act of pure abstraction, favoring its application to the real world of existing things.⁶ The key thrust of the *Treatise on Universal Algebra* correspondingly is an attack on the traditional quantitative role of mathematics. For Whitehead the world cannot be completely explained by quantitative properties. Furthermore, the *Treatise* anticipates Whitehead's later concern for the unification of concepts, limited in this work to the unification of diverse algebras.

Shortly after the appearance of the *Treatise*, Whitehead and Bertrand Russell's monumental work, *Principia Mathematica*, was published during 1910–13 in three volumes, its primary aim being the reduction of pure mathematics to a very few fundamental logical concepts. As the authors state in their introduction, the aim was at "diminishing to the utmost the number of undefined ideas and undemonstrated propositions (called respectively *primitive* ideas and *primitive* propositions) from which it [mathematics] starts."⁷ Instead of analyzing the *Principia*, I will examine one of Whitehead's short but significant essays written while he was collaborating with Russell. This essay, "On Mathematical Concepts of the Material World" (1905), is particularly important for understanding his later attack on the foundations of science.⁸ And it is this attack which makes possible Whitehead's later integration of science and religion.

"On Mathematical Concepts of the Material World" is significant in three respects. First, Whitehead uses the abstract mathematical symbolism of the *Principia* to challenge the classical concept of the world. Thereby his use of applied mathematics is emphasized. He opposes the development of abstractions which have no contact with the concrete world. Second, Whitehead carries out his first sustained criticism of scientific materialism. Third, Whitehead develops an alternative concept of the world which he feels is more adequate than the Newtonian model for describing the dynamics of a world in the process of change.

Whitehead's objective in writing the essay was "to initiate the mathematical investigation of various possible ways of conceiving the nature of the material world. . . . The memoir is concerned with the possible relations to space of the ultimate entities which (in ordinary language) constitute the 'stuff' in space."⁹ In this essay he limits himself to mathematical and logical concerns, indicating that it has only "an indirect bearing on philosophy."¹⁰ Furthermore, he avoids the problem of the relationship between the concept of the material world and "some perceiving mind" or its relation to existence.¹¹

To accomplish his goal Whitehead outlines five alternative concepts. He begins by describing the classical or Newtonian concept of the material world, which involves the triadic relation among points of space, particles of matter, and instants of time.¹² He attacks the classical concept on two fronts. First, it exempts change from the world. Second, it contains an unnecessary notion, namely, the notion of "particles." The concept of the "particle of matter" is not required to carry out the mathematics of the laws of nature. In fact the "particles of matter" are introduced, Whitehead argues, solely to account for our gross sense perceptions.¹³ He binds these two criticisms into one by arguing that when "the properties of matter are dealt with, an appalling number of extraneous relations are necessary."¹⁴ And these extraneous relations are introduced to account for the change witnessed in the world.¹⁵

Whitehead employs Occam's razor in order to develop alternatives to the classical concept of the material world. Concept II is formulated by trimming out the particles of matter from the scheme leaving only points and instants. Concept III, similar to the Leibnizian alternative, is formulated by "abandoning the prejudice against points moving."¹⁶ In such a view, geometrical relations change with time. But, for our purposes, Concept IV and particularly Concept V are most intriguing.

Concepts IV and V take lines rather than points as their primitive entities. Following his principle of never allowing our abstractions to take precedence over the concrete reality of the world which they represent, Whitehead writes: ". . . a closer specification of the linear objective reals of these concepts [Concepts IV and V] is to say that they are the *lines of force* of the modern physicist, here taken to be ultimate *unanalysable* entities which compose the material universe, and that geometry is the study of a certain limited set of their properties."¹⁷ Concept IV involves the intersection of four lines at an instant of time but, like Concept I, requires the introduction of "particles" and consequently entails a large set of extraneous relations accounting for the relations between the particles and the points of intersection. Concept V is Leibnizian in its monism, where particles as objective reals do not exist.¹⁸ The world is, rather, a product of the intersection of the lines of force, called interpoints, which are capable of disintegration. In fact, Whitehead's description of these is remarkably similar to his later theory of "actual entities": ". . .

when motion is considered, it will be found that the points of one instant are, in general, different from the points of another instant, not in the sense of Concept III that they are the same entities with different relations, but in the sense that they are different entities."¹⁹ Consequently, interpoints are real entities constituting the world, resulting from the intersection of lines of force.²⁰ Using this method, Whitehead eliminates the necessity of the "ether" since the set of linear objective reals "forms the entity (the ether) which 'lies between' the corpuscles of gross matter."²¹ And with this he accounts also for action at a distance without requiring reference to any intervening corpuscles.

But Whitehead's novel concept of the material world with its possibility of disintegration from moment to moment must also be capable of accounting for the endurance we experience in the world. His solution to this problem is not fully developed for twenty-five years; however, the suggestions he offers bear resemblance to his mature metaphysical position. A corpuscle, he argues, must be conceived as "a volume with some special property in respect to the linear objective reals 'passing through' it."²² Endurance then is a property of the persistence of the "type" of points occupying the volume rather than a property of some perduring substratum. Concept V, as Whitehead himself realized, is deficient in not having an adequate theory of motion.²³

We may now review the alternative advanced by Whitehead in the essay "On Mathematical Concepts of the Material World," which grew out of his consideration of linear rather than punctual notions. The lines of Concept V are the lines of force of physics which emerge in *Process and Reality* as the vector transmission of feeling. Whitehead's alternative replaces the classical concept of matter by the concept of intersection points which disintegrate with time. Consequently, for Whitehead change is primary, and endurance is a derivative notion. Finally, his alternative reduces the description of the material world to one set of entities (namely, lines of force and their interrelations) foreshadowing his mature metaphysical scheme where only one class of entities and their interrelations are required to account for the whole range of experience.

The last book appearing in the mathematical period was *An Introduction to Mathematics* (1911), which is an excellent introduction to issues in the philosophy of mathematics. While no new ideas are developed, its chapters deal with themes central to the later development of Whitehead's metaphysics. For example, Whitehead's philosophical intuitions are revealed in his description of the periodicity of nature: "The whole life of Nature is dominated by the existence of periodic events, that is, by the existence of successive events so analogous to each other that, without any straining of language, they may be termed recurrences of the same event."²⁴ The notion of "periodic events" will take on an ever-widening significance in Whitehead's middle and final periods, when he no longer limits his investigations to mathematics and logic but explores much broader issues in the philosophy of nature and metaphysics.

2

In his middle period Whitehead examines the relation between our perceptual experience of nature and the abstract entities of natural science, such as points, moments, and matter. He no longer writes from a purely mathematical perspective, but he is not yet concerned with the broader issues of metaphysics. He does not attempt any synthesis of mind and nature, limiting

his investigation to nature as closed to mind. For this reason Whitehead refers to the task of these works as that of "panphysics" rather than metaphysics.

The three major works of this period make contributions to both scientific and philosophical theory. At the scientific level, the three works promote Whitehead's alternative to Einstein's theory of relativity. In *An Enquiry concerning the Principles of Natural Knowledge* (1919) he derives the Einstein-Lorentz equations. *The Concept of Nature* (1920) serves as a companion volume to the former work, supplementing and clarifying it but avoiding any detailed mathematical treatment. These two may be read as a unit corresponding to Einstein's special theory. In *The Principle of Relativity* (1922) he turns from the consideration of the status of space-time measurements (a consideration of geometry) and devotes his attention instead to the derivation of the law of gravitation (a consideration of physics). Unlike Einstein's theory, where the special theory is a case of the general theory, Whitehead's alternative involves two metrics, one uniform (geometry) and the other contingent (physics), corresponding to the concerns of the first two works of this period and the concern of the third work.²⁵

The physical aspects of Whitehead's formulation grew out of his philosophy of nature, which is critical of Einstein's approach. In Whitehead's judgment, Einstein "cramped the development of his brilliant mathematical method in the narrow bounds of a very doubtful philosophy."²⁶ The works of the middle period seek to develop an alternative theory of relativity within a more adequate philosophical framework.

Principles of Natural Knowledge and *Concept of Nature* are dominated by epistemological interests. In both Whitehead develops "The Method of Extensive Abstraction," which describes the process of deriving scientific abstractions from our immediate experience of the world.²⁷ This method echoes Whitehead's concern in the mathematical period to have contact with the concrete things of the world. He uses the method to criticize the "fallacy of bifurcation," where nature is bifurcated into two systems of reality. "One reality," Whitehead writes, "would be the entities such as electrons which are the study of speculative physics."²⁸ This reality constitutes the abstractions of science postulated as the "cause of awareness." The other reality is "nature apprehended in awareness" or the world as perceived in sense perception.²⁹ With this Whitehead clarifies his initial displeasure with the classical concept of the material world since its concepts are the abstractions of science, not the reality itself.

Whitehead opposes the bifurcationist attitude of traditional science and challenges their description of nature as "a distribution of material thought all space at a durationless instant of time."³⁰ This description is a mere abstraction. Whitehead appeals instead to our immediate experience of nature and especially to our awareness of change to establish a more adequate philosophy of nature: "Nature presents itself to us as essentially a becoming and any limited portion of nature which preserves most completely such concreteness as attaches to nature itself is also a becoming and is what I call an event."³¹ Whitehead's alternative to the traditional philosophy of nature involves an elucidation of events and their relationships. The central feature of events is their durational quality.³² "Scientific objects" such as electrons and molecules are scientific abstractions derived from the concrete events which constitute nature. The abstractions of science, Whitehead argues, are a limited perspective on the full concreteness of nature. This step is crucial for the creative efforts of Whitehead's mature philosophy.

As primarily epistemological, the first two works of the middle period center on the description of our immediate experience of the world, that is, of the world as contemporary with us. In *Principle of Relativity* Whitehead explores how events in the past world condition events in the future. Therefore, his investigation shifts from the uniformity of contemporary events to the contingent physical relations existing between events. This shift of emphasis is foreshadowed in an interesting passage in *Concept of Nature*: “. . . to a large extent, the appearance of sense-objects [i.e., colors, sounds] is conditioned by the adventures of material objects [i.e., bits of matter]. The analysis of these adventures makes us aware of another character of events, namely their characters as fields of activity which determine the subsequent events to which they will pass on the objects [i.e., the qualities] situated in them. We express these fields of activity in terms of gravitational, electromagnetic, or chemical forces and attractions.”³³ Thus events have two characteristics—their durational quality and their character as fields of activity. In *Principle of Relativity* Whitehead devises a physical law to express the fields of activity, namely, the gravitational and electromagnetic fields. We see in the middle period the same thrust as in the first period, when the problem of change and endurance was central. Now change is related to the durational quality of events, and endurance is related to their fields of activity.

The solution finally reached in the middle period is remarkably similar to Whitehead's alternative to the classical concept of the material world; however, in *Principle of Relativity* a law of motion has been proffered. Whitehead's solution should be understood as a rejection of materialism. I will now give a brief description of Whitehead's position. For mathematical simplicity Whitehead introduces the term “event-particle” to refer to “events whose dimensions are ideally restricted.” If an event is restricted in all but one dimension, it is termed a route, which represents the “transition through the continuum of nature.”³⁴ (Routes are similar to Minkowskian world-lines.) A stretch of a historical route is termed a “kinematic element” which represents the spatiotemporal process in the element of the route.³⁵ The kinematic elements are the parts which constitute (through the fields of activity) the whole, which is the route. The law of gravitation describes the contingent physical relations between the kinematic elements.

Whitehead's solution consequently involves a doctrine of emergence. The enduring physical objects which we experience in the world are emergent from the relations existing among the parts—the events of nature. But we must not make the mistake of identifying electrons and molecules with the parts since electrons and molecules are enduring objects and therefore equally constituted by the elements from which they emerge.

The works of the middle period describe the makeup of the physical world, but they attempt no description of the synthesis of mind and nature. Whitehead has intentionally put brackets around the question of values in nature and the metaphysical description of human existence which become so central in his final period. However, these topics do not go unnoticed by Whitehead. For example, in *Concept of Nature* he writes: “The values of nature are perhaps the key to the metaphysical synthesis of existence. But such a synthesis is exactly what I am not attempting.”³⁶ He indicates that one problem with the traditional description of the world is the failure of science to account for the unity of biological organisms.³⁷ And in the preface to the second edition of *Principles of Natural Knowledge* he states that “in the immediate future” he hopes “to embody the standpoint of these [three] volumes

in a more complete metaphysical study."³⁸ We may therefore think of the middle period as a bridge to Whitehead's final metaphysical synthesis. In the middle period he expands his initial attack against scientific materialism by developing a new philosophy of nature. But this period finds Whitehead's thought in a state of metamorphosis, completing itself in the metaphysics of his final period, where all aspects of reality are interpreted within a single framework, making possible the integration of scientific and religious experience.

3

The transition from the middle to the final period in Whitehead's career is accompanied by his moving from Cambridge, England, to Cambridge, Massachusetts. The reasons underlying Whitehead's decision to take a teaching position at Harvard, which are outlined by Ernst Hocking, are important for understanding the interdisciplinary character of Whitehead's final period.³⁹ According to Hocking, in England there existed a traditional division between humanistic and scientific concerns. At Harvard, on the other hand, through the work of Josiah Royce and William James, humanistic and scientific concerns had found a common ground. In fact, Royce and his colleagues met for informal discussions on a regular basis, meetings which after Royce's death were carried on by "The Royce Club."⁴⁰ Members of this club first suggested the possibility of Whitehead's coming to Harvard after his retirement from the University of London. Upon learning of such a possibility Whitehead wrote on January 13, 1924: "The post might give me a welcome opportunity of developing in a systematic form my ideas on Logic, the Philosophy of Science, Metaphysics, and some more general questions, half philosophical and half practical, such as Education."⁴¹ Shortly after in August 1924 Whitehead wrote of his hopes to embody the works of the middle period into a complete metaphysical study. The rapid succession of Whitehead's publications after arriving at Harvard is evidence that he achieved this goal. In fact six of his major publications appear in the short period of four years.⁴²

The works of Whitehead's final period form a unity, which is a product of the consistent application of his metaphysical scheme to diverse aspects of human experience. For this reason it is not necessary to carry out the tedious task of expository analysis for each of the individual works in the final period. Instead I will explore themes common to all the works of this period, focusing my attention on Whitehead's integration of science and religion.

The final period is marked off from the earlier periods by the expansion of the range of topics considered. Probably, the single most important development is the inclusion of human experience as an aspect of nature. In the middle period Whitehead had intentionally put brackets around this issue. But in his metaphysical analysis human experience becomes central for understanding the nature of reality in general. To discover the capacities inherent in the events constituting nature, Whitehead proceeds by "tacitly [taking] human experience as an example upon which to found the generalized description required for metaphysics." With the introduction of this principle the key task for metaphysics becomes the determination of "which among such capacities fade from realization into irrelevance, that is to say, by comparison with human experience which is our standard."⁴³

This methodological approach to metaphysical problems finds its roots in Whitehead's earlier writings. In the middle period, for example, "immediate

experience” was the watchword for establishing an adequate philosophy of nature. In *Process and Reality* Whitehead makes a similar claim: “The elucidation of immediate experience is the sole justification for any thought; and the starting point for thought is the analytic observation of components of this experience.”⁴⁴

But Whitehead’s metaphysics might appear arbitrary to some people since there seems to be no justification for assuming that human experience is in any way analogous to the “things” constituting the physical world, such as electrons, atoms, cells, and low-grade organisms. Aware of this criticism, Whitehead offers justification for his claims: “But any doctrine which refuses to place human experience outside of nature, must find in descriptions of human experience factors which also enter into the descriptions of less specialized natural occurrences. If there be no such factors, then the doctrine of human experience as a fact within nature is a mere bluff, founded upon vague phrases whose sole merit is a comforting familiarity. We should either admit dualism, at least as a provisional doctrine, or we should point out the identical elements connecting human experience within physical science.”⁴⁵ Whitehead follows the second alternative. His metaphysics involves taking one component of experience, such as physics or psychology, and then imaginatively generalizing the factors comprising that component in such a way that they are applicable to all disciplines of interest.⁴⁶ In principle it does not matter which field of study one uses as the starting point since each discipline is a window through which one may view the general structures and categories constituting reality as such.

One tests these imaginative generalizations by trying to apply them to the facts discovered in diverse fields of study.⁴⁷ Whitehead’s analysis in *Science and the Modern World*, for example, constitutes the application of this principle to science (sense perception), while the analysis in *Religion in the Making* constitutes the application to religion (religious intuition). By examining diverse aspects of our experience, Whitehead endeavors to “frame a coherent, logical, necessary system of general ideas in terms of which every element in our experience can be interpreted.”⁴⁸ In fact, Whitehead saw the primary significance of his endeavors as the unification of science and religion: “Philosophy frees itself from the taint of ineffectiveness by its close relations with religion and with science, natural and sociological. It attains its chief importance by fusing the two, namely, religion and science, into one rational scheme of thought.”⁴⁹

According to Whitehead’s methodology there may be diverse starting points in framing a consistent metaphysical system. The starting point for Whitehead was modern physics: “It is equally possible to arrive at this organic conception of the world if we start from the fundamental notions of modern physics, instead of . . . from psychology and physiology. In fact by reason of my own studies in mathematics and mathematical physics, I did arrive at my convictions in this way.”⁵⁰ The studies in mathematics and physics constitute the first two periods in his career. In order to understand Whitehead’s mature metaphysics, which is the ground for his synthesis of science and religion, I will show how Whitehead expands upon his early investigations regarding the physical world by incorporating a metaphysical description of human experience. Accordingly, I will examine his analysis of scientific experience, human experience in general, and religious experience.

Whitehead’s final analysis of the nature of physical existence is rooted in his

earlier investigations. In fact, the major difference between his final and earlier positions is terminological, not substantive. Whitehead continues his attack on the traditional materialistic foundations of science. He continues his emphasis on change in the world. As in his early writings, the enduring objects in the world, such as electrons, molecules, and large physical objects, are emergent products of the relationships existing among the ultimate entities constituting nature. As Whitehead explains: "An event is the grasping into a unity of a pattern of aspects. . . . If the pattern endures throughout the successive parts of the event, and also exhibits itself in the whole, so that the event is the life history of the pattern, then in virtue of that enduring pattern the event gains external effectiveness."⁵¹ Matter, therefore, is an enduring property which emerges from the parts making it up. The parts, called actual occasions, are quantum-like processes, existing only at one time and at one place. According to Whitehead, the failure of classical physics (i.e., Newtonian physics) rested in the "fallacy of misplaced concreteness," that is, the abstractions of science, namely, particles of matter, are taken to be the concrete realities making up the universe. As Whitehead expresses it, "the enormous success of the scientific abstractions, yielding on the one hand *matter* with its *simple location* in space and time, on the other hand *mind*, perceiving, suffering, reasoning, but not interfering, has foisted onto philosophy the task of accepting them as the most concrete rendering of fact."⁵²

Thus all periods of Whitehead's career are motivated by his desire to reevaluate the foundations of science. In the first period he developed an alternative to the classical concept of the material world which rested on linear rather than punctual notions. The lines of force of physics intersect creating "interpoints" which disintegrate with time. In the middle period a philosophical interpretation of his alternative is rendered explicit. Nature is constituted by "events," which have two primary characteristics: They are durational, and they are fields of activity. In the final period the "philosophy of organism" emerges with a richness not previously developed. The entities constituting nature are termed "actual occasions," and their fields of activity are given the technical term "prehensions." However, while the basic description of Whitehead's alternative to the classical foundations of science remains unchanged in his mature metaphysics, the analysis of the internal constitution of actual occasions and of the nature of their (prehensive) relationships is accomplished through the elucidation of human experience.

The novel idea of including human nature as an element in nature (as opposed to the classical dualism where mind is outside of nature) results in significant advances in Whitehead's philosophy. The notions of value and freedom, in particular, can no longer be excluded from descriptions of nature. This point is made explicitly in *Function of Reason*, where Whitehead attacks the "obscurantism" of the traditional scientific attitude, challenging it for not providing an adequate explanation of the urge toward growth and complexity in the universe. He particularly criticizes the use of materialistic mechanism in physiological psychology for its failure to account for the purposiveness witnessed in animal behavior. In opposition to the mechanistic attitude Whitehead writes: "We shall never elaborate an explanatory metaphysics unless we abolish this notion of valueless, vacuous existence. . . . But if we discard the notion of vacuous existence, we must conceive each actuality as attaining an end for itself. . . . This is the doctrine that each actuality is an occasion of experience, the outcome of its own purposes."⁵³

The internal constitution of occasions of experience involves, accordingly, a process directed toward some goal. In framing a metaphysical interpretation which encompasses all aspects of reality, Whitehead searches for a coherent explanation of the fundamental dualities in nature such as atomicity and continuity, change and endurance, efficient and final causation, and the tendency toward degradation and the countertendency upward.

The primary motivation for introducing values and purposes into nature was Whitehead's recognition that traditional science based on materialism could not give an adequate account of the emergence of life. This has been indicated in the discussion above. The same point is made by Whitehead quite forcefully in *Science and the Modern World*:

... a thoroughgoing evolutionary philosophy is inconsistent with materialism. ... Evolution, on the materialistic theory, is reduced to the role of being another word for the description of the changes of the external relations between portions of matter. There is nothing to evolve, because one set of external relations is as good as any other set of external relations. There can merely be change, purposeless and unprogressive. But the whole point of the modern doctrine is the evolution of the complex organisms from antecedent states of less complex organisms. The doctrine thus cries aloud for a conception of organism as fundamental for nature. ... The organism is a unit of emergent value, ... emerging for its own sake.⁵⁴

With this Whitehead turns the tables on traditional science. He can now look to biology and the human sciences, with their emphasis on the study of living organisms instead of traditional physics, for insight into the nature of the entities constituting reality. Whitehead calls his alternative to materialism the "philosophy of organism."

According to Whitehead's metaphysical method, the test of his explanation of physical existence rests in its application to other aspects of experience. In fact, while Whitehead's vision is rooted in his mathematical and physical investigations, the plan for most of the works of his final period is to begin with an analysis of human experience (psychology and physiological psychology) and show its applicability for understanding other disciplines. A complete exposition of Whitehead's account of human experience is not feasible in this essay; however, a brief description is in order.⁵⁵

Perhaps the easiest way to understand Whitehead's metaphysics is to describe the process of human decision making. We are constantly making trivial and, in some cases, earth-shattering decisions. Decisions are never made in a vacuum; there are usually alternatives to consider. The selection among alternatives is influenced by the purposes and values, which are our future goals, as well as by our past experiences. Furthermore, every decision has a period of gestation in which the alternatives are weighed, and, finally, a concrete, single decision is reached—even if it is the decision to put off making a decision.

Whitehead's metaphysical analysis involves uncovering the general characteristics comprising the process of decision making. Each characteristic is given a technical term. The decision event itself is called an actual occasion of human experience. Before the concrete decision is reached, the alternatives, called the "data," are synthesized, compared, contrasted, and/or negated. The synthesizing process takes time, accounting for the durational quality of experience. The process is guided by an aim toward reaching a particular decision, which is called "the subjective aim." The decision reached is influenced

ZYGON

also by experiences and decisions reached in the past (called the “past actual world”) both by oneself and by others. This causal influence is called “causal efficacy.” The feeling of these influences is called a “prehension.” Prehensions have a vector quality—“they feel what is *there* and transform it into what is *here*.”⁵⁶ Expanding on this notion, Whitehead has written: “A prehension reproduces in itself the general characteristics of an actual entity: it is a referent to an external world, and in this sense will be said to have a ‘vector character’; it involves emotion, and purpose, and valuation, and causation.”⁵⁷ Accordingly, prehensions describe the fields of activity of the actual occasions. But, besides the causal influence, there is an element of novelty in every decision, which varies in degree with the kind of decision being made. The decision to apply the brakes of one’s car, for example, when one sees a red light has a low degree of novelty, whereas the decision of Leonardo Da Vinci to paint the *Mona Lisa* shows a very high degree of novelty, in fact, creative genius.

The process of reaching a decision, especially the element of novelty, is central to Whitehead’s description of “consciousness.” Consciousness arises in the contrast of fact with fiction; it is the comparison of actuality with possibility. This is the origin of reason which “is a factor in experience which directs and criticizes the urge towards the attainment of an end realized in imagination but not in fact.”⁵⁸ When the decision is finally reached, Whitehead refers to this as the achievement of “satisfaction.” Once satisfied, the decision is complete. It becomes and then perishes.

This brief account focuses on the internal constitution of decision events in the process of their becoming concrete, but it does not explain the continuity we all experience in the human psyche. Whitehead argues that the human self is a complex society of decision events or actual occasions having a singular, temporal, linear order. The endurance of an individual self is the endurance of a pattern in decision making.

The similarity between Whitehead’s analysis of human experience and his analysis of physical existence should be obvious. Process for both is dominant, while endurance is emergent from the internal relations among the atomic units of process. The entities constituting the physical world are internally related through their vector force fields of activity. The entities (decision events) constituting the human psyche are internally related through the vector transmission of feeling. The endurance of an individual electron is the endurance of a pattern of relationships holding among the individual “electronic occasions” making up the society.⁵⁹ The endurance of vegetable and animal bodies is the endurance of a society of cells. The endurance of an individual human psyche is the endurance of a pattern of decision making. Whitehead makes a similar comparison:

If we substitute the term “energy” for the concept of a quantitative emotional intensity, and the term “form of energy” for the concept of “specific form of feeling,” and remember that in physics “vector” means definite transmission from elsewhere, we see that this metaphysical description of the simplest elements in the constitution of actual entities agrees absolutely with the general principles according to which the notions of modern physics are framed. The “datum” in metaphysics is the basis of the vector-theory in physics; the quantitative satisfaction in metaphysics is the basis of the scalar localization of energy in physics; the “sensa” in metaphysics are the basis of the diversity of specific forms under which energy clothes itself. . . . the general principles of physics are exactly what we should expect as a specific exemplification of the metaphysics required by the philosophy of organism.⁶⁰

Whitehead gives his justification for the inclusion of human experience within nature by pointing out the identical elements connecting human experience within physical science. Whitehead's metaphysics binds together under one unifying scheme of thought what traditionally have been dual realities: mind and matter. The difference between human experience and physical existence is a difference in degree, not kind. Whitehead, however, should not be understood as promoting panpsychism. His references to the mental pole of all actual occasions is a reference to the general capacity of the upward thrust in nature. He does not mean that electrons have consciousness but merely that they have the possibility of contrasting ways of being. The vibratory nature of such entities appears as evidence of this for Whitehead.⁶¹

The comparison of human experience with physical existence supports Whitehead's claim to the adequacy and comprehensiveness of his general metaphysical vision. It remains to examine the nature of religious experience as lending further support to this claim. *Religion in the Making* (1926) represents Whitehead's most sustained treatment of religious experience. Just as he attacks the dogmatism of scientific belief, so Whitehead opposes the dogmatism of religious belief and seeks instead to disclose the various factors constituting the general nature of the religious experience of mankind. In his analysis he focuses on the centrality of values in all religious experience:

Religion is founded on the concurrence of three allied concepts in one moment of self-consciousness. . . .

1. That of the value of an individual for itself.
2. That of the value of the diverse individuals of the world for each other.
3. That of the value of the objective world which is a community derivative from the interrelations of its component individuals, and also necessary for the existence of each of these individuals.⁶²

Consequently, religious experience involves the emergence of individual values and the totality of their interrelations. It is first rooted in self-valuation, "but it broadens into the concept of the world as a realm of adjusted values, mutually intensifying or mutually destructive."⁶³ Reminiscent of his predecessor Royce, Whitehead concludes, "Religion is world-loyalty."⁶⁴

Whitehead's doctrine of God centers in his analysis of values, accounting for the introduction of novel values into the world and the adjustment of achieved values through the binding of the multiplicity of the world into a unity. Following his epistemological principle that the structures of reality are acquired through the elucidation of experience, he argues: "Any proof which commences with the consideration of the character of the actual world cannot rise above the actuality of the world. It can only discover all the factors disclosed in the world as experienced. In other worlds, it may discover an immanent God, but not a God wholly transcendent."⁶⁵ God, accordingly, is immanent in the world. God's primary function is in the realm of values. God both coordinates the emergence of values into a totality and makes possible the emergence of individual novelty.⁶⁶

But there is a danger implicit in the intensity of religious emotions—a danger leading to uncriticized religious dogmatism.⁶⁷ The justification for the interpretation of religious experience lies in its applicability to diverse disciplines, thereby countering dogmatic claims. In the concluding chapters of *Religion in the Making* (chaps. 3 and 4), Whitehead departs from his

phenomenological description of religious experience and compares his metaphysical description (as developed in other works) "with the deliverances of religious experience."⁶⁸ His analysis centers on the description of the unification of the individual units of value (the value of an individual for itself) into a universal community. God, according to Whitehead, functions to bind the diverse attainment of value in the world into a universal society having a consistency and harmony of purpose. God "is the measure of the aesthetic consistency of the world."⁶⁹

Above I outlined Whitehead's analysis of scientific experience, human experience, and religious experience. Each was a selective abstraction from the concreteness of experience in general. For each a general description of the factors disclosed in that particular type of experience was given. The adequacy of the general description was established through its application to diverse disciplines. In describing scientific experience, Whitehead argued that the world was an emergent product of the interrelations among the entities (energy events) constituting nature. In the description of human experience, the human psyche was an emergent product of the interrelations among decision events. In the description of religious experience, the universal community was an emergent product of the interrelations among individual accomplishments of value. Thus the same metaphysical categories apply to diverse aspects of experience.

Based on this analysis we can uncover two mutually supportive ways in which science and religion are integrated in Whitehead's thought. The first is metaphysical; the second is practical.

Science and religion are integrated at the metaphysical level through the sharing of a common metaphysical foundation. Whitehead opposes the traditional dualism in Western philosophy, where one set of categories describes the material world of particles and a second set describes the spiritual world of mind or soul. Instead, the same metaphysical categories describe all aspects of reality. In this spirit Whitehead has written: " 'Actual entities'—also termed 'actual occasions'—are the final real things of which the world is made up. There is no going behind actual entities to find anything more real. They differ among themselves: God is an actual entity, and so is the most trivial puff of existence in far-off empty space. But, though there are gradations of importance, and diversities of functions, yet in the principles which actuality exemplifies all are on the same level. The final facts are, all alike, actual entities; and these actual entities are drops of experience, complex and interdependent."⁷⁰ The differences are differences in degree, not in kind. The differences in degree are differences in the capacities which different levels of reality display. The capacity for freedom is central to the description of human experience, for example, but fades from realization into irrelevance in an electron.

Science and religion are integrated at the practical level through the sharing of a common concern for values. Whitehead's analysis of religious experience maintains the traditional emphasis on the function of religion in the domain of values and the moral life. His analysis of scientific experience, on the other hand, calls for a reevaluation of the foundations of science where purposes and values become central categories. For this reason I believe that Whitehead's integration of science and religion ultimately rests in his reevaluation of science rather than in his novel insights regarding religion, especially his doctrine of God. It is at the practical level of values that Whitehead can

have the most immediate impact on the science-religion dialogue. Integration at the metaphysical level requires acceptance of Whitehead's metaphysical scheme. But integration at the practical level requires only a reevaluation and a redirection of the attitudes of scientists—a difficult task, indeed, but one gradually gaining support as the world faces both ethical and ecological crises.

The appeal to the practical should be, however, only the first point on an agenda toward a radical reevaluation of the foundations of science. Ultimately, a scientific concern for values will deteriorate if it is not rooted in a vision encompassing the intrinsic value of the natural world itself.

4

In sections 1 through 3 I argued that the integration of science and religion within the Whiteheadian perspective demands a reevaluation of the nature and task of science. But is a science based on values and purposes a living option? In concluding this essay I shall examine the thought of a number of philosopher-scientists, representing biology, brain physiology, chemistry, and physics, who give an affirmative response to this critical question. Each is an independent thinker who finds Whitehead's thought relevant to the foundations of their respective concerns.

Whitehead's metaphysical scheme is particularly relevant to the foundations of the biological sciences. Many biologists have found reductionistic materialism (characteristic of traditional physics) very limiting in accounting for the emergence of novel forms and for understanding the mysteries of living organisms. Theoretical biology has been struggling to establish itself as a discipline in the hard sciences by emulating physics. However, if biology uses physics as its model for describing life, it reduces life to objective mechanisms. In order to resolve some of the controversies in biology, C. H. Waddington anticipated writing a book about the relevance of Whitehead's thought for theoretical biology. In an unpublished essay, he outlined the direction of his thinking. He described the power of Whitehead's thought in four areas: (1) in overcoming reductionism and mechanism, (2) in describing reality in terms of events which become rather than as objects which endure, (3) in characterizing the organizing relations constituting the interactions among organized units, and (4) in countering the antiscience movement characteristic of many contemporary humanists.⁷¹

A similar position is developed by L. Charles Birch, a renowned zoologist. Birch argues that evolutionary theory is most comprehensible when it expresses the fundamental continuity in nature. How is it possible, he would ask, for subjective experience to emerge from a wholly objective world? Consequently, lower stages in the evolutionary chain must embody categories of existence that become conspicuous in higher states. Birch opposes the reduction of biology to biochemistry or biophysics. Instead, he believes we must interpret the lower (electrons, atoms, and molecules) in terms of the higher (living organisms). As he cogently states: "Indeed, we may reverse the mechanical proposition and imply that the nature of the ultimate building blocks of the universe can only be known in any adequacy so far as we know what these building blocks give rise to at the highest levels of organization. We cannot know the potentiality of electrons and protons without knowing something of their manifestations in living organisms. In short, a world in which life and mind and sensation are possible requires a different sort of explanation from one in which these things are not possible."⁷² To find the explana-

tion of the world compatible with biological and evolutionary principles, Birch is drawn to the thought of Whitehead and Charles Hartshorne.

Whiteheadian metaphysics finds support also in the essays of R. W. Sperry, a world leader in brain research. Sperry himself does not intentionally articulate Whitehead's thought. Rather, he has independently reached conclusions about the nature of the brain and the physical world which are highly compatible with process thought. While he opposes some Whiteheadian interpretations of reality, he agrees that mental events are causal agents in the real world,⁷³ and he is convinced that we need a new science which incorporates values and which can serve as a "final referent and framework for any ethical or moral system."⁷⁴

While the immediate implications of Whitehead's vision lie in the domain of biology, his metaphysics has promise for providing a conceptual foundation for chemistry, particularly in understanding the nature of compounds and chemical bonding. In a very exciting and intriguing paper, Ivor Leclerc describes the chemical status of atoms and molecules using a Whiteheadian perspective.⁷⁵ Leclerc uses a Whiteheadian analysis of the complex interrelationships existing among events to describe the whole-part aspects of compounds. Writing in a similar vein, Paul Bogaard argues that "Whitehead's schema does . . . provide categories which allow us to probe certain presuppositions of central importance to chemistry and they in turn act as one test of his philosophical critique."⁷⁶ Bogaard traces the historical development of modern chemistry showing how Whitehead's metaphysical system can illuminate the dynamic interactions existing in chemical compounds. Furthermore, he hopes that the developments in modern chemistry can serve as a corrective to some of Whitehead's philosophical presuppositions concerning the relations between parts and emergent wholes.

The relevance of Whitehead's thought for physics has been discussed above. Whitehead's early works, as well as *Science and the Modern World*, grew out of his considerations of the developments in relativity physics and quantum mechanics. However, Whitehead's work dates from the mid-1920s. In looking toward the future, we might ask what promise Whitehead's thought has for more recent developments in physics, especially quantum mechanics.

In a recent study of Whitehead's mature metaphysics in its relation to the present state of interpretation in quantum mechanics Henry J. Folse, Jr., argues that

. . . the philosophy of organism provides a natural context for the acceptance of the Copenhagen Interpretation of quantum theory, especially with respect to the ideas of Bohr and Heisenberg. . . . The thesis herein defended is that if the organic view of Whitehead is substituted for the classical materialistic view, then the Copenhagen Interpretation loses its paradoxical quality and the potential clash of doctrines with the materialistic view is overcome.⁷⁷

Whitehead's theory is therefore compatible with quantum theory, even though it was developed before the Copenhagen Interpretation. Abner Shimony has argued that Whitehead's theory is not compatible with quantum theory.⁷⁸ However, it is evident when reading the two papers by Folse and Shimony that the former is more accurate in his understanding of Whitehead's philosophy and that the latter is very weak.

In spite of Shimony's analysis in 1964, in a recent lecture he commented

that Whitehead's philosophy should be given serious consideration by quantum physics: "... Whitehead's philosophy of organism, which is an attempt to encompass physical and psychological phenomena in a unitary manner, along lines of high level scientific theories and using concepts like 'occasion,' 'feeling,' and 'prehension,' as theoretical concepts, seem to me far from exhausted. It is disappointing to find no discussion of Whitehead in Schroedinger's philosophical works, if only because confrontation with Whitehead would have compelled Schroedinger to give a fuller and more explicit account of the limits of comprehensibility, as he sees them, than he ever presents in his extant writings."⁷⁹ From this evidence it is justified to view Whitehead's philosophy as important for giving a conceptual foundation to the current developments in quantum physics.

Steps in this direction have been taken independently by the quantum physicist David Bohm, whose insights are highly compatible with Whitehead's metaphysics. Holography is one of Bohm's central conceptual metaphors, for it represents "a new order not hitherto given serious attention in physics."⁸⁰ That is, holograms show that the whole is "enfolded" or implicated in the parts. His analysis is highly reminiscent of Whitehead's criticism of science for committing "the fallacy of misplaced concreteness": "... the explicate order is an abstraction from the implicate, having no independence of substantiality of existence. This means, however, that 'localization' cannot be a fundamental notion. What is 'local' in one order is enfolded throughout the whole of space (and time) in another order. . . . Any one order is no more fundamental than any other. Space and time are thus an abstraction from the universal flux of process."⁸¹ But Bohm's emphasis on the internal constitution of reality (the implicate order) is not limited to the analysis of physics. He expands his analysis to include all levels of experience, including human experience: "... the whole existence, including inanimate matter, living organisms, and 'mind' arises in a single ground, in which these are all enfolded, or contained implicitly. . . . Living organisms are to be regarded as particular manifestations of what is ultimately enfolded in the inward depths of the holomovement. . . . So, in a certain sense, we could say that the energy of life more typically reveals the innermost order of the holomovement than does inanimate matter."⁸² Thus Bohm joins the chorus with Waddington, Birch, Sperry, Leclerc, and Bogaard (as well as Shimony) in calling for a new era in science. Each agrees that we have reached a situation in which the old foundations and philosophical presuppositions are no longer satisfactory. We need a new vision in which the notions of value, purpose, and life find their way back into the natural world.

Whitehead's metaphysical scheme can provide the foundation for this new vision, for its major premise is that science can no longer limit its domain to the objective, physical, material world. No longer, Whitehead has argued, can purposes, values, goals, and aims be categories irrelevant to the explanations of scientific theories. In the opening sections of this essay I outlined the development of Whitehead's reevaluation of the foundations of human thinking. According to his methodology, this reevaluation must be tested by examining the appropriateness of his vision in its application to diverse disciplines. In this final section I indicated the direction the thought of some philosopher-scientists has taken as they search for new foundations in science.

But we must be cautious in the adventure toward a new order in science. The new order in science requires a correlate reworking of the methods of

ZYGON

science. Science traditionally has been ill equipped to deal with the notions of value and purpose. Its methodology has in principle blocked its investigation of the categories so apparent in human experience. Consequently, it is futile to seek confirmation of the new order in science using the methodology of the older order. We must develop a new methodology within which experiments can be performed to test the adequacy of the new metaphysical system in its application to diverse disciplines.

NOTES

1. As quoted in Lucien Price, ed., *Dialogues of Alfred North Whitehead* (London: Max Reinhardt, 1954), p. 14.
2. Victor Lowe, *Understanding Whitehead* (Baltimore: Johns Hopkins Press, 1966), p. 121. See also his "A. N. Whitehead on His Mathematical Goals: A Letter of 1912," *Annals of Science* 32 (1975): 85-101.
3. Lowe points out that Whitehead envisaged no "integrated sequence of investigations" and "never paid any special attention to being consistent with his former self" (*Understanding Whitehead*, p. 121).
4. Lowe, "A. N. Whitehead on His Mathematical Goals," pp. 88-89.
5. The phrase "fallacy of misplaced concreteness" first appears in Alfred North Whitehead's *Science and the Modern World* (New York: Free Press, 1967), p. 51 (first published by Macmillan Co., 1926), and represents Whitehead's attack on the tendency of science to substitute its theoretical abstractions for the concrete realities of the world.
6. Alfred North Whitehead, *A Treatise on Universal Algebra* (Cambridge: Cambridge University Press, 1898), p. vii.
7. Alfred North Whitehead and Bertrand Russell, *Principia Mathematica*, 3 vols. (Cambridge: Cambridge University Press, 1910-13), 1:1.
8. Alfred North Whitehead, "On Mathematical Concepts of the Material World," in *Alfred North Whitehead: An Anthology*, selected by F. S. C. Northrop and Mason W. Gross (New York: Macmillan Co., 1961). Whitehead's essay appears the same year as Albert Einstein's "On the Electrodynamics of Moving Bodies" (in H. A. Lorentz et al., *The Principle of Relativity*, trans. W. B. Perrett and G. B. Jeffrey [New York: Dover Publications, 1923], pp. 37-38), in which Einstein develops his special theory of relativity, and bears close resemblance to his own alternative theory of relativity worked out in his *The Principle of Relativity* (Cambridge: Cambridge University Press, 1922).
9. "On Mathematical Concepts of the Material World," p. 11.
10. *Ibid.*
11. *Ibid.*, p. 13. In this essay time is defined in terms of "instants," whereas in his later writings the "epochal theory" of time is developed, in which instants are abstractions from concrete durations.
12. *Ibid.*, p. 14.
13. *Ibid.*, p. 29.
14. *Ibid.*, p. 16.
15. *Ibid.*, pp. 28-29.
16. *Ibid.*, p. 30.
17. *Ibid.*, p. 32 (my emphasis).
18. *Ibid.*, p. 33.
19. *Ibid.*
20. *Ibid.*, p. 35. Whitehead differentiates between Concepts IV and V: "In Concept IV the interpoints are the points, and there are no other points. In Concept V the interpoints are, in general, only portions of points, and a point may contain no interpoint or many interpoints."
21. *Ibid.*, p. 34.
22. *Ibid.*, p. 43.

23. *Ibid.*, pp. 12, 82. Whitehead comments that if some hypothesis concerning the motion of objective reals and correlating it with the motion of electron points could be found, then a theory for the laws of electromagnetism and gravity would easily follow. In *Principle of Relativity* (n. 8 above) he carries out such a task.

24. Alfred North Whitehead, *An Introduction to Mathematics* (Oxford: Oxford University Press, 1948), p. 121.

25. Robert M. Palter, *Whitehead's Philosophy of Science* (Chicago: University of Chicago Press, 1960); John L. Synge, "The Relativity Theory of A. N. Whitehead," Lecture Series no. 5 (Institute for Fluid Dynamics and Applied Mathematics, University of Maryland, 1951).

26. Alfred North Whitehead, *The Concept of Nature* (Cambridge: Cambridge University Press, 1920).

27. Alfred North Whitehead, *An Enquiry concerning the Principles of Natural Knowledge* (Cambridge: Cambridge University Press, 1919), pp. 101–64, and *Concept of Nature*, pp. 74–98.

28. *Concept of Nature*, p. 30.

29. *Ibid.*, p. 31.

30. *Principles of Natural Knowledge*, p. 2.

31. *Principle of Relativity* (n. 8 above), p. 21.

32. In the middle period, events may be either long or short. In the final period, events continue to be either long or short but are constituted by "actual occasions," which are events with only one member.

33. *Concept of Nature*, p. 170.

34. *Principle of Relativity*, p. 68.

35. *Ibid.*, pp. 78, 81, 87.

36. *Concept of Nature*, p. 5.

37. *Principles of Natural Knowledge*, p. 3.

38. *Ibid.*, p. ix.

39. Ernst Hocking, "Whitehead as I Knew Him," in *Alfred North Whitehead: Essays on His Philosophy*, ed. George L. Kline (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1963), pp. 7–17.

40. *Ibid.*, p. 9.

41. *Ibid.*, p. 10.

42. This list includes the works published between 1926 and 1929.

43. Alfred North Whitehead, *Process and Reality* (New York: Macmillan Co., 1929), p. 172.

44. *Ibid.*, p. 6.

45. Alfred North Whitehead, *Adventures of Ideas* (New York: Free Press, 1967), pp. 184–85.

46. Alfred North Whitehead, *The Function of Reason* (Boston: Beacon Press, 1958), p. 76, and *Religion in the Making* (New York: World Publishing Co., 1960), pp. 86–87.

47. *Process and Reality*, pp. 4, 7–8, 24–25; *Religion in the Making*, pp. 86–87; and *Adventures of Ideas*, pp. 184–86.

48. *Process and Reality*, p. 4.

49. *Ibid.*, p. 23.

50. *Science and the Modern World* (n. 5 above), p. 152.

51. *Ibid.*, p. 119.

52. *Ibid.*, p. 55.

53. *Function of Reason*, pp. 30–31.

54. *Science and the Modern World*, p. 107.

55. One of the best introductions to Whitehead's metaphysics is the chapter, "An Introduction to Whitehead's Philosophy," in John B. Cobb, Jr., *A Christian Natural Theology* (Philadelphia: Westminster Press, 1965), pp. 23–46.

56. *Process and Reality*, p. 133.

57. *Ibid.*, p. 28.

58. *Function of Reason*, p. 8.

59. *Process and Reality*, p. 150.

ZYGON

60. *Ibid.*, p. 177.
61. *Science and the Modern World*, pp. 131–37.
62. *Religion in the Making*, p. 58.
63. *Ibid.*, pp. 58–59.
64. *Ibid.*, p. 59.
65. *Ibid.*, p. 69.
66. *Ibid.*, p. 152.
67. *Ibid.*, p. 81.
68. *Ibid.*, p. 87.
69. *Ibid.*, p. 96.
70. *Process and Reality*, pp. 27–28.
71. C. H. Waddington, "Whitehead and Modern Science" (paper presented at the Conference on Process Thought and Modern Science, Rockefeller Foundation Study and Conference Center, Bellagio, Italy, June 12–17, 1974). (Papers from this conference are available for a small charge from the Center for Process Studies, 1325 North College Avenue, Claremont, California 91711.) Waddington died last fall.
72. L. Charles Birch, "Interpreting the Lower in Terms of the Higher," *Christian Scholar* 37 (1954): 404.
73. R. W. Sperry, "Mental Phenomena as Causal Determinants in Brain Function" (paper presented at the Conference on Brain and Consciousness, University of California, Irvine, April 5–7, 1973).
74. R. W. Sperry, "Science and Moral Judgment" (adapted from a paper presented at the annual meeting of the American Association for the Advancement of Science, Washington, D.C., December 1972), p. 19.
75. Ivor Leclerc, "Some Main Philosophical Issues Relevant to Contemporary Scientific Thought" (paper presented at the Bellagio Conference [n. 71 above]).
76. Paul A. Bogaard, "Whitehead and Modern Chemistry" (unpublished paper, Mount Allison University, Spring 1974), p. 1.
77. Henry J. Folse, Jr., "The Copenhagen Interpretation of Quantum Theory and Whitehead's Philosophy of Organism," *Tulane Studies in Philosophy* 23 (1974): 33–34.
78. Abner Shimony, "Quantum Physics and the Philosophy of Whitehead," *Boston Studies in the Philosophy of Science* 2 (1962–64): 307–30.
79. Abner Shimony, "Philosophical Comments on Heisenberg and Schroedinger" (paper presented at a meeting of the American Philosophical Association, San Diego, California, March 29, 1975), p. 17.
80. David Bohm, "The Implicate or Enfolded Order: A New Order for Physics" (paper presented at the Bellagio Conference), p. 4.
81. *Ibid.*, p. 8.
82. *Ibid.*, pp. 10–11.

PRINCIPAL WORKS OF ALFRED NORTH WHITEHEAD

- A Treatise on Universal Algebra*. Cambridge: Cambridge University Press, 1898.
- Principia Mathematica*. 3 vols. Cambridge: Cambridge University Press, 1910–13. With Bertrand Russell.
- An Introduction to Mathematics*. Oxford: Oxford University Press, 1948. First published by Home University Library, 1911.
- An Enquiry concerning the Principles of Natural Knowledge*. Cambridge: Cambridge University Press, 1919. Second edition, 1925.
- The Concept of Nature*. Cambridge: Cambridge University Press, 1920.
- The Principle of Relativity*. Cambridge: Cambridge University Press, 1922.
- Science and the Modern World*. New York: Free Press, 1967. First published by Macmillan Co., 1926.
- Religion in the Making*. New York: World Publishing Co., 1960. First published by Macmillan Co., 1926.

Retrospective

Symbolism: Its Meaning and Effect. New York: Macmillan Co., 1927.

Process and Reality. New York: Macmillan Co., 1929.

The Function of Reason. Boston: Beacon Press, 1958. First published by Princeton University Press, 1929.

Adventures of Ideas. New York: Free Press, 1967. First published by Macmillan Co., 1933.

Modes of Thought. New York: Free Press, 1968. First published by Macmillan Co., 1938.