Reviews

Tradition in Science. By WERNER HEISENBERG. New York: Seabury Press, 1983. 141 pages. $10.95 (paper).

This small book is a collection of nine talks, *Festschrift* contributions, and reminiscences from the last four years of Werner Heisenberg's life, 1973-1976. An encomium delivered at the time of his retirement in 1970 by Hans-Peter Dürr, his successor as superintendent of the Max Planck Institute for Physics and Astrophysics, serves as an epilogue.

While much of the material is retrospective, it is not a set of afterthoughts to his *Physics and Beyond* (New York: Harper & Row, 1971), the chronologically organized epitome of his intellectual journey through the scientific, philosophical, and political terrain of a thrilling, turbulent, and tragic time.

Each of the nine pieces was intended to stand by itself, and Heisenberg surely did not envision them as the chapters of a book. As a consequence, the collection suffers to some extent from disjointedness. To a much greater degree, it suffers from repetitiveness because six of the nine pieces focus on, and all but one touch on, a major theme which was much on Heisenberg's mind during the last years of his life.

That theme is the evolution during Heisenberg's lifetime of the concept of fundamental particle—an evolution in which he was one of the prime movers. In 1910 it was still possible for physicists to think of the electron as a very tiny billiard ball having, besides electric charge, the philosophically remarkable property that it could not be subdivided. The quantum revolution of the mid-1920s, when Heisenberg came to center stage, forced the final abandonment (already implicit in Niels Bohr's work of a decade earlier) of the billiard-ball picture. But the prediction or discovery between 1920 and 1940 of a few more indivisible, fundamental entities—the proton, the neutrino, and the pion among them—seemed to promise a day when the entire universe could be constructed on a very parsimonious base, fulfilling at last a program mooted by Democritus. Even in the knowledge that the basic entities are very different indeed from little billiard balls, it has remained convenient to call them fundamental *particles*.

By the 1960s, the search for fundamental particles had led to a bewildering excess of riches. To give one example of how this came to pass, evidence began to accumulate that the proton had structure. This in turn implied that the proton is not truly fundamental but is composed of entities—still called particles—yet more fundamental. But experiments at ever-increasing energies did not succeed in shattering the proton into a few basic subprotonic particles. Instead, physicists were confronted with a rapidly growing zoo of particles on more or less the scale of the proton. The problem evoked the earlier one of atomic spectroscopy: to explain a bewildering multitude of spectroscopic lines on a simple basis. That was the very problem solved by quantum mechanics. Just as the quantum revoltuion had shifted the focus of attention from the lines themselves to their interpretation in terms of energy level differences between

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the stationary states of an atom, the new discoveries turned attention to classifying the particles—now far too numerous to be regarded as fundamental—in terms of families of energy states. The very energetic collisions taking place in accelerators and in cosmic-ray events represented not so much the creation of new forms of matter out of old as they did the creation of matter from energy in accordance with a very complex set of rules of the kind that mathematicians call symmetry transformations. Heisenberg was among those who came to the view that the concept of central concern was not fundamental particles but fundamental symmetries, just as in atomic spectroscopy the concept of central concern is not families of spectral lines but the energy level structure that gives rise to them. Indeed, he and others came to feel that the particles taken individually were not fundamental at all; as he puts it, "A proton can be taken as composed of kaon and Λ-hyperon, an electron as composed of pion and neutrino; they are no more elementary than a hydrogen atom" (p. 104). In this view, the term "consist of" lacks meaning in the question, "What do protons consist of?" (p. 83).

Heisenberg brings a particularly powerful philosophical point to bear on this matter in the last essay, "Thoughts on *The Artist's Journey Into the Interior*." Using a biological analogy, he begins with Goethe's evocation of the *Urpflanze*, which "embodies and makes immediately visible . . . the principle on which plants are constructed" (p. 132). He then traces the quest of biologists from the plants as a whole to their organs, to their cells, to their subcellular structure, and finally to the DNA which "contains the building-plan of the organism." But this "ur-organism" is merely a very complicated molecule about which it is not useful to make the distinction between animate and inanimate. Thus, "the biological road into the interior . . . has not been infinitely lengthy; . . . it has found a well-defined natural termination" (p. 132). But arrival at this terminus raises a Platonic question: To the extent that the totality of information contained in the DNA is the Platonic idea of the organism, is it more real than the material realization embodied in the organism itself? Indeed, what is *real* to mean?

Heisenberg argues that a continued quest for ever more fundamental particles is an effort to avoid a like confrontation with the Platonic question by taking refuge in a jejune infinite regression, thereby denying arrival at the finite terminus. With this quest he associates a fear that a finite goal implies an end to science. He quite rightly finds the fear groundless, making a distinction between the closure of a particular field of science (like classical mechanics or thermodynamics) and the closure of the whole science.

Heisenberg's stress on the importance of the fundamental symmetries is the common currency of modern theoretical physics. But there was much controversy during the late 1960s and early 1970s concerning the basic question: Should the search for subprotonic particles be abandoned? The affirmative position shared by Heisenberg and others was a minority view; the mainstream of research continued to be guided by the hypothesis that all of the particles called hadrons (including the well-known proton and neutron, but more than a hundred others as well) are made up of triplets of truly fundamental particles called quarks, of which there are only a few kinds. In this view the electron, which belongs to a much smaller family called leptons, is also truly fundamental.

On the side of the controversy favored by Heisenberg, the leading picture was the bootstrap theory put forward by Geoffrey Chew and elaborated by others. One of the most spectacular intellectual nonevents of the 1970s was the creation of a putative universal synthesis by Fritjof Capra, who was for a time

one of Chew's associates. Capra's synthesis, *The Tao of Physics* (Berkeley, Calif.: Shambhala, 1975), was enormously popular for some years among nonscientists. It conflated a version of the bootstrap theory with a macaronic mystical-spiritual theology drawn from Eastern sources. The bootstrap theory furnished objective verification of an eclectic Oriental mysticism, and vice versa. Capra's proposal suffered a fate predicted by Jeremy Bernstein in a review written for *The American Scholar*:

> if I were a Tibetan monk or the swami in an ashram in New Delhi and if Fritjof Capra or anyone else came to my door clutching the latest copy of *Physical Review Letters* . . . and told me that X's gauge theory of Y's neutrino experiment forged the missing link between Western science and, say, the *Tao-te-ching* or the *Bhagavad Gita*, my reaction would be to gather up my belongings and head for the Himalayas. [For it would soon turn out that] X and Y were both hopelessly in error—with the corollary that all of Eastern mystic thought had now been shown to be definitely wrong, scientifically speaking (48 [Winter 1978-79]:6).

This fate is not shared by Heisenberg's work, and the contrast highlights the clarity of his judgment. While the final word is not in, events appear to have proven Heisenberg wrong; the quark picture has been extraordinarily fruitful even though no one has yet seen an isolated quark. There is mounting evidence supporting the view that the quark and the electron are truly fundamental particles. Arguments have been put forward, indeed, to the effect that quarks may be inherently nonisolable; should that turn out to be the case, they would be indivisible *a fortiori*. But whether Heisenberg was wrong or right in the short term is less important than the way in which his participation in the discourse has contributed to the ongoing process of deepening our understanding of the universe. There is a vital difference between being wrong and (as Wolfgang Pauli often put it) being not even wrong.

The title essay, "Tradition in Science," merits a few words in another context. On the occasion of Copernicus's five-hundredth birthday, Heisenberg considered the way in which tradition governs three kinds of crucial choices which the scientific worker must make: the choice of problems, of methods for dealing with them, and of concepts for formulating them.

Heisenberg's view of the choice of problems stresses the historical-social and is not peculiar to science. Able workers are drawn to fields and to specific problems in which there is interest. Conversely, fields fall into neglect when traditional themes are exhausted. Interest is sustained by intense personal interaction among the workers in the field, and by the expectations of individuals that they can participate fruitfully. These matters have been considered much more fully by J. R. Ravetz in his *Scientific Method and Its Social Problems* (Oxford: Oxford Univ. Press, 1971).

With respect to method, Heisenberg sees the so-called scientific method of the past four centuries in fairly conventional terms. He argues, however, that the basis for the appeal of this tradition has changed radically. The original motivation for pursuing scientific method, evident in Galileo and even more so in Kepler, is an essentially religious conviction that God has created the universe in a manner whose investigation is most susceptible to this methodology. For today's scientist the motivation lies, rather, in a long history of success. The fate of an alternative approach is exemplified in Goethe's sallies into science. His descriptive, naturalistic science, though thoughtfully motivated, was swept aside by the overwhelming success of the traditional method.

In the area of concept the effect of tradition is mixed. It is the inevitable and invaluable source of the attitudes with which the scientist confronts new prob-

lems. As long as these problems fall within the realm of what T. S. Kuhn has called normal science, tradition is beneficial. But when, on the brink of a scientific revolution, the problems become alien to traditional concepts, tradition becomes more of a hindrance than a help, in part because it misleads us into framing questions which have no meaning in the new context.

Heisenberg concludes that tradition plays an essential role in science. Unfortunately, so general is the definition of *tradition* implicit in his arguments that one wonders whether the term denotes anything more than the sum total of collective experience which the trained scientist brings to his work. However this may be, the theologian will find Heisenberg's use of the term, and his view of its role in the work of the scientist, very different from its much more specific connotation and function in his own field. Perhaps this merely reflects the fact that scientists spend little time reflecting explicitly on the way in which tradition bears on their work, even when that bearing is significant. In Kuhnian terms, the science student devotes years to absorbing a tradition, just as the theology student does. Yet the word is used rarely if ever in the education of the former and frequently in the education of the latter; this difference may itself present a fertile field of inquiry.

The organization of each piece in this collection is clear and direct, as one expects from so lucid a thinker. Four of the nine pieces were originally written in English; the other five were translated from German by Peter Heath with a skill revealed in the near absence of stylistic differences between the originals and the translations. There are only a few infelicites: on page 76 "spin-path interactions" is substituted for the universal English technical usage "spin-orbit interactions," on page 104 the Λ-hyperon becomes A-hyperon and the quark is given a charge of 3 rather than $\pm 1/3$ or $\pm 2/3$, and on page 124 there is a misprint of "axiomatization" which will not likely mislead. This little book is required reading for the serious student of the modern scientific *Weltanschauung*.

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Order and Organism: Steps to a Whiteheadian Philosophy of Mathematics and the Natural Sciences. By MURRAY CODE. Albany: State University of New York Press, 1985. 265 pages. $12.95 (paper).

In the face of the enormous complexity and strange paradoxes of modern science and mathematics, it is refreshing to hear a mathematician and philosopher assert that a philosophy of mathematics and the natural sciences should be based on an understanding of commonsense realism. Though initially charmed by such a claim, we shall probably react skeptically to it and then insist on a full philosophical justification.

In my judgment, Murray Code, who is a professor of mathematics and statistics, does justify successfully the commonsense grounds of mathematics and science through his sensitive and accurate interpretation of Alfred North Whitehead's philosophy. Be fairly warned, however, that this is no naive

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presentation about mathematics or its use in the natural sciences. It employs the full breadth and sophistication of Whitehead's philosophy as enhanced by the considerable mathematical and philosophical talents of Code himself. Commonsense realism may indeed be the clue to understanding mathematics and its foundations, but the *justification* of this position requires the finest of rational and mathematical considerations, which Code gives in an exceptionally well written and straightforward presentation.

His basic position, following Whitehead, is that one must make a primary commitment to the ontological meaning of *events* (Whitehead's actual entities), and not to their potential logical and mathematical structures, before one can untangle the paradoxes and anomalies of contemporary mathematics and its applications in the sciences. This is Whitehead's *ontological principle* interpreted by Code carefully for the philosophy of mathematics and science. In contrast, Code believes that most contemporary philosophy of mathematics and science erroneously accepts the primacy of logical and mathematical structure and then attempts to interpret the foundations of mathematics and physical reality in terms of this structure.

It is not easy to assess the religious implications of Code' work. There is no comment by him on the religious significance of his book. His sources in process thought as listed in the bibliography are almost exclusively general philosophers and philosophers of science. No current process theologians are mentioned except Charles Hartshorne, and he is mentioned only in a footnote about Leibniz. Only one casual mention of God and theology occurs.

In this light, I offer a judgment about the religious relevance of his work only in terms of its impact on me. In my *Logos: Mathematics and Christian Theology* (Lewisburg, Penna.: Bucknell Univ. Press, 1976), I attempted to show how changes in mathematics affected ancient and contemporary theologians, including those influenced by Whitehead. I affirmed that changes in Whitehead's understanding of mathematics led him to his doctrine of actual entities which subsequently had an enormous impact on process theology. Code's book has convinced me that I also as a mathematician have overemphasized a primacy of mathematical and logical structure for both historical and philosophical analysis and have failed to accept the salutary effects of a more radical Whiteheadian approach for an understanding of the foundations of mathematics and science. This means that, as a result of Code's work, I am far more enthusiastic about reconciling science and mathematics with those emphases of process philosophy that have been so fruitful for presenting Christian theology.

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Transformation and Convergence in the Frame of Knowledge: Explorations in the Interrelations of Scientific and Theolgoical Enterprise. By THOMAS F. TORRANCE. Grand Rapids, Mich.: Eerdmans, 1984. 355 pages. $24.95.

These eleven essays, mostly written during the 1970s, advance the basic Torrancian thesis that the framework of knowledge in every age must be reformed

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in the light of objective reality. Although the essays cover a range of topics, from a historical analysis of the "making of the modern mind" to a biblical study of the concept of immortality, they all support the claims of realism, whether in physics, in the philosophy of science, or in theology.

According to Thomas Torrance, the Church Fathers transformed the Greco-Roman frame of knowledge in the light of the Incarnation and the doctrine of creation *ex nihilo*. The medieval scholastics (with the exceptions of Anselm of Canterbury, Richard of St. Victor, and Duns Scotus) allowed an Aristotelian frame of knowledge to be imposed on their science and their theology to the detriment of both. The Protestant reformers rediscovered the pre-Augustinian notion of real, ontological relationships, with immediate results for theology and longer-range benefits for early modern science. With René Descartes and Isaac Newton, however, a rigid framework of logic and a dualism of matter and form were imported into the sciences and, under their impact, back into theology (chaps. 1, 8). Matter-form dualism has been eliminated from modern physics through the field-theories of James Clerk Maxwell (chap. 6) and Albert Einstein, who finally wedded geometry to matter and energy in the general theory of relativity (chaps. 2, 3, 7, 8). A realist orientation has been revived in the philosophy of science through the efforts of Karl Popper and Michael Polanyi (chaps. 3-5). Theology is restored to its proper focus in the being and acts of God in the theology of Karl Barth (chaps. 8, 9).

Much of this material has been covered in Torrance's previous writings. Those who desire an introduction might do well to turn first to earlier, more unified works like *Space, Time and Incarnation* (London: Oxford Univ. Press, 1969) and *Divine and Contingent Order* (Oxford: Oxford Univ. Press, 1981). Those, on the other hand, who are familiar with Torrance's work and would like to see some of the latest developments in his thinking will find much new ground broken in this volume. The three essays on the philosophy of Polanyi add significantly to those already published in *Belief in Science and in Christian Life* (Edinburgh: Handsel Press, 1980). Polanyi is compared in detail with the thinking not only of Einstein, Popper, and Kurt Gödel, but with that of Niels Bohr, whom the author had not previously rated very highly (pp. 124-29). In fact, Torrance's eminent fairness to Bohr is an indication of his own objectivity and willingness to question presuppositions.

Torrance's open-mindedness is further shown by his engagement with more recent physical theories, like the nonequilibrium thermodynamics of Ilya Prigogine (pp. 186-88), and by his ability to go beyond the thinking of his own mentor, Barth, with regard to the sciences and the possibility of a natural theology (p. x, chap. 9). Most impressive, in my view, is the study of the faith and philosophy of Maxwell, which shows Torrance's historical methodology at its best and fills in an important lacuna in the history of ideas.

Few readers will fail to find something in these essays to disagree with, but many may gain valuable insights from a close reading of difficult material.

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The Christian Frame of Mind. By THOMAS F. TORRANCE. Edinburgh: Handsel Press, 1985. 63 pages. £3.50 (paper).

The expressed purpose of this slim volume by Thomas F. Torrance "is to set before the reader some considerations regarding the distinctive contribution of the Christian mind to human life and thought" as they relate to contemporary science (p. 3). This unambitious collection of rather disparate lectures may not be fully appreciated unless seen within the context of his ongoing thesis that the possibility of the integration of science with theology derives exlusively from the central historic event affirmed throughout orthodox Christendom, namely, that God in Jesus Christ has assumed our very creaturehood into inseparable yet inconfused union with Himself. Christ, not creation, is the final ground of Truth.

As such the direction of Torrance's argument is not apologetic, that is to say moving from science to Christian faith, but conversely it attempts to expose the *Christian preconditions* of realist science. Hence his historical theological excursion into Greek Patristics (Chapter 1: "The Greek Christian Mind") serves to identify several ancient Christian categorial foundations of science. Then, in the subsequent chapters "The Concept of Order in Theology and Science" and "Man, Mediator of Order" the categories recur, by proximity if not design, in various contemporary scientific forms. The import of his exposition is this: only science configured to incorporate the categorial impact of Christian theology will prove to be, in the final analysis, in accord with the contours of cosmic reality. A case in point is that of Michael Faraday and James Clerk Maxwell, who were both "deeply influenced by the Christian doctrine of creation in thinking out a way to express 'the real modes of connection' in nature" (p. 24). The electromagnetic field theory foundational to the Einsteinian revolution in physics resulted.

These theological substructures of science, making no claim to be exhaustive, may be distilled into four premises. The first is that the creation of the universe, being an act of the creative Divine *will* rather than a derivative emanation of His *nature*, mandates the radical contingence of the cosmos. It has not been until relativity theory, quantum indeterminacy, Gödelian uncertainty, and the thermodynamics of open systems that one may claim theologico-scientific harmony on this issue. Furthermore, in a contingent, open universe, as Michael Polanyi stresses, the integration of the various disciplines occurs at the boundaries. It is the temporal boundary which is of greatest theological relevance such that, for example, our constantly expanding universe demands extrascientific explanation both of its origin and destiny.

Second, the contingent universe perdures through the fiat of God—the second Person of the Trinity. From Him derives all lawful natural regularity and order, without which the entire scientific enterprise would collapse. It seems clear, to embrace the providential Living Word of God entails a rejection of an ultimately *indeterminate* universe fundamental to Max Born and his Copenhagen school of quantum mechanics. On the strength of the reinterpretive work of those such as David Bohm (see e.g., "Hidden Variables and the Implicate Order," *Zygon* 20 [June 1985]:111-24) this majority interpretation has been called into question once again. If Torrance's thesis is correct, Christian theology should prove *prophetic* in the ultimate outcome of this debate.

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A corollary to God's providential superintendence of nature is that its becoming is purposeful and therefore good. The conclusion ensues: the natural and the moral, the scientific and the ethical, the metaphysical and the axiological are inseparable—a mentality which surely is pervading both the academic and activist landscape in light of the impending horrific prospect of nuclear and genetic mismanagement. However, this ground swell of concern will dissipate in the flux of ethical relativism and political conventionalism unless it finally recognizes that obligation emanates from "the *ultimate ground of all order*" of God in Jesus Christ (p. 20).

Third, issuing from nondualist Judeo-Christian monotheism, as distinct from the dualism of Greek rationalism and Roman pragmatism, Torrance argues for the correlation of the human mind with the external world and with God. Cosmologically this is evidenced in the "anthropic principle" in which against infinitesimal odds the universe anticipatorily has expanded at the only rate which would accommodate the factors necessary for humanity's existence. Epistemologically the *intuitive immediacy* of the human mind with the world establishes the mediatorial prominence of humanity graced to bring to intelligible expression the invisible structures and purposes of the universe. Thus the scientist may well "discover things passed over in silence by Holy Scripture" (p. 7). Unfortunately this subtle correlation is passed over in near silence as well and, despite its central role throughout Torrance's corpus, it is nowhere neatly expounded. This intuitive link implies that the foundations of science are ultimately no more demonstrable than those of religion. The personal coefficient is inextricably part and parcel of *proper* scientific method.

Reading between the lines the penetrating charge emerges: instrumentalism and positivism are scientifically heretical.

Fourth, the depravity of humankind pervades not just conduct but also thought such that humans are alienated both from God and creation. Only in the atoning life of Christ has this state been reversed. Therefore, unabashedly Torrance concludes, only the mind reconciled to God in Jesus Christ is capable of resonating with the deeper, more subtle structures of reality. If Torrance were a universalist such an assertion would be a benign truism. Because he is not, however, this claim will raise the ire of the historian of contemporary science in this post-Christian era. Although in one instance Torrance does cite moral integrity as a precondition for mathematical rigor, a more satisfactory reading would emphasize either the constraints imposed by atheistic science at its intersection with cosmology, or a residuum of tacit Christian categories operating throughout the sciences without which the whole enterprise would come to a screeching halt.

The concluding chapter, "The University within a Christian Culture," serves, rather superficially, to define the academic climate requisite to the emergence of a Christian frame of mind. The call for interdisciplinary integration ultimately predicated upon the unity of the Truth in God, in the final analysis, is a plea to restore the proper sense of the *uni*-versity.

This compilation purports to be an introduction, albeit *ex post facto*, to Torrance's more substantial and satisfying *Divine and Contingent Order* (Oxford: Oxford University Press, 1981) and *Transformation and Convergence in the Frame of Knowledge* (Grand Rapids, Mich.: Eerdmans, 1984). If one intends to read these, little will be gained from *The Christian Frame of Mind* apart from the final chapter. If one has little prior acquaintance with Torrance, the lack of theological and epistemological underpinnings in this brief text may generate misunderstanding if not antipathy for the significant conceptual revolution of

which he continues to be more a prophet than a practitioner. It is neither a place to begin nor a place to end, but you might find it, as I did, an avenue to meditate upon the unspoken.

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Darwin's Legacy. Edited by CHARLES L. HAMRUM. San Francisco: Harper & Row, 1983. 125 pages. $5.95 (paper).

Darwin's Legacy consists of a group of talks given at Nobel Conference XVIII, October 5 and 6, 1982, at Gustavus Adolphus College in Minnesota. The speakers were paleontologist and evolution theorist Stephen Jay Gould, biographer Irving Stone, paleoanthropologist Richard E. Leakey, biologist and philosopher Peter Medawar, sociobiologist Edward O. Wilson, and church historian Jaroslav Pelikan.

Gould celebrates Charles Darwin's impact on Western thought and Darwin's scientific gifts. He welcomes the now generally acknowledged truth that Darwin was a great scientist in contradiction to once-fashionable detractions. His concern is why Darwin rather than some other evolutionist occupies primacy of place in the history of biology. Why has Darwin rather than some other figure become the symbol of this notable mutation in human thought? First, he argues, Darwin's theory, unlike others, was useful in doing scientific work. Second, natural selection was radical in its assault on conventional pieties about progress and providential design. Third, Darwin made no exception for human beings but caught up every creature in a universal theory. Fourth, Darwin's stature has grown as the full range, consistency, and force of his thought have come to be recognized. Finally, Darwin attracts us because of his humanity.

And yet, Western thought has been reluctant to deal with Darwin, primarily, Gould thinks, because we have a bias toward progress, a gradualist view of progressive change, a belief in determinism which rules out chance, and a liking for "adaptationism" which implies that, in Alexander Pope's phrase, "whatever is, is right" (pp. 95-96). Natural selection (especially in its modern form) erodes all of these biases.

Stone is an unreconstructed triumphalist, an extreme whig who seemingly has not heard that science and religion were not at war in the nineteenth century nor that presentism is out of favor. It is surprising to see the discoveries of Louis Pasteur, Madame Curie, Ignaz Philipp, Semmelweis, and others as well as the CAT scan and an understanding of DNA attributed to Darwin's methodological innovations. It would seem that Darwin not only discovered evolution, he virtually invented science as well. Even though Stone, like the other speakers, is preoccupied with the problem of scientific creationism, he has not caught up with the shift in strategy in the antievolution campaign which seeks not to ban Darwinism but to compete with it.

Leakey believes that humankind's survival may depend on our willingness to recognize that we are *a* species and *one* species. He defends the study of human

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origins as contributing to that knowledge. In countering neocreationism Leakey stresses the fullness of the fossil record of human evolution although he points out that the record will not answer all questions and may never answer some. One major problem both in analyzing the fossils and in communicating what they tell us to the general public is the disparity between the clarity of the evidence itself, which grows in amount almost daily, and the various classification schemes which are imposed on it. Leakey calls for more scientific flexibility and less rivalry.

Medawar discusses the evidence for evolution, which concept he carefully distinguishes from Darwinism. The fortunes of Darwinism may rise and fall over time, but no qualified individual has any doubt about evolution itself. The lay public, he says, has misunderstood and continues to misunderstand this. Another popular error is to suppose that evolution or any other scientific hypothesis can be proven beyond the possibility of error. He debunks some of the popular "proofs" of evolution and argues that evolution rests on its explanatory power and not on a body of "proofs" as is sometimes imagined by both its friends and enemies. Medawar does acknowledge "proofs" of evolution's plausibility. While all this is true, his argument is so chatty and paradoxical that as a counter to neocreationism it probably will do more harm than good.

Wilson explains what sociobiology is ("the systematic study of the biological basis of social phenomena . . . in all kinds of organisms . . .") and what it is not ("a particular theory of behavior") (p. 53). He distinguishes it from ethology as being more concerned with complex and group behavior than with individual behavior. Perhaps with Medawar in mind, he implies that biologists have a greater appreciation of natural selection's virtues than do philosophers, and he insists that sociobiology rests firmly on a basis of natural selection. Reviewing Darwin's pioneering contributions, Wilson defends the merger of biology and social science into his "gene-culture coevolution" concept, an idea that he acknowledges is resisted but such resistance no longer seems to him, "defensible" (p. 70).

Pelikan is odd man out in this collection because his contribution deals not with Darwin and his legacy but with John Henry Newman and his. The evolution of evolution, Pelikan's topic, takes the form of a discussion of Newman's view of the development of Christian doctrine. With so many accomplished historians of science working today, one wonders why Pelikan was selected for this assignment. Perhaps he wondered himself.

The volume is poorly edited with several accidental and double negatives apparently preserved from the oral presentations. There are also some surprises: in addition to the absence of any fireworks between Gould and Wilson, Pelikan mistakes William Paley's *Evidences of Christianity* for his *Natural Theology* and Medawar professes no knowledge of how natural selection might be falsified—a point on which Gould quickly corrects him.

Zygon readers will find little in the addresses that will be new to them, but the exchanges between the participants and the audience should be of interest. The collection as a whole illustrates the difficulties that exist in popularizing science. Efforts here range from the glibly patronizing to the academically detailed that make no concession to popular ignorance.

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The Universe is a Green Dragon: A Cosmic Creation Story. By BRIAN SWIMME. Sante Fe, N.M.: Bear, 1985. 173 pages. $8.95 (paper).

In this book Brian Swimme of the Institute in Culture and Creation Spirituality, Oakland, California, tells the story of the evolution of the cosmos with the dimensions of meaning which he finds embedded in its unfolding. Swimme intends to stand in the traditions of Plato, Thomas Aquinas, Pierre Teilhard de Chardin, and Eric Jantsch, showing special regard for the nature theologian Thomas Berry of the Riverdale Center, New York. The book is written in the style of an evening's conversation between "Thomas" (Berry) and a "youth" who represents humankind, earth's youngest advanced life form. Green is a color of living things, and dragons are mystical beings—powerful, fierce, benign, revealers of cosmic wisdom, filled with fire. Although there are no dragons, we humans are dragon fire.

Swimme's approach is drawn explicitly as an alternative to the mechanistic view. Mechanism begins with the primary datum of the universe and with the principle of parsimony declares no further explanations necessary for its present reality, nor for its origins or destiny. Swimme also begins with the primary datum, but for him the universe reveals a radical teleology. Because it exists, its antecedents existed, worked, and created in order that it could be—and be in this way. Its origins and properties have their source in ultimate mystery, in no-thing-ness.

Of course as in most natural philosophies, in this *Weltanschauung* too there is a latent ethics, and this is the thrust of Swimme's discourse. Called into being by the universe, it is the appropriate response of the human, the only known self-reflexive life form, to be respectful of the characteristics and powers that effected and still effect it. We are called to value that which the universe values. And we are enabled and guided in our behavior by the characteristics of the cosmos.

Swimme certainly shares this same view with the natural philosophers in whose traditions he professes to stand. It is in the results of his examinations of the properties of the universe that he diverges dramatically. Having a contemporary doctorate in dynamical systems in physics and biology Swimme looks at significant aspects of the world from that viewpoint.

Thus the most patent universal property of the cosmos underlies the fact that it sticks together. This attracting property he calls allurement, and its activity love. His account reads like a contemporary version of the activity of Aristotle's unmoved mover at its best. In an insightful demonstration of its significance Swimme performs a thought experiment: What would happen if allurement were suddenly switched off? Gravity would cease to bind galaxies and planetary systems, and each heavenly body would centrifugate. Molecules, atoms, and nuclei would self-destruct with the cessation of electromagnetic and nuclear forces. One would be hard pressed to find a more fundamental cosmological property! In the human, allurement finds its definitive elements in interest, enchantment, and love; and it expresses itself in creativity and celebration. Moral evil results from response to the allurement of some particular aspect of the cosmos without taking perspective from the whole.

Other powers of the universe that guide and assist us in appropriate behavior are illustrated by land, sea, wind, fire, and life. Tradition or memory, the way

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the past works in the present, is revealed by looking at the land. Interconnectivity—the ways elements of the universe dissolve into one another, define, and are defined by their relatedness—is illustrated by the sea. A propensity for sharing, for the diffusion of being and celebration, a universalization of the second law of thermodynamics, is seen in the wind. Self-organization and the interlacing of subsystems into one is latent in the numinous mystery of fire. Cosmic energy, fantasy, imagination, and adventurous play are embodied in life.

From these Swimme arrives at the centrality of love, of self-expression as the primary sacrament of the universe; at a vision of global societal transformation based in realizations of our shared primal origins; at an ecological ethics of sweeping proportions; and at an optimistic, enthusiastic, and challenging view of the role of the human in the cosmos with an ethics so radically different in outlines from traditional frameworks as to be scarcely recognizable.

Is it successful? How do you judge something that reads more like a serious work of art? This is not a *Summa* or *Principia* in style; it is much closer to the *Divine Milieu*. The music of the spheres would lose something significant played on a kazoo. Here are highly imaginative scenarios artistically splashed up before us by a systems scientist who has studied the best that modern physics and biology have to offer. As an art piece it can be appreciated by those quite young as well as by the more mature, by the uneducated as well as the savant.

But can "serious" philosophy be done artistically? (No one in the Scriptural traditions would doubt that mature spirituality can be.) I think that Swimme would argue, and I tend to agree, that no invention is properly human without its elements of enthusiasm, enchantment, play, celebration, and love. Why not put them up front? Would that more "serious" philosophy had!

I agree with the thrust of this book. It is well past the time for doing natural law ethics without the modern view of the cosmos. However Swimme's great leap forward does, I think, risk leaving many unable to bridge the gap from more traditional points of view. But as a solid beginning this book is provocative even for the specialist. There are obviously many more powers and characteristics of the universe, or ways of nucleating them, that could be integrated into this schema for its enrichment. Every discipline would have its own. So much the better.

The reproductions of stellar photographs at the start of this book are excellent. Typographically the book reads very easily, although unfortunately in section 2 the typesetter got stuck on the page-header "SEA."

A particle physicist may take exception, as I do, to Swimme's use of quantum fluctuations or quantum "stickiness," but these are small points. More centrally risky is his heavy dependency on teleological persuasion and language of anthropocentric personifications. Those like me, whose philosophical nose is tweaked by teleological language that sounds as though antecedent purposefulness is schemed by the non-self-reflective universe, might try the quite formally rigorous ontological interpretation. I think it holds consistently throughout, although with Swimme's dramatic use of personifications it cannot be said for certain which one he intended. For his provocative, insightful, challenging creativity I would give him the benefit of the doubt. This book is worth reading—more than once.

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Einstein's Space and Van Gogh's Sky: Physical Reality and Beyond. By LAWRENCE LESHAN and HENRY MARGENAU. New York: Macmillan, Collier Books, 1982. 268 pages. $6.95 (paper).

Lawrence LeShan and Henry Margenau have constructed a provocative role for the social scientist in the 1990s. Social science is to be the mediator between the natural/physical sciences and what I will term "transcendent consciousness"—including aesthetics, ethics, and the parapsychological. This mediation by the "methodology of domains," as the authors have termed it, is applied in parallel form through the realms of physics, biology, art, ethics, consciousness, and the paranormal. The authors envision cognition as the core of the methodology.

Cognition, according to the authors, is organized by "domains of experience": "In each of these certain observables appear. Some domains bear a sequential relationship to each other, and when this is true, a number of definite statements can be made about their relationships. Domains fall into larger groupings called *realms*, and each realm has a special organization of reality (metaphysical system) which is necessary to make the data from it lawful" (p. 33).

The two operable clues to a social science of domains or alternate ways of constructing reality—in a word, cognition—are the nature of "observables" and the process by which "metaphysical systems make data lawful." To the reader it appears that quantum physics provides the role model for the credibility of this method in the authors' reliance on such epistemic constructs as "complementarity," "unknowability," and "spontaneity." This reliance is exhibited in one way in the authors' definition of the term *observable*, that is, "any quantitative constructs related to an observable, sensory event by an operational definition or, more generally, a rule of correspondence . . ." (p. 57). (A rule of correspondence is "the connection between P-facts and constructs" and is usually a measurement operation made with instruments [p. 57].) "In this sense, then, the mass of an atom or the charge of an electron remains an observable" (p. 111). These observables then become part of a larger organizational structure by which "physical science makes rational and meaningful all cognitive experience."

In addition to observables, P-experiences or protocol experiences make up part of the cognitive system. P-experiences are ambiguous, but the authors seem to prefer nondefinitions of P-experiences. They are neither percepts nor sensations but rather, as the Greek names *protos* and *kolla* imply, "first glance experiences" (p. 51). Constructs, as the creative, ideal results of P-experiences, and systems of varying kinds are the other constituents of a domain or alternate reality. P-experiences are characterized by incoherence, irrationality, spontaneity, instability, and subjectivity.

The method so described by the authors is additionally characterized by the unique parallel processes found in diverse domains of human experience. In the chapter "Guiding Principles In the Search for Scientific Theories," the authors suggest criteria for the acceptance and rejection of constructs and theories. They are simplicity, extensibility, multiple corrections, logical fertility, stability of interpretation, causality, and elegance (p. 81). Guarding against reductionism in physical science, in philosophy, and in other areas, the authors

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suggest that reductionism be replaced by "transcendent elaboration" in the molar (macrocosmic and microcosmic) worlds, and molecular world. This elaboration appears to be an immanent interconnectedness of facts appropriate to a specific domain without regard for levels or hierarchies of value from one domain to another.

The remainder of the book is based upon the acceptance of the assumptions of the social scientific method prepared by LeShan and Margenau. It includes both the comprehension of the method and the accountability of the method in the areas of art, psychology, and consciousness. The authors appear to intend its applicability to all areas of knowledge. In praise of the effort one must cite the creative imagination in bridging the wide gap that has existed between social science, the physical sciences, and the humanities. To the book's credit it finds parallel value in the diverse processes of human experience and calls for a method to help us sort out the variables, avoid blatant reductionism, and tolerate diverse dimensions with some comfort. In criticism of the effort the book is not clearly written and the transitions from the world of Albert Einstein and Werner Heisenberg to Isaac Newton or Goethe are difficult to grasp, although each chapter has poignant points which one who has read in the field can refute. Methodology as the present effort to bridge the gap is key. Whether methodology as described by the social scientist or by the philosopher, it is clear that, in order to construct a meaningful cognitive experience of various gestalts, the method for so doing has high intellectual priority. In this purpose the book both succeeds and fails: it succeeds in outlining a method, but it fails in the application to the many and diverse disciplines to which the book alludes.

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Insight-Imagination: The Emancipation of Thought and the Modern World. By DOUGLAS SLOAN. Westport, Conn. and London: Greenwood Press, 1983. 287 pages. $29.95.

"The future of the human being and of all the earth now hang upon our recovery of imagination" (p. 241). Here Douglas Sloan offers a social soteriology for modern culture; he argues that, if we can transform our thinking, we can transform the world. And the way we transform our thinking is through the recovery and cultivation of insight and imagination.

What makes this book so readable and valuable is its clear diagnosis-cure structure. Sloan, who teaches history and education at Columbia University, tells us just why the modern world is sick and then recommends an appropriate postmodern remedy. The symptoms of our ailing modern culture are well known to social critics: the spoilation of nature, the continuing suicidal buildup of nuclear weapons, spreading illiteracy, the breakdown of personal relations, a haunting sense of futility, cynicism, uncivility, and outright violence. What is the cause of these symptoms? Along with other postmodernists Sloan believes the underlying disease is the widespread habit of fragmented thinking endemic to modern science.

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The core problem is that we think badly. We think atomistically and divisively. We perceive the world as divided up into quantifiable and isolatable parts. We reduce wholes to their component parts, and then we measure and manipulate the parts in the effort to control them. Most importantly, modern scientific epistemology separates the object of study from the inquiring subject. This rips the human person out of reality and turns persons into spectators. We look at what is real with an "onlooker consciousness." This leaves all the affective dimensions of life—feeling, intuiting, valuing, willing—to the realm of groundless human subjectivity. Because science is concerned almost exclusively with quantitative relationships, it has nothing to contribute in enabling us to deal with qualitative issues such as the ultimate meaning of existence (pp. 125-26). This is the voice of a humanities scholar raised against the hegemony of the natural sciences.

Sloan's diagnosis is still more precise. It is not scientific thinking per se that is the problem. It is rather the unwarranted assumption we moderns make that quantitative and measurable analysis applies to all spheres of life. It is not the rise of science but rather *scientism* that constitutes the ontogenesis of the modern malady. Our problems are the result of a twofold distortion of science: first, inflated claims which imply that science alone apprehends the truth and, second, the misapprehension of science as nonhuman, as something separate and distinct from the humanities. Sloan's criticism is directed not against "science itself" but rather against the "deep, underlying forms of thinking and consciousness which are prior to science and which reach into every realm of human behavior (p. 4, cf. pp. 24-25, 109-10).

The appropriate cure, of course, is better thinking. In this case, the prescribed medicine is a large dose of holistic thinking which integrates the sciences with the humanities. It begins with the recognition that scientific reason is grounded in a fuller rationality which extends beyond the boundaries of the calculating intellect. We have access to this fuller rationality through the use of our imagination. Imagination is "that fundamental capacity for insight that is the source of all cognition and of all new meaning and knowledge.... Imagination is that participation of the whole person—in logical thinking, feeling, and willing—in the act of cognition. The imagination places the human being in a context of intelligibility that spans the cleavage between subject and object, a context of meaning that includes both" (p. 69). To cure our divisive thinking with a heavy dose of insight and imagination is to take the first step toward a cure for all the world's ills: "the recovery of the wholeness of imagination is also a healing (a making whole) of the human being—and potentially the world" (p. 158).

Sloan is impatient with our culture and its basic educational constructs which still thinks in the categories of Newtonian mechanism. Our culture has not caught up with the new physics, with what is really going on in science. Quantum theory and relativity and the subsequent developments in the philosophy of science have led to a much more holistic and less mechanistic vision of reality. After citing Werner Heisenberg, Jacob Bronowski, Charles Birch, Michael Polanyi, and Owen Barfield, Sloan settles on an exposition of his paradigm of postmodern holism, the physics of David Bohm. Bohm, like Sloan, believes that the root problem of modernity is divisive thinking and that what our time calls for is a transformation of human consciousness. Such a transformation will commence when we realize that "new perspectives, new lines of inquiry, a new grasp of the whole, a new level of meaning—comes only in an immediately participative act of Insight or Imagination" (p. 130). But in addi-

tion to this epistemology, Bohm's cosmology also attracts Sloan, especially the concept of the implicate order which stands underneath and unites the multiplicity of items we experience at the level of the explicate order. The implicate order is in movement. It is a "holomovement." The entire world in which we find ourselves and of which we are a part, which includes both matter and consciousness, is an unfolding manifestation of this infinitely more comprehensive holomovement. Whenever things appear to human consciousness as separate and unconnected we must remind ourselves of this more comprehensive and underlying unity (pp. 119-24). We might note in passing that for a parallel treatment of this topic one could consult the article, "David Bohm, Postmodernism, and the Divine" (*Zygon* 20 [June 1985]:193-217).

Now, how do we move from a Bohm based theory to daily practice? All through the diagnosis in the early pages of the book Sloan promises to spell out a program of educational therapy at the end. He says it is through education that we can initiate the transformation in human thinking and subsequently in the world as a whole. But when I arrived at the end point, rather than a helpful therapeutic prescription I found only more diagnosis. The diagnosis here takes the form of a trite diatribe against our present educational system which allegedly limits learning to the narrow sphere of scientific and quantifiable reasoning. He contends that our school system is "culturally bankrupt" because it restricts itself solely to "instrumental education, one based solely on the heaping up of information and the development of narrow mental facility and technical reason" (p. 198). "Contemporary education, in theory and practice," he says, "has moved steadily from any conceptions of knowing as involving the participation, harmonizing, and liberation of the whole person. . . . A premium is placed on narrow intellectual attributes, while other capacities and aptitudes, personal, social, moral, aesthetic, go unattended" (pp. 193-94). All the products of our schools can do when they become citizens is conceive of a public policy which "is steadily reduced to mean mainly the efficient implementation of technique and the smooth management of institutions, rather than the engaged and critical consideration of the larger goals those techniques and institutions are to serve" (pp. 196-97). Sloan here is simply following the lead of most self-appointed architects of a postmodern future in using contemporary educational institutions as a whipping boy.

This diatribe does not square with my personal experience, however. Like most of the readers of this journal, I attended school once. And at present my wife is an elementary school teacher; we have many friends in the educational professions; and we have a house full of kids who are strewn out over the local landscape in various grades of both parochial and public schools. A concentration on "narrow intellectual attributes" is the last phrase I would think to use to describe what we witness in school everyday. Oh yes, there are courses in the sciences, history, and language. But there are complemented with music, art, athletics, home economics, shop, and hobby clubs. The attempt to educe—to draw out and actualize—whatever potential a particular child might have is made from a variety of angles so as to open up the appropriate avenue or avenues for that child's fullest development. The "concern for the harmonious development of all aspects of the person" (p. 206) belongs to the tacit and sometimes explicit philosophy of education which prevails, at least in the communities with which I am familiar. I think Sloan is simply committing the straw-educator fallacy here. Although some educators and some institutions just may be guilty of the narrowness of which he speaks, I do not believe his criticisms apply to education in general.

When public criticisms of our education system are ordinarily rendered, it is often on just the opposite grounds than Sloan's. Instead of too much science and math, the current public outcry in the United States is that we do not have enough. Our educational standards have been deteriorating while our SAT scores have been plummeting. In 1980 the United States Department of Education and the National Science Foundation said that most Americans are moving toward "virtual scientific and technological illiteracy." Whatever the problem is that we are facing in our educational system at present, it does not seem to be due to an overconcentration on the narrow fields of science and mathematics.

We are using two criteria here, of course, by which to evaluate our educational process: narrowness and quality. To the extent that Sloan's criticism actually does apply—and Sloan's criticism is in principle one we should keep in mind—we should ask our public schools to seek a public philosophy which incorporates a holistic vision regarding the ultimate purpose of life, a unifying vision which could help to integrate better the whole round of courses and disciplines. In seeking a public philosophy with a unifying vision, however, we would not necessarily reduce our vigilance regarding the quality of instruction in the sciences and mathematics.

Sloan insists that an education of imagination in its fullest sense will require a fundamental change of premises about our ways of knowing (p. 202). But just what change should we make? It is not clear. He calls for a change in premises but offers no recommendations for concrete changes in day to day policies, procedures, or practices. He recommends that our schools teach language, history, and natural science. But, I ask, where is this not already being done? He recommends that poetry be used to help in the child's understanding of nature and that geography be tied in with concurrent studies in history. But, again I ask, where is this not already being done? Are our contemporary teachers such complete nincompoops as to have missed these obvious connections? We may need to improve the quality of our instruction, but the complementarity of the disciplines in principle already exists.

Sloan wants us to be more creative. He wants us to have greater inner resources and ultimate purposes. He wants us to integrate knowledge and value, and he demands that we change our curricula so as to get these things. But alas he does not provide us with actual models of curricula which differ in any noticeable way from what already exist.

This criticism aside, I recommend the book. The complex relationship between natural science and modern culture needs to simmer continually on the front burner, and this book keeps the heat on. It is full of interesting insights regarding the relationship between the Western notions of the free individual and the distanced objectivity required to pursue scientific inquiry. Furthermore, it joins a larger chorus of voices which is calling for a reassessment of our modern way of life and attempting to sing a new postmodern song. This chorus wants to intone a new harmony, and I believe we need as much creative insight and imagination as we can garner for writing the new music.

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