THE RELEVANCE OF TILLICH FOR THE THEOLOGY AND SCIENCE DIALOGUE

by Robert John Russell

Abstract. This paper explores the relevance of the theology of Paul Tillich for the contemporary dialogue with the natural sciences. The focus is on his *Systematic Theology*, volume I. First I discuss the general relevance of Tillich's methodology (namely, the method of correlation) for that dialogue, stressing that a genuine dialogue requires cognitive input from both sides and that both sides find "value added" according to their own criteria (or what I call the method of "mutual creative interaction"). Then I move specifically to a Tillichian theological analysis of twentieth-century theoretical science and its empirical discoveries, including Big Bang, inflationary, and quantum cosmologies, quantum physics, thermodynamics, chaos and complexity, and molecular and evolutionary biology, suggesting how they relate to such Tillichian themes as finitude and the categories of being and knowing (time, space, causality, and substance) and to Tillich's understanding of such symbols as God, freedom and destiny, creation, and estrangement. In doing so, my intention is to provide a point of departure for further extended analyses of Tillich's theology in relation to contemporary natural science.

Keywords: Big Bang cosmology; categories of being and knowing; chaos and complexity; creation; estrangement; freedom and destiny; God; inflationary and quantum cosmologies; method of correlation; method of creative mutual interaction; molecular and evolutionary biology; natural science; quantum physics; spacetime; systematic theology; thermodynamics.

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My paper begins to explore the relevance of the theology of Paul Tillich for the contemporary dialogue with the natural sciences. Here I focus almost exclusively on the first volume in Tillich's *Systematic Theology* (1967) and leave to future writings a more complete treatment of Tillich's work. First I discuss the general relevance of Tillich's methodology (namely, the method of correlation) for that dialogue, stressing that a genuine dialogue (or what I call "mutual creative interaction") requires cognitive input from both sides and that both sides find "value added" according to their own criteria. In doing so, I argue against some of his neo-orthodox critics that Tillich's method of correlation does indeed involve a two-way interaction with culture. Then I move specifically to a Tillichian theological analysis of science, or, more particularly, of both twentieth-century theoretical science and its empirical discoveries. I propose that such an analysis is possible if, in light of Tillich's two formal theological criteria, we view science as revealing some aspects of that which concerns us ultimately and determines our being or nonbeing. Then I undertake such an analysis by focusing on specific topics in science drawn from Big Bang, inflationary, and quantum cosmologies, quantum physics, thermodynamics, chaos and complexity, and molecular and evolutionary biology, in correlation with specific sections in the structure of Tillich's theological system. I conclude by suggesting how this analysis can contribute strikingly to the current state of the theology-and-science dialogue.

Methodology in Theology and Science as an Extension of Tillich's Method of Correlation

I believe Tillich's method of correlation can be seen as a precursor of what is now one of the most productive methodologies in the growing interdisciplinary field of theology and science.[1] After briefly summarizing Tillich's method, I will turn to the interdisciplinary context. Among the diverse ways scholars relate theology and science, I believe the most significant methodology to date is based on two pivotal claims: (1) Theological methodology, when properly conceived, should be, and in fact already is, analogous to scientific methodology—though with several important differences or disanalogies. (2) The sciences and humanities form an epistemic ordering in which lower levels (physics, chemistry, biology, and so on) place cognitive constraints on higher levels (aesthetics, ethics, and so on), but the processes, concepts, properties, and laws the latter deal with are genuinely emergent and cannot be reduced to those of the former. Theology, being the most inclusive field, is maximally constrained and yet irreducible to the rest of human knowing.[2] The arguments for both analogous methodologies and a nonreductive epistemology are drawn directly from the pioneering writings of Ian Barbour (1990), as well as those of Arthur Peacocke (1993), Nancey Murphy (1990), Philip Clayton (1989), and John

Polkinghorne (1994). What I wish to focus on in this paper, however, is the first claim: that theological reasoning is analogous to scientific reasoning. By calling Tillich's method a precursor, I mean that the method of correlation is implicit in the particular form of theological methodology which these scholars see as being analogous to scientific methodology.[3]

I will then propose that we go beyond the analogy that theology is like science by making science and theology genuinely interactive while retaining their asymmetric relationship consisting of both (1) constraints from science on theology and (2) the irreducibility of theology to science. To qualify as a genuine interaction, this eightfold methodology not only includes five ways in which scientific theories and discoveries are imported hermeneutically into the theological context, it also argues that theological theories (i.e., doctrines) have historically played, and should more explicitly today play, a cognitive role in the development of new scientific theories as well in the choice between existing ones. I call this "the method of creative mutual interaction," and I credit Tillich's own method with providing many of its fundamental tenets.

I will then return to Tillich and assess several key comments he makes on the relations between science and theology in light of this eightfold methodology. We will find that Tillich is remarkably on target, which is all the more notable given that his comments were published half a century ago and before these developments in philosophy of science.

TILLICH'S METHOD OF CORRELATION. Tillich's method of correlation plays a crucial and pervasive role in his entire system. According to Tillich, "the method of correlation explains the contents of the Christian faith through existential questions and theological answers in mutual interdependence" (1967, 1:60).[4] A theology shaped by this method seeks to combine the statement of the truth of the Christian message with the interpretation of that truth for each generation. It does so by attempting to balance the demands of kerygmatic theology, which emphasizes the unchangeable truth of the message that is being addressed to the temporal situation, with those of apologetic theology, which emphasizes that the answers given to the temporal situation are answers to questions implied in that situation. The method of correlation thus unites message and situation (1:3–8).

Tillich offers three meanings for the term *correlation*: correspondence between two sets of data, the logical interdependence of concepts, and the real interdependence of things or events (1:60). Although his method includes all three, it is the notion of real interdependence that is most pivotal. It points to the divine-human relationship within religious experience, including the cognitive dimension of experience. This means that, "symbolically speaking, God answers man's [*sic*] questions, and under the impact of God's answers man asks them. Theology formulates the questions

implied in human existence, and theology formulates the answers implied in divine self-manifestation under the guidance of the questions implied in human existence" (1:61).[5] Thus there is a "mutual dependence between question and answer" (1:64).[6] Tillich stresses that these questions are "existential"; they arise out of an analysis of the human situation. The answers theology offers, however, are expressed in what Tillich calls "symbols."[7] They are "contained in the revelatory events on which Christianity is based and are taken by systematic theology *from* the sources, *through* the medium, *under* the norm" (1:118). The question of medium is particularly important for understanding Tillich's significance for theology and science. He clearly stresses that, along with history, groups, and individuals, nature can be a medium of revelation: "there is no reality, thing, or event which cannot become a bearer of the mystery of being and enter into a revelatory correlation. . . . Nature . . . can be a medium of revelation in an ecstatic experience" (1:120).[8]

Before we close this brief look at Tillich's method, it is important to recall the formal criteria he gives for what constitutes theology: Its object must be of ultimate concern for us, that which determines our being or nonbeing (pp. 12–14). These criteria must be kept in mind when assessing my suggestions on how theories and discoveries of science can be germane to theology (below).

THE ANALOGY BETWEEN THEOLOGICAL AND SCIENTIFIC METHODOLOGY. Barbour introduces his discussion of scientific methodology with the work of Carl Hempel. In the 1950s, Hempel offered what has become a widely accepted description of how theories are constructed and tested in the natural sciences, drawing on arguments from the philosophy of science in the first half of this century (Hempel 1966). Compared to the simpler idea of direct induction from data to theory as proposed by Bacon and Mill in the seventeenth century, Hempel portrayed scientific methodology in terms of a "hypothetical-deductive" path. One moves from data indirectly to the level of theory in a process which involves imagination, analogy, and models as well as logical inference. Then, as Karl Popper had shown earlier, theories are open to falsification against the data by the predictions one deduces.

In the 1950s and 1960s, Thomas Kuhn (1970), Norwood Hanson (1958), Michael Polanyi ([1958] 1962), Stephen Toulmin (1961), Imre Lakatos (1978), and others supplemented Hempel's account in a broader view that stresses the historical and contextual dimensions of scientific research. Barbour provides a particularly helpful overview of their work. According to Barbour, these philosophers showed that metaphysical concepts and assumptions pervade scientific theories and underlie scientific methodology. Data are theory laden, and theories influence the decisions as to which data are relevant. The testing of scientific theories is compli-

cated, too, by the fact that ad hoc auxiliary hypotheses can always be constructed to ward off potential falsifiers. Networks of theories, and not just isolated concepts or equations, are tested as a whole. Finally, the criteria for choosing between rival theories go far beyond predictive success to include coherence with other, accepted theories, explanatory scope, fertility in suggesting new domains for application, conceptual simplicity (Occam's razor), aesthetic qualities like beauty, and the avoidance of ad hoc moves. Because such criteria transcend the details of the particular theories being considered, they provide a framework for a rational choice between rivals.[9]

Theological Methodology as Analogous to Scientific Method. Barbour, Murphy, and Clayton claim that one can view theological method as analogous to scientific method. I take their claim to be both a description of the way many theologians actually work and a prescription for progress in theological research. Here doctrines are seen as theories, working hypotheses held fallibly and constructed in light of the data of theology—for example, a combination of scripture, tradition, reason, personal and community experience, and the encounter with world cultures and with nature, including the discoveries and conclusions of the social, psychological, and natural sciences. They are held seriously but tentatively, and they are open to being tested against such data. It is here in particular that the natural sciences are particularly germane: the theories and discoveries of cosmology, physics, evolutionary and molecular biology, anthropology, the neurosciences, and so on, should serve as crucial sources of data for theology, both inspiring new insights and challenging traditional, outmoded conceptions of nature.

There are, of course, important differences between the methods of theology and those of the natural sciences. One is that theologians lack criteria of theory choice that fully transcend the influences of the theories under dispute. Another difference involves the extent to which beliefs influence both the relevancy and the interpretation of data, and the power of imagination, analogy, and models in theory construction. A third difference is that, as in the social sciences but unlike in the natural sciences, much of the data for religious scholars come from subjects; in effect, religious scholars are typically seeking to interpret the interpretation of others—what Clayton calls the problem of the "double hermeneutic." Murphy, drawing on Lakatos, has underscored the importance of "novel facts" in settling disputes and the avoidance of the ad hoc as a sign of epistemic progress in theology.

These similarities and differences make the appropriation of scientific methodology in theology both promising and challenging. My hope is that as theologians begin to shape their work in this way we will be able to decide whether such a move is genuinely fruitful.[10]

An Interaction Model of Theology and Science. Still, a major challenge exists for constructive conversations between theology and science: Can theology and science be genuinely *inter*active, each offering something of intellectual value to the other although in different ways and without any appeal to "authority," or is the only role for theology that of critically integrating the results of science into its own conceptual sphere (i.e., hermeneutics)? In order to answer this key question, let me suggest a diagram that makes more explicit not only the ways in which science can influence theology but also the distinctive ways in which theology has historically been, and presumably now could explicitly be, an influence on science (see fig. 1). In one sense I am merely summarizing what has already been discussed by Barbour, Peacocke, Murphy, Clayton, Polkinghorne, and many others. In another sense I am offering a constructive proposal that could make the theology-and-science interaction much more explicit and, even more important, help us assess its true value to both communities.

The diagram consists of eight ways in which science might influence theology and theology, science. More ways could, and probably should, be added upon further reflection. Individual theologians or scientists typically use one path in particular, often without acknowledging the existence of the other paths. Some shift between them depending on the topic being addressed. My suggestion is to consider what looking at the set of paths as a whole might tell us about the state of discussions in theology-and-science and what it might suggest for improving the conversations.

The eight paths divide into two sets: those now routine ones that describe the movement from science to theology, highlighting the differences in these ways, and those more controversial ones that describe the movement from theology to science, again highlighting their differences.

1. *From science to theology*. As figure 1 suggests, there are at least five ways, or paths, by which the natural sciences can affect constructive theology. (I focus on physics and cosmology for specificity, but my comments would apply to the other sciences as well.) In the first four, theories in physics, including the key empirical data they interpret, can act as *data for theology* both in a direct sense ([1] and [2]) and indirectly via philosophy ([3] and [4]). (1) Theories in physics can act directly as data that place constraints on theology. So, for example, a theological theory about divine action should not violate special relativity. (2) Theories in physics can act directly as data either to be explained by theology or as the basis for a theological constructive argument. For example, $t = 0$ in Big Bang cosmology could be explained theologically via creation out of nothing (*creatio ex nihilo*). Such an explanation can serve to confirm the theological theory, although proof is out of the question. Note: the theological explanation should be considered a part of theology and not an explanation lying within the domain of science. (3) Theories in physics, after philosophical analysis, can act indirectly as data in theology. For example, the contingency of

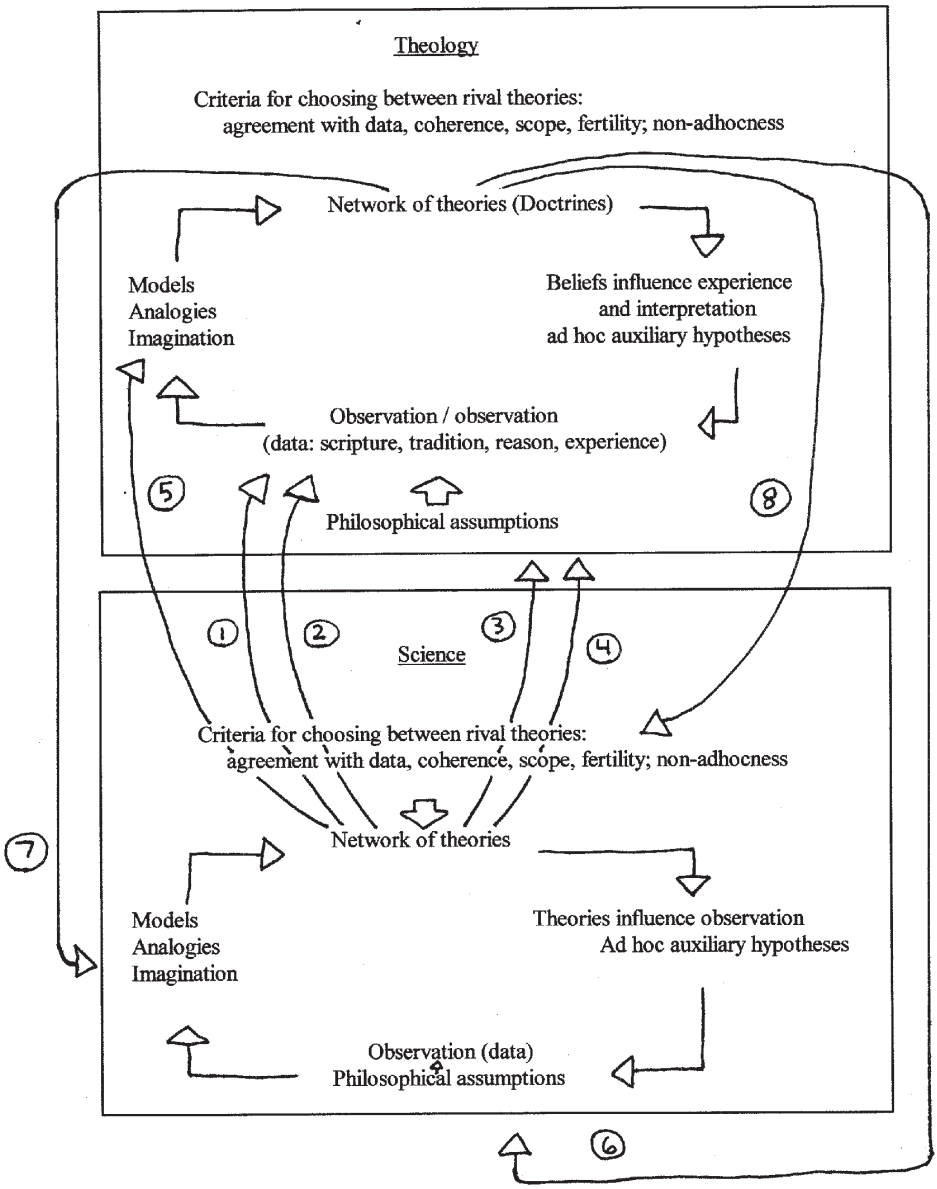

Fig. 1. Method of Creative Mutual Interaction.

the Big Bang universe, as a philosophical claim based on science and given concrete expression by such issues as $t = 0$, can serve within natural theology as evidence for the existence of God. Similarly, an indeterministic interpretation of quantum mechanics can function within theological anthropology as providing a precondition at the level of physics for the bodily enactment of free will. (4) Theories in physics can also act indirectly as the data for theology when they are incorporated into a fully-articulated philosophy of nature (such as that of Alfred North Whitehead). Finally, (5) theories in physics can function heuristically in the theological context of discovery, by providing conceptual inspiration, experiential inspiration, practical or moral inspiration, or aesthetic inspiration. So Big Bang cosmology may inspire a sense of God's immanence in nature.

2. *From theology to physics.* To see the genuinely interactive but asymmetrical nature of the relations I am proposing, I suggest at least three paths by which theology can influence science. I want to stress at the outset that by "influence" I am in no way appealing to theologians or assuming that they speak with some special kind of authority, whether based on scripture, church dogma, magisterial pronouncements, or whatever. Quite the contrary; the overall context should be an open intellectual exchange between scholars based on mutual respect and the fallibility of hypotheses proposed by either side and based on scientific or theological evidence. The case I wish to make is that such influences have occurred historically and continue to occur in contemporary scientific research. It is first of all, then, a descriptive claim, but it has a mildly prescriptive component as well: I believe that intentionally exploring such influences could be as fruitful for science as it has been for theology, and that it could be particularly fruitful for the theology-and-science interaction. That said, let us turn to three paths from theology to physics:

(6): As already mentioned, theological theories provide some of the philosophical assumptions which underlie scientific methodology. Historians and philosophers of science have shown in detail how the doctrine of creation *ex nihilo* played an important role in the rise of modern science by combining the Greek assumption of the rationality of the world with the theological assumption that the world is contingent. Together these helped give birth to the empirical method and the use of mathematics to represent natural processes.[11] Other assumptions grounded in the *ex nihilo* tradition, however, including goodness and purpose, were not carried over into the scientific conception of nature. It would be interesting to reopen the question of the value of these assumptions for contemporary science. Is there a sense, for example, in which neo-Darwinian evolutionary biology includes teleonomy? Do values have a partial, evolutionary grounding in nature? Would scientific theories that incorporate such ideas be more fruitful than those that do not, or are they hopeless ventures today?[12] (7): Theological theories can act as sources of inspiration in the scientific context of discov-

ery, that is, in the construction of new scientific theories. An interesting example can be found in the variety of theologies and philosophies which, to a varying degree, apparently influenced many of the pioneers of quantum theory in the period 1900–1930, including Vedanta for Erwin Schrödinger, Baruch Spinoza for Albert Einstein, and Søren Kierkegaard for Niels Bohr.[13] Another example is the subtle influence of atheism on Fred Hoyle's search for a steady-state cosmology.[14] Still others include a Whiteheadian approach to science, in which experience, or *prehension*, is posited at every level of reality, including those treated by physics and biology (see Birch and Cobb 1981). Or, one could search for temporal irreversibility in fundamental physics (Prigogine 1980). Finally, (8) theological theories can lead to selection rules within the criteria of theory choice in physics.[15] If one considers a theological theory to be true, then one can delineate what conditions must obtain within physics for it to be true. These conditions in turn can serve as reasons for an individual research scientist or group of colleagues to choose to pursue a particular scientific theory. For example, if on the basis of revelation we claim that humankind bears the image of God (*imago dei*), and if the image of God includes libertarian free will and with it the possibility of enacting our choices bodily, then we might well prefer quantum mechanics to classical mechanics, because the former is compatible with an indeterministic interpretation.

Together these eight paths portray science and theology in a much more interactive, though still asymmetric, mode. I suggest calling this the method of creative mutual interaction. Given this method, we can begin to delineate the conditions needed for real progress in theology and science. First, scholars in each field would need to find that such an interaction was fruitful according to the criteria of their own research field. So would scientists believe that their research was more fruitful by having engaged with theology and philosophy in these ways? Would theologians consider their research to have benefited by engaging with science? Second, as major changes occur in one field and these changes are taken seriously by the other, would the corresponding effect of these changes be considered fruitful by scholars in that other field? Ideally a process such as this, once set in motion, could continue indefinitely. Finally, it might be possible to compare these results with those of scientists and theologians who have chosen not to engage in mutual interaction. It might also provide a useful typology for comparing and evaluating the ways that various scholars allow science to influence their theology or theology to influence their science. In any case, even accomplishing the first step would be an event of enormous significance not only for theology and science but I believe more generally for our contemporary culture which is frequently skeptical, even bitter, toward religion (and sometimes toward science).

AN ASSESSMENT OF TILLICH'S METHOD OF CORRELATION IN LIGHT OF THE SITUATION IN THEOLOGY AND SCIENCE TODAY. It is time to sketch out an initial assessment of Tillich's method of correlation in light of the situation in theology and science today, as described above. This assessment should seek first to disclose and make explicit the elements in Tillich's thought that continue to prove salutary to us today and that at least in a formal if not in a historiographic sense appear to be contained in today's positions as, at least in part, their foundations. Only then should it point to ways in which today's positions go beyond the limits of Tillich's argument.

General Assessment. Perhaps the first and most elementary point is that Tillich's method sought to combine kerygmatics and apologetics. In Tillich's day, such a method differed from both neo-orthodoxy, with its focus primarily on the kerygma ("unique message"), and liberal Protestantism, with its concern for apologetics ("common ground"). At the same time it sought to bring the strengths of each into a single, balanced method. To me this is remarkably like the hypothetical-deductive system Hempel speaks about in describing the modes of reasoning in science. To the extent that Hempel's view of scientific methodology is analogous to theological methodology, it seems clear to me that the specific current theological methodology to which it is analogous is one whose roots lie, at least formally, in Tillich.

Probing a bit deeper, we recall that Tillich exposes the interpenetration of kerygma and apologetics, or what he calls the "mutual dependence between question and answer." The answers offered by theology both subtly shape and are shaped by the questions given in reason and existence. The presence of this doubly subtle role undercuts the views of Tillich's contemporaries who separate question and answer into isolated spheres; the fact that it is subtle challenges those others who reduce theology to the sphere of human culture. For me Tillich's argument anticipates the discovery by philosophers of science that all data are theory laden and that metaphysical assumptions and concepts underlie and are contained in scientific methods and theories.

Finally, Tillich stresses the role of analysis in discovering the questions given in existence. This is far from a direct relation between a fact of life literally interpreted and a theological concept taken ahistorically. Instead the questions arise indirectly by an existential analysis, and the responses given are expressed in terms of symbols continually reinterpreted in the context of the present existential situation. For me this argument anticipates the position that philosophy plays a key role in mediating the theories and discoveries of the sciences as they are brought into the theological arena. It also points to the claim that theological responses to questions posed by science are always explicated using the particular conceptual frame-

work of the scientific theory at hand, and not in a trans-theoretical framework that is expected to work for all scientific theories regardless of their specific structures. But because this time-dependent view of the interaction is incorporated into a time-independent method, it shows how the conversations between theology and science can continue as views change on each side, and how the changes can be reincorporated to the advantage of the conversation. Finally, Tillich's insistence that nature can be a medium of revelation is a crucial claim if we seek to include nature, and its theoretical interpretation in terms of the theories and discoveries of science, in the theological conversation.

Specific Assessment of Three Key Statements. With these general remarks in mind, I want to reflect briefly on three comments Tillich makes that clarify and qualify his views on method as regards the issues in theology and science. These reflections are meant to convey both my agreements with Tillich and the ways in which I think we have moved beyond his position in light of the past four decades of research in theology and science. I will use the method of interaction presented above to specify which paths in this scheme either reflect Tillich's views or go beyond them.

1. The first comment pertains to the role of philosophy in theology and science. According to Tillich,

> The point of contact between scientific research and theology lies in the philosophical element of both, the sciences and theology. Therefore, the question of the relation of theology to the special sciences merges into the question of the relation between theology and philosophy. (1967, 1:18)

I have two reactions to this comment. First, I strongly agree with Tillich in stressing the philosophical elements in both science and theology. As path (3) suggests, these elements not only serve to mediate between science and theology; a philosophical analysis of scientific facts and theories provides a crucial way in which these facts and theories can be integrated into constructive theology.[16] Second, however, Tillich's comment tends to overlook the fact that theological theories can act in "downward" ways on science, too. Specifically, theological theories can provide some of the philosophical assumptions that underlie scientific methodology, following path (6) (Foster 1934, 446; Whitehead 1925, chap. 1). They can also act as sources of inspiration for the construction of new scientific theories (path [7]), and they can lead to the formulation of criteria of theory choice in science (path [8]). These arguments go beyond the scope of what was generally accepted in the philosophy of science when Tillich developed his methodology.[17]

The second comment by Tillich involves the content of revelation:

> Knowledge of revelation does not increase our knowledge about the structures of nature, history, and man. Whenever a claim to knowledge is made on this level, it must be subjected to the experimental tests through which truth is established. If such a claim is made in the name of revelation or of any other authority, it must be

disregarded, and the ordinary methods of research and verification must be applied. (1967, 1:129)

I find this comment to be true in part. On the one hand, Tillich is right in arguing that theological knowledge cannot serve as data for science.[18] I have incorporated this argument by making the interaction model asymmetric: theology, being at the top, is constrained by all, but it constrains none.[19] (It is why I have not added a "path [9]" from theological doctrine to scientific data.) Moreover, as Tillich points out, no appeal to religious authority can change the truth expressed by this asymmetry. On the other hand, I differ crucially with Tillich in my claim that theology can lead, at least indirectly, to the discovery of new scientific knowledge through paths (6)–(8). Of course Tillich is absolutely right that the scientific community has sole authority over the status of such knowledge. The point here is that, if theologically inspired scientific theories pass these secular tests, their success reflects encouragingly, even if only very indirectly, on the truth content of their theological sources.

The third comment by Tillich contains several assertions that deserve to be treated individually; I have inserted [a], [b] and [c] into the quotation to make referring to them easier:

[a] Knowledge of revelation cannot interfere with ordinary knowledge. Likewise, ordinary knowledge cannot interfere with knowledge of revelation. [b] There is no scientific theory that is more favorable to the truth of revelation than any other theory. [c] It is disastrous for theology if theologians prefer one scientific view to others on theological grounds. And it was humiliating for theology when theologians were afraid of new theories for religious reasons. (1967, 1:130)

I would respond as follows: [a] If by "interference" Tillich means epistemic reductionism (the claim that theological knowledge can be reduced fully to scientific knowledge), then his goal of guarding against it is certainly right, and I agree with his move to guarding against it by affirming that revelatory knowledge transcends the capacities of ordinary knowledge, though it may occur within and through it. However it no longer seems necessary to add the additional move [b] in order to achieve his goal. On the contrary, as I have already argued, scientific theories can offer modest and indirect support to theological theories by serving as data to be explained theologically or as data which then tend to confirm theology. [c] It is disastrous for someone to use theological reasons within a scientific context of debate as though such reasons could not be challenged because of their reputed theological authority. Still, it is acceptable for theologians to prefer one scientific theory over another because such preferences can indicate to scientists that there are theological reasons for choosing which of several competing theories to work on via path (8) or for constructing scientific theories that compete with existing ones via path (7), as long as in both cases the results are tested strictly by the scientific community.

Finitude and the Categories in the Dimension of the Inorganic and in Light of Special Relativity

SUMMARY OF TILLICH'S VIEWS. According to Tillich, the categories of being and knowing—namely, time, space, causality, and substance—are ontological and thus present in all finite being. They also are forms by which the mind grasps and shapes reality. Systematic theology must deal with them, at least in a way which shows their significance for the question of God. What is particularly important here is that the categories display a double relation to being and nonbeing. Being forms of finitude, they bring together an affirmative and a negative element that unite anxiety with courage in our search for meaning. The analysis of this duality is therefore crucial to the theological formulation of the question of God. Here I focus on the categories from the perspective of the dimension of the inorganic (Tillich 1967, 1:192ff.), both because this makes the connection with physics most natural and because the characteristics of the inorganic continue to be present, though partially transformed, as we move into the realm of the life, mind, spirit, and history.[20]

The positive element of time is the creative character of the temporal process. Through the irreversible flow of time the genuinely new is produced. Yet time is transitory and the present moment fleeting. Because the past is no more, the future not yet, and the present a mere moving boundary between past and future, time takes on an illusory, negative quality, manifesting the power of nonbeing at the heart of finitude. The present implies space in which to be, and to be means to have space: a physical location ranging from one's body to the world and including a social space. Yet we never possess our space. Each of us is a pilgrim on earth, eventually to lose every place we have occupied and finally to lose being itself. In courage we affirm our present moment and its space, yet our anxiety is triggered by the transitory nature of time and the inevitable loss of space.

The third category is causality. The power of a cause is to make its effects real. Causality thus points to the power of being and its resistance to nonbeing. Yet because the reality of an effect depends on its cause, causality expresses the inability of anything to contain within itself the power of its own reality. All things are contingent; only God is *à se* (that is, necessary or self-sufficient). The anxiety of finite contingency requires courage, but its source cannot be found in the chain of finite being. Substance points to that which underlies the flux of appearances, the power of being over nonbeing. Yet substance is nothing beyond the accidents in which it is expressed, and the accidents are in constant flux. Hence substance, too, displays the power of nonbeing and leads to anxiety as we anticipate the final loss of substance and accidents at death.

The question of God, then, is the question of the possibility of courage in facing the anxiety brought on by the power of nonbeing in each of the categories.

TIME, SPACE, AND CAUSALITY IN SPECIAL RELATIVITY. How would the reconceptualization of time and space in special relativity affect the issues Tillich raises? It is helpful to note that Tillich treats space and time as separate and time (though "interdependent"[21]) as directional (i.e., irreversible[22]) as found in ordinary experience and as embedded in the worldview of classical physics. Here, however, it is important to distinguish between two areas in classical physics: classical mechanics and classical thermodynamics. (1) In classical mechanics (i.e., Newtonian physics), time and space are regarded as separate categories.[23] The rate of time's flow and the space of the present moment are the same for all observers. Time is reversible: Newtonian physics does not give us a basis for the irreversibility or directionality of time. (2) Time as irreversible (time's arrow) does occur in classical thermodynamics through the second law of increasing entropy.[24]

Time and Space Become Spacetime. Einstein's special theory of relativity, however, overthrows the separate treatment of time and space, though, like classical mechanics, it still provides no physical basis for our experience of time's irreversibility. In relativity, time and space are mathematically combined into "spacetime" through what are called the Lorentz transformations. Spacetime, in turn, is routinely given a geometrical interpretation, following the early ideas of Minkowski. The consequences of a spacetime view of the world are deeply counterintuitive. Of course, though they hold in principle, in practice they are usually unnoticeable to us because their size depends on the velocities involved relative to the speed of light. Still, they are in principle a clue to the ontology of the world and thus highly important to Tillich's categorical analysis.[25]

First, according to relativity, a moving clock ticks more slowly than the one I hold in my hand, an effect called *time dilation*. Suppose I buy a box of identical firecrackers, light all their fuses at once, and throw all but one of them in different directions and at different speeds. Ordinary experience and Newtonian physics would predict that they will all go off simultaneously. Careful measurements and relativity predict that the one I keep nearby explodes first, and the rest at later times depending on how hard I threw them. In essence, the rate of time's flow is not absolute; it depends on relative velocity.

Next, relativity undermines the assumptions that we share a common present and that this present forms a universal boundary between a common past and a common future. Instead, the present is defined in relation to a given observer at a given moment in time, and it differs for observers in relative motion. This means that we each define a set of events in spacetime as filling our present and forming our world.

Causality Revised: The Lightcone Structure of Spacetime. According to relativity, nothing can travel faster than the speed of light, c, relative to a given observer. This fact alters our understanding of causality profoundly.

Imagine I am located momentarily in spacetime at an event *O*. I can influence those future events *F* only if I can send light, or something slower, from *O* to *F*. Similarly I can be affected by past events *P* only if they can send signals from *P* to *O*. This limitation is represented by what we call the *lightcone* at *O*: it divides spacetime relative to *O* into the causal future *F* and the causal past *P*, and it leaves the rest of spacetime relative to *O* to form what can be called the causally isolated "elsewhen" *E*, since events in *E* cannot affect or be affected by *O*. The elsewhen contains all possible presents constructed by all observers in relative motion that share *O* as a common event. Conversely, events which I consider to be simultaneous to me will be considered to lie in either the past or the future elsewhen by others moving relative to me. The lightcone structure thus leaves spacetime causally fragmented into countless separate events with distinct, though partially overlapping, causal pasts and futures and acausal elsewhens.

PHILOSOPHICAL INTERPRETATIONS OF RELATIVITY AND THEIR THEOLOGICAL IMPLICATIONS. The problem of giving a satisfactory philosophical interpretation of time and space in special relativity has pervaded the history of science since Einstein first produced his theory. Given the demise of the classical view of a universal present, some scholars have abandoned temporality entirely, arguing for a "block universe" interpretation in which spacetime is merely a four-dimensional geometry of events, and all events, whether I consider them past or future, are equally "real." Many physicists, including Einstein, take this sort of Platonizing view of spacetime, but it certainly has its problems. For example, how can I take free will seriously if all events in the future, as well as in the past, exist equally with the present? Other scholars, persuaded by our experience of time and freedom, maintain a "flowing-time" interpretation of special relativity. Polkinghorne and Peacocke assume such a view and extend it to God's relation to time: even God cannot know the future, because the future is simply not yet (Isham and Polkinghorne 1993, 135–44). Process scholars such as Barbour and David Griffin adopt a similar view, insisting on a metaphysics of becoming that includes a flowing-time view of the world. Charles Hartshorne candidly admits that relativity physics "is a puzzling case for my thesis, the most puzzling indeed of all," because by erasing a "definite cosmic present" it seems to undercut God's temporal experience of the world (Hartshorne 1967, 93). Trinitarian theologians such as Jürgen Moltmann, Wolfhart Pannenberg, and Ted Peters argue that God acts proleptically from the future to shape the present. In doing so, though, they too implicitly assume the notion of flowing time with its universal present, and it is the latter that seems to violate relativity. Must we, after all, concede to a timeless block universe view?

The dilemma has driven some scholars to broaden the question scientifically in hopes of strengthening the case for flowing time in light of

relativity. Barbour and Polkinghorne have suggested that the expanding universe provides a universal, or cosmological, present—as well as a direction for time's flow.[26] Others, such as John Lucas, have gone so far as to call for a revision of relativity theory, or at least its embedding in a broader theory that would reinstate the notion of an empirical cosmic now (Lucas 1993, 235–46).

Using the methodology suggested above, we can highlight the differences in these approaches by identifying the paths they represent between science and theology. Path (1) indicates the way relativity poses a challenge to an unnuanced assumption of a universal present as generally found in theology. Clearly all the scholars discussed so far recognize the importance of such a challenge and seek creative ways to address it. The clearest response is to recognize that the theory of relativity is open to a philosophical interpretation (block universe; flowing time) and thus to alternative paths that still take science seriously. We can view Polkinghorne and Peacocke as following path (3) to introduce relativity via a particular philosophical interpretation (i.e., flowing time) into the theological discussion. Similarly, we can view process scholars like Barbour and Griffin as following path (4), first by adopting a fully articulated philosophy of nature that already incorporates relativity theory and then by introducing this philosophical system into the theological arena. Moreover, by broadening the argument by appealing to the scientific case for a cosmological present, Barbour and Polkinghorne actually represent a combined approach that now includes path (1)—but this time in a way that allows for a flowing-time interpretation not only philosophically but with additional empirical confirmation. Finally, those like Lucas who call for a revision or generalization of relativity theory represent paths (7) and (8).[27]

TILLICH'S ANALYSIS IN LIGHT OF RELATIVISTIC SPACETIME AND CAUSALITY. What does this entail for Tillich's analysis?[28] For me it underscores the ambiguities Tillich pointed to in both time and space. Time in our individual experience can still be the locus of creativity, the category in which novelty occurs. But what gives time its direction if we are missing a physical basis in relativity for temporal irreversibility? What gives the future a common meaning if the speed at which we move into it—the rate of time's flow—is contingent on our motion with respect to each other? And what meaning would be left to an existence whose fundamental category is temporality (or to the polar elements of freedom and destiny, or dynamics and form) if a spacetime block-universe view[29] were to become increasingly persuasive?

Moreover, the relativistic connection between time and space means that the change in our view of time is directly connected to the change in our view of space. If time is no longer something shared ontologically by communities, then the "world" that occupied the common present in polarity with the "self" is gone. There is no common temporal boundary

that binds all of us together. Before relativity, the shared past and shared future characterized the "world as it is now" in relation to the "self as it is now." But with relativity, the "world" dissolves into countless separate events and their associated lightcones, demarcating separate but overlapping causal pasts and futures.

We each still construct our own present in which we have a sense of spatial extension into a wider world. The difference is that this present and this wider world are no longer a shared present and world. Gone is the common ontological present that relates us to others in a wider, common world in which we live and that points to the unity of the world. Instead, space as defined by the temporal present is lost as the common present dissolves into a diversity of events in time.[30] Perhaps a flowing-time interpretation of relativity will yet prove itself able to redress these concerns and provide something of what ordinary experience and classical physics both gave us, but as path (1) implies, we must be vigilant in resisting those anthropomorphisms that science contradicts. Perhaps other explorations along paths (3), (4), (7), or (8) will succeed instead. With the debate still active, one hesitates to claim foreknowledge of the outcome.

For Tillich's analysis, though, some implications seem clear already. On the one hand, relativistic spacetime underscores—much more dramatically than ordinary, classical time and space did—what Tillich describes as the illusory, negative quality of time, the impermanent sense of being in a place among others, and through these features the power of nonbeing manifesting itself in spacetime. Moreover, we can think with Tillich of God as present to us in each moment if we reconceive of God as present to each and every momentary event instead of to each and every common present. In this way, the concepts of God as the ground of creativity and the source of courage in face of ambiguity and anxiety can still flourish. On the other hand, the ambiguous status of time's arrow in relativity given the central role it plays in Tillich's ontology, the sense of the self's profound temporal isolation, the loss of a "world," and in its place the presence of an elsewhen related to every moment yet forever causally hidden—these aspects of relativity, while heightening the existentialist dimension of Tillich's writings, clearly challenge the ontology that grounds his philosophical analysis of existence.

SUBSTANCE IN RELATIVITY. We have talked about relativity's effects on our views of space, time, and causality. What about its effects on the concept of substance? Perhaps the most important effect here is the equivalence relativity gives to two of the properties of matter that in classical physics and ordinary experience are entirely different: the mass of an object and its energy. Compress a spring and you give it stored, or potential, energy. Release it suddenly and it dances about, turning its stored energy into the energy of movement, or kinetic energy. What relativity adds to

this picture, though, is stunning: the compressed spring weighs more than the same spring when it is not compressed and quiescent. Adding potential energy, e, is equivalent to adding mass, m, as specified by Einstein's most famous equation of all, $e = mc^2$.

Relativity, then, places in equivalence the property of mass, which classical physics would consider an invariant property of a piece of matter, with energy, which classical physics would consider a variable property of matter. As an invariant property, mass seemed intimately connected with matter, a kind of fundamental manifestation of what material existence means. Energy, light, heat, motion, and power seemed loosely connected with matter, because an object could be given any amount of them without changing its mass. Moreover, mass and energy were separately conserved in classical physics: The mass of an object did not change as you moved it. Similarly, as potential energy was transformed into kinetic energy, the total amount of energy remained constant. Now, however, it is the total amount of mass-energy that is conserved, with mass and energy changing into each other.

Note, though, that this does not mean that energy is equivalent to matter, a common slip in popular books on the new physics. Nor does it mean that the "stuff" of the world is just energy congealed into lumps. (Such a view is suggested by quantum field theory, but not by special relativity theory.) In this sense relativity is merely a kinematic theory, telling us how to relate measurements of observable properties, and not a dynamic theory like classical mechanics, telling us how these properties change in time.

TILLICH'S ANALYSIS IN LIGHT OF SUBSTANCE IN RELATIVITY. How might this affect Tillich's philosophical analysis of the category of substance? We recall the way he used the concept of substance to underscore the duality of being and nonbeing, and thus the question of God found in being. Insofar as it underlies the flux of appearances, substance points to the power of being over nonbeing. Insofar as it is inseparable from the appearances through which it is expressed, substance displays the power of nonbeing and leads to anxiety. This duality of substance points to the power of God underlying being and evokes in us courage as we wrestle with such duality.

With this in mind, I think we can see at least some effect of relativity on Tillich's analysis, though we will find more when discussing quantum mechanics below. Intuitively, mass pointed to the stability of substance, its power to underlie the flux of appearances, and this intuition was borne out by the fact that in classical physics—and of course in ordinary experience—mass is conserved separately from energy. Energy pointed to the dynamics of flux, the evanescent character of all natural processes, since it is always changing from one form into another—though its conservation according to classical physics suggested a permanence of a sort. In relativity, how-

ever, these properties are combined into a new single property, mass-energy, which is conserved and in which mass and energy transform into each other.

To me this accentuates Tillich's duality, for it gives to substance (traditionally, mass) an intrinsically transitory quality (traditionally, energy), and it adds to the character of flux (traditionally, energy) the enduring quality of permanence (traditionally, mass); yet it does so without conflating or confusing the concepts of substance and appearance, or of mass and energy. This, then, suggests that permanence and transitoriness in turn evidence a duality in the character of being that underscores Tillich's sense of the duality of the power of being and nonbeing, and this in turn enhances the existential analysis as it discloses the question of God.

Tillich on Symbols of God, Freedom and Destiny, Divine Action, Causality, and Substance in Light of Quantum Physics

THREE INTERPRETATIONS OF QUANTUM PHYSICS. It is a stunning fact that though quantum physics is one of the two uncontested pillars of twentieth-century physics (the other is special relativity), its philosophical interpretation is still starkly contested after nearly a century of debate. Quantum processes are characterized by the following:

Radical chance which seems to defy a full causal explanation: Why does one of a billion identical uranium atoms decay at a particular time when the rest do not?

Wave-particle duality: Why do electrons produce a wavy pattern of dots on a screen after passing through slits in a metal plate, acting both like particles (the individual dots) and like waves (the wavy pattern of dots)?

Self-interference and nonlocality: Why do particles that have once interacted still act instantaneously as though they were part of a single system even when they have become separated by vast distances?

These and other phenomena press for an explanation, but all such attempts leave us with more puzzles than answers. Of the leading ways to understand quantum physics, three are of particular prominence among scientists and philosophers.[31]

Niels Bohr and Epistemic Complementarity. By the mid 1920s, Bohr had formalized an approach that emphasized the epistemological limitations of quantum physics. According to what is often called the Copenhagen interpretation, we are forced to describe the results of measurement on atomic systems in complementary ways, referring to both their wavelike and their particle-like character, even though we have no way to reconcile these contradictory pictures with what we might believe to be the

real nature of atoms. More technically, we describe the results of experiment using spatial and temporal language (e.g., this result happened here at a specific time), and we describe the causes underlying these processes using mathematical equations (e.g., the Schrödinger equation and the wave function), but we cannot combine the spacetime description and the causal mode of explanation into a single, seamless account (e.g., these causes affected the wave function at this point in time and space producing the experimentally recorded event). Thus, spacetime description and the causal mode of explanation stand in a relation of complementarity. If Bohr is correct, we cannot use our epistemic tools to expose the actual, ontological structures in the microworld, even though we believe they exist and cause the results we measure in the lab.

Einstein and Ontological Determinism. Einstein never accepted Bohr's approach, arguing instead for a realistic and causal description of these processes—and one consistent with special relativity. Until the famous Einstein-Podolsky-Rosen thought experiment in 1935, he tended to argue that quantum physics was incorrect. After the thought experiment, he came to accept quantum physics as a correct but incomplete theory. Somehow there must be additional (often referred to by others as "hidden") causes at work in nature that we should be able to describe and understand more fully than the Copenhagen interpretation would allow. Beginning in the early 1950s, David Bohm took up this approach and actually provided a deterministic approach to quantum processes. Bohm's approach, however, leads to a radical reformulation of our underlying conception of matter and causality, as suggested by his term the "implicate order," as well as other problematic issues.

Heisenberg and Ontological Indeterminism. In the 1920s, Werner Heisenberg adopted the Copenhagen interpretation. Eventually, however, he argued for an ontological interpretation of quantum physics as pointing to genuine indeterminism in nature. Drawing on Aristotle's distinction between potential and actual, Heisenberg argued that the properties of quantum systems are potentialities: some become actualized in the process of measurement, and others remain as potential aspects of the atomic system.

In 1967, J. S. Bell announced a theorem that was to have profound consequences for our understanding of—or perplexity about—quantum physics. Bell's Theorem showed us that the data produced by quantum systems force us to abandon what is called *local realism*: that is, the combination of *locality*, meaning consistency with special relativity (thus all interactions are limited by the speed of light) and *realism*, meaning that the properties of a quantum system exist independently of whether or not we measure them. Consider two particles that are bound together and then

become physically separated. Lab A takes measurements on one of the particles, and Lab B takes similar measurements on the other particle. Bell showed that if local realism holds, the results from Labs A and B would be correlated according to a simple mathematical formula which we now call *Bell's inequalities*. Quantum physics, in turn, predicts that Bell's inequalities will be violated. Over the past decades, a variety of actual measurements like this have been performed, and the results violated Bell's inequalities! This result is consistent with quantum physics but challenges either special relativity or realism. One way out is to suggest that, though the systems are separated, they are somehow interacting instantaneously, but this seems to contradict special relativity. Alternatively, one could give up on realism and view properties as arising from the process of measurement, but this seems odd—Does the proverbial tree fall when its falling is unheard? One final option is to suggest that the separated systems are not really separated; the underlying metaphysics of matter might be far more nonseparable or holistic than the picture of tiny particles separated and interacting suggests.[32]

TILLICH AND QUANTUM MECHANICS. There are at least two ways one can introduce the discussion of quantum mechanics into systematic theology. First there is what I have called path (1): quantum mechanics as such places constraints on what we can say about nature.[33] For example, regardless of how we interpret it, quantum mechanics points to a view of nature radically different from what we find in ordinary experience. We are challenged to bid good-bye to the classical world, though this is precisely the world that pervades theology. The second way is path (3), employing one of several alternative philosophical analyses of quantum mechanics such as those suggested above, each pointing suggestively toward a relatively unexplored philosophy of nature. It is this second path that I will explore here.

Personal and Impersonal Symbols for God in Tillich and Quantum Complementarity. Many scholars have found Bohr's writings on complementarity to provide a rich framework for theological conversation. Barbour, in particular, directed this conversation to the theology of Tillich in the mid 1970s (Barbour 1974). Here Barbour carefully examines Tillich's use of personal and impersonal symbols for God and, closely related to it, the presence of both the numinous and the mystical in religious experience as discussed by Ninian Smart, Rudolf Otto, Conrad Hyers, Winston King, and others.[34] Barbour concludes that, though it is not appropriate to use complementarity in describing the relation between different world religions, it can be used creatively for analyses such as Tillich's, which identify both personal and impersonal symbols within a given religion, as well as for discussing Tillich's ontological polarities, for example, freedom and destiny (Barbour 1974, 84–91). Barbour also identifies several key features of

quantum complementarity that are absent from theology: a unifying mathematical formalism, consistency at the level of theory (doctrine) more than at the level of models (interpreted experience), and predictive power (Barbour 1974, chap. 5).

Freedom and Destiny in Light of Quantum Indeterminism. Although I find these discussions fascinating, I believe it is worthwhile to explore the ontological analysis offered by Heisenberg and adopted by many scholars today.[35] If ontological indeterminism is taken seriously, its implications for theology bear on the questions of both human freedom and divine action in nature.[36] Let us focus briefly on each of these questions.

Tillich (1967, 1:182–86) identifies the polarity of freedom and destiny as the third element in the ontological structure of being. It is pervasive not only in the human dimension but in all dimensions in life. It is of importance for theology equal to that of a proper conception of reason, and without it revelation cannot be understood. Thus, Tillich immediately challenges the usual juxtaposition of freedom and necessity, arguing instead that the correct contrast is between possibility and necessity.[37] This point is crucial if we are to avoid reducing the concept of freedom to "indeterministic contingency" and necessity to "mechanistic determinacy." Such a reduction would undercut the essential meaning of freedom as found in the immediacy of human experience. Thus, for Tillich the issue of determinism and indeterminism moves on a level secondary to that of freedom and destiny. Similarly, Tillich focuses our attention not on free will, which reifies the will into a thing that necessarily lacks freedom, but rather on the human person as a complete and responsible self. In short, "the negation of necessity never constitutes experienced freedom." Instead freedom is experienced as "deliberation, decision, and responsibility."

Still Tillich states, almost as an aside, what I think is a key issue, namely, that by serving as a "protest" against the problem of determinism, the assertion of indeterminism actually points to the fact that "the moral and cognitive consciousness presupposes the power of responsible decision." It is at this point that quantum indeterminism might play a crucial role, for though it in no way constitutes or even adequately characterizes our conception of freedom as such, it does seem to contribute a necessary (if insufficient) element for the plausibility of Tillich's presupposition that we do in fact have the power to act responsibly. To put it succinctly, I believe that physical indeterminism provides a necessary (if not sufficient) condition for the possibility of alternative somatic dispositions; without it I find it hard to understand the claim that we can act responsibly in the world even if we accept Tillich's broader discussion of freedom and destiny in polarity.[38]

Stated in slightly different terms, a necessary (if not sufficient) condition for the possibility that we can act freely in the world is that we are not entirely constrained deterministically at the inorganic and organic dimen-

sions of our somatic existence by the causal laws of physics. Here we recognize one of the immense challenges to the human spirit during the modern period, namely, the mechanistic world view of Laplacian determinism. Mechanism included a philosophical commitment not only to determinism, drawing on classical physics, but also to epistemic reductionism, in which the properties and processes of the whole can be derived from and are reducible to those of its parts. Tillich (1967, 1:184) argues against the reductionistic aspect of mechanism, using the whole-part dialectic to claim that the determinism of the whole cannot be derived from the determinism of its parts, but he does not take into account the shift to physical indeterminism offered by at least one interpretation[39] of quantum mechanics. If atomic and subatomic processes are genuinely underdetermined by the laws of physics, perhaps they are open to the effects of top-down causality stemming from what Tillich calls the dimensions of mind and spirit.[40] My point is that, without clearly integrating physical indeterminism into his argument, I do not see how Tillich can defend the agency of the whole *on its parts*, even if the whole is not determined entirely by its parts.[41]

Divine Action and Quantum Indeterminism. I close this section by pointing to two areas that may prove fruitful. The first is the problem of divine action[42] and the new possibility of a noninterventionist approach. I am reminded of Tillich's basic approach to miracles as signs pointing to the divine power in nature and history and not to negations of natural laws.

Discussion of divine action may not be particularly appropriate in a Tillichian context, where God as the ground of being transcends the theistic framework that divine action normally operates out of, and even more so where Tillich launches a pointed attack on supranaturalistic theology. Still, Tillich's comment on miracles suggests at least common cause with theists who are concerned with developing a noninterventionist view of the relation between God, nature, and history. To be specific, an indeterministic philosophy of nature may make it possible to bring together in a richer correlation the elements of revelation that Tillich referred to as the objective occurrence, or "miracle," and its subjective reception, or "ecstasy" (1967, 1:111, 129–31).

Causality and Substance in Light of Quantum Indeterminism and Nonlocality. The second area that may prove fruitful is Tillich's analysis of causality and substance in light of quantum indeterminism and the nonseparability of matter as suggested by the discussion of Bell's theorem. According to Tillich, natural causality displays both the power of being (a cause has the power to make its effects real) and nonbeing (the power of its own reality is not contained in the effect). If quantum indeterminism is valid, the power of nonbeing would seem even further evident: now the effect not only does not possess its own cause in itself, but it does not even result from a sufficient cause in a preceding natural event. Yet it would

also seem to underscore the power of God not only as the ground of being—God continuously granting existence to creatures—but also the power of God to act within the processes of nature to grant them causal efficacy. In this heightened sense, God's power is truly mediated by natural processes, so that God works "in, with, under, and through" the web of nature.[43]

Finally I am reminded of Tillich's comment that substance is nothing beyond the accidents in which it is expressed, and that these accidents are in constant flux (dynamics) in relation to pervasive patterns (form). If the idea of nonseparability is at all correct, the quantum mechanical concept of substance might best be expressed in terms of a global, holistic ontology, ineffably hidden within the ambiguities of properties. Substance would seem more like indefinitely extended Aristotelian potentialities than the simple atomic materialism of classical physics. It would also seem like Tillich's view of the insubstantiality of substance that displays the power of both being and nonbeing.

God as Creating and Physical Cosmology

TILLICH'S CRITIQUE OF NATURAL THEOLOGY. Tillich begins his short section (1967, 1:204–10) on the ontological, cosmological, and teleological arguments found in natural theology by claiming that they fail as arguments for the existence of God but succeed in exposing the question of God implied in finite existence.[44] Correctly understood, the ontological argument directs our attention to the way in which potential infinity, i.e., that which is truly unconditional, is present in actual finitude, i.e., the actual world of existence (1967, 1:206). The unconditional is found both in what is true-itself, that by which we each judge various claims to truth, and in what is good-itself, that by which we each judge various claims to goodness. These, in turn, manifest being-itself, the ground and abyss of everything.

The cosmological argument, correctly understood, points to the question of God that emerges from the unconditional element in the asking of any question. It is urged on us by the threat of nonbeing and our consequent experience of anxiety. The tradition has given us two versions of the cosmological argument, both of which are valid in forcing the question of God on us, but invalid in claiming to render God in terms of the existence of a highest being. The first is what the tradition labeled the *cosmological argument*. It seeks to move from the finitude of being to an infinite being. The second is the traditional *teleological argument*, which seeks to move from the finitude of meaning to a bearer of infinite meaning. The cosmological argument starts with the endless chain of causes and effects and points to a first cause, or with the contingency of all things to a necessary substance. Tillich reinterprets first cause and necessary substance as symbols expressing the question of God. The teleological argument starts with

finite meanings which we recognize as constantly threatened. This implies an infinite and unthreatened cause of meanings and points to God.

Natural theology[45] succeeds, then, when it consists in an analysis of existence that exposes and elaborates the question of God implied in existence. It fails when it goes beyond this and claims to be an argument that proves the existence of God, because God as being-itself is beyond essence and existence. Natural theology thus plays a crucial role in Tillich's system, because its failure to provide arguments exposes its true worth in driving reason to "the quest for revelation."

GOD AS CREATING. With this prolegomenon in place, Tillich then offers us his doctrine of God ("The Reality of God" [1967, 1:211–89]) with extraordinary insight into the history of religion and its philosophical transformation. Throughout his elaboration of God as being, living, creating, and related, Tillich continually returns to his fundamental affirmation of God as being-itself. I want to focus particular, though brief, attention on Tillich's analysis of God as creating (i.e., his doctrine of creation [1967, 1:252–70]), because it provides a promising link to the wide-ranging discussions concerning God and cosmology over the past four decades.

According to Tillich, "the divine life is creative, actualizing itself in inexhaustible abundance. The divine life and the divine creativity are not different. God is creative because he [*sic*] is God" (1967, 1:252). The doctrine of creation that follows from this assertion is not about an event in time but about the fundamental relation between God and the world. It discloses the world in its creatureliness and the divine creativity as its correlate. The divine creativity is given through three symbols: (1) God's originating creativity, (2) God's sustaining creativity (preservation), and (3) God's directing creativity (providence).[46] Each of these offers important connections to scientific cosmology.

1. Creation from nothing (*creatio ex nihilo*) is the classical formulation of God's originating creativity. It functions negatively to protect Christianity from every form of ultimate dualism. God does not create using eternal essences,[47] powers, forms, or matter (e.g., Platonism). Creation from nothing also functions positively to assert that creatures, being finite, include the heritage of both being and nonbeing. This point is later clarified in Tillich's analysis of existence (1967, 2:20–21). For something to exist means that it stands out while still remaining in nonbeing in two distinct ways: it first exists potentially, by standing out of absolute nonbeing (*ouk on*), and then it exists actually, by standing out of relative nonbeing (*me on*). In the first sense it is finite, the unity of being and nonbeing. In the second sense it is actual but changing, because existence never fully actualizes all its potentialities. Creation from nothing also underscores the primacy of time as the category of finitude in the divine life and in creaturely existence. Following Augustine, Tillich asserts that time was

created *with* the world; creation is not a past event in the history of the world.[48]

2. Preservation. The world as creaturely depends continuously on the creative activity of the ground of being for its existence. Tillich argues against understanding preservation in a deistic mode, where the world is thought of as independent, obeying its own laws. Instead preservation means that God continuously creates time and things together, again following Augustine. Moreover, God sustains the world by ensuring the continuity of the structure of reality as regular and calculable.

3. Providence. God directs all creatures to their future fulfillment, or *telos*. God's creativity works through human freedom and the spontaneity and structural wholeness of nature.

GOD AND COSMOLOGY: A TILLICHIAN ANALYSIS. Tillich's analysis of natural theology and the theology of creation provides grounds for at least partial contact with the past four decades of theological discussion of twentieth-century physical cosmology. After a brief summary of Einsteinian cosmology (e.g., the Big Bang), we will turn to Tillich's analysis.

Big Bang Cosmology. As is well known, Einstein's theory of general relativity is a theory of gravity that incorporates special relativity but not quantum mechanics.[49] It abandoned the Newtonian concepts of separate and absolute Euclidean space and time as a fixed container in which matter moved under the force of gravity. Instead it began with the spacetime framework of special relativity. It then made the geometry of spacetime responsive to the motion of matter by allowing spacetime to be curved, and at the same time it required the motion of matter to be determined by the curvature of spacetime. When applied to the growing astronomical data of the early-to-mid twentieth century, it depicts the universe as an expanding three-dimensional surface. The geometry or shape of the surface might be closed, like a three-dimensional sphere, flat, like Euclidean space, or open, like a three-dimensional saddle. If it is closed, the universe has a finite size and will recontract after expanding to a maximum extent in a few hundred billion years, to end in a fiery point (singularity). If it is flat or open, it will expand and cool forever. These scenarios are often called "freeze or fry." In all three cases, though, the universe is expanding from an initial singularity of infinite temperature and density, and vanishing size some 12 to 15 billion years ago. This event is normally designated as $t = 0$, where t represents cosmological time. At this event the physics of general relativity breaks down, and it is meaningless scientifically to speculate about what lies behind or before this event. It is not even clear whether the event, if it actually exists and is not just an artifact of general relativity, could be detected or confirmed by direct empirical evidence (Stoeger 1988). Within the framework of general relativity as applied to the astronomical data, such an event can be considered the beginning of time.

Tillich and Big Bang Cosmology. There is an enormous body of literature on the purported theological implications of Big Bang cosmology (Peters 1989; Russell 1989, 177–209; 1993, 293–329; Drees 1990; Murphy and Ellis 1996; Worthing 1996; Clayton 1997). One way to sort out the writers is in terms of the degree of relevancy accorded $t = 0$, ranging from direct relevance (i.e., $t = 0$ proves or directly confirms creation from nothing)[50] to complete irrelevancy (including both those who argue for a two-worlds view of theology and science in general and those who are key contributors to the theology and science dialogue but find $t = 0$ in particular to be irrelevant to theology—see Polkinghorne 1994, chap. 4, esp. 73; Peacocke 1979, 78–79; Stoeger 1988, 219–47; and compare Barbour 1966, 366–68, 377, 380, 414, 458 with Barbour 1990, 128–29). My intent, here, is quite limited; it is to explore the way a Tillichian approach would respond to Big Bang cosmology and $t = 0$ in particular.

Clearly Tillich would reject the claim that $t = 0$ is directly relevant to theology: he says as much in volume 3 (1967, 3:320). Still I do not believe he would see it as entirely irrelevant to theology, for surely such an event invites philosophical interest. What, after all, are we to make of a physical event, $t = 0$, which in Big Bang cosmology is the cause of a future event at $t > 0$, but which is not the effect of a previous natural cause?[51] Science may find a new cosmology without an essential singularity—indeed it seems to have done so in recent years (see below). But the fact that an event such as $t = 0$ is referred to within a scientific theory such as Big Bang cosmology is significant in demonstrating the capacity of science to point to powerful philosophical issues about causality, space, time, and existence in general. It thus seems eminently reasonable that a philosophical analysis of $t = 0$ could bear, in turn, upon theology, including both natural theology and Tillich's doctrine of creation as paths (2) and (3) portray it.

Regarding Tillich's interpretation of natural theology, an absolute beginning of the universe would certainly underscore the question of God posed by the threat of nonbeing: a universe of finite past temporal existence would seem surrounded by nothingness as well as laced through with it (e.g., the unity of being and nonbeing). An absolute beginning would thus heighten not only the ontological argument but the traditional cosmological argument as well, in which a finite chain of causes and effects points to a first cause. Clearly the existence of *any* universe, whether its past and future are finite or endless, is a fundamental form of contingency that raises the question of God and thus leads, at least by path (3), from science to theology. Still, the contingency of a universe with a finite past would seem more complex than that of a universe in which time never ends, for the temporal finitude of such a universe would tilt the scales toward nonbeing; compare this to an eternal one, where the infinity of time tilts the scales toward the power of being. If, as Tillich suggests, the

reality of an effect depends on its cause, and thus if causality expresses the inability of anything to contain within itself the power of its own reality, an event such as $t = 0$, which is purportedly not the result of a preceding natural cause, would vividly underscore the contingency of the universe and its utter dependence on God as its source and ground. Living in such a universe could not help but intensify the anxiety of being a creature and the thirst for a courage which only God can provide.

The issue of $t = 0$ is also at least indirectly relevant to the theology of creation as Tillich develops it. Focusing on the *ex nihilo* tradition and following path (2), $t = 0$ in Big Bang cosmology serves as an example of the meaning of the Augustinian insight that time was created *with* the world. Augustine clearly argued against the Platonic idea that God created the world at some point in an endless span of preexisting time. Path (3) suggests that, while $t = 0$ is an empirical example of the philosophical category of contingency, it is not the only example. Indeed, Aquinas held that even an eternal world would be contingent. Beginning with the creative character of the divine life, Tillich adds to Augustine and Aquinas the recognition that creation is not a past event in the history of the world. Instead the world as creaturely must be preserved by God; its continued existence depends on the creative activity of the ground of being. In my opinion, the discovery that the universe has a finite past does not contradict these claims, and it might be taken as supporting Augustine's attempt to refute the idea of a preexisting time.[52]

Inflation and Quantum Cosmology. Now let us turn briefly to inflation and quantum cosmology. The inflationary Big Bang model was first proposed by Alan Guth and colleagues in the 1970s to overcome certain technical problems posed by the Big Bang model.[53] The effect on $t = 0$ is fascinating: In some inflationary cosmologies, we may never know whether an essential singularity exists, even if it does[54]—a situation that John Barrow calls "undecidable."[55]

More recently, attempts have been made to unify quantum physics and gravity and apply the results to cosmology. Proposals by Jim Hartle and Stephen Hawking, Andrei Linde, C. J. Isham, Alan Guth, and others are still in a speculative stage, but there are already some indications of what different quantum cosmologies might look like, including models with or without an initial singularity (eternal inflation), with open or closed domains embedded in an open or a closed mega-universe, and so on (Hartle and Hawking 1983, 2960–75; Linde 1987, 61–68).

Inflation and Quantum Cosmology: The Shifting Conversations with a Tillichian Theology. What effect has the transition to inflationary and quantum cosmologies had on the conversations with theology? Clearly the case for a direct relation between cosmology and theology in which $t = 0$ strongly supports Christian theology is undercut, and making such a

case would seem riskier than ever.[56] In my view this only serves to reinforce Tillich's insistence that theology responds to a philosophical analysis of existence rather than the technical results of secular research. Following his lead, I suggest we look for indirect relations between cosmology and theology involving a philosophical analysis of cosmological theories and their assumptions. In such an approach, the philosophical implications for theology of inflation and quantum cosmology may differ from those of Big Bang cosmology, but they are in no way eliminated. Instead, ontological, cosmological, and teleological issues resurface again as fertile sources of theological discussion (Drees 1990; Russell, Murphy, and Isham 1993).

1. Ontological. Whether or not there was a beginning, the very fact of existence drives us to ask why anything exists at all. Actually Hawking himself underscored the fundamental nature of this question, and had the insight that science per se may not be able to answer it, when he wrote in the conclusions of *Brief History*, "What is it that breathes fire into the equations and makes a universe for them to describe?" (1988, 174)

2. Cosmological. Why is the universe intelligible and its intelligibility expressible in terms of mathematical law and a theory of efficient causality? Einstein returned to this fundamental question when he commented that "the eternal mystery of the universe is its comprehensibility" (Einstein 1978, 283–315; cf. Heller 1995, 107–21).

3. Teleological. Why do the most general laws of physics, such as those underlying quantum gravity, and the natural constants used in quantum gravity, have the form and values they do? Could *everything* have been different such that no possible domain of the mega-universe would have been capable of life and mind? More generally, to what extent are inflation and quantum cosmologies relevant to theology? Are there specific features of inflationary and quantum cosmologies that deserve particular theological attention such as $t = 0$ received in the past? As we begin to probe questions like these, it will be exciting to see what results are found in the next few years.

Finally, the ongoing developments in quantum gravity and quantum cosmology provide a rich example of what I have called paths (7) and (8). Here in real time (and not just through such historical examples as that of Hoyle's steady state) we can study the ways nonscientific factors play a role in both the formation of new theories and the reasons for choosing between them. A nice example of (7) comes from a comparison between the work of Roger Penrose and that of Hartle and Hawking. In Penrose's approach, the universe arises through a small fluctuation in a quantum field in eternally existing superspace. According to Hawking, however, the universe as a whole arises from the dovetailing of three-geometries in a quantum superspace leading to the formation of the four-dimensional spacetime manifold with no initial singularity. How do we decide between them? According to Chris Isham, the Penrose approach runs into

trouble by its arbitrariness: why should one point in an infinite and homogeneous superspace be the seed for the universe and not others? (Isham 1988, 375–408) In Isham's view, Hawking's model avoids this problem and is thus preferable. What is interesting here is the parallel Isham points out between his argument against the fluctuation model and Augustine's rejection of the Platonic demiurge model in which God creates the universe at a point in an eternally preexisting time. Instead, Augustine asserted—and Tillich agrees—that God creates time along with the universe;[57] it is this concept of time arising with the universe that parallels Augustine's conception of the creation of time by God.[58] Other scientists, including Hawking, have noticed this similarity too (Russell 1993, 293–329, esp. 318–20). As an example of path (8), we can consider the theological claim sometimes made that the image of God (*imago dei*) includes the capacity for free will. But for us to be genuinely free, we must presuppose the possibility that we can enact our will by choosing between alternative somatic dispositions, a possibility frequently seen as ruled out by Laplacian determinism but regained through the indeterminism that Heisenberg's interpretation of quantum physics affords. It is reasonable, therefore, to extend this concern to the choice between an Einsteinian cosmology, with its inherent determinism, and a quantum cosmology. Clearly there are crucial scientific reasons for moving to the latter, but it is important to note that theology can be seen as offering intellectual reasons for such a move as well.[59] Paths (6), (7), and (8) may lie beyond the theological methodology developed by Tillich, but surely if we take such paths, Tillich's insistence on the crucial importance of a philosophical analysis will be of lasting worth in making these conversations productive.

Perhaps the most important result to emerge from the shifts in cosmology over the past decades is the emergence of the inflationary Big Bang as a permanent description of *our* universe from the Planck time some 12–15 billion years ago to the present. Gone is the time when Hoyle's steady state model posed a serious challenge to the Big Bang, with its picture of a single, ever-expanding universe whose fundamental features were time independent. Instead the domain of debate has shifted to the pre-Planck era and what might lie endlessly before the Big Bang in quantum superspace. We have witnessed what Joel Primack and Nancy Abrams call an encompassing revolution, as distinguished from the kind of Kuhnian replacing revolution one usually thinks of when scientific paradigms change (Pannenberg 1976). In such an encompassing revolution, the new paradigm, for example, quantum cosmology, contains the old one, for example, Big Bang cosmology as a limit case, for example, when quantum effects can be ignored. Said another way, we can have complete confidence in relying on the Big Bang scenario, because we know just where it fails: prior to the Planck time. In this sense the Big Bang is here to stay.[60]

Given this perspective, the time is ripe for a renewed theological focus

on the universe in which we have evolved, and a setting aside of what used to be interesting issues surrounding $t = 0$ but which now are rapidly becoming outmoded. Surely we would commit the genetic fallacy if we assumed that the most important clue to the universe we live in is found in its ancient origins. Instead we are poised as never before to focus research in theology and science on the universe's 15-billion-year history and the evolution of life, at least on planet Earth and perhaps throughout countless galaxies. Such a focus will raise fundamental questions about the meaning of life and its relation to the universe in which it has evolved—questions which, if Tillich is right, science alone cannot truly answer but which theology can and must address through the method of correlation and, perhaps, the extensions of Tillich's method suggested in this paper.

Creation, Estrangement, and Thermodynamics

ENTROPY AND ORDER IN THERMODYNAMICS. Classical thermodynamics pictures the world primarily in terms of the second law, in which there is an inevitable increase of entropy in systems closed to their environment. Entropy is a measure of how much or how little energy is available to the system to do work: an increase in entropy means a decrease in the amount of work that can be accomplished by the system. Entropy can also be thought of as a measure of the disorder in the system. Systems that do not exchange matter or energy with the rest of the world tend toward maximum disorder, their usable energy spent by being transformed into heat energy. Twentieth-century thermodynamics, in contrast, focused on open systems exchanging energy and matter with the environment, such as plants and animals in the biosphere or the earth-sun as a system. These so-called dissipative systems are far from thermal equilibrium; spontaneous fluctuations can occur in which the system moves to greater states of order and complexity, though the system and its environment still obey the second law of increasing entropy. This process has been called "order out of chaos" by Ilya Prigogine and other scientists. Biological evolution is possible from a thermodynamic perspective precisely because of the flux of visible light from the sun, which drives the biosphere and is then dissipated by the earth as thermal radiation. The earth-sun system as a whole is increasing in entropy. Even the universe can be looked at (though with many technical difficulties) as a system of increasing entropy as the temperature of the microwave background radiation cools toward absolute zero.

A Tillichian Perspective on Continuous Creation and Thermodynamics. This order-out-of-chaos scenario can play a fruitful role in our thinking theologically about God's continuous creation of natural complexity in both the physical/astrophysical and biological/evolutionary arenas. As we saw earlier in the section on cosmology, the universe is historical, moving through distinct epochs or καιροι which are once off, never to reoccur.

Similarly, biological evolution displays this historical and punctuated character. The order-out-of-chaos scenario strengthens this view even at the elementary level of physical processes. Dissipative systems move through definite and distinctive καιροι even as they ultimately approach annihilation. They mark the passages toward a greater good to the extent that we identify the good and the beautiful with increasing complexity, including biological complexity, life and mind, or, more generally, the emergence of what Tillich called the "multidimensional unity of life" in all its possibilities, including the organic, psychic, and spiritual dimensions along with the ubiquitous physical/inorganic dimension.

A Tillichian Perspective on Estrangement and Thermodynamics. But we should hold dialectically in relation to this the fact that increasing entropy ultimately drives these processes toward ultimate burnout. Closed systems display this fact more clearly, but even open systems have a finite lifetime before they run out. In fact, if we think about the physical processes underlying disease, suffering, and death, we inevitably find these processes to be driven by increasing entropy. Ultimately, these same processes underlie the complex interactions which at the human level we call sin and evil, just as they underlie the simpler interactions in the nonhuman world often called natural evil. Of course the term *sin*, and Tillich's interpretation of sin in terms of estrangement, apply to humanity alone and certainly not to nonhuman nature. Still, the continuity between humanity and all of nature, the universality of estrangement as the transition from essence to existence, and the coincidence between creation and estrangement all point to an aspect of estrangement that precedes the evolution of humankind and provides the necessary, but not sufficient, preconditions for the phenomenon of estrangement as sin in human life.[61]

In this sense, the inevitable generation of entropy seems at the physical level to be one of the necessary preconditions for the possibility of natural and moral evil. We know that entropy is not a substance but a property or characteristic of processes in transformation. I am reminded of Tillich's understanding of evil, in which he speaks of "structures of destruction":

> Destruction under the conditions of existential estrangement is not caused by some external force . . . but it is the consequence of the structure of estrangement itself. One can describe this structure with a seemingly paradoxical term, "structure of destruction"—pointing to the fact that destruction has no independent standing in the whole of reality but that it is dependent on the structure of that in and upon which it acts destructively. . . . [Destruction] "aims" at chaos; but as long as chaos is not attained, destruction must follow the structures of wholeness; and if chaos is attained, both structure and destruction have vanished.[62]

Here we can see a striking analogy between the fully developed theological account of evil given by Tillich and what I am proposing are its underlying and necessary, though certainly not sufficient, conditions at the elementary physical/inorganic and biological/organic dimensions.

The double role entropy plays in all of nature, characterizing the emergence of complexity and order while underlying the processes of dissipation and disorder, seems to provide conditions within the inorganic and organic dimensions that feed into the much more subtle processes we know as ecstatic and tragic in the immediacy of human experience. The ubiquity of thermodynamics, in which the second law applies to all physical systems, hints at the universality of estrangement from essential being.[63]

NOTES

I want to thank A. Durwood Foster for his careful reading of an earlier version of this paper and for his extensive and very helpful comments.

1. It would be very interesting to know whether Tillich's method is an actual source for, or had an influence on, the method used by scholars in theology and science. An affirmative answer would not be entirely surprising, given the theological training many of them have had.
2. The idea of an epistemic hierarchy is, in brief, as follows: Physics places constraints on biology: no biological theory should contradict physics, and so on up through the other sciences and humanities. On the other hand, the processes, properties, and laws of biology cannot be reduced without remainder to those of physics, and again on up through the other sciences and humanities. Though scholars differ on the precise ordering of the disciplines and the role that cross-disciplinary fields like genetics play in the scheme, the idea of an epistemic ordering is crucial to warding off both the philosophical claims of reductionism and a dualistic (or even more foliated) ontology of "levels." Peacocke gives an extremely helpful diagram of such a hierarchy in two dimensions: epistemic complexity and phenomenological "size." See Peacocke 1993, 217.
3. Clearly Tillich, too, argued against epistemic reductionism, but this is not my focus here. It should be noted, however, that his "case against levels" (1967, 3:12–15) is, in my opinion, a rejection of *ontological* levels as a kind of generalized ontological dualism, and not a rejection of the *epistemic* hierarchy as adopted here and sometimes called epistemic emergence. In fact, the neo-orthodox tendencies in his writings would move in the direction of separating theology in large measure from secular knowledge, which contrasts with the hierarchy model, in which there are very stark upward epistemic constraints which even theology must consider.
4. He explains in the Introduction to vol. 2 that the relation is one of "independence and interdependence."
5. Needless to say, the method of correlation is much more complex than merely providing ready-made "answers" from a fixed inherited Christian tradition for the existential "questions" inherent in life, though it is occasionally described in this way.
6. This aspect of Tillich's method drew sharp criticism from neo-orthodox theologians—as even Tillich noted (1967, 1:61).
7. The notion of symbol is crucial for Tillich's theology, since he claims that only symbolic language can both express our ultimate concern and participate in that reality. Perhaps the best source for what Tillich means by symbol is his *Dynamics of Faith* (1957), chap. 3, 41–43, where he lists six characteristics of a symbol: (1) it points beyond itself to something else; (2) it participates in that to which it points; (3) it opens up levels of reality that are otherwise closed to us; (4) it unlocks dimensions and elements of our soul that correspond to these dimensions; (5) it cannot be produced intentionally but instead grows out of the individual or collective unconscious, by which it must also be accepted; (6) it can both grow and die when it no longer produces a response. "Signs" share only the first characteristic and are therefore incapable of expressing ultimacy.
8. Note that such revelation is not "natural revelation" (p. 119). It should also be borne in mind that "medium" here primarily refers to experience; one might understand Tillich to be treating nature not only as a medium but even as a source, whereas he would not treat experience as a source.
9. Here and following, see Barbour 1990, especially chap. 2. Two caveats are appropriate here. First, it is important to emphasize that these scholars differed in crucial ways about the philosophy of science. Barbour's point here is to stress what is shared by them and to represent it in a simplified but instructive model. Second, it is also important to realize that many of these ideas had been discussed before. Hempel himself, for example, had already underscored the

influence of theory on observation. Still, neither he, nor Karl Popper for that matter, incorporated it in the fundamental ways that Kuhn and Lakatos did.

10. For a thoroughgoing application of Lakatos's methodology in theology, see Hefner 1993.

11. For example, to view nature as created *ex nihilo* implies that the universe is contingent and rational, and these views provide two of the fundamental philosophical assumptions on which modern science is based. By the creation *ex nihilo* tradition I mean to include its long and complex development by Jewish, Muslim, and Christian theologians and philosophers during what is often called the Patristic and Middle Ages. Of course other sources of these assumptions were contributory, but it is important to remember that the doctrine of creation *ex nihilo* has, in historical fact, served in this way. See, for example, Foster 1969; Collingwood 1945; Klaaren 1977; Lindberg and Numbers 1986; Deason 1986; Kaiser 1991.

12. For rarer, subtle, and nonreductive views, see Ayala 1998, Wildman 1998, Birch 1998, and Barbour 1998. Reductive views are frequently proposed by sociobiologists among others who typically ignore the implicit role of philosophy in their own arguments and seek to appeal directly to the "authority of science." The literature is well known.

13. Historical work to date is suggestive, though far from complete; a thorough study of this crucial period could help us decide just how influential theology or philosophy was to each of the early quantum theorists.

14. For an extremely careful and recent account of the extrascientific factors at play in cosmological debates in this century, including the implicit role of religion, see Kragh 1996.

15. In a similar way, John Barrow uses the anthropic principle, not as an argument for design, but as a way of allowing biology to place constraints on physics (i.e., conditions that are required if the evolution of life is to be possible), and these constraints lead Barrow to the discovery of new explanations of hitherto disparate phenomena in physics. Such explanations seem like prime examples of what Murphy, using Lakatos, would call "novel facts," suggesting Barrow's research program is progressive. Note the unusual way in which "novelty" is used by Murphy and Lakatos.

16. This point is often made in the scholarly literature in the field, though it is frequently overlooked in more popular accounts of theology and science, which tend to focus more on the direct upward relations, namely, what I call paths (1) and (2). Tillich was clearly aware of such upward relations, but he quite rightly, in my opinion, focused attention on the more subtle role for philosophy here, what I have termed paths (3) and (4).

17. Notable exceptions include Michael Polanyi and Alfred North Whitehead.

18. Another way of saying this is to maintain that science is incapable of solving or settling issues raised within theology, notwithstanding the claims sometimes made by such scientists as Paul Davies, Freeman Dyson, or Frank Tipler. Note, however, that these claims are distinct from, though related to, the claims of the reductionist to explain away theology.

19. This asymmetry underlies the claim that theology has *no* authoritative role vis-à-vis human knowing (e.g., science).

20. Tillich first discusses the categories in relation to the dimension of the inorganic in vol. 1 of *Systematic Theology*, but he extends this discussion to the other dimensions throughout vol. 3, showing how the characteristics of the categories found in the dimension of the inorganic continue to be present in, and yet are transformed by their appearance in, the dimensions of life, mind, spirit, and history. In doing so, Tillich counters a reductionistic interpretation prominent in science that would give the inorganic dimension complete jurisdiction over the discussion. At the same time, he dismisses a total separation between the dimensions that characterized so much of neo-orthodoxy in its two-world approach to theology and science. This makes Tillich's discussion perennially relevant to the concerns of those engaged in theology and science. A fuller treatment would include his case against levels—his metaphor of the multidimensional unity of life—and their relevance to the holistic epistemologies discussed in theology and science; the appearance of and transformation of each dimension out of those that condition it; and the way the categories are to be understood in the dimensions of life, mind, spirit, and history.

21. Tillich avoids a strictly classical treatment of space and time as entirely separate by describing them as "interdependent" in the following sense: space is the predominant category in the realm of the inorganic, whereas time is predominant in the dimension of history. He even hints in passing at their relativistic connection, noting that the motion of things in time is treated in terms of the "'fourth dimension' of space." See Tillich 1967, 3:315. Of course Tillich's understanding of "fourth dimension" is probably rooted in a Euclidean framework and would not capture the truly revolutionary sense of fourth dimension found in the pseudo-Euclidean geometry of relativistic spacetime.

22. The irreversibility of time is central to Tillich's understanding of what makes time time. He calls it "the element of 'after-each-other-ness'" (1967, 3:313). See his ensuing discussion for its relation to the other categories under the dimensions of life, mind, and spirit.
23. One could also compare Tillich's views with the further distinction between relative and absolute time and space in Newton's system.
24. Classical thermodynamics can be reduced to mechanics by assuming the atomic theory of matter, as seen in the statistical mechanics of the latter nineteenth century. Thus, statistical mechanics is said to eliminate the arrow of time as a fundamental feature of the classical worldview. However, the study of nonlinear, nonequilibrium thermodynamics in the twentieth century has led some to claim that thermodynamics, and with it the directionality of time, is a fundamental feature of nature even within the inorganic dimension.
25. *Both* relativity and quantum mechanics affect our views of causality and substance. I limit my comments here to the effects of relativity on space, time, causality, and substance and return to the effects of quantum mechanics on our notions of causality and substance, as described below.
26. This is a helpful idea, but my reservation is that it appeals to an apparently arbitrary phenomenological feature of this particular universe, namely, its expansion; it is not grounded in the underlying spacetime ontology.
27. I am developing an alternative approach that is consistent with relativity and that supports a modified view of flowing time, the openness of the causal future, God's experience of individual spacetime events, and a Plotinian/Pannenbergian view of the divine eternity.
28. Clearly for most practical purposes Newtonian physics works extraordinarily well, because most of our lives are spent in the classical limit (relative velocities much less than the speed of light). In the sense that Tillich's is a philosophical analysis of human existence, the shift to relativity may not be important (although this too leads to further subtleties). But to the extent that Tillich's arguments are in principle, or that we consider those aspects of human existence that do involve special relativity (an obvious example being the atomic age and its reliance on the relativistic equation $e = mc^2$—see below), the shift does matter, and it is the latter with which this paper is primarily concerned.
29. Note again Tillich's brief comments on time as a dimension cited above.
30. These implications of relativity underscore poignantly the radical change in worldview wrought by contemporary physics. Compare the prospect of causal isolation of the elsewhen feature with the unity of the world in which "all parts of the universe are contemporal, conspatial, causally conditioned by each other, and substantially distinct from each other" (Tillich 1967, 3:314).
31. Technical references include the classic work, Jammer 1974; recent work includes Cushing and McMullin 1989; for an accessible account, see Herbert 1987.
32. Recent developments in fundamental physics, such as string theory, might offer important ways to address these concerns. To discuss such ideas, we would start with the unification of relativity and quantum physics and pursue its development in terms of field theory, and so forth.
33. As above with relativity, I recognize that classical physics works for most practical purposes within the classical limit (Planck's constant h). Still, because we are looking at an in-principle argument, we must consider the change in worldview brought on by quantum physics.
34. Hyers also insisted that the dialectic in religious experience is not Hegelian or Marxian synthesis but a "fundamental duality." I find Hyers's comments very suggestive of quantum complementarity. See Barbour 1974, 81 n. 19.
35. Heisenberg's ontological interpretation of quantum physics has a number of current supporters. C. J. Isham writes, "The most common meaning attached to probability in classical physics is an epistemic one. . . . However, unless hidden variables are posited, the situation in quantum theory is very different. . . . In particular, there are *no* underlying microstates of whose precise values we are ignorant. If taken seriously, such a view of the probabilistic structure in quantum theory entails a radical departure from the philosophical position of classical physics" (1995, 131–32). According to Paul Davies, "Prior to quantum theory, physics was ultimately *deterministic*. . . . The quantum factor . . . implies that we can never know in advance what is going to happen. . . . We shall see that this indeterminism is a universal feature of the microworld (date??, 4). Ian Barbour writes, "[*A*]*lternative potentialities* exist for individual agents. We urged, in accordance with critical realism, that the Heisenberg Principle is an indication of objective indeterminacy in nature rather than the subjective uncertainty of human ignorance (1966, 315–16; 1990, 123). For earlier sources and references on the ontological interpretation of indeterminacy, see Margenau 1949, 287–302; Heisenberg 1952; Popper 1956.

36. I want to underscore the fact that this is only one of many alternative philosophical interpretations, all of which are compatible with existing data. It is entirely possible, even likely, that one of them will eventually succeed in displacing the others when new experiments and theories dealing with quantum phenomena become available. Thus, we must be tentative when choosing one interpretation with which to work. However, we always work within an interpretive framework, not only in quantum physics but in every field of inquiry, so this in itself gives no reason to pull back from the task of selection and engagement.

37. It might help to recall Tillich's four levels of ontological concepts: the basic ontological structure, the elements of this structure (i.e., the three polarities, including freedom and destiny), the characteristics of being that characterize existence, and the categories of being and knowing (including time, space, causality, and substance) (1967, 1:164–65).

38. As noted previously, Tillich refers to the issue of the "indeterminacy of subatomic processes" in his discussion of the category of causality, arguing that all such processes require a preceding "situation or constellation which is its cause." Again, I entirely agree with Tillich about causality as a category. I intend here to focus on the third ontological element, freedom and destiny, for which the notion of the *indeterministic causality* plays, I am claiming, a crucial role. In particular, the ontological interpretation of quantum mechanics, which Tillich clearly has in mind by the phrase "indeterministic causality," bears indirectly, but I believe necessarily, on the presuppositions that constitute the intelligibility of human freedom, particularly as responsibility within the polarity of freedom and destiny.

39. Recall, though, that there are deterministic interpretations as well.

40. Of course this leads us into the thicket of the mind-body problem, including current controversies over the relation of mind and brain in light of the neurosciences and ongoing debates in the philosophy of mind. See Russell, Murphy, Meyering, and Arbib 1999.

41. Scholars such as Nancey Murphy and Theo Meyering are pursuing this sort of issue in terms of "supervenience." Perhaps their research will help to settle the question of whether Tillich did indeed adequately address the problem of freedom without appealing to quantum indeterminism. Cf. Russell, Murphy, Meyering, and Arbib 1999.

42. One of the key issues that have divided liberals and conservatives is the issue of divine action or, more specifically, special providence. Here we extend the discussion to include nature as well as history. Does God act in specific events in special ways, beyond sustaining all events in being and, because of God's faithfulness, in the regularity scientists express by the laws of nature? Liberal theologians tend to interpret special divine action in terms of our subjective response to what is merely the unfolding of these laws, theologically reducing special to general providence but avoiding an interventionist interpretation of divine action. Conservative theologians tend to start with the objective aspect of divine action and accept that, in order for God to act, God may have to suspend the laws of nature or violate the causal integrity of the processes of nature. What is important to note is that both sides presuppose that nature is a closed causal system, which they get from the modern, mechanistic worldview. Thus, classical physics (and its philosophical interpretation) is the real culprit here in leading theology into a "forced option." But, arguably, science and its philosophical interpretation have changed with quantum mechanics. If natural causes are necessary but not sufficient to determine effects, then we can argue that God adds to natural causes that which is sufficient to determine the effect. Note that this does not reduce God to a natural cause, since by this argument natural causes are insufficient factors in determining the effects we observe. Nor is it an epistemic God-of-the-gaps argument, since it is based on what we know (and interpret) about the world through science and philosophy and not on our ignorance of the world. Finally, it is not an ontological-gaps argument because God has created a world out of nothing (*ex nihilo*) including its laws of nature, and these are open to God's as well as human agency. For further reading see the CTNS/Vatican Observatory series, "scientific perspectives on divine action."

43. Arthur Peacocke's well-winnowed phrase.

44. Evidence for his claim apparently comes for Tillich in the historical fact that for centuries neither supporters nor critics of the arguments for the existence of God have prevailed. This is because "the one group did not attack what the other group defended" (Tillich 1967, 1:204.) Those attacking were correct in claiming that the form and method of the argument, as well as the concept of God as existing, failed in their attempt to prove the existence of God. Still, for its defenders the argument communicated a crucial implicit meaning, pointing to God as the creative ground of essence and existence. It revealed the question of God as it is given, at least implicitly, in human finitude. Although the question is valid, pointing to an underlying aware-

ness of God, the answer, framed in terms of God's existence, should be rejected. Instead of conceiving of God as existing (or not existing), we should understand God as the "creative ground of essence and existence." As Tillich puts it, "God does not exist. He is being-itself beyond essence and existence. Therefore, to argue that God exists is to deny him" (1967, 1:205).

45. Again, note that Tillich rejects the phrase *natural theology*, though he does not reject the concern and some of its impact.

46. As an indication of the importance of the doctrine of creation, note that Tillich views it as providing the basis for the doctrines of incarnation and eschatology.

47. According to A. Durwood Foster (personal communication), "there are residual suggestions in Tillich that the essences are eternal."

48. Two comments are called for here. First, for Tillich, time cannot be thought of as having a beginning or an ending in the inorganic dimension; in fact, these ideas are meaningful only in the dimension of history. Thus, he rejects the attempt to relate the beginning of physical time to the symbol of creation (1967, 3:320). Compare this with the discussion below on $t = 0$ in Big Bang cosmology. Second, Tillich understands the divine and eternal life as including temporality but transcending it. Our time includes nonbeing both as the estrangement of existence from essence and the existential disruption of the moments of time. But the world's time, though created with the world, will go on to participate in eternal life. See Tillich 1967, 3:318–21, 396–401, 419–20. I am grateful to Durwood Foster for stressing this point to me.

49. General relativity can be considered a classical theory of gravity in the sense that it does not incorporate quantum mechanics, though it is a relativistically correct classical theory because it does incorporate special relativity. The current search for quantum gravity is an attempt to combine relativity and quantum mechanics into a theory of gravity.

50. See, for example, the allocution of Pope Pius XII to the Pontifical Academy of Sciences in Rome, 1951. See the *Bulletin of the Atomic Scientists* 8 (1952): 143–46, 165, for a translation of part of the papal text. For an excellent discussion of it see McMullin 1981, 17–57. According to McMullin, the pope later refrained from this claim after being cautioned by Georges Lemaître. Though a Roman Catholic priest and one of the founders of Big Bang cosmology, Lemaître had a two-worlds view: keep theology and science entirely separate. For a scholarly argument, see Craig 1979. See also Jastrow 1978, 115–16.

51. Remember, an event at $t < 0$ would not be admissible in Big Bang cosmology, because $t = 0$ is an essential singularity.

52. It might be useful to recall that Tillich wrote the *Systematic Theology* (1967) at a time when Hoyle's steady state cosmology was a serious competitor to Big Bang cosmology. Tillich's concern is clearly to show that faith in creation is not dependent on Hoyle's being wrong.

53. These include the horizon problem, the matter/antimatter ratio, and so on. For a helpful discussion, see Trefil 1983.

54. In the sixties, Hawking, Penrose, and Geroch proved several singularity theorems, which showed that Big Bang cosmology must include an essential singularity, $t = 0$. Part of the proof required that the mass-energy ρ and pressure p of the universe obey a simple constraint (namely, that $\rho + 3p/c > 0$, where c is the speed of light), which in the case of Big Bang cosmology was entirely reasonable. In some inflationary scenarios, this constraint is violated during the inflationary epoch. Hence these models do not necessarily include an initial singularity; they may have one, but they also include the possibility of having no temporal beginning. See Kolb and Turner 1990.

55. The move to inflationary models also provides a scientific explanation for why the initial conditions of the standard model seemed so fine-tuned for the evolution of life: such cosmologies can have countless domains in which the natural constants and even the specific laws of physics can vary.

56. Yet the story is more subtle. Carl Sagan and Stephen Hawking, for example, also seemed to assume that a direct relation exists between the issue of $t = 0$ and the existence of a creator God. In his introduction to Hawking 1988, Sagan claimed that Hawking's no-boundary model, in which the universe has a finite past but no beginning point, leaves God with "nothing to do" (see Sagan in Hawking 1988, x. Similar remarks by Hawking can be found). Sagan's argument apparently follows path (1) from science to theology and seeks to pose a constraint on what theology can claim, namely, if the universe has no beginning, then theologians cannot claim that God created it. Presumably the further, if implicit, constraint is that, because the universe is run entirely by natural laws, all God could have done was create it at the now nonexistent beginning event; thus, for all intents and purposes, God does not exist. It is interesting to compare Sagan's

move to that of Hoyle. Both apparently see a direct relation between a theological claim (the existence of God) and a scientific claim (the existence of $t = 0$), but they move in different directions: Hoyle from atheism to science (path 7 and 8), Sagan from science to atheism. (It would be intriguing to know whether Hawking's work was triggered in part by motivations such as those of Hoyle.) Actually, Sagan's argument misses its mark, because it is really aimed at a rather outmoded, deistic conception of God in which all God is needed for is an initial creation. As Tillich so clearly argues, God is the ongoing Creator of the universe even if there was no beginning, and the laws of nature, far from restricting God's interaction with and action in the world, are our meager attempts to describe one dimension of God's action as Creator.

57. In Augustine's opinion, for God to wait, as it were, for a long time and then suddenly create the universe at some point in a preexisting time would undercut the unchangeable character of God.

58. Philo of Alexandria took a position similar to that of Augustine.

59. It no longer need be reiterated that the role of theology here is purely intellectual/academic and in no way presupposes an appeal to religious authority. Thus, although it could be seen as irrelevant, the voice of theology in such scientific issues would hopefully not be seen as offensive.

60. This is of course an overstatement. First of all, quantum gravity applies to the entire universe, not just its origins. If this is true, a careful philosophy of nature will have to take into consideration all the problems raised by such a theory, including those inherited from the philosophical problems of quantum mechanics. Second, the demise of steady state cosmology may well be premature, because a number of cosmologists continue to construct models whose roots can be traced back to Hoyle's early work. See, for example, Arp, Burbidge, Hoyle, Narlikar, and Wickramasinghe 1990, 807–12.

61. Tillich describes estrangement as universal and coincident with creation in a variety of texts, including 1967, 1:B and 2:B.

62. Tillich 1967, 2:60. I have developed these ideas further in an exploration of the problem of theodicy following the analysis of Reinhold Niebuhr (Russell 1984). I have also made suggestions along these lines in relation to what Polkinghorne (1989) calls the "free-process" defense. See Russell 1990.

63. I hope to pursue the question of the relation between thermodynamics (and thus entropy) and the essential structure of finite being in future work.

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