SCIENCE AND RELIGION: A SYMBIOSIS

RICHARD F. HAGLUND, JR.

Sometimes people ask if religion and science are not opposed to one another. They are: in the sense that the thumb and fingers of my hand are opposed to one another. It is an opposition by means of which anything can be grasped.[1]

—Sir William Bragg

For most of us, there is little doubt that science was victorious in its centuries-long warfare with theology. From Galileo—kneeling in the robes of a penitent criminal before his Inquisitors, pleading for mercy on the grounds of age and infirmity—we have come full circle, to William Jennings Bryan in the dock at the Scopes "Monkey Trial"—trying desperately to demonstrate the Bible as the infallible guide to the story of Creation, then succumbing without dignity to the pitiless goad of Clarence Darrow.

But this picture of a single titanic intellectual and spiritual conflict, with science emerging at last triumphant and religion banished to the nether realms of social myth and private ethical concerns, is far too simple. The war of science against religion has actually been waged on three broad fronts: a *social* revolution, which in Jacques Barzun's words "has enthroned science in the name of increased production, increased communication, increased population and increased specialization";[2] an *intellectual* revolution, directed at achieving "a comprehensive knowledge of the cosmos through science";[3] and, most significantly, a revolution in *consciousness*, that is, in man's felt way of perceiving himself and the world about him.

Of these three interlocking struggles, only the social revolution seems to have been concluded with any degree of finality. Indeed, the enthusiasm for science generated by its transformation of society has lent substantial strength to those who, in the name of science, have sought to discredit the world-picture of religion on intellectual grounds. Nevertheless, the conviction that there has occurred a "completed revolution of the intellect caused by science,"[4] and that theistic religion is thus as outmoded as the phlogiston theory, remains just that: a deep-seated conviction, but certainly not an experimental observation.[5] In spite of the optimism of the eighteenth and nineteenth-century popularizers of scientific enlightenment, we have yet to see many of the results we might reasonably expect from such an intellectual revolution. The completely rational theology foreseen by the *philosophes* has not appeared.[6] Nor have the attempts to reduce human behavior (particularly ethics) to biology and chemistry been successful.[7] Moreover, the scientific criticism of religious history and literature—with the avowed aim of eliminating "mythical" or "unscientific" (which is to say, prophetic, miraculous and eschatological) elements—has brought the critics themselves a number of embarrassing surprises.[8]

Yet, strangely, the protagonists of religion continue to accept a basically defensive position *vis-à-vis* science and scientists. It has often been remarked that this unfortunate state of affairs is not due to any intrinsic incompatibility of scientific and religious thought, but rather to basic misunderstandings of the contrasting languages and practices of the two disciplines. What is less often noticed is that scientists are in large measure responsible for the misunderstandings, because they have consistently presented scientific practice "as though it were the outcome of a world-view with which it was in fact fundamentally incompatible."[9] As a result, the revolution in consciousness which led to the birth of modern science about the time of Galileo has been widely misinterpreted.[10] However, regardless of who bears the blame, we are all impoverished by the notion that the only possible relation between science and religion is one of perpetual conflict between unequally-equipped antagonists, whose will to fight is sustained by irreconcilable views about ways of knowing.

A thoughtful examination of the methods and underlying metaphysics of science discloses the possibility of a symbiotic and synergistic relationship with religion. There are, of course, familiar examples of physicists—Kepler, Newton, Maupertuis, Faraday and Einstein, to name several—for whom a fundamentally religious or mystical perception of reality served as the nourishing substratum of their most significant scientific speculations.[11] But too often, these cases are dismissed as anomalous, as if, for instance, Newton's preoccupation with theology represented a singular aberration of an otherwise extraordinarily lucid mind. In this essay, I shall try to show that such creative and fruitful interplay of religious and scientific thought is by no means an accident; on the contrary, it arises naturally from the fact that both the theory and practice of science must be guided by insights and judgments which cannot be formalized because of their subjective nature. We have long been accustomed to the idea that, in our present embryonic stage of intellectual and spiritual growth, we cannot demand a comprehensive and coherent picture of the universe from religion alone. In my judgment, we must now recognize the essential inconclusiveness of science, too, and learn to view science and religion "not as mutually destructive or reconcilable elements, but as polarities in a mutually-sustaining and dynamic tension."[12]

The existence of a symbiotic relationship between science and religion does not imply, however, that the two are "equal" in some sense. Religion is, and must be, a universal and ultimate human concern.[13] Science, on the other hand, while it should be a universal concern, can in no way be an ultimate concern unless we intend to renounce our humanity. However, religion will not solve the elementary particle dilemma; the solution to that problem will come from more and better science, not less. Nor will the difficult problems of theology be solved by the ultimate convergence of science and religion, as some scientists have suggested.[14] The object of quantum mechanics is not the search for God, but for wave functions and probability amplitudes, and knowledge of the scattering cross section does not lead to eternal life. For the moment, the conflicts will persist—but whether they persist to our salvation or damnation depends on us, rather than on the progress of the disciplines themselves.

I. *Science and Method*

Several years ago P. B. Medawar touched a tender nerve in the body scientific by asserting that "the scientific paper . . . misrepresents the processes of thought that accompanied or gave rise to the work that is described in the paper."[15] He concluded that, by pretending to complete objectivity and forcing their results into an inductive format, scientists were not only deceiving themselves and confusing the non-scientific world about the methodology of science, but actually impeding the progress of their research.

The general response to his ideas was predictably negative. We have convinced ourselves that the inductive method of the sciences has provided us with a triumphant and basely objective way of ferreting out the "irreducible and stubborn facts of nature"[16]—a notion seemingly confirmed by the "thingness" and utility of the technology which goes hand-in-hand with science and which, indeed, is often thoughtlessly equated with it. The humanities in general, and religion in particular, seem to suffer by comparison, because they deal in basically subjective insights.

However, this simple subjective-objective dichotomy is spurious, for the scientific method actually has a strong subjective component which effectively determines the social and intellectual structure of scientific inquiry. As we shall see, this subjective aspect of science makes it not only possible but in fact desirable for the religious and scientific communities to be allies rather than antagonists, for the benefit of science as well as of humanity.

A convenient starting point for discussion is the stereotype of the scientist drawn by Harping in "The Abacus and the Rose":

> Professor Lionel Potts doesn't know what the sun weighs, but he knows it weighs something. Something exact, to three places of decimals. Lionel Potts knows that everything weighs something. Everything can be measured and photographed and spectrographed and God-knows-what-o-graphed. That's it: Everything in Lionel Potts's world can be graphed—just graphed. Everything can be described. Who would dare tell Professor Lionel Potts, FRS [Fellow of the Royal Society], that beauty cannot be described? Who would hope to persuade him that description is not enough? That life, life outside the laboratory, also calls for judgments?[17]

Potts's business, as we have all been told since early childhood, is to make precise measurements of natural phenomena, and then to fit these data into an orderly, usually mathematical, scheme called a "theory." In this view—known variously as positivism or operationalism[18]—science deals with two kinds of statements and only two: empirical propositions which can be verified by sense experience, and formal definitions or tautologies (as in mathematics). Statements of value, feeling or purpose are considered meaningless for science. Thus a scientific theory is to be judged solely by its ability to account for all known observations and to predict the course of similar events in the future.

Clearly, science without substantial objectivity, or without careful measurements, is no science at all. But Harping's description of Potts as a man bent on quantifying the universe, oblivious even to "a single impulse from a vernal wood," is very superficial. Potts may not be a metaphysician, but he cannot make a single measurement or focus his dispassionate eye on any aspect of physical reality without asking a great many difficult questions, all of which call for personal (which is to say, *subjective*) judgments: What shall I measure to begin with? And once the data are in hand, what is to be done with them? Why do I claim that identical pulses of electricity in the same kinds of wires represent protons in one case and neutrons in another? If a measurement does not agree with a theory which has successfully explained all previous measurements, is the measurement in error? Or must the theory be revised? Suppose two theories explain the measured data equally well. Which theory is right? And what does "right" mean, anyway?

The concept of scientific theory as a purely objective resumé of experience shatters on these questions, precisely because science is much more than mere measurement. It is fundamentally a search for *intelligibility* in nature. Hence, "an accurate determination of the speed at which water flows in the gutter at a particular moment of time is not a contribution to science," writes Michael Polanyi,[19] because standing by itself, it is neither profound nor of intrinsic interest. And the problem of selecting interesting and profound experiments is only the beginning. The data arising from such experiments can be fit by an infinite number of mathematical functions, which thus embody them in a comprehensible pattern. But each such function or set of functions may have a completely different physical interpretation, and lead to divergent predictions for the future of the system being studied. Operationalism cannot give us a self-evident, logical criterion for choosing one mathematical embodiment of the data over another. Moreover, the question of extrapolating from a theory which comprehends present measurements to predictions of future behavior necessarily involves judgments of value.

Still more compelling arguments against Harping's view of the scientist can be found in the history of science. The Copernican revolution, for instance, was based not so much on new data as on a reinterpretation of extant observations in light of Copernicus' metaphysical ideas.[20] In fact, the Babylonian and Ptolemaic theories could probably have given better fits to the available data at that time than could the heliocentric theory. "Contemporary empiricists," notes E. A. Burtt, "had they lived in the sixteenth century, would have been the first to scoff out of court the new philosophy of the universe."[21] Copernicus' hypothesis was sustained at first more by his unshakeable confidence in the inherent beauty and simplicity of his theory than by the data—a pattern to be repeated in the monumental discoveries of Einstein, Planck, Schrödinger and Dirac in our own day.[22]

A more accurate description of the workings of science must still begin with the premise that the sensory experiences of the scientist—whether casual observations or measurements from carefully-contrived experiments—remain the primary data, the "givens," of scientific theory. But according to Planck, these brute facts remain a "chaos of elements" without any discernible pattern "unless there is the constructive quality of mind which builds up the order by a process of elimination and choice."[23] The scientific propositions founded on experimentation "are not derived by any definite rule from the data of experience," says Polanyi. "They are first arrived at by a form of guessing based on premises which are by no means inescapable and which cannot even be clearly defined; after which they are verified by a process of observational hardening which always leaves play to the scientist's personal judgment."[24] This process of guessing, in turn, influences the future course of experiment or observation. When a scientist begins work in the laboratory, he has already imagined a tentative order in the phenomena he intends to study. The experiment may be designed either to verify that conjectural picture of the world, or to prove it false; it may well be, after all, as helpful to know what kind of universe is *impossible* as to know what sort of world is probable. But in either case, both the experiment and the data it produces are already "theory-laden."[25]

This view of the scientist muddling toward cosmic truths by way of inspired or lucky guesses may not be as awe-inspiring as the operationalist picture of the disembodied Eye of science surveying the world by the cold light of reason and discerning inductively the underlying order in its apparently random processes. Nevertheless, this more accurate perspective displays the most remarkable feature of the scientific enterprise—which is not, as we sometimes erroneously suppose, its closely-defined universe of discourse, but rather its amazing tolerance for ambiguity. "One of the secrets of science carefully kept from the layman," remarks E. F. Taylor, "is that scientists can proceed fruitfully for many years in a given field without really knowing what they are doing. Indeed, one of the principal goals of scientists is simply to find out what they are doing."[26] Thus the scientific method is as much a way of *defining* physical reality as of understanding it.

This is not to say that there are *no* rules to guide the conduct of science. One usually requires of theoretical constructs that they be logically fertile, satisfactorily connected to other theoretical ideas, simple, and elegant: in addition, it is demanded that they satisfy the requirements of causality; and that their major premises be relatively permanent and stable. Experimental observations are usually judged by their fulfillment of theoretical predictions, and by their agreement with independent methods of measuring the same quantity.[27] But powerful as these criteria are, Polanyi comments, "I could give you examples in which they were all fulfilled and yet the statement which they seemed to confirm later turned out to be false." Hence, "Any exception to a rule may thus conceivably involve not its refutation, but its elucidation and hence the confirmation of its deeper meaning."[28] And it is crucial to see that a decision either to reject the exceptional theory or experimental result, or to examine it further in the hope of finding "its deeper meaning" must be based on an act of personal judgment by the scientist.[29]

Thus the task of identifying a scientific truth in a crowd of competing hypotheses is rather like judging a beauty contest, in which one seeks some pleasing combination of features the *particulars* of which are only partially describable. Indeed, one may select a theory which has one or two glaring defects, just as one might choose a beautiful woman in spite of a ski-jump nose. Niels Bohr's original version of quantum theory is a case in point: It violated the hitherto successful theory of classical electrodynamics, but was tentatively accepted, rather than being rejected out of hand, because it seemed to be the only reasonable solution to the baffling problem of atomic spectral radiation.

It may be objected that the truth of a scientific theory can be recognized unequivocally by its consequences or its fruitfulness. That is true—but when one is in the middle of the search, how is it possible to see that a proposition is true from a knowledge of consequences which are yet to be discovered? Again, one may argue that scientific truth is recognizable because it will be the hypothesis which most closely conforms to the criteria outlined above. However, these "rules of science" do not specify scientific procedures explicitly; they actually serve only as somewhat flexible constraints. It is impossible to put them in the form of a checklist for determining what the scientist will accept as true, because he does not know beforehand what the truth looks like in all its particulars. He has, instead, only an intimation or intuition of how it is *likely* to appear. Thus these "rules" limit the strategies and tactics employed in the pursuit of science, but do not prescribe them—much as the rules of chess do not determine whose strategy will win or lose, but only that neither player in a match may move his knight in a straight line.[30]

But if the rules or principles which guide us to the solution of scientific problems are not discernible *a priori*, "cannot even be clearly defined,"[31] and thus remain forever *tacit*, how can scientific inquiry survive at all? It is because, Polanyi argues, the premises of science "can be embodied in a tradition which can be held in common by a scientific community" and which undergoes a creative reinterpretation at the hands of every person who enters that community.[32] To be sure, many aspects of the communal tradition are controlled explicitly—as, for example, the theory of statistics which governs the handling of experimental errors. But "the major principles of science . . . are continuously remolded by decisions made in borderline cases and by the touch of personal judgment entering into almost every decision."[33] A tradition of science can be sustained in this way only if there exists a community which is in principle dedicated to "the fourfold proposition (1) that there is such a thing as truth; (2) that all the members love it; (3) that they feel obliged and (4) are in fact capable of pursuing it."[34]

The apparent tough-minded objectivity of science arises *not* because it deals only in observations and logical tautologies, but because the social contract of this scientific community requires of all its members (1) that for the sake of free discussion truth be divorced as much as possible from anthropomorphic characterizations;[35] (2) that questions of purpose in natural phenomena be left to metaphysicians wherever possible;[36] (3) that every theory be submitted in good faith to experimental analysis; and (4) that experimental observations be made available to the entire community for rigorous public discussion.

The idea of tacit knowledge sustained in a community by a tradition embodying rules of practice, mutual respect and a love of truth leads quickly to the realization that science, like vital religion, is a marvelous and fragile undertaking which can survive only under particularly favorable intellectual and spiritual conditions. This constitutes the fundamental basis for an alliance between the scientific and religious communities, for whatever threatens the survival of one imperils the continued existence of the other. Both disciplines, for example, are endangered by pietistic fallacies—represented in religion by an emphasis on outward appearances; in science, by the preoccupation with method and measurement. Pharisees and positivists serve important, but essentially negative, functions;[37] left unchecked, they can vitiate and finally kill the profound inward aspects of both science and religion. Similarly, religion and science may be damaged or destroyed by the coupling of limitless moral outrage and philosophical skepticism in existentialism and Marxism. For if, as the existentialists assert, "man is his own beginning, author of all his values,"[38] the acceptance of a communal tradition, so vital to the practice of religion or science, is an act of spiritual and intellectual treason, to be abhorred by every honest man. Or if, on the other hand, science and religion are controlled by the state as the embodiment of the people's will and ostensibly for its interests, individual freedom inevitably disappears—and without it, the creative re-interpretation of the scientific or religious heritage cannot occur.[39]

This is not to say that in such an alliance there would be no conflicts; there are profound points of disagreement, and what we must expect is a kind of creative dissonance, as in good friendships. But the day when one might feel obliged to keep religion in one mental compartment and science in another is past, or ought to be. Science, for its own good if for no other reason, can no longer pretend to be a world apart from the rest of man's intellectual and spiritual strivings. Moreover, the increasing demands on science to be responsive to human needs necessitates a *rapprochement* with the larger religious community, because it is there that the ultimate concern for human needs and values resides.

A pervasive awareness of the essential unity of human life and values is not easily achieved. But to those who make the effort, there opens up the welcome prospect of a religious faith released from the pressure of an intolerably narrow perspective of the universe, and of a science helping in the discovery of "a meaningful world which could resound to religion."[40]

II. *Science and the Consciousness of Reality*

It is tempting to assume that the great scholars of antiquity, the Renaissance and the Middle Ages did not develop modern science because their methods were inadequate. Yet there were sciences in all those periods of history—astronomy, biology, physiology, mechanics, for instance—which used all the methods of contemporary science: experiment, observation, measurement, classification, and inductive and deductive theorizing. And still theology, not mathematics, was queen of the sciences! Clearly, then, the change from the animated Macrocosm of Thomas Aquinas to the curved intergalactic space-time continuum of Einstein is *not* explicable simply in terms of the construction of the telescope, the invention of the calculus, and a few more centuries of observational and theoretical astronomy. Such a profound change in world-view can only be accounted for by a drastic reordering of "the whole apparatus of concepts and categories, within which and by means of which all our individual thinking, however daring and original, is compelled to move."[41]

It is this revolution in human consciousness which we must now consider. In tracing the history of this intellectual upheaval and the gradual emergence of the contradictions implicit in it, we shall see unfolding what I have earlier called the "inconclusiveness" of modern science. This metaphysical incompleteness turns out to offer important opportunities for a *personal* alliance between science and religion, much as the ambiguities in the scientific method open up possibilities for mutually profitable dialogue between the religious and scientific *communities.*

Consider for a moment the problem of perception. Our links with the familiar world of objects are various sensations: mechanical vibrations which rattle our auditory mechanisms, or electrical oscillations in the optic nerve. Physics tells us that these sensations arise from the motion of particles; but whether or not this is true, it is the sensations and not the particles which are the fundamental data of human and scientific experience. We live, then, in a sort of two-level world: One level is comprised of the particles, or more precisely, an *unrepresented* sub-sensible or super-sensible basis of the external world. The other level, which is the familiar world of appearances and phenomena, is made up of *representations* which our brains construct from the bare input of our sense organs. Note carefully that the representations include more than the sensation itself; "these mere sensations must be combined by the percipient mind into the recognizable and nameable objects we call 'things,' " observes Barfield, by a process which he has christened "figuration."[42] The representations are, in a manner of speaking, the costumes in which the sensory experiences appear after passing through the various dressing rooms of the mind.

We discover in a sort of experimental fashion that most human beings share the same or similar representations of sensory experiences; thus reassured, we impute the label "reality" to representations which are *collective.* Hence, our familiar world is in fact a world of collective representations.[43]

It is characteristic of twentieth-century Western minds that in figuration we are largely unconscious of the relation between ourselves and the representations. In analytical thinking, we deliberately consider the representations as wholly outside and independent of ourselves. But it was not always so. There was a time, extending back beyond the ancient Greeks to the great Oriental civilizations, and forward at least until the end of the Middle Ages, when man's primary experience of the representations was that of a *participant,* rather than an observer. For the participating consciousness, both figuration and analytical thinking are altered by this awareness of extra-sensory links between the observer and the phenomena.[44] And while sophisticated theoretical thought is quite possible in such a frame of mind (as in ancient science), its subjects—that is, the phenomena—are necessarily different because of the change in figuration. A participating consciousness did *not* see the same thing we see when looking, say, at a tree or at the moon. To such a mind, "the world was much more like a garment which men wore about them than a stage on which they moved."[45] And thus, for the scientists of antiquity, the only model of the universe which made any real sense was organismic, not mechanical. Man the microcosm was constantly aware of being nurtured in and by a macrocosmic Nature conceived, as in Plato's *Timaeus,* as "the nurse of all becoming."[46]

The origins of modern science may be traced to the gradual disappearance of these extra-sensory links to the world of nature. In the organismic model, for example, thought and space were connected, because every motion in the mind of man was the product of motion in the receptacle of his Becoming, which in turn reflected movements of the Forms of the ideal world.[47] However, Aristotle's speculations on the nature of thought led him to the conclusion that thought could be divorced entirely from external movement. Thus, in our world space is an object of perception, rather than its cause; the "receptacle of becoming" is no longer an active organism which brings about life and natural processes, but simply a neutral medium "out there" in which the phenomena are displayed.[48]

In addition, it was necessary to break the cycle of time, Plato's "moving image of eternity," and change the eternal round of history into a real succession of events *ordered* by time, viewed now as a dimension or as one of the coordinate axes of reality. This concept of linear time, for which we are primarily indebted to the Israelites,[49] made possible the evolutionary orientation of modern science, and the notion of cause and effect on a cosmic scale.

Galileo is one of the first modern scientific minds, and it is important to understand that he occupies his pivotal position in the history of science because, for him, participation in the phenomena has effectively ceased. This assertion can be verified in two different ways.

One piece of evidence is his ability to conduct thought-experiments, in which he considers "not real bodies as we actually observe them in the real world, but geometrical bodies moving in a world without resistance and without gravity—moving in that boundless emptiness of Euclidean space which Aristotle had regarded as unthinkable."[50] Galileo was not by any means the first man to construct a mechanomorphic model of the universe.[51] However, the abstract character of his models and the idealized space in which he imagines observing their evolution in time stamps his model-building as original and thoroughly modern.

An even more significant token of Galileo's rejection of the participating consciousness is his treatment of hypotheses. Hypotheses—including the heliocentric hypothesis—had been made long before his time. But for ancient and medieval thinkers, the primary concern in constructing an hypothesis was not to establish some particular one as an accurate picture of the universe, but to comprehend the Forms of an idealized nature by an act of indwelling, or participation.[52] Hence, it was of little consequence that several different hypotheses might save the same physical appearances;[53] there was simply no pressing need to choose among them. The astounding notion which occurred to Galileo[54] was that, if the heliocentric theory could save all the astronomical appearances, it was literally, *physically* true. It is this concept which marked for him the final break with both ancient science and the carefully rationalized theology of the Catholic Church. And only in this context can we understand Ricardi's instructions to Galileo's Inquisitor, "that the *absolute* truth should never be conceded to this opinion [the heliocentric theory], but only the *hypothetical*, and without Scripture."[55] (Italics added.)

Perhaps Ricardi had a premonition that analytical mechanics might one day become sufficently cogent and appealing to convince scientists that only such knowledge of the external world could be truly satisfying. At any rate, that is precisely what happened: Inspired by Galileo's success in saving the appearances with abstract mechanical models, others following him began the erection of a hollow, lifeless image of the universe, which was declared to be Reality itself and was, indeed, worshipped after a fashion (witness the talk of "the temple of science"). Small wonder Barfield speaks of the "idolatry" of modern science!

This might not have happened if scientists had paused to consider the metaphysical underpinnings of their work. But the peculiar circumstances surrounding the birth of modern science—the sense of revolt against the monolithic worldview of Scholasticism, and its early alliance with technology—conspired against that kind of meditative thinking. Modern science began as and "has remained predominantly an anti-rationalistic movement, based upon a naive faith," declared Alfred North Whitehead. "Science repudiates philosophy. In other words, it has never cared to justify its faith or explain its meanings."[56]

This disdain for philosophy gave physicists a false sense of security about the epistemological foundations of their work, and, ultimately, made the transition to atomic and molecular physics an emotional as well as an intellectual shock. But metaphysical conundrums were of little concern to science until the beginning of the twentieth century. Through three hundred years of magnificent achievements, the stubborn scientific faith of Galileo hardened into a dogma epitomized in Laplace's contention that he could "embrace in the same formula the movements of the greatest bodies of the universe and those of the lightest atom."[57] Henry Power, one of the first members of the Royal Society, felt that "the infallible demonstrations of Mechanicks" would "lay a new foundation of a more magnificent Philosophy never to be overthrown."[58] So, from its beginnings as *a* physical theory, analytical mechanics came to be considered *the* physical theory, and "it was as such that classical physics superseded organismic physics, tried to rule philosophy, and influenced even sociology and politics."[59]

However, when physicists actually moved to incorporate the "lightest atoms" and the phenomena of electricity and magnetism into the all-encompassing vision of mechanics, Laplace's creed could no longer be sustained. Between 1855 and 1926, almost every fundamental concept of mechanics was discarded or altered beyond recognition. Mass, length and time were redefined in Einstein's special and general theories of relativity. Planck, Bohr and Schrödinger developed a theory of quantum mechanics to describe atomic phenomena, with probability distributions replacing the simple mechanical causality of classical physics. From the laboratory came experimental data describing particles with wave-like behavior, and light waves which looked like beams of particles. The story has been told well elsewhere.[60] What is important for us is that relativity and quantum mechanics explicitly deny the possibility of a complete causal description of a physical system without any reference to an observer. The difficulty is most acute with atomic systems, where Heisenberg's uncertainty principle decrees the impossibility of a simultaneous measurement of all the variables needed for a comprehensive picture of the system. Measurements are possible, and they can be integrated into a causal framework, but we cannot mold "these isolated bits of perception and isolated causal chains into an objective model of the event; what fails is the 'objectifiability of nature.' "[61] Thus the physicist can no longer sit in the gallery as a disinterested spectator, but has been forced to come on stage with his machine.

With the breakdown of mechanism, some theoreticians looked to mathematics as a refuge. "Our quanta," wrote Arthur Sommerfeld, "remind us of the role that the Pythagorean doctrine seems to have ascribed to the integers, not merely as attributes but as the real essence of the physical phenomena."[62] Note well the change: In classical physics, mathematics was used as a shorthand for ordering the representations; now we have a new "idol," with wave functions and quantum numbers replacing the classical universe of point particles. But here, too, physicists came in for an unpleasant surprise, this time from the mathematician Gödel, who proved in an historic paper that even such a simple system as whole number arithmetic cannot have within itself a proof of its consistency.[63] Mathematicians and philosophers alike saw in Gödel's theorem the end of hope for a complete, self-consistent mathematical model of physical processes. Bertrand Russell, for instance, suggested that "physics is mathematical not because we know so much about the physical world, but because we know so little: it is only its mathematical properties that we can discover."[64]

Considered by itself, the failure of the mechanical model is certainly not catastrophic. Relativity theory, after all, does not require one to give up mechanism; it asks rather that one pay more careful attention to operational definitions of mass, length and time.[65] Even the paradoxical results of quantum mechanics—such as the wave-like behavior of electrons in crystals—might be made perfectly intelligible if one assumed that the electron was a more complicated object than an ordinary billiard ball.

Lord Russell's comment, on the other hand, hints at a profound *metaphysical* inconclusiveness in physics: that there is no self-evident, logical way of choosing an undergirding conceptual framework into which one can integrate particular experimental or theoretical results. That framework must be supplied by the scientist from his own perceptions and intuitions of the underlying realities of nature. When Einstein, for example, renounced the Newtonian ideas of space and time, he did so because he saw in them certain fundamental contradictions which demanded resolution. But he was led to this insight not by logical deduction, but by "intuition, resting on sympathetic understanding of experience," derived, as Einstein himself said, from a "cosmic religious feeling."[66] Similarly, the crucial role of symmetry concepts in particle physics could not have been deduced logically from the character of physical laws. Someone with a fundamentally aesthetic view of nature had to postulate the existence of still-undiscovered symmetries in the "zoo" of protons, neutrons and mesons—and then follow that intuition to the discovery of a new kind of order. Thus, just as Gell-Mann's classification of elementary particles on the basis of symmetries might be said to be as much art as science, so Einstein's general theory of relativity "was religion as much as science."[67]

In the final analysis, it is apparently the metaphysical incompleteness of physics which prevents the erection of a comprehensive, self-consistent model of the universe. And this should make us skeptical of claims for both comprehensiveness and logical consistency in any other science, because physics deals with the simplest models and has the most formal mathematical structure of all the sciences. I have no intention of stigmatizing scientific knowledge as meager or unsatisfactory. On the contrary: the Schrödinger equation is also "a thing of beauty, and a joy forever." But we must eschew the scientific idolatry which attempts to define reality solely in terms of some particular set of collective representations or hypotheses, and learn, instead, to meet reality in all the levels and varieties of human experience.

Once we acquire the intellectual and spiritual courage to discard our monolithic world-view, the metaphysical inconclusiveness of science ceases to appear as a threatening gap in our comprehension of nature. It offers, instead, the opportunity for laying new foundations in scientific thought—based on philosophy, art, and certainly on theology. In this way, we may also recover that feeling for the purposefulness of nature which was the special delight of the sophisticated scientists of antiquity.

We need, finally, to understand clearly that the failure of ancient science was not rooted in its mode of consciousness, but rather in its attempt to achieve a complete world picture through a single mode of thought. With the shift away from participation in the phenomena and the consequent bifurcation of the universe into objects and observers, we have gained an understanding and control of natural processes of which the ancients could only dream. Yet Laplace made the same mistake as Aquinas. Therefore it is not the method of science which we must renounce, but the madness. To this end, we would do well to pray with William Blake:

May God keep us
From single vision and Newton's sleep.[68]

III. *Problems and Prospects*

To recapitulate: We have drawn two major conclusions about science, based on the example of physics: First, that its methodology does not consist of prescriptions for "doing" science, but rather of rules of art, which are embodied in a tradition of practice preserved in and by a community dedicated to individual freedom and the pursuit of truth. Second, that physics, although it deals with the simplest and most fundamental phenomena of nature, is seemingly unable to give an account of these phenomena which is simultaneously complete and logically consistent, thus casting grave doubts on the ability of any scientific enterprise to do so. From these conclusions, I have inferred the possibility of a dialogue between science and religion, based on (1) their common interest in preserving moral and intellectual freedom for the scientific and religious communities; and (2) on the need of science for periodic infusions of categories and concepts not available in its own storehouse—a need which has frequently been met by theological, religious or mystical perceptions of the universe.

In all of this, I have stressed the contributions which religion can make to the progress of scientific activity and thought. Since I have assumed from the beginning that religion has a more fundamental claim on man than science, that is as it should be. After all, if "the fear of the Lord is the beginning of wisdom,"[69] how could a physicist resist? But even assuming this to be so, we are entitled to wonder how science can be a symbiotic partner with religion unless the relationship benefits religion as well.

Certainly the gift of science to religion is *not* the imparting of the scientific consciousness to religious thought. The end of participation in the collective representations of the phenomenal world occurred in Israel long before it happened in the West; and, interestingly enough, in the ancient East, where this revolution in religious thought did not occur, the development of science was substantially delayed.[70] So science is, if anything, the *product* of the revolution in theological consciousness: The Jews succeeded in divorcing their Creator from his creation long before Galileo was able to get the Prime Mover out of Aristotle's scientific cosmology.

Nor can science fill its proper place by permitting itself to be pressed into service wherever theologians need to buttress their own grand schemes of the universe. Of the myriad abuses of this type, two examples will suffice. One is the propensity of some religious thinkers for distorting scientific concepts to fit some theological principle—as when we are told that the quantum mechanical uncertainty principle gives us once more the possibility of free will, as if that were something which Laplace could take away and Heisenberg restore. A similar misuse of science is the all-too-frequent attempt to harness it to the task of "proving" scriptural accounts of creation—an effort that often, curiously, goes together with adducing gaps in scientific knowledge as "proofs" for the existence of God. I believe these abuses are based not on faith in the ability of religion to comprehend all truth, but instead on the unfortunate modern skepticism which accepts any scientific proposition, no matter how well-founded it may or may not be, as the only kind of knowledge worth having. And that is false to both religion and science.

On the other hand, science does offer to religion a valuable example of the continual interplay of creative doubt with an abiding faith in the basic orderliness of the universe. This fundamental article of scientific faith is grounded in "the medieval insistence on the rationality of God, conceived as with the personal energy of Jehovah and with the rationality of a Greek philosopher."[71] Unfortunately, now that religion has fallen into disrepute as the source of a unifying vision, this priceless legacy from medieval theology has been largely forgotten. Nevertheless, it remains possible for the scientist to work both critically and worshipfully, thus offering to the practice of religion one particular means (among many) of loving God with all one's mind.

Scientific propositions may also properly serve to confirm individual faith or elucidate theological principles. C. S. Lewis has written that the story of the Incarnation of Christ

> has not the suspicious *a priori* lucidity of Pantheism or of Newtonian physics. It has the seemingly arbitrary and idiosyncratic character which modern science is slowly teaching us to put up with in this wilful universe, where energy is made up in little parcels of a quantity no one could predict, where speed is not unlimited, where irreversible entropy gives time a real direction and the cosmos, no longer static or cyclic, moves like a drama from a real beginning to a real end. If any message from the core of reality were ever to reach us, we should expect to find in it just that unexpectedness, that wilful, dramatic anfractuosity which we find in the Christian faith.[72]

Newton, of course, would have used quite a different aspect of physics to bolster his faith, but that should not disturb us. The point is that religion is made lively and strong by any honest activity of the mind, *if* the activity is directed to that end. Science will serve as well, or as poorly, as art or literature in this regard.

As to the role of religion in science: Einstein observed that "religion without science is blind; science without religion is lame."[78] What so cripples science is its tendency toward idolatry—that is, toward the treatment of some particular set of collective representations as if it were itself the sub-sensible basis of the phenomenal world—and, paradoxically, the freedom of its practitioners. Religion can be of use in both areas.

The most helpful thing religion can do with idols, of whatever shape or size, is to smash them thoroughly. This ought not to be done with any trace of condescension or hostility, but rather with the frank good humor becoming an honest friendship. It is the function of religion as much as it is of science to replace illusion or ignorance with reality. Thus, when the scientist insists that he and he alone is able "in principle" to explain man or the universe, the theologian ought to smile and remind him that "there are more things in heaven and earth than are dreamt of in your philosophy."

This, however, is essentially a negative, critical function, and there is a more vital service to be performed. Because of the autonomy which the scientific community grants practicing scientists, specialization of research may lead not only to fragmentation of knowledge (which is tolerable if one can prepare for it and take certain countermeasures), but also to the aimless piling up of research papers which remain unintelligible to all but those working in the same tiny disciplinary niche. Religion offers a strong antidote to this poisoning of thought through its perspective of a God who created man and nature in infinite variety and staggering complexity, but who reveals himself in unexpected and delightful ways as the author of a cosmic orderliness and meaning. Such a perspective can serve as a constant reminder to science and scientists that the whole of the phenomenal world is wonderfully more than the sum of the parts into which it has been sliced for the relentless scrutiny of the various scientific disciplines.

All of this suggests the prospect for a mutually supportive relationship between science and religion, in which science might lend to the search for God the strength and critical appreciation of a mind viewing nature from outside, and with religion in turn offering to science the inspiration of eternal orderliness derived from its perception of man *in* nature. The creation of such a working synthesis of science and religion is necessarily a personal matter, of course. But it must be based on a steadfast refusal to gloss the apparently inevitable points of difference between disciplines, and a determination to treat conflicts as opportunities for a union in diversity, rather than as challenges to do battle over contested territory of thought. Such a relationship would, I think, be especially satisfying to Latter-day Saints, for whom no enterprise which forever splits spirit and intellect can ever be fulfilling.

However it may be achieved, a symbiosis embracing science and religion is essential if we are to avoid a dangerous compartmentalization of our thought and experience. That the relentless and sometimes heedless pursuit of science has unintentionally compromised our intellectual and spiritual integrity is clear from the persistent feeling of oppression and alienation that pervades so much of modern art and literature; from the "two cultures" problem outlined by C. P. Snow; from the burgeoning, irrational hatred of technology; and from the widespread, haunting feeling that "mankind is at the helm of a black ship bound for hell."[74] The malaise is curable, though, and religion can prescribe the specifics of the cure. What is required as a condition of understanding is intellectual humility and submissiveness coupled with a childlike and faithful curiosity. The medicine, it is said, tastes bitter at first, but comes in time to be quite agreeable. And if enthusiasm for trying the cure is wanting, we need only remember that the disease gives every indication of being fatal.

Recommended Reading

For those interested in further pursuit of this and related subjects, I would suggest the following books, which are arranged roughly in order of personal prejudice.

Jacques Barzun, *Science, the Glorious Entertainment*
Owen Barfield, *Saving the Appearances: A Study in Idolatry* (p)*
Stanley L. Jaki, *The Relevance of Physics*
J. Bronowski, *Science and Human Values* (p)
Michael Polanyi, *Science, Faith and Society* (p)
*Available in paperback.

Notes

[1]Quoted by Stanley L. Jaki, *The Relevance of Physics* (Chicago: Univ. of Chicago Press, 1966), p. 457.

[2]*Science, the Glorious Entertainment* (New York: Harper and Row, 1964), p. 24.

[3]*Ibid.*

[4]*Ibid.*

[5]Hugh W. Nibley, "Archaeology and Our Religion," unpublished paper.

[6]For an introduction to the fascinating activities of the *philosophes*, see Herbert Butterfield, *The Origins of Modern Science* (London: G. Bell and Sons, 1950), Chap. IX.

[7]C. S. Lewis, *The Abolition of Man* (New York: Macmillan, 1966), and Jaki, *op. cit.*, Chap. IX, "Physics and Ethics."

[8]Hugh Nibley, "New Discoveries Concerning the Bible and Church History," (Provo: Brig. Young Univ. Press, 1963), and "The Expanding Gospel," *BYU Studies*, 7:3-27.

[9]Charles Singer, *A Short History of Scientific Ideas to 1900* (Oxford: Oxford Univ. Press, 1959), p. 420.

[10]While I have epitomized Galileo as the man whose thought marks the boundary between ancient or medieval and modern science, I think it is important to realize that he, like Newton after him, was "standing on the shoulders of giants." For accounts of Galileo's intellectual precursors, see, for example: E. J. Dijksterhuis, *The Mechanization of the World Picture*, trans. C. Dikshoorn (Oxford: Oxford Univ. Press, 1961).

[11]Arthur Koestler, *The Sleepwalkers* (New York: Macmillan, 1968); Gerald Holton, "Johannes Kepler's Universe," *American Journal of Physics*, 24:350 ff. (1956); Jaki, *op. cit.*, Chap. X, "Physics and Theology"; Rene Dugas, *A History of Mechanics*, trans. J. R. Maddox (Neuchatel: Editions du Griffon, no date given), pp. 263ff.; Cornelius Lanczos, *Albert Einstein and the Cosmic World Order* (New York: Interscience, 1965).

[12]Wayne J. Pond, private communication.

[13]The phrase "ultimate concern" is Paul Tillich's.

[14]Cf. Charles H. Townes, "The Convergence of Science and Religion," *The Improvement Era*, February 1968, p. 62.

[15]P. B. Medawar, "Is the Scientific Paper Fraudulent?" *Saturday Review*, Aug. 1, 1964, pp. 42-43.

[16]William James, as quoted by Alfred North Whitehead, *Science and the Modern World* (New York: Macmillan, 1925), p. 3.

[17]J. Bronowski, *Science and Human Values* (New York: Harper and Row, 1950), p. 88.

[18]For a concise discussion, see Ian Barbour, *Issues in Science and Religion* (New Jersey: Prentice-Hall, 1966), pp. 162-66, 239-43.

[19]Michael Polanyi, *Science, Faith and Society* (Chicago: Phoenix, 1946), p. 49. Polanyi is an eminent British physical chemist who in recent years has turned his attention almost exclusively to the philosophy of science.

[20]Butterfield, *op. cit.*, Chap. II.

[21]Quoted by Polanyi, *op. cit.*, p. 27n.

[22]A poignant expression of the trials of scientific faith is given by Einstein: "In the light of knowledge attained, the happy achievement seems almost a matter of course. . . . But the years of anxious searching in the dark, with their intense longing, their alternations of confidence and exhaustion, and the final emergence into the light—only those who have experienced it can understand that." Quoted by Barzun, *op. cit.*, p. 92.

[23]Quoted by Jaki, *op. cit.*, p. 353. Max Planck, a German physicist, was awarded the Nobel Prize for his pioneering work in quantum theory.

[24]Polanyi, *op.cit.*, p. 42.

[25]Norwood R. Hanson, quoted by Barbour, *op. cit.*, p. 139.

[26]Erwin F. Taylor, *Introductory Mechanics* (New York: John Wiley, 1963), p. 107.

[27]Henry Margenau, *The Nature of Physical Reality* (New York: McGraw-Hill, 1950), Chaps. V, VI.

[28]Polanyi, *op. cit.*, p. 31

[29]Thus Polanyi, *loc. cit.*: "In my laboratory I find the laws of nature formally contradicted at every hour, but I explain this away by the assumption of experimental error. I know that this may cause me one day to explain away a fundamentally new phenomenon and to miss a great discovery. . . . Yet I shall continue to explain away my odd results, for if every anomaly observed in my laboratory were taken at its face value, research would instantly degenerate into a wild-goose chase after imaginary fundamental novelties."

[30]A. A. Moles, in his *La Creation Scientifique* (Geneva: Rene Kister, 1957), has attempted to catalog the strategies of different scientists, e.g., those who like to use the method of contradiction in theoretical work, and those whose experimental tactics consist of apparently random but actually extremely clever and sophisticated tinkering. See also Barzun, *op. cit.*, pp. 92-95.

[31]Polanyi, *op. cit.*, p. 42.

[32]*Ibid.*, p. 56.

[33]*Ibid.*, pp. 58-9.

[34]*Ibid.*, p. 71.

[35]This is a continuing process in physics. A current example is the growing preference for the neutral term "interaction" in place of the older, anthropomorphic concept of "force."

[36]It is not yet clear how far this requirement can be carried in dealing with sentient systems,

as in biology or psychology. For two opposing points of view, see Polanyi, *The Tacit Dimension* (New York: Doubleday-Anchor, 1967), pp. 36-52, and J. Bronowski, "New Concepts in the Evolution of Complexity," *American Scholar*, Autumn 1972, pp. 570 ff.

[37]Thus C. F. von Weizsäcker: "Positivism . . . says no more than science already knows. It is then in a sense the null class among philosophical systems, with the merit of the most radical self-criticism." (*The World-View of Physics* [Chicago: Univ. of Chicago Press, 1952], p. 113.) Nevertheless, this self-criticism can be extremely useful; Ernst Mach's positivist attacks on classical mechanics not only pointed out serious shortcomings in the theory, but stimulated Einstein to do something about them. The result was the theory of relativity.

[38]Polanyi, *The Tacit Dimension*, p. 80.

[39]Polanyi, in the Introduction to *Science, Faith and Society*, declares that he was originally led to the search for a new scientific epistemology by the abuses of science in the Soviet Union —a society which in theory was founded on scientific principles. In practice, though, party ideologues nearly destroyed Soviet biology in the 1940s, and tried as late as the middle 1950s to force Russian physicists to renounce relativity theory in the name of Communist doctrine. See Jaki, *op. cit.*, Chap. XI, "The Fate of Physics in Scientism."

[40]Polanyi, *The Tacit Dimension*, p. 92.

[41]Francis MacDonald Cornford, *From Religion to Philosophy* (New York: Harper and Brothers, 1957), p. 45.

[42]Owen Barfield, *Saving the Appearances: A Study in Idolatry* (New York: Harcourt, Brace and World, 1965), Chap. III. Quotation from p. 24.

[43]*Ibid.* Cornford, *op. cit.*, pp. 43-50. Erwin Schrödinger, *What is Life? and Other Scientific Essays* (New York: Doubleday-Anchor, 1956), p. 210.

[44]As in totemism. See Barfield, *op. cit.*, Chap. IV, and Cornford, *op. cit.*, pp. 55-63, 73-90.

[45]Barfield, *op. cit.*, p. 94.

[46]Plato, *Timaeus*, trans. F. M. Cornford (Indianapolis: Liberal Arts Press, 1959), p. 48 (Para. 49a).

[47]Plato notes that "the revolutions of our own thought are akin to them [the motions of the heavens], though ours be troubled and they are unperturbed." *Timaeus*, p. 45.

[48]This same process led to the development of perspective in painting.

[49]Barfield, *op. cit.*, Chap. XXII.

[50]Butterfield, *op. cit.*, p. 5.

[51]Oresme and Buridan, who preceded Galileo, realized that a mechanomorphic nature would need no celestial intelligences to drive the spheres—which would be more in accord with the biblical accounts, in which no such animating spirits were mentioned. For this reason, mechanical models even had the limited backing of Catholic theologians. Jaki, *op. cit.*, pp. 416-17.

[52]For Plato (*loc. cit.*), "by learning to know them [the revolutions of the heavenly bodies] and acquiring the power to compute them according to nature [that is, to save the appearances], we might reproduce the perfectly unerring revolutions of the god and reduce to settled order the wandering motions in ourselves."

[53]"Saving the appearances" is a technical term for the proper use of hypotheses; we would probably say that an hypothesis "fits the data." See Barfield, *op. cit.*, pp. 46-52.

[54]Thus the germ of this idea was also stated by Kepler: God, he says, "founded everything in the world according to the norm of quantity." Hence, when "harmonies [of numbers] . . . accommodate experience," we have arrived at the real order of nature. See Gerald Holton, *loc. cit.*

[55]Quoted by Giorgio de Santillana, *The Crime of Galileo* (Chicago: Univ. of Chicago Press, 1955), p. 317.

[56]Whitehead, *op. cit.*, p. 24.

[57]Quoted by Jaki, *op. cit.*, p. 67.

[58]*Ibid.*, p. 93.

[59]*Ibid.*

[60]Jaki, *op. cit.*, Chaps. II and III. Albert Einstein and Leopold Infeld *The Evolution of Physics* (New York: Simon and Schuster, 1955). (It is not as well known as it should be that

Einstein was one of the most gifted and understandable popularizers of modern physics.) Banesh Hoffman, *The Strange Story of the Quantum Theory* (New York: Harper and Brothers, 1947).

[61] von Weizsäcker, *op. cit.*, p. 33.

[62] Quoted by Jaki, *op. cit.*, p. 108.

[63] Jaki, *op. cit.*, pp. 127-130.

[64] *Ibid.*, p. 128.

[65] "Einstein's *relativity of time* is a reform in *semantics*, not in metaphysics." Phillipp Frank, *Einstein, His Life and Times* (New York: Alfred A. Knopf, 1947), p. 63.

[66] Albert Einstein, *The World as I See It* (New York: Covici, Friede, 1934), pp. 22, 264.

[67] Lanczos, *op. cit.*, p. 112.

[68] Quoted by Barzun, *op. cit.*, p. 295.

[69] *Proverbs* ix, 10.

[70] Jaki, *op. cit.*, p. 419.

[71] Whitehead, *op. cit.*, p. 18.

[72] C. S. Lewis, *The Problem of Pain* (New York: Macmillan, 1966), p. 25.

[73] Quoted by Jaki, *op. cit.*, p. 345.

[74] Barzun, *op. cit.*, p. 18.

and God said:

$$\text{``}\frac{mv^2}{r} = \frac{Ze^2}{r^2}$$

$$mvr = \frac{nh}{2\pi}$$

$$r = \frac{r^2h^2}{12\pi mze^2}$$

$$E = \tfrac{1}{2}mv\frac{Ze}{r}$$

$$E = \frac{2\pi^2h^2}{nh} = Ry\text{''}$$

and there was:

Light