describing the formal properties of the relation that is the construct or model, theorems are rigorously deduced. Between (*a*) these theorems conceived in their logically realistic meaning and (*b*) the observational data known in their radical empirical denotative meaning, epistemological rules of correspondence involving operational definitions are set up. When the radically empirical images called for by the model's theorems and the epistemic rules of correspondence occur, as tested by the operationally prescribed experiments, the logically realistic theory is said to be confirmed to become a mathematical physical theory.

Applied to religion, the second major subject in the concern of this conference: What does this epistemological clarification of any subject mean? First, it means ridding religion of the muddles suggested by so much of its naïve, realistic language. Second, this entails using careful study of Hume, William James, and the Buddhist–Vedantic Hindu epistemologists to separate the radically empirical factor in human secular and religious literature and experience from the linguistically distorted on the one hand and from the warrantable speculatively inferred on the other hand, and then, in conjunction with a non-muddled radical empirical-logical realistic interpretation of science, determining whether such a non-muddled epistemological formulation, perhaps even with scientific content, does not exist also for religion.

There are reasons[2] for believing that the answer is "Yes!" Clearly, however, this is too difficult a matter to pursue on the present occasion.

NOTES

1. *Albert Einstein: Philosopher-Scientist,* ed. Paul A. Schilpp (Evanston, Ill.: Library of Living Philosophers, 1949), pp. 683–84.
2. Cf. my *Man, Nature and God* (New York: Simon & Schuster, 1962).

COMMENTARY ON THEOLOGICAL RESOURCES FROM THE PHYSICAL SCIENCES

by Ian G. Barbour

Let me first underscore Brown's last point about the importance of analyzing wholes as well as parts. A statistical ensemble has relatively little unity but can usefully be treated as a unit. There are other cases

Ian G. Barbour is chairman of the Department of Religion and professor of physics, Carleton College.

in physics in which a more highly integrated system is analyzed as a whole. For example, one has to write the quantum wave functions for an atom as a whole; the separate electrons lose their identity, so one cannot even talk about electron A and electron B as if they were distinguishable. The Pauli Exclusion Principle which governs the addition of electrons to the total configuration of an atom could not be reduced to any kind of force acting on individual electrons. Or again, one calculates energy levels for a solid-state structure or crystal as a total system.

Now the importance of dealing with wholes as well as parts becomes even more significant in biology, and eventually in our view of man. On the one hand we must recognize that the whole is a collection of parts: man is a biochemical mechanism, programmed by DNA molecules, etc. Man is indeed composed of nothing but atoms; yet in man there occur patterns of activity and types of event which do not occur in separate atoms. So we must also use distinctive concepts and theories which refer to higher levels of organization in integrated systems. There may be events which are not specifiable in terms of parts alone, or system laws which require what Northrop calls a relational rather than atomistic approach. The point is that one can use a variety of types of explanatory model at different levels. We can talk about human personality, and about DNA, without assuming that knowledge of the latter somehow makes the former obsolete. We can acknowledge that there are interlevel laws, without accepting the kind of reductionism which ends by asserting that religion is really psychology, and psychology is biology, and biology is just complicated chemistry and physics. So I would want to defend the importance of theories and concepts dealing with wholes at a variety of levels, starting with the atom and going on to the organism and to man.

A second problem is Brown's use of boundary values. In physics one can extrapolate a function beyond the range of ordinary values and gain some light on the ordinary values, but only if one postulates continuity. Here one has to avoid two extremes. Much of orthodox theology sees man as totally discontinuous from nature. The opposite extreme so stresses the continuity of man and other creatures that any distinctive aspects of man are neglected. This is one of the strengths of Teilhard's *Phenomenon of Man*—he recognizes continuity as well as genuine novelty in evolutionary history. He speaks of thresholds where new levels of organization and activity appeared, yet he portrays a continuity in which the roots of the higher are already present in the lower. In making extrapolations, we perhaps have to strike some sort of balance between continuity and discontinuity which both recognizes what

man has in common with lower forms and yet does justice to his distinctive qualities.

Let me turn now to Brown's discussion of the use of models, which is pointed up in what Northrop says about the status of theories. I agree with what Northrop said about the downfall of naïve realism. Certainly one of the most striking things about modern physics is the way it has undermined the naïve realism of classical physics, which said that a theory is simply a literal description of the world as it is in itself and apart from the observer. Take the earlier model of the atom as a minute solar system, which you still see in General Electric advertisements, the model of a nucleus with electrons circling around it. This you can visualize, this is a mechanical model. You can describe it in common-sense terms, in ordinary language. But the striking thing about modern physics is that you can no longer picture the atom at all! It's a set of probability waves in harmonic relationships that you cannot visualize. There is the striking case of the wave-particle dualism: on Monday, Wednesday, and Friday you call the electron a wave; on Tuesday, Thursday, and Saturday you call it a particle. This has had a very far-reaching impact on the scientist in his treatment of what a theory is. Is the atom a wave or is it a particle? Well, in some experiments you have to describe it as wave-like, in others as particle-like, and there is no way of putting these two models together. You have to recognize the limitations of models and concepts. There is also the breakdown of any simple separation between the observer and the observed, between subject and object. The observer disturbs the system. You cannot deal with the atom-as-it-is-in-itself, apart from the experiment.

In modern physics there is indeed a great gap between the observational terms, on the one hand, and the theoretical terms, on the other. Often there are only statistical relationships between them, and these only give you probabilities. This partially accounts for the fact that there are such widely divergent views among physicists as to the relation between theories and reality. Is the wave function real or not? The positivist, impressed by the non-observability of all these theoretical terms, says, "The sense data are real and the theory is simply a summary of the sense data." The instrumentalist, impressed by the results of science, says, "The theory is just calculational machinery for making predictions. It is a useful fiction, a mental construct, a human invention to correlate observations and to make predictions." The idealist, impressed by the logical consistency of the mathematical theory and its beauty and formal structure, and its remoteness from observables, says, "Reality is more like an idea than like a thing." Avoiding these extremes, I would tend to end up where Northrop does, with a kind of

critical realism that says, "Yes, science is trying to describe reality, but it does so only very indirectly in highly symbolic and abstractive language." One has to use models, but one has to recognize their limitations; one has to realize that they are partial and limited, that each one selects certain aspects and emphasizes those, that none of them corresponds exactly in any simple way to reality. Yet often the model leads to the new breakthrough in a new area, where the bare mathematical formulas alone offered no clues as to how the theory might be modified or expanded; thus you cannot discard models.

Now I would just add this footnote. Within philosophy, the poverty of positivism has become generally apparent. Its successor, linguistic analysis, recognizes the diversity of the functions which language serves. Different types of languages try to do different things. The language of religion is the evocation and the expression of worship and of life orientation. And these are very different functions from those of scientific language. Now some analytic philosophers have carried this so far that they are unwilling to ask about the truth of either scientific or religious language, and they simply say: "With scientific language we correlate observations and make predictions; with religious language we evoke and express ethical conduct, worship ultimate commitment." It seems to me they have gone too far and have ended by throwing out the question of reality. I would agree as to the diversity of the functions of language and the distinctive ways in which language in the religious community is used, including the personal involvement that it entails. I would also want to point to religious experience, as many of Northrop's writings certainly do, and as a man like Teilhard does on his own more personal, more mystical side.

This distinctive religious area is also one in which our models are inadequate. Some people find personal models of God more adequate, some prefer impersonal models, and certainly neither is completely suitable, and neither is a literal picture. I think there are shortcomings of either one, but a model does not have to represent everything. If one wants to use personal models and speaks of God as Father or King or Judge, symbols drawn from personal imagery, or if the Christian uses Christ as a model for God in some sense, then this may point to certain types of experience, but it also needs to be supplemented by other models. Tillich, for instance, talks about the necessity of using both personal and impersonal symbols, God both as the power of love and as the ground of being. The logic of models in both science and religion, and their relation to experience, need to be explored more fully if we want to make any kind of comparison between the two fields.