

# Natural science, temporality, and divine action

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In the twentieth century, science has discovered that the universe itself has had a history—that the cosmos was very different in the past from how it is today and that it will be different again in the future; that space is relational and not absolute; that the passage of time and judgments of simultaneity are observer-dependent assessments. The Newtonian picture of the ceaseless rearrangements of the components of an essentially unchanging world, taking place within the fixed container of space and during the steady flow of an absolute time, is no longer on the scientific agenda. Instead, the universe is perceived as relational and endowed with becoming. Yet absolutes remain, such as the speed of light acting as the limit on the rapidity of information transfer. In relativity theory (in the scientific sense), not all dissolves into a relativistic haze (in the popular sense).

These scientific discoveries carry some influence over into metaphysics and on into theology. The relationships involved are not those of strict entailment, for each discipline has its own due autonomy. Physics constrains metaphysics but it does not determine it. Yet there are certain clusters of consonant ideas that naturally associate with each other. The progression in forming such a cluster is first to abstract from science a metascientific view of aspects of physical process, then to incorporate this view within an appropriately extended wider metaphysical scheme, and finally to correlate with the latter a consonant theological understanding. At each stage of this formation, there is scope for argument and dissent, but certain associations of ideas emerge that seem persuasive and that have exerted considerable influence on contemporary thinking. The purpose of this essay is to illustrate this process by considering metascientific and metaphysical ideas about temporality and their bearing on theological concepts of God's relation to time and on understandings of divine action. In regard to this last subject, it is God's particular action within the process of creation (what is often called special providence) that will be the focus of our attention, rather than simply the general divine sustaining of the world in its orderly being (general providence).

The fact that there is an unavoidable degree of ambiguity in the results of such an exercise is illustrated at the start by the fact that one can identify four different metascientific accounts of the nature of time, each claiming to derive from contemporary physics. I shall describe them in turn, together with the metaphysical views and theological stances that seem to associate most naturally with each of them.

## THE PASSAGE OF TIME IS A TRICK OF HUMAN PSYCHOLOGICAL PERSPECTIVE

The claim is made that the most obvious human aspect of the experience of time, the ever moving present in which events that were future and potential are momentarily realized and become actual before receding into the fixed record of past history, is no more than the way in which we are constrained to perceive a reality that, in its fundamental nature, is actually atemporal with all events, whether classified by us as "past, present or future," equally real and existent.

(1) Metascience: Those who hold this highly counterintuitive position often assert that it is a consequence of the special theory of relativity. Russell Stannard writes "According to relativity theory, physical reality simply is."<sup>1</sup> We are presented with the package deal of the space-time continuum. This seems to have been Einstein's own view, for on the death of his friend Michele Besso he wrote "Michele has left this strange

world just before me. This is of no importance. For us convinced physicists the distinction between past, present and future is an illusion, although a persistent one."<sup>2</sup>

The argument, of course, is not so crude as to say that the equations of relativistic physics can be written neatly and comprehensively in fourdimensional form and why should one then treat the dimension of time differently from the three dimensions of space? History is not being equated with geography, or the possibility of time travel assimilated to that of motion in space, in so simple-minded a way. Centered on any "event" (space-time point) there is the forward lightcone of future events that can be causally affected by that event and the backward lightcone of past events that are capable of having influenced the event under consideration. These two domains are quite distinct and they are invariant, that is to say they are the same whichever observational frame of reference is used to define them. In between, however, is a large domain of points that are spacelike in relation to the original event and this means that they can transmit no physical influence to it. This spacelike domain is fourdimensional and different observers take different three dimensional slices through it as they define their different planes of simultaneity (see figure 1). (In a Newtonian world, there would be a unique three-dimensional spatial domain of simultaneity on which all observers were agreed). It is argued that all points in this four-dimensional spatial domain are of equal status and so they all should be treated as equally real. Shifting the position of the originating event E then leads to a similar conclusion for the whole space-time continuum.

I believe this argument to be fallacious. Each observer's "plane of simultaneity" is a retrospective reconstruction. No observer has knowledge of a distant event until it is unequivocally "past," that is to say, it lies in that observer's backward lightcone. There is, therefore, no privileged status of reality attaching to these distant events that demands they be granted atemporal existence.

Another way of expressing the same point would be to say that it is perfectly consistent with special relativity (which here is acting as a kinematical specification of the geometry of space-time) to suppose that there is a particular frame of reference (equivalently, a definition of a preferred time axis) that expresses the moving actual present moment (and presumably coincides with our psychological perception of that present moment), provided that this frame does not have a special role in relation to the dynamical theories of physics. In other words, the "present moment frame" would be "hidden" as far as physics is concerned but it could well be discernible as far as other wider experience (human psychological perception, for instance) was concerned, or metaphysical theory required. There is only real cause for uneasiness about this solution if one takes a physical reductionist view and insists on identifying science (more accurately, metascience) with a totally adequate metaphysical account of reality. In that case, the present moment frame might seem otiose, but nothing compels this limited view.

Much the same reply can be made in response to another argument sometimes explicitly made but more often implicit, that because the equations of physics express in no obvious way the existence of a present moment (there is no special status about  $t = 0$ , one might say), such an existence is to be denied, contrary to common sense experience. "So much the worse for physics," I would reply. Its inability to express the present moment is better understood as indicating the inadequacy of physicalism rather than as abolishing the idea of the moving present.

The limitations of a purely physics-based approach are further exemplified by the latter's inability to give a clear and universally accepted answer to the question of the origin of time's arrow. So far we have been discussing what the philosopher John McTaggart would have called the A-series: past-present-future. Time's arrow is a way of referring to the untensed B-series: earlier-later. With one exception (which was important at the epoch of the very early universe but negligible today) the fundamental laws of physics are all time-reversal invariant, that is to say they make no distinction between past and future. The direction of the arrow of time is undefined by them. Physics has to build into the solutions of its equations this direction in which causal influences are made to propagate (technically, by selecting retarded potentials and by discarding advanced potentials). It is commonly believed that in some way time's arrow is an emergent effect of increasing complexity, with appeal being made to the second law of thermodynamics so as to use the direction of the increasing entropy of isolated systems in the definition of the orientation of time. From this point of view, irreversibility is a secondary, rather than a fundamental, property of natural process.

Since measurement is the irreversible registration of an observation, there may well be a connection here with the unresolved measurement problem in quantum mechanics.<sup>3</sup> This latter process also implies a direction of time's arrow since the variety of possible outcomes that might result from measuring a property of a quantum system are only resolved into a definite value on a particular occasion after the act of measurement has taken place.

(2) Metaphysics: The criticisms of the foregoing metascientific view have been based on its being by no means entailed by physics and on its inadequacy to accommodate broader aspects of the human encounter with reality. There is resistance to the claim that the human experience of the moving present may lightly be dismissed as a mere psychological trick of perspective. Yet if these objections are over-ruled or held to be of little force, then the resulting metaphysical picture is clearly that of the block universe<sup>4</sup>: the unified totality of all space-time events in their undifferentiated atemporal reality. Within that totality there is a B-series ordering, discriminating what precedes from what follows, but no temporal A-series ordering induced by the moving boundary between past and future.

Proponents of this view usually deny that the coexistence of the "future" with the "past" implies a rigid determinism. Space-time events simply are, and the question of what causal relationships there might be discernible between them is held to be a separate issue. Nevertheless, a suspicion continues to lurk in some minds that, at the very least, determinism is most naturally compatible with a block universe.

(3) Theology: The theological view point that seems consonant with a block universe is the idea of classical Christian theology, stemming from Augustine and Boethius, that God knows the whole history of creation timelessly and "at once" (*totum simul*). All "presents" are simultaneously known by God. In a block universe this must surely be so. If the reality of all events is fundamentally atemporal and God knows everything as it actually is, then the divine knowledge must itself be atemporal. Conversely, if God does know everything at once, this seems to imply a theological endorsement of the idea of the block universe for the same reason, namely that divine knowledge is totally truthful knowledge. Defenders of classical theism might respond that creation is temporal and God has true knowledge of that temporality, even if that knowledge is acquired atemporally. At issue is the question of how faithfully divine ways of knowing reflect the nature of the reality that is known.

If God's untensed knowledge of created reality is so totally different from tensed human knowledge, this might well seem to call into question the validity of any attempt at an argument based on *analogia entis* when it comes to considering divine agency. In fact, the tradition of classical theology has usually had recourse to the idea of God's primary causality being at work in and through the secondary causalities of creatures in a way that is open neither to explication nor exhibition. Thomas Aquinas is the patron saint of this proposition and its modern defenders have included the Anglican theologian Austin Farrer.<sup>5</sup> The ineffability of this claim has been the basis of both the questionings of its critics and the support of its adherents. It certainly delivers divine action from any possible taint of anthropomorphism.

As with the metaphysical discussion of the block universe, so in relation to divine atemporal knowledge and primary causality there has arisen the question of whether this view inclines too much towards determinism and carries the risk of abolishing creaturely freedom. The response of Aquinas was to deny that this is so. God does not "foreknow" the result of a free act. Instead, in the divine simultaneous apprehension of all presents, God knows all such acts as and when they happen, which no more compromises creaturely freedom than does the temporally simultaneous knowledge gained by another human observer of the same act. Nevertheless, some suspicions linger in this respect, not least in regard to how divine primary causality relates to the secondary causality of free human acts.

At the level of the scientific observation of physical process, primary causality would seem to be indistinguishable from naturalism. It appears that the causal net of physical process could be drawn as tight as one liked without prejudicing the proposal. This feature is both one of its great merits in the eyes of its proposers (invulnerability to scientific discovery, whatever form it may prove to take) and also one of its great defects in the eyes of its opponents (God's presence and agency ought to make a difference to what

happens). It seems strange that naturalism and divine primary causality could be identical in their physics and so radically different in their metaphysics.

## TIME IS A SECONDARY CONSTRUCTION

This radical view sees temporal sequences as emerging properties in certain physical situations, but it denies to time a fundamental place in the description of the nature of the physical world.

(1) Metascience: The origin of such an opinion lies in continuing efforts to construct a theory of quantum gravity. At present, the two great physical theories of the twentieth century, quantum mechanics (describing the behaviour of systems of atomic size or smaller) and general relativity (the modern theory of gravity, treated as the effect of the curvature of spacetime induced by matter) are imperfectly reconciled with each other. Their mutual integration is necessary both for the consistency of physics and also for the particular task of understanding the very early universe. General relativity is fundamental to all cosmological theorizing and before the Planck time of  $10^{-43}$  seconds the universe was small enough for quantum effects to be of great significance. While such an infinitesimal cosmic epoch might seem remote, processes occurring then are thought to have had lasting consequences for properties such as the distribution of matter in the universe.

Quantum gravity is currently an extremely uncertain and speculative discipline but one way in which attempts are being made to resolve its problems accords a prime role to space and a secondary role to time.<sup>6</sup> The rules of quantum mechanics are applied to the immense variety of spatial geometries that might be conceived to exist and probability amplitudes (the basic quantum mechanical calculational entity) evaluated for transitions between them. In certain appropriate circumstances, a "classical" type of trajectory can form in which a sequence of spatial geometries "stack up" to form a succession that is susceptible to a temporal interpretation. In this particular case (which has held in our particular universe from about the Planck time onwards), time emerges as a contingent feature of events.

All that may seem perplexing enough to the non-physicist. The matter is further complicated by the way in which quantum theory is being applied to the problem. One of the unresolved interpretative difficulties that I referred to earlier is the measurement problem. How does it come about that the fitful quantum world yields a definite answer on each actual occasion of its experimental interrogation when the theory itself only assigns probabilities for a range of possible outcomes? Various proposals have been made, of which the most generally popular is some variation of the Copenhagen interpretation: It is due to the intervention of the macroscopic "classical" measuring apparatus. If, however, one is trying to apply quantum mechanics to the whole universe this particular option is not available; there is nothing left over to play the role of the measuring apparatus! Quantum cosmologists have, therefore, favored an interpretation that has not widely commended itself to other physicists. This is the so-called "many worlds" interpretation proposed by Hugh Everett III. He suggested that every possible outcome of an observation is in fact realized and our belief to the contrary is due to the division of the universe at each such act of measurement into a series of parallel worlds in each of which only one outcome is perceived to happen.

Clearly this is a proposal of immense prodigality in relation to the scope of physical reality. Its employment has the consequence, seldom emphasized clearly by quantum cosmologists, that in the circumstances where a time sequence is derivable at all there will not simply be one such sequence but a vast variety of differing parallel cosmic histories.

These heady speculations are properly called metascience since they go far beyond anything that can claim the status of sober agreed physical understanding. Their durability as scientific ideas is open to question.

(2) Metaphysics: The ideas of quantum cosmology are too novel and currently uncertain to have fed into any developed metaphysical account. The general picture is of a reality that at one level is fundamentally characterized by quantum mechanical disorder but in which patches of temporal ordering emerge. Reality is multi-valued in terms of the incompatible but parallel histories that are realized as subsystems within it. Yet

in a total sense, the picture is orderly to the point of being deterministic. The basic equation of many worlds quantum cosmology is what might be dubbed "the Schrodinger equation of the universe." (Technically, it is the Wheeler-DeWitt equation, which differs from the Schrodinger equation by not including a time derivative because of the secondary character of time in this formulation.) This grandiose and somewhat notional construct is a perfectly deterministic linear equation in a vast array of variables. Time is only secondary and emergent because, fundamentally, the quantum universe, as this speculative theory understands it, simply "is."

(3) Theology: At either level of interpretation, this view abolishes any notion of a true history capable of accommodating or expressing God's economy of interacting relationship with creation. Overall, there is no time but simply fuzzy quantum being; in those subsystems where "time" emerges there is a great variety of alternative and equally valid temporal unfoldings (a world in which Judas betrays Christ and a world in which he does not?). At best, one might say, the universe is God's multi-screen experimental theater with every conceivable scenario being enacted. Such an account of reality not only subverts the significance of human biography and responsibility (true moral beings could not exist in a realm of multiple happenings) but it would also be fatal to an historically based religion such as Christianity.

It is interesting to consider briefly Frank Tipler's so called physical theology<sup>7</sup> for it operates with just this world view. Tipler's treatment is strongly physicalist and reductionist. Human beings are treated as finite state machines (computers) and life is equated to the processing of information. A final state boundary condition is imposed on the Schrodinger equation of the universe that requires that in the dying fractions of a second of a collapsing universe, all parts of it are in causal contact with each other. This is held to facilitate the coming-to-be of a cosmic computer, Omega (a "physical god" in Tipler's phrase), whose ever-faster racing operations will permit the processing of an infinite number of bits of information in that ultimate event of the universe's death. Tipler regards this conjectural achievement as fulfilling a "physical eschatology," claiming that Omega will "resurrect" people by constructing emulations (computer copies) of the fleshy computers that they were when biologically alive.

This is all extremely fantastic and it has made little impression on theologians with a scientific background.<sup>8</sup> For our present purpose we can regard the baroque conjectures of Tipler's physical theology as giving a measure of the actual theological vacuity of this point of view of the nature of time.

## THE EVOLUTION OF TIME IS A CLOSED PROCESS

In this view, time is treated as a measure of the stage of development of the unfolding of a physical process that is causally closed in upon itself. The laws of physics control the state of the world and determine fully how one such state gives rise to its temporal successor. This is the picture that many people, including some theologians, believe is the deliverance of modern science: the clockwork universe. Others believe that the uncertainties of quantum mechanics have negated this account as far as subatomic processes are concerned but they are unsure what implications this carries for the macroscopic world in which all human experience and action appears to be located.

(1) Metascience: The distinction between science and metascience is made abundantly clear by the existence of rival interpretations of the fundamental character of quantum theory. Heisenberg's uncertainty principle is a statement about limitations on the precision attainable in measurements made on quantum systems. In other words, it is an epistemological conclusion. The great majority of physicists have followed Niels Bohr in interpreting it ontologically, that is to say as expressing an actual degree of indeterminacy in the behavior of quantum entities. It is this interpretation that is the basis of the widespread belief that the quantum world displays a degree of openness towards the future and that its probabilistic nature is an expression of a rift in a tight causal nexus. However, there is no forced move from epistemology to ontology and a minority of physicists have wanted to hold to a deterministic account of quantum phenomena, with its probabilism then arising from our ignorance of all the causal determinants actually at work. Causes of this covert type are given the generic name of "hidden variables." David Bohm constructed just such an account of quantum mechanics,<sup>9</sup> which is identical to conventional quantum theory in its experimental consequences but totally contrasting in its picture of the nature of physical process. The

choice between Bohr or Bohm is metascientific. It is based on judgments of naturalness and lack of contrivance, on metaphysical preferences for deterministic or open process, but not on tests of empirical adequacy. It is, therefore, perfectly possible in the twentieth century still to hold to an account of the physical world that is as unproblematically objective and deterministic as was the eighteenth-century mechanics of Newton and Laplace. Contrary to the claims made by some theologians, 10 this statement is not modified by the nineteenth-century discovery, through the insights of Faraday and Maxwell, of field theories. A classical field is a perfectly mechanical system, differing only from the mechanics of particles in that it involves an infinite number of degrees of freedom (ways in which it can change) rather than a finite number. The mathematical consequence of this is that its expression is in terms of partial differential equations rather than ordinary differential equations, but both kinds of equations are equally deterministic. One may also note that classical fields are local entities, that is to say independent changes can be made at spatially separated points because there is no integrating constraint imposed on the structure of the whole.

(2) Metaphysics: Because total knowledge of the present implies perfect prediction of the future and perfect retrodiction of the past for a deterministic system (Laplace's celebrated calculating demon with universal knowledge), it is perfectly possible to assimilate the apparently temporal metaphysics of this option to the atemporal picture of option 1. Traditionally, however this has tended not to happen and a deterministic universe has usually been considered temporally despite, as we noted earlier, there being no intrinsic way of representing the present moment in its equations. The mathematically minded could picture the moving present as being the unfolding surface of solutions as the deterministic equations are interactively integrated from the starting point of their initial conditions. A computer would generate a time-dependent solution in precisely this successive fashion, so that one could think of the history of a universe of this type as being the analogue integration of the equations of the fundamental theory.

(3) Theology: Because of the feasibility of assimilating option 3 to option 1, it would be possible to associate with a closed universe the theological picture of divine primary causality acting in and under its secondary tight determinism. One must emphasize once again, however, that the classical theologians who defend the notion of primary causality do so while repudiating determinism and claiming the compatibility of divine atemporal knowledge with temporal human choice and responsibility.

The most common theological response to a closed universe has been that of deism. In a clockwork world, the Creator has nothing much to do except to be the Cosmic Clockmaker who set it all up and now simply lets it tick away. One sees this view developing in the eighteenth century among the post-Newtonian generation. Sir Isaac himself had certainly not taken up this position, for he saw a causal role for spirits (for example, producing every fifty thousand years or so angelic corrections to the motion of the solar system, which otherwise, he thought, might have wobbled apart) and he made his celebrated but mysterious assertion that space was the "sensorium of God." His successors thought otherwise. The God of deism was too much an absentee landlord to carry much conviction and the transition to atheism then came relatively easily.

The contemporary atemporal deism of Maurice Wiles, which simply assigns to the deity the single great act of holding the world in being, is in the same tradition." One feels that Wiles does not wish to risk a divine interruption into what he believes to be the self-contained process of the universe. An unnecessary deference to a particular and contentious metascientific account has been allowed to induce impotence in theological thinking about special providential divine action.

## THE EVOLUTION OF TIME IS AN OPEN PROCESS

While acknowledging the role of physical causality expressed through the interchange of energy between constituent parts, this fourth option suggests that these effects do not suffice to determine completely the temporal development of the world. There is held to be scope for the action of additional causal principles in bringing about the future. What character these principles might have is discussed below.

(1) Metascience: Contemporary understanding of physical process detects within it a considerable degree of intrinsic unpredictability. This arises partly from the probabilistic character of quantum theory and partly from the exquisite sensitivity of the so-called chaotic systems of classical non-linear dynamics<sup>12</sup> that implies that their future behavior rapidly comes to depend upon a degree of knowledge of the fine detail in their initial conditions that is way beyond our powers to attain. (For example, a simple calculation shows that the precise motion of air molecules in a room comes-after so short a time as 10<sup>10</sup> seconds-to be sensitive to the positions of electrons on the far side of the observable universe!) There is a large and inescapable epistemological deficit in our knowledge of the behavior of physical process. The metascientific question is what ontological significance, if any, is to be assigned to this fact.

I have argued that the realist philosophy that is so natural a stance for a scientist to take, encourages us to align epistemology and ontology as closely as possible-what we know or cannot know about the physical world is to be treated as our principal guide to what we believe actually to be the case.<sup>13</sup> In other words, intrinsic unpredictability is to be treated as a signal of an underlying ontological openness. This is not a logically forced move (physics constrains, but does not of itself determine, metaphysics) but it is a permissible, and for a scientist, a natural metaphysical strategy to pursue.

In fact, as we have already seen, this is indeed the policy embraced by most physicists in relation to quantum theory. Bohm's deterministic interpretation makes it plain that it is not necessary to understand the theory in an indeterministic, ontologically open sense, but that way of understanding is so natural that for most scientists it has become the (unconscious) consensus choice.

In the case of chaos theory, the majority approach has been different. The most popular metascientific conclusion has been to take absolutely seriously the deterministic equations from which classical chaos derives and to draw the lesson that apparently complex and random behavior can have a simple and deterministic underlying origin. This is, of course, a possible metascientific way of reading the situation, and it has doubtless been encouraged by the fact that the underlying structure in this case corresponds to the time-honoured Newtonian equations of motion. It is not, however, the only possible metascientific strategy. I have proposed the alternative of a realist reading in which the chaotic unpredictabilities are taken to be signals of openness.<sup>14</sup> Newton's equations are then treated as downward emergent approximations to a more supple and subtle physical reality, valid in those special circumstances in which parts can adequately be isolated from the whole in which they participate.

This metascientific conjecture has not been worked up into a fully articulated theory. However, the general character of its consequences can be made clear. Chaotic systems are not totally random in their behavior but are confined to a certain set of possibilities called a strange attractor. The different patterns of motion represented by the strange attractor have the same energy but different structure. Therefore the openness that chaotic systems are conjectured to possess will relate to the possibility of the action of new causal principles, over and above those of constituent physics, which are of a pattern-forming, rather than an energetic, kind. Moreover, these causal principles will act holistically rather than locally, for the sensitivity of chaotic systems means that they are intrinsically unisolatable and they must be discussed in the context of their total environment. From this picture, there emerges the concept of a new kind of causality, complementing the energetic bottom-up causal exchanges between parts described by conventional physics and having the character of top-down, holistic, pattern formation. I have called this metascientific picture "contextualism" and the corresponding causal principles "active information." The latter phrase has also been used by Arthur Peacocke on the basis of a somewhat different argument.<sup>15</sup>

It would be possible to consider a hybrid scheme in which the widely supposed openness of quantum events had its consequences amplified and made apparent in the macroscopic world of human agency and divine providence through the sensitivity of chaotic systems to small fluctuation at the subatomic level. There are, however, technical problems that make this proposal problematic. One is our inability to solve the measurement problem in quantum theory. With this question unresolved, we are ignorant of how precisely the microscopic and the macroscopic levels relate to each other. Another difficulty has been an inability to identify clearly what is the quantum equivalent of classical chaos. The hybrid scheme may well be part of the metascientific picture being developed but it would seem unwise to rely on it alone.

(2) Metaphysics: This particular approach extends the range of causes that may be thought to be at work in determining the open future. Among the possible consequences of active information could be:

(a) Holistic laws of nature that encourage the coming-to-be of certain kinds of complexity. Stuart Kauffman has made a proposal of this kind in relation to biological evolution.<sup>16</sup>

(b) Here might be found a glimmer (no more) of how one might conceive of the relationship between mind (intention-like pattern forming) and brain (physical activity-like energetic exchange).

(c) Theology is offered the possibility of understanding its discourse of God's special providential action, often expressed in terms of the Spirit's guiding of the world, in terms of divine interaction through active information within creation.

All three kinds of causal activity would be at work within the nonlocalizable, unpredictable cloudiness of chaotic systems. While they would be genuinely determinative of the future, they would not be disentangleable from each other or unambiguously identifiable. One could not itemize physical process, saying "Nature did this, human agency did that, God did the other."

A reality in which such a variety of causal principles is at work is clearly one in which temporal process is to be taken absolutely seriously. This option presents a metaphysics of dynamic becoming in contrast to one of static being. The future is not up there waiting for us to arrive; we play our part in bringing about its actual character, contingent on our executed intentions as well as on the operations of other causalities and agencies.

(3) Theology: The option under discussion has the attraction of allowing scope for the operation of divine special providence in the history of the universe. Because of the hidden character of active information, God's action will not be demonstrable, though it may be discernible by the discriminating eye of faith. The balance between divine agency and other forms of causality is left open in this proposal, which, therefore, has to continue the long theological discussion of the relationship between grace and free-will, considered now in a cosmic setting. A critical theological question is whether the cost of this idea is an unacceptable reduction of the Creator to the role of an unseen cause among creaturely causes. A possible metascientific contribution to the consideration of this issue is to note that the other agencies may be expected to combine energetic and informational causalities to some degree,<sup>17</sup> but providential action can be conceived to be of a purely informational kind. This would seem consonant with the notion of divine guidance and leading exercised through the Spirit and it would distinguish it from creaturely causalities.

The strongly temporal character of the metaphysics proposed would seem to imply that God, knowing the universe in its actual reality, would know it temporally. The future is brought into being as time evolves and it would seem that God, knowing all that can be known, would nevertheless not yet know the unformed future. God's act of creation would not simply imply a divine kenosis of omnipotence in allowing the creaturely other truly to be itself, but also a divine kenosis of omniscience in allowing the future to be open.

Thus, the theological picture consonant with this option is one that sees in the divine nature a temporal pole of engagement with creation (as well, of course, as an eternal pole of the steadfastly unchanging character of God) and a knowledge of creation, always complete in terms of realized history but not embracing a future that is open and not yet actualized. These ideas have been supported in different ways by a number of people writing on the interface between science and theology.<sup>18</sup>

## CONCLUSION

Such a dipolar view of God and of divine current omniscience, rather than total omniscience, has also been characteristic of process theology.<sup>19</sup> It may seem surprising that a process option was not included in the foregoing discussion. The reason for its omission lies at the metascientific level of the chain of argument. The punctuated, discrete event ("actual occasion") picture of physical process presented in the thought of

A. N. Whitehead and his followers, is very difficult to reconcile with scientific knowledge. Conventional quantum theory certainly has its discrete, discontinuous moments of change ("the collapse of the wave packet"<sup>20</sup>), but they are associated with particular kinds of events, namely measurements. In between such macroscopic interventions, a quantum system evolves in a perfectly smooth, continuous way according to the rule of the Schrodinger equation.<sup>21</sup> I do not detect a point of anchorage for process metaphysics in what we know about physics. Therefore, the generalizing chain of consonant concepts, which I discussed in relation to the four selected options, appears broken at the first link in the case of process thought. The final link is also suspect, since process theologians' view of divine action solely through persuasive lure, with the ultimate initiative lying with the concurring event itself, presents, in my opinion, an account too weak to be adequate to the Christian experience of prayer or to Christian thought about God's providence in history.

One might claim that the ontological interpretation of chaos theory, set out in option 4, offers an opportunity to express some of the more theologically congenial aspects of process thinking (such as the openness of creation to the future) in a context that is scientifically more persuasive. A similar comment might be made about the ideas of Teilhard de Chardin.<sup>22</sup> His concept of "radial energy" corresponds to nothing that is scientifically recognizable in energetic terms, but it could be reinterpreted as a metaphor for the informational form of agency proposed above.

One final topic must bring this essay to a close. Theologians like to speak about *kairoi*, moments of significance of the fullness of time. One might ask whether there are any pale reflections of this concept to be found in the scientific account of cosmic history. I think there are. Examples would be the initial spontaneous symmetry breaking in the very early universe, when the supposed highly symmetrical Grand Unified Theory was broken down and crystallized into the currently experienced forces of nature lying within the narrow anthropically fruitful band in which the development of carbon-based life is possible, and also at the start of the development of that life here on Earth, in the unknown sequence of biochemical events by which the particular genetic code, present and active in the DNA of all living terrestrial beings, came to be the selected possibility.

<sup>1</sup>Russell Stannard, *Grounds for Reasonable Belief* (Edinburgh: Scottish Academic Press, 1989), 98.

<sup>2</sup>Quoted in Ilya Prigogine and Isabelle Stengers, *Order Out of Chaos: Man's New Dialogue with Nature* (New York: Bantam, 1984), 294.

<sup>3</sup>See, for example, John C. Polkinghorne, *The Quantum World* (Hammondsworth: Penguin, 1990), ch. 6.

<sup>4</sup>For a discussion of some of the issues, see C. J. Isham and John C. Polkinghorne, "The Debate over the Block Universe," in Robert John Russell, Nancy Murphy, and C. J. Isham *Quantum Cosmology and the Laws of Nature*, eds. (Vatican City State: Vatican Observatory, 1993), 134-44.

<sup>5</sup>Austin Farrer, *Faith and Speculation* (London: Adam & Charles Black, 1967).

<sup>6</sup>See C. J. Isham, "Quantum Theories and the Creation of the Universe," in *Quantum Cosmology*. A somewhat different approach is given in Stephen W. Hawking, *A Brief History of Time* (New York: Bantam, 1988), ch. 8.

<sup>7</sup>Frank J. Tipler, *The Physics of Immortality* (New York: Doubleday, 1994). <sup>8</sup>Ian G. Barbour, *Religion in an Age of Science* (London: SCM Press, 1990), 151; Arthur R. Peacocke, *Theology for a Scientific Age* (London: SCM Press, 1993), 345; John C. Polkinghorne, *Science and Christian Belief* (London: SPCK, 1994), 165-6.

<sup>9</sup>D. Bohm and B. Hiley, *The Undivided Universe* (London: Routledge, 1993). <sup>1</sup>Wolfhart Pannenberg, *Towards a Theology of Nature* (Louisville: Westminster/John Knox, 1993); Thomas F. Torrance, *Divine and Contingent Order* (Oxford: Oxford University Press, 1981), ch. 3.

1Maurice F. Wiles, *God's Action in the World* (London: SCM Press, 1986). 2James Gleick, *Chaos* (New York: Penguin, 1988). 3John C. Polkinghorne, *Reason and Reality* (London: SPCK, 1989), ch. 3.

14Tbid., and see also the discussion in John C. Polkinghorne, *Scientists as Theologians* (London: SPCK, 1996), ch. 3, and in Ilya Prigogine, *The End of Certainty* (New York: The Free Press, 1997).

15Peacocke, *Theology for a Scientific Age*, chs. 3 and 9.

16Stuart A. Kauffman, *The Origins of Order* (Oxford: Oxford University Press, 1993).

'7See the discussion in Polkinghorne, *Scientists as Theologians*, 40. '8Ibid., 41.

19See, especially in the science and theology context, Barbour, *Religion in an Age of Science*, ch. 8.

2See Polkinghorne, *The Quantum World*, ch. 6.

2'This is a difficulty for those writers who rely on quantum theory alone to provide a conjectured site for divine action; see William G. Pollard, *Chance and Providence* (New York: Charles Scribner's Sons, 1958); Thomas F. Tracy, "Particular Providence and the God of the Gaps," and Nancey Murphy, "Divine Action in the Natural Order: Buridan's Ass and Schrodinger's Cat," in *Chaos and Complexity*, eds. Robert John Russell, Nancey Murphy,

and Arthur R. Peacocke (Vatican City State: Vatican Observatory, 1995), 289-358. Divine action becomes sporadic rather than continuous.

22Pierre Teilhard de Chardin, *The Phenomenon of Man* (New York: Harper, 1959).

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