

“COMPLEMENTARITY” IN SCIENTIFIC AND THEOLOGICAL THINKING

by *D. M. MacKay*

Theology, at least in its Christian theistic form, is all-embracing. Our world is declared to be God's world—the whole of it. All our knowledge—physical, biological, historical, philosophical—is knowledge of God's creation. If this is not an empty claim, then the theologian is bound to seek relations between the statements made in different academic disciplines and those he makes in specifically theological terms.

Faced with the conceptual disparity between assertions about breeding habits of the fruit fly or the isotopes of helium on the one hand, and about the Kingship of Christ or the necessity of regeneration on the other, we may be tempted to create a verbal relation, where no other is apparent, by invoking the omnibus name of “complementarity.” Physicists have popularized this term to represent the relation between “wave” and “particle” aspects of the behavior of light without fully understanding it. Why should not the theologian ease his conscience by following in such distinguished footsteps and broadly declare his theological statements and those made in other disciplines to be simply “complementary”?

The most obvious objection, of course, is that such a blanket use of the term is logically empty unless we can say what it would mean for two statements not to be complementary. By what criteria are we to distinguish statements that show genuine complementarity from those which are totally unrelated, related but only supplementary, or related but flatly contradictory? How can we prevent complementarity from becoming yet another fashionable escape gate from intellectual integrity in theology?

D. M. MacKay, Research Professor of Communication, University of Keele, Keele, Staffordshire, presented this paper at a conference on “Science and Religion: The Complementarity Hypothesis,” organized by J. H. Hick, in Birmingham, England, April 1969. “I am indebted to a number of friends, especially to Dr. J. M. Forrester, for helpful criticisms of an earlier draft of this paper,” the author says.

[*Zygon*, vol. 9, no. 3 (September 1974).]

© 1974 by The University of Chicago. All rights reserved.

There is, however, a second objection to be raised to the tongue-in-cheek proposal above, namely, that to invoke the use of the term in physics as a justification of its use in theology would be both dangerous and misleading: dangerous, because the validity of the concept in theology might then seem to be dependent on the changing winds of fashion in physics; and misleading, because complementarity is not basically a physical concept but a logical one.¹ In discussing whether religious and other types of assertion are logically complementary, the greatest confusion arises from attempts to use complementarity in quantum mechanics as the "paradigm case." The current debate in quantum physics is relevant to us now, I suggest, mainly as a cautionary tale.

WHY COMPLEMENTARITY?

Why then spend time in discussing the concept at all in the context of theology? If (as I suggest) we should resist its automatic invocation as a universal panacea, why not drop it altogether? The answer offered in this paper is that whether we like it or not, we need it; and by "we" I mean not just Christian apologists seeking new clarification of the faith as science marches on, but anyone, whether Christian or not, who wants to avoid logical blunders in seeking to bring science and faith into confrontation. Complementarity stands not for a physical theory, still less for a mystical doctrine, but rather it stands for a particular kind of logical relation, distinct from and additional to traditional ones like contradiction, synonymy, or independence; it demands to be considered along with others whenever there is doubt as to the connection between two statements. In the context of science and theology, it offers an alternative both to the view that makes all divine activity supplementary to the (presumed incomplete) chain mesh of scientifically describable cause and effect ("God in the gaps"), and to the "watertight compartment" theory that religious and scientific statements are logically independent. Complementary statements are not logically independent. By saying that they are about the same situation we mean that there is at least one feature of one of the statements whose alteration or absence would necessitate a change in the other(s). They show correlations, or at least what might be called "existential covariance." As logical relations go this is a weak constraint but not a negligible one. We shall see that it can sometimes be asymmetrical, in the sense that the alteration or absence of a feature in description A would necessitate a change in B, but not conversely. (The absence of one letter from a line of print would necessitate a change in the physical account of the ink particles, but the absence of many ink particles could be tolerated without requiring a

change in the list of letters.) But, in any event, it falls far short of logical independence in the range of possible descriptions that it allows to be mutually compatible.

On the other hand, the logical possibility of complementarity imposes additional obligations on anyone who wants to argue that two statements about the same situation are not compatible. It is here that we make contact with the history of atomic physics. What excited the physicists who first used the term was the discovery of an apparent contradiction that had to be lived with. What their different experiments taught them about the nature of light (and of matter) could not be expressed in conventional terms without inconsistency; yet each statement seemed abundantly justified by the results of the appropriate experiment. Understandably, at first sides were picked and furious attempts made to demonstrate flaws in the evidence for the wave picture or for the particle picture. When Bohr eventually proposed that the two should be regarded as not contradictory but complementary, however, he was doing much more than recommending acceptance of the inevitable. His main point could be paraphrased thus in general terms: If we acquire knowledge of a situation by different modes of interaction, the description found valid in one mode may be inapplicable in another, and more than one description may be required to do justice to the situation. This means in practice that two disparate descriptions can be checked for compatibility only after due allowance has been made for the standpoint from which each is valid.

THE NOTION OF "STANDPOINT"

Clearly, the key notion that needs explication here is that of the "standpoint" of a description, or, more pertinently, that of a "difference of standpoint" between two or more descriptions. Rather than pursue the technicalities of the example of quantum physics, which I have discussed elsewhere,² I had better begin with some simpler cases in which the notion of difference of standpoint is more or less literal.

Take for instance the familiar disparity between left- and right-eye views of our visual world. We look directly down a line of street lamps with one eye and see the fainter lights lying to the left of the brighter. Viewed with the other eye, the fainter lie to the right. Here is an apparent contradiction, which in a two-dimensional world would be irreconcilable. Yet, when we use both eyes, the disparities at once cooperate to give us a unified view of a line of lights receding in depth. The two views, we say, are complementary.

Trivial though it may seem, this example has much to teach us. In the first place, to speak of complementarity here is not so much to

emphasize the removal of apparent contradiction (for in normal binocular vision none is experienced); rather, it points to the possibility of gaining information about an additional dimension from a proper use of the two views. Second, as explained above, complementary views are by definition views of the same subject: In this sense complementary descriptions must have a common reference,³ although they need not, and in general will not, refer to the same aspects of it. Third, there could be no excuse for claiming that two disparate views of the same subject were complementary rather than contradictory unless in some respect (of position or time, for example) they were different in standpoint. It is because left and right eyes are not related in the same spatial way to the subject that we accept that their views may differ without contradicting each other. Fourth, what gives meaning to the additional dimension we perceive as "depth" is that we have to reckon with it. We have to walk farther, for example, if we want to reach the lamps judged farther in depth.

This leads, however, to a fifth point. If, instead of using the synthesizing machinery of our binocular visual system, we were obliged to look at each of two stereoscopic views one at a time, we might have great difficulty in perceiving, or even inferring, all the order in depth implicit in them. (An extreme example would be a pair of stereoscopic pictures of a leafy forest, where individual trees might be completely camouflaged in monocular view, though clearly identifiable when viewed stereoscopically.)

This point is especially relevant to disparate verbal descriptions, which can only be considered one at a time. If, as I shall argue, there are pertinent similarities between reducing a scene to a number of complementary projections and reducing a situation to a number of complementary verbal descriptions, we can expect that individuals may differ in their ability to synthesize such descriptions; indeed there may be subjects so complex that no single integrative perception is humanly possible. (See end of the next section of this paper.)

Consider as a second example the familiar plan and elevation drawings of a building. Here the views are orthogonal—each standpoint is "blind" to one dimension of the subject which is fully displayed to the other(s). Moreover, our stereoscopic faculty cannot synthesize the disparate views. Only an effort of imagination, aided by training and experience, enables the architect or builder to envisage the subject as a whole; and for the uninitiated layman the task may prove impossible, though he will be perfectly capable of recognizing the unity of the building in each projection once he has had experience of it in other ways—for example, by moving about in its vicinity.

Note that for our purpose we are taking the case of "full projec-

tion," where every point in the original subject finds itself represented in each two-dimensional view (though those lying in line with the eye are of course presented as coincident). If we had only orthogonal photographs of the outside of a building, then in general the surface shown in each would not be the same, and it would not be strictly true to say that all are representations of exactly the same subject. With full point-by-point projection, however, we can say in one sense that each projection exhausts the subject—leaves no point unaccounted for—although each leaves undisplayed an aspect of the situation, namely, the order of the points in the missing dimension. (With a subject of more than three dimensions, of course, more than two plane projections would be needed to specify the order of points completely.) It is tempting (and often harmless) to say that each projection "leaves *something* out" which the others supply; but this expression can cause confusion. If any point of the subject were made momentarily luminous, it would "flash up to be counted" in each of the projections; so what each projection leaves out is not "things" in the sense of parts of the subject but rather the relations between parts of the subject—things that can be said in each case without impugning the accuracy of a projection that necessarily omits them. This ambiguity of the term "exhaustive" must be clearly recognized if discussion is to be coherent. In what follows I shall always use it according to the criterion already indicated: That if all the features listed in an exhaustive account of a situation were eliminated one by one, we would be left with nothing. In this sense a full projection of a geometrical figure, point by point, is exhaustive, for if every point represented in the projection were removed from the original we would be left with nothing. The electronic description of a telegraphic signal is exhaustive,⁴ for if every feature of the signal so described were removed, the signal would disappear. Such an account, however, does not in general exhaust the relation structure of the subject; and it is of the essence of complementary accounts that they are not exhaustive of what can be said about the subject.

HIERARCHIC COMPLEMENTARITY

So far the two or more complementary descriptions in our examples have been logically at the same level, employing concepts of the same kind though in different patterns of relationship. We now turn to an illustration of a different kind, where the concepts in one description are different in logical level from those in the other(s). Consider a computing machine programmed to solve some mathematical problem, and suppose we ask a mathematician and an electronics engineer to account for its behavior, each in his own terms. The mathematician

invokes his equations and their boundary conditions and declares that the behavior is fully determined by these. The engineer invites us to follow the chains of cause and effect through all the transistors, etc., in the machine, and equally convinces us that he has accounted for all the behavior. Yet neither account even mentions what the other presents as the key factors. One talks about the order of equations, the other about the currents in transistors. These concepts are quite disparate. Yet each claims to be talking about the same happenings. Each (in real life) would recognize the other's account to be both valid and essential "from its own standpoint." In short, the two are complementary, in the sense we are using.

What then do we mean here by a standpoint? It has nothing now to do with a limitation on the evidence physically available—we may assume for the sake of argument that each observer has the same information presented to his eyes. Colloquially, we would describe the difference between the two by saying that one reads as mathematical tokens events that the other analyzes electronically. The contrast between their standpoints lies in the kind of categories appropriate to each—the kind of cognitive interaction with the subject to which each is made liable by his particular "state of readiness." The one, "set" to read mathematically, witnesses mathematical transactions; the other, "set" to analyze electronically, witnesses electronic transactions. Neither observer need leave any happening of this particular kind unaccounted for, though each systematically fails to mention what the other emphasizes.

Note, however, that the question whether a particular standpoint (in this sense) is valid is essentially an empirical one. If I discover that I have been reading as a message in Morse code the buzzing of a fly, I do not claim to have perceived a complementary aspect of the situation but confess to a mistake. If a key transistor breaks down in the computer, the engineer warns the mathematician against any attempt to read the results mathematically. Conversely, cumulative experience that it makes sense in practice may sometimes offer the best evidence for the validity of a perceptual standpoint—as, for example, in our recognition of other people's activity as personal and conscious.

In examples of this kind there is a significant asymmetry between the descriptions from the different standpoints.⁵ Some sort of electronic transactions must be describable if anything mathematically significant is going on in the computer; but the converse is not true. (There are, for example, power supplies and regulators whose activities have no mathematical significance.) Some sort of thermodynamic transactions must be describable if anything electronic is going on; but the converse is not true; and so on. The levels of description in such cases form a hierarchy.

But, a critic might ask, Even when we restrict attention to the computing circuits, can we really describe the engineer and the mathematician here as perceiving complementary aspects of the same data? Surely the mathematician's data include a vast array of the facts of mathematics which (we assume) the engineer does not possess. Is it not these extra data that make the difference?

This objection confuses two sorts of data. There is no dispute that the kinds of perceptual standpoint available to a man depend on the data of his whole past experience and his constitution; it is not the data he *brings to* the new situation, however, but those which are *offered by* the situation that we are saying can be perceived in complementary ways.⁶ This becomes clear when we reflect that the engineer and the mathematician of our example could well be one and the same person, fully equipped for either perceptual standpoint, but choosing one or another standpoint according to the kinds of question he wishes to answer by his observations. There are innumerable contexts, such as proofreading, tapestry weaving, and the like, where the transition to higher-level perception may even be facilitated by a change (of viewing distance, for example) which reduces the total amount of information perceptible in the data. What is needed is not extra information per se but rather a different set of perceptual categories in terms of which to respond to its impact.

A further objection may be considered. Granted the distinction between the aspects perceived, how certain are we that the different sets or states of readiness required are mutually exclusive? Can we not sometimes be aware simultaneously of the meaning of a passage and of a misprint in it, for example?

Indeed we can; and it is important to see that the claim that two aspects are complementary does not depend on showing that our experience cannot reflect both at the same time. Recall the example of binocular vision. It is normally only by closing one eye at a time that we even become aware of disparities between the two views that combine in depth perception. What justifies us in describing them as complementary is that their geometrical viewpoints are mutually exclusive; that both cannot simultaneously be valid from the same point rather than that we cannot perceive them simultaneously, using two eyes. Similarly with the mathematical and engineering views of the computer's activity: What makes them complementary is the mutual exclusiveness of the respective schemes of explanation, rather than that one person cannot entertain both. To opt for a mathematical scheme of explanation is to undertake to play that particular game through to the end without introducing electronic categories into that game, and conversely. We may be fully aware that both games can legitimately be played and may acquire some measure of skill in keep-

ing both going more or less at the same time in our own heads. Once we know the code, we can even use data in one set of categories to check the accuracy of descriptions in the other. But the descriptions and explanations generated by either, for events that admit of both, are in principle exhaustive—they have no vacancies in their chain mesh of cause and effect for concepts from the other—and in that sense they are logically complementary.

For my present purpose the chief point to emphasize in conclusion is a negative one. Explanations of the same events in different categories may each claim to be exhaustive (in the sense of the preceding section) without any necessary implication of logical rivalry; they can be judged incompatible only if the correlate of the one in the categories of the other is contrary to what the other affirms. To say, for example, that “machines and living mechanisms are irreducible to the laws of physics and chemistry”⁷ is true in the sense that in the categories of physics and chemistry we can neither formulate nor answer all the questions appropriate to machines and living mechanisms. It is misleading, however, if it is taken to deny that physics and chemistry can account for all the physical events in such mechanisms. It might be less ambiguous and more accurate to say that machines and living mechanisms demand explanation in categories complementary to those of physics and chemistry, thereby removing any possible excuse for reductionist opponents to pose as the defenders of physicochemical law.

QUANTUM-MECHANICAL COMPLEMENTARITY

Perhaps a word should now be said on where complementarity in quantum physics fits into the background we have sketched. Our contention has been that to call two statements “complementary rather than contradictory” is to make a simple logical claim about the way they are related, which requires no knowledge of physics whatever to understand. Essentially, as I have suggested elsewhere,⁸ the claim is that the logical preconditions attached to the exact use of key terms in each are mutually exclusive. (A nonhierarchical example would be terms such as “to the left of,” or “in between,” as used in geometrical descriptions of the same subject from two different viewpoints; a hierarchical example would be a pair of terms such as “English” and “electrical” as used in different descriptions of a telephone signal.)

What then of physical complementarity? Is it hierarchical or nonhierarchical? The categories of wave language and particle language seem so disparate that they might well be expected to be related hierarchically; but in fact their complementarity has a direct analogue

in the Theory of Information which can easily be seen to be symmetrical. (Readers not interested in technicalities may skip the following four paragraphs without loss.)

It is well known that in acoustics a musical note, or a speech wave, can be specified by the spectrum of frequencies (with their amplitudes and phases) that go to make it up. The transformation from a description of the sound wave in terms of its amplitude as a function of time, to one in terms of the amplitude of its spectrum as a function of frequency, is known as a Fourier transformation. Now it so happens that pairs of "conjugate" descriptive variables (such as frequency and time), which are related in this way by a Fourier transformation, have a peculiar property. Purely for mathematical reasons (nothing to do with physics), the more precisely a wave is localized in terms of the one variable, the more diffusely it is in terms of the other.⁹

The narrower the duration of a wave in time, the broader is its frequency spectrum, and conversely. A wave restricted precisely to a point in time (i.e., a momentary impulse, like the sound of an infinitely brief pistol shot) has an infinitely broad spectrum—that is, a completely undefined frequency. A sinewave with a well-defined frequency must extend uniformly to infinity in time; it has a completely undefined epoch. Thus the precondition of definition of "exact frequency" logically precludes the attribution of exact frequency to a wave function restricted to a finite range of time, and vice versa. Frequency and time are logically complementary descriptors. The two can be mixed in one description only at the cost of an irreducible and reciprocal imprecision in each; the more exact the one, the less exact the other. The minimum product of the two imprecisions, $\Delta\nu \cdot \Delta t$, is in fact a constant with the value $\frac{1}{4}\pi$,¹⁰ and is associated with what Gabor called a "quantum of information."¹¹

To cut a long story short, this leads to the mathematical representation of a signal by a figure in which the frequency and time axes are at right angles.¹² Descriptions purely in terms of frequency and of time can be thought of as very roughly analogous to projections at right angles; they are complementary in basically the same sense as the plan and elevation projections of a building (i.e., symmetrically and nonhierarchically). A similar complementarity exists between descriptions in terms of wave number (the reciprocal of wavelength) and of spatial coordinates.

The complementarity of microphysical descriptions in terms of wave and particle properties now follows directly, from the empirical finding that "particle energy" E and "particle momentum" p are always proportional to "wave frequency" ν and "wave number" $\bar{\nu}$ in the ratio h , Planck's constant; that is, $E = h\nu$; $p = h\bar{\nu}$. Assuming this proportionality, it is evident that a precise specification of the energy or momentum of an event logically excludes the possibility of assigning a precise epoch or location to it. Reciprocal imprecision is logically inevitable, and the minimum product of the two imprecisions (in energy and epoch, or momentum and position) is, as we would expect, just h times the mathematical "quantum" $\frac{1}{4}\pi$ (i.e., $h/4\pi$).

This brief excursion into technicalities is meant to serve two purposes: In the first place, and incidentally, it makes quite clear that complementarity in microphysics between energy and epoch, or be-

tween momentum and position coordinates, hangs on the empirical relations $E = h\nu$, $p = h\bar{\nu}$ and is not therefore in any sense absolute. If we want to find an example of logically unquestionable complementarity in this area, we must go to the mathematics that underlies it. Second, we can see that although it may be tempting for historical reasons to take as "paradigmatic" the microphysical case, this would logically have been to start from the wrong end, involving us in protracted debate as to which adventitious features we could afford to ignore. Starting from the general logical concept of complementarity I have outlined, one will find it easy to check that the relationship Bohr claimed to find in microphysics was indeed a particular nonhierarchic case of the same concept. The vindication of its use in theology, I would argue, must proceed in the same way, quite independently of dubious analogies with current physical theory.

THEISTIC AND SCIENTIFIC DESCRIPTIONS

For biblical theism the successive events of the natural world are the continual expression of one eternal creative fiat. As Mascall has put it: "The relation between God and the world, to which the term 'creation' applies, is to be identified not with an act in the past by which the world was originated, but with an incessant activity by which it is conserved in existence."¹³ The "world" here referred to is thus the whole of our space-time and not any particular temporal cross section of it; and the creative act that gives being to our space-time is clearly not itself an isolable event in our time, any more than the creation of a novel by a human author is an event on the time scale of its characters. There is no suggestion in the Bible that the world be identified with God, as in pantheism; but equally there is no room for the deistic idea of nature as an independent agency with which God merely interferes from time to time.

For our present purpose what matters is not whether we accept the biblical doctrine (though I personally do) but rather what kinds of relation it implies between theistic and scientific statements. One immediate consequence is a dynamic rather than a static conception of "laws of nature." The Creator is faithful, therefore dependable regularities in His activity are worth the seeking; but His thoughts are higher than ours, therefore we cannot lay down in advance the form the regularities must take and must seek them in humility and openness of mind.¹⁴ Science has a legitimate category of "events we would have no scientific right to expect"; but the notion of "scientific impossibility" is nonsensical.

On the other hand, the biblical concept of miracle is not at all coextensive with that of the scientifically inexplicable. Emphasis in the Bible is primarily upon the way in which the events termed "miracu-

lous” made sense—were found to be coherent in terms of the personal faithfulness of God to his ongoing relationship with the people concerned. If a miracle had to defy all natural understanding, well and good—that was the Creator’s business, and the existence of the whole show defied natural understanding anyway; but the recognition of the cause of a miracle in a “natural” event would not *ipso facto* lessen its miraculous status.

It is clear that this way of talking about natural events amounts to a “reading of their significance” as the Creator’s utterance. What is less clear is to which scientific statements, if any, such “readings” are complementary. For example, is the biblical doctrine of creation complementary in any rigorous sense to the various scientific theories of cosmological beginnings?

To the extent that the two kinds of accounts, each in principle exhaustive in the sense defined above (“The Notion of ‘Standpoint’ ”),¹⁵ use categories which are hierarchically related and refer to the same pattern of events, it would seem reasonable to describe them as “not contradictory but complementary.” On the other hand, to call the story told by the cosmologist a “complementary account of the creation” in the theistic sense would, I think, be open to criticism; for, as already noted, it is not only some early events of our space-time but the whole of it which is declared to issue from the divine creative act. To quote Mascall again: “The fact—if it is a fact—that creatures begin in time is really altogether irrelevant to creation; creatures are created, whether they begin in time or not, provided only that they exist.”¹⁶ In other words, the concept of a “first event” referred to by some cosmologists as “the creation of the universe” is not the same concept as the theologian’s which is referred to by the same name. By the same token, the story of evolution is logically neither a rival of, nor strictly complementary to, the creation narrative of Genesis 1—any more than the early history of the characters in a novel would be either a rival of, or complementary to, a narrative of their conception by its author, although each (in a different sense) answers a question about “origins.” It is only when we are considering created history as a whole that we can strictly say that the scientific and theistic answers to the question of origins have the same reference and are complementary in the sense of describing *different aspects of the situation* from mutually exclusive standpoints, though not in fact answering the same question.

COMPLEMENTARY EXPLANATIONS

When we come to particular events, however, it is the notion of scientific explanation that most commonly creates an apparent conflict with theistic claims. “The Lord sent an east wind” (but had not

this a sufficient chain mesh of preexisting physical causes?). "The Lord hardened Pharaoh's heart" (but would not a psychologist have been able to explain the process without reference to God?). "The Lord answered my prayer" (but was not the event you call the answer clearly the result of processes set in motion before you prayed?). The absence of any vacancies for nonphysical causes in the official scientific scheme of explanation encourages many people to abandon the category of divine activity as outdated by the march of science. Of course it is possible, as Pollard recently has done,¹⁷ to reject the deterministic image of science and make room for divine activity in the domain of "chance"; and present knowledge certainly cannot gainsay such a move. But for our purpose it is more interesting to consider whether the move is necessary or even appropriate to the reinstatement of the doctrine in question. Does that doctrine in fact presuppose the absence of a sufficient natural explanation of the events attributed to the hand of God?

Our suggestion is that it does not—that in fact the theistic and scientific accounts here (whether or not we believe them) are hierarchically complementary. "Consider the fowls of the air . . . your heavenly father feedeth them";¹⁸ nothing could be more naturally explicable than the food supply of birds. "You thought evil against me: but God meant it unto good, . . . to save much people alive";¹⁹ no suggestion here that the action of Joseph's brothers was inexplicable—rather the contrary. What seems to be meant by such claims is rather that when we have finished giving our natural account of these processes, there remains a complementary and equally necessary story to be told, in terms of their significance from the standpoint of their creator, in whose creative activity alone they had their being.

In the case of prayer, for example, it is not just the event you called the answer, but the whole pattern of events, including your praying, which a deterministic scientist would hope to find explicable in terms of a causal chain mesh. After Heisenberg, this hope may be empirically unfounded; but, even if it were true, it would not *ipso facto* invalidate the claim that your prayer was answered. The categories of such a claim are defined from a different logical standpoint, from which the decision to pray was not inevitable (see next section), and the outcome was by definition unknown. To recognize an event as an answer to prayer is no more antiscientific than to recognize an event in a computer as the solution to the problem being solved in it.²⁰

THE STANDPOINTS OF CREATOR AND CREATURE

In the context of predestination, it is equally important to recognize that the extratemporal standpoint of the creator of a space-time

(whether real or imaginary makes no difference at this point) is necessarily different from that of any agent within that space-time. To a novelist, for example, the question, "In your novel, whom does Tom Smith choose to marry?" has a definite answer in the "eternal present tense": "Tom chooses to marry Betty." This statement, however, is not only one that could not be known by Tom himself but one that could not correctly be believed by him, before he had made up his mind—for a Tom who believed it would not be the Tom to whom it applied. Hence, a 'predestinarian account of created events from the standpoint of a creator has no unconditional claim on the assent of his creatures—no validity in their logical framework—insofar as it specifies the outcome of decisions they have not yet made; and even in retrospect it acquires validity only insofar as they can then switch to the logical standpoint of the creator. It does not retrospectively nullify their libertarian view of the choice before the event, since it fails to specify any alternative view that they would have been unconditionally correct to hold before the event.²¹ Instead, it complements that view by presenting an aspect of the situation necessarily not visible or credible in fully definitive detail from the standpoint of a choosing creature but known and indeed determined by the creative author. The standpoints are in this sense mutually exclusive.

It follows that even predestinarian explanations of created events as the acts of their creator cannot be reduced to mere *translations* of libertarian explanations in terms of human actions (such as prayer) within the created history; for it is not the terms used but the facts asserted in the one explanation which are necessarily different from (though not contradictory of) those asserted in the other. Something must be sayable from the one standpoint as the necessary correlate of what can be said from the other if both are to be valid from their respective standpoints; but they need not say the same thing, and in general must not, if their subject matter is human agency.

This is not, of course, to say that there can be no features in common between two such complementary accounts. The same account of the location and contents of Tom's house, for example, could be valid for both Tom Smith and his author, just as complementary geometrical projections may (and generally do) have at least one dimension in common. What matters is that at least one feature in one account demands a different logical standpoint from that which is appropriate to its correlate in the other.

MIRACLE

I noted earlier that from the standpoint of biblical theism a miracle is not primarily a breach of natural law but an event with a communica-

tive significance, over and above that of the creator's ubiquitous activity of "care and maintenance." In order to have special "information content" it must be out of the ordinary in some respect (especially appropriate to need, for example), but not necessarily inexplicable in scientific terms.

Can we then invoke complementarity in order to hold to the universality of scientific law while still believing in miracles? I think not, unless the notion of scientific law is weakened beyond recognition. On any careful reading of the Resurrection story, for example, what is reported to have happened to the body of Christ seems clearly an alternative to what could have been expected in the course of nature. It made sense only because of who He was; and it is presented as a unique and focal climax to the created drama. I can find no encouragement to believe that anything comparable could be expected or explained on the basis of our scientific study of God's normal creative pattern.

It would seem to follow that, although the reading of miraculous (or any other) events as acts of God is hierarchically complementary to any scientific analysis of their causes that proves to be possible, the notion of complementarity offers no way in for the dogma that all historical events have been instances of scientific law. What distinguishes a miracle from other providential events is its having an alternative rationale to the normal. It makes sense first and foremost as an expression of the Créator's faithfulness to His purpose for the people involved. In terms of this overriding criterion of rationality, its coherence with our scientific expectations based on normal precedent is irrelevant and may therefore be expected to vary from case to case. To take a simple analogy,²² if our knowledge of a mother's behavior pattern were based only on her "care and maintenance" routine for her baby, we might find it hard to explain on that basis what happens when she talks to the infant. The invocation of complementarity would be out of place, for the rationale of personal address—the criterion in terms of which it makes sense—is an alternative to that of care and maintenance, and any coherence with the "laws of care and maintenance" is likely to be variable and accidental.

CONVERSION

Finally, what of the operation of the Holy Spirit in conversion and sanctification vis-à-vis psychological mechanics? I am aware that some people might describe every genuine conversion as a miracle. I know of no biblical basis, however, for denying that a coherent account could in principle be given of the psychological correlates of conversion and the ensuing work of the Holy Spirit in the believer; and I

would suggest that in fact the spiritual and psychological accounts are hierarchically complementary.²³ In other words, to equate all conversions with brainwashing would be logically as question begging as to equate all purposeful behavior with that of a mindless robot. Equally, to insist that true conversions must be "either psychological or spiritual" would be to countenance a false statement of the issue. A true conversion, if it takes place in an integrated personality, might admit of explanations at both a psychological and a spiritual level of significance, and the two could indeed be mutually supportive on the lines indicated in the section on "The Standpoints of Creator and Creature." The distinction between genuine and spurious conversions cannot be made in terms of psychological explicability but only in terms of the appropriate spiritual criteria.

This, after all, is quite parallel with what we had to say about the distinction between a computer genuinely solving an equation and one bungling the job. The behavior of both is electronically explicable; only the appropriate mathematical criteria can determine whether either is in fact doing mathematics, although the electronic engineer may be able in case of breakdown to warn the mathematician to expect incoherence.

The last point has its moral, too, for the relation between psychology and religion, particularly in the domain of evangelism; but the moral is very different from that which might be drawn from a book like Sargent's *Battle for the Mind*.²⁴ In a computer, what counts as a "breakdown" is fairly clear and universally agreed. In the human being, unfortunately, things are less clear-cut. Certain types of gross breakdown are generally recognized; but when we ask exactly what psychological criteria should be met if spiritual problems are to be dealt with coherently by the person concerned, it becomes clear not only that our knowledge is woefully inadequate but also that the spiritual situation of the psychologist himself can powerfully affect his estimate of what constitutes "normality." This is hardly surprising but has to be borne in mind if the computer analogy is not to mislead.

CONCLUSION

Though it has been ranging rather widely, my argument has had only a few main threads which I must now draw together. Perhaps the easiest way to do this will be to consider a possible objection to each.

To start with a linguistic query: Have I not departed from normal usage by allowing complementarity to hold between more than two descriptions, whereas in quantum physics only pairs of descriptions are called complementary?²⁵ Objections of this kind are not uncommon but would seem to have the semantics upside down. When Bohr

called wave and particle descriptions “complementary,” his aim was to classify and elucidate their puzzling relation by using an already defined and understood term, not to introduce and define a new term by pointing to their puzzling relation. The term he used (or at least its English equivalent) is expressly allowed in the *Oxford English Dictionary* to relate more than two things. Like most terms adopted in physics, it has acquired a technical use there with a narrower range; but there is not the remotest justification for urging theologians to use it with physical rather than logical overtones when they happen to need it.

Am I then recommending simply a loose appeal to common usage (“*Complementary*. [b] Of two [or more] things: Mutually complementing or completing one another’s deficiencies”—*OED*)? Not at all. The common term can be sharpened for logical use as applied to multiple descriptions without restricting it to dyadic relationships.²⁶ In particular, I have suggested as a necessary condition (which applies both in hierarchic and nonhierarchic cases) that two (or more) descriptions must, respectively, employ terms whose preconditions of precise definition or use are mutually exclusive if they are to be termed complementary in a sharp sense. This rules out, for example, logically equivalent expressions of the same statement in different languages or idioms, for which we already have the term “synonymous.”

To speak of theological and scientific statements in particular as complementary, however, might invite a different kind of objection. Surely, it may be said, this reduces the theistic to just one among many complementary views, all of them incomplete, whereas biblical theism at least would claim to embrace and unify all other levels of analysis of our world. This complaint would be only partly answered by my insistence that theistic and scientific descriptions may be hierarchically related. The sting is in the suggestion of “incompleteness.”

The distinction we need here, I think, is between the divine knowledge of a situation, which is by definition all-embracing, and particular theistic descriptions of that situation, which at certain points may quite deliberately have to ignore as irrelevant the categories of scientific explanation. An analogous distinction holds between our personal knowledge of a fellow human being, which embraces both his mental and physical nature, and the descriptions we give of his behavior in personal terms, which may at certain points have no room for the complementary categories of physical causation.²⁷ A personal explanation may of course include references to physical causation—for example, “The flood carried away the bridge, so he decided to stay at home.” But whatever personal categories do occur, we are left with no room at that point in our explanation to mention the corresponding physical brain processes, even when we may fully under-

stand them. However complete our knowledge, our expression of it in one set of categories, even at the highest hierarchic level, leaves a need at some points for complementary accounts that start all over again using other categories, if we are to bear witness to all we know.

What then of the recurrent suggestion that talk of complementarity opens the way to “doublethink,” either by insulating incompatible beliefs in logic-proof compartments or by cutting an unbridgeable gulf between the domains of religion and of science which can be crossed only by an irrational “leap of faith”? The short answer must be that, if in fact the categories of theistic and scientific description are complementary, it would require an exercise in doublethink to make them otherwise; but that in any case the fears expressed are groundless if complementarity is properly understood. To call two or more accounts of the same situation complementary is to imply that each becomes valid from a specifiably different logical standpoint. Chronologically, what comes first may be the discovery in brute experience that each is necessary, which then initiates attempts to specify the presumed differences in standpoint;²⁸ but logically it is only those differences that legitimize any disparity between the accounts. The apologist who invokes complementarity incurs a corresponding obligation to indicate those differences in his own case. No encouragement here to “prefer comfort to industry,” as some critics have thought fit to suggest.²⁹ Equally—and this has been a main thesis of the present paper—the antiapologist who wants to lay a contradiction at the apologist’s door has an obligation to show that the disparate terms presuppose no relevant difference in logical standpoint. Discomfort and industry cannot here be left only to the believer, even if the believer’s positive data may give him the stronger incentive to be industrious.

Note, however, that it is only *descriptions or explanations* (of the *same* situation) from different standpoints that can properly be called complementary. A fable and its moral, for example, are not complementary in this sense since a statement of the moral does not bear witness to the events in the fable at all. If the moral of a story *S* is (*M*): “Crime does not pay,” we might call *S* an illustration of *M*, or *M* a generalization from *S*; but *M* is not an event description at all, and so cannot be complementary to *S*. On the other hand, (*E*): “The criminal got the worst of it” might perfectly well be complementary to a story *S* in nonevaluative categories since it purports to describe the events that *S* also describes. In the current debate as to whether any—and if so, which—theological statements are related in a fablelike way to biblical narratives, the notion of complementarity is thus irrelevant. Paul’s statement that “God was in Christ reconciling the world to

himself”³⁰ offers an account of the life and death of Christ which can properly be called complementary to that of a naive eyewitness, for both purport to bear witness to the same events from different standpoints; if these events did not take place, neither account could be valid. On the other hand, to say that “the story of Christ’s life and death means that God has reconciled the world to himself” is to make a very different type of statement: a statement about the story rather than about the events as such. Bearing no witness to the alleged events, it has no claim to complementarity with any account of those events.

Thus, however convenient it might be to treat Christian theology as a language game in which it is improper to ask whether any of the events described really happened (and I am unconvinced that this would be either historically honest or convenient in the long run), such a move has no support whatever from the theory of complementarity.

I conclude with a plea for balance and common sense in clarifying and using appropriately what I believe to be a commonsensical and necessary logical concept. The literature of the subject has sometimes been discolored by intemperate attacks on both the rationality and the motives of those who have espoused or rejected the notion of complementarity, in microphysics and elsewhere. Vague allegations that the idea (as here defined) has been shown to be “incoherent” turn out on closer examination to be baseless, though there is plenty of evidence of incoherence in the idea as understood by the critics! My hope is that this overlengthy review of the subject may help restore objectivity to the discussion of its intrinsic merits.³¹

NOTES

1. In “Complementarity II” (*Aristotelian Society: Supplementary Volume* 32 [1958]: 105–22) I suggested that the logical notion underlying both physical and other uses of the term could be characterized as follows: “Two (or more) descriptions may be called logically complementary when (a) They purport to have a common reference[,] (b) Each is in principle exhaustive, (in the sense that none of the entities or events comprising the common reference need be left unaccounted for), yet (c) They make different assertions, because (d) The logical preconditions of definition and/or of use (*i.e.*, context) of concepts or relationships in each are mutually exclusive, so that significant aspects referred to in one are necessarily omitted from the other” (pp. 114–15). In *a*, I would now delete the words “purport to.” The force of *b* here is of course permissive; if a description A does not claim to take account of certain of the entities comprising the situation described by B (as with the mathematical explanation of a computer’s activity discussed in the section on “Hierarchic Complementarity” below), the corresponding features of B have no complementary correlate in A, but this does not prevent A from being complementary to the appropriate part of B. The point is that even where A does claim to take account of the total situation, in the sense that nothing would remain if all features named in A were removed, *c* and *d* can still apply. Some of the arguments in the present paper will be found amplified in “Complementarity II” and in my earlier papers, particularly “Complementary Descriptions” (*Mind* 66 [1957]: 390–94).

2. "Complementarity II"; also D. M. MacKay, "Complementary Measures of Scientific Information-Content," *Methodos* 7 (1955): 63-90.

3. Note that this stipulation does not require a neutral description of the common reference. All that is necessary is some acceptable means of identification. For example, if the lamps making up an advertising sign are flashing on and off, two observers reading the sign and studying the physics of the lamps, respectively, could help each other to be sure of the common reference by calling, "There it is," "Now it's gone," "Now it's there again," until reasonable doubt was dispelled without ever producing a neutral description.

4. That the electronic description fails to mention those features that make it a signal does not make it less exhaustive in the above sense but only shows the need for another, complementary, description, which is not in the least rendered "otiose" by the exhaustiveness.

5. I pointed out the asymmetry between the complementary frames of reference of "actor" and "spectator" in "Mindlike Behaviour in Artefacts," *British Journal for the Philosophy of Science* 2 (1951): 118; for a recent lucid discussion of asymmetry between hierarchically related descriptions, see Michael Polanyi, "Life's Irreducible Structure," *Science* 160 (1968): 1308-12.

6. In other words, the situation as it lies open to the inspection of anybody, regardless of what he makes of it. Of course, what one man is qualified to perceive in a situation may be imperceptible by another not so qualified, even though it is there to be perceived.

7. Polanyi.

8. See n. 2 above.

9. L. Brillouin, *Science and Information Theory* (New York: Academic Press, 1956), p. 113.

10. The numerical value depends on the definition of "imprecision." With a different definition, it is $\frac{1}{2}$.

11. D. Gabor, "Theory of Communication," *Journal of the Institute of Electrical Engineers* 93 (1946): 429.

12. *Ibid.*

13. E. L. Mascall, *Christian Theology and Natural Science* (London: Longmans, 1956), p. 133.

14. So far from being in "ideological conflict" with science, biblical doctrine seems to me to underwrite the scientist's confidence in the worthwhileness of his discipline. See my "The Sovereignty of God in the Natural World," *Scottish Journal of Theology* 21 (1968): 13-26; *Science and Christian Faith Today* (London: Falcon Books, 1960); *The Clockwork Image: A Christian Perspective on Science* (London: Inter-Varsity Press, 1974).

15. It is, of course, no part of my purpose to claim that scientific accounts are or ever will be in practice exhaustive in this sense. At best, they have to classify many events as "random" or "inexplicable" or "indistinguishable" and can claim to be exhaustive in principle only because of the existence of such categories in the official scientific scheme. My point, as before, is that exhaustiveness in scientific categories does not have to be denied to make room for a theistic account of the same happenings.

16. Mascall (n. 13 above), pp. 134-35.

17. W. G. Pollard, *Chance and Providence* (New York: Faber & Faber, 1958).

18. Matthew 6:26.

19. Genesis 50:20.

20. "Sovereignty of God" (n. 14 above).

21. D. M. MacKay, *Freedom of Action in a Mechanistic Universe* (Cambridge: Cambridge University Press, 1967).

22. "Sovereignty of God" (n. 14 above), p. 18.

23. M. A. Jeeves, *Scientific Psychology and Christian Belief* (London: Inter-Varsity Press, 1967); see also D. M. MacKay, ed., *Christianity in a Mechanistic Universe* (London: Inter-Varsity Press, 1965), chap. 2.

24. W. Sargent, *Battle for the Mind* (London: Heinemann, 1957).

25. H. Bedau and P. Oppenheim, "Complementarity in Quantum Mechanics: A Logical Analysis," *Synthese* 13 (1961): 201-32, esp. n. 41.

26. Its other technical meanings ("complementary angles," "complementary colors," "complementary classes," etc.) also exemplify the basic notion of "completing one another's deficiencies"; but the context of each is too specialized to justify taking any one of them as a normative model for complementary categories, descriptions, or explanations. The differences are important; but if "the common use" means what is common to all those examples, including Bohr's use of the term, then mine would seem to be as much in conformity with it as any.

27. D. M. MacKay, "Man as Observer-Predictor," in *Man in His Relationships*, ed. H. Westmann (London: Routledge, 1955), pp. 15-28, esp. 24-25.

28. D. M. MacKay, "What Makes a Contradiction?" *Faith and Thought* 97 (1968): 7-14.

29. P. Alexander, "Complementary Descriptions," *Mind* 65 (1956): 145-65.

30. 2 Corinthians 5:19.

31. The following, written in 1953, still summarizes my attitude: "Whenever a new concept swims into philosophical ken there is a danger that it will be overworked by the Athenians on the one hand and abused by the Laodiceans on the other. Complementarity is no universal panacea, and it is a relationship that can be predicated of two descriptions only with careful safeguards against admitting nonsense. Indeed the difficult task is not to establish the possibility that two statements are logically complementary, but to find a rigorous way of detecting when they are not. . . . A good deal of consecrated hard work is needed on the part of Christians to develop a more coherent and more biblical picture of the relationship between the two. . . . But if once we recognize that at least most theological categories are not 'in the same plane' (in the same logical subspace) as most scientific categories, there is no longer any theological merit in hunting for gaps in the scientific pattern. Gaps there are in plenty. But it would seem to be the Christian's duty to allow—indeed to help—these gaps to fill or widen as they will, in humble and cheerful obedience to the truth as God reveals it through our scientific discipline, believing that to have theological stakes in scientific answers to scientific questions is to err in company with those unbelievers who do the like" (D. M. MacKay, "An Analogy and Its Limitations," *Christian Graduate* 6 [December 1953]: 163-64).