

“The Doctrine of Creation out of Nothing
in Relation to Big Bang and Quantum Cosmologies”

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Introduction.

In his Papal Encyclical, *Fides Et Ratio*, John Paul II refers to three different modes of truth: 1) the truth of science and everyday life, based on immediate evidence and experimentation; 2) philosophical truth, gained through speculative reason; and 3) religious truths, partially grounded in philosophy and found in various religions.¹ Revelation guarantees the unity of truth, though, by showing us that “the God of creation is also the God of salvation history.” This point is crucial to the Pope’s argument since, as he insists, “it is the one and the same God who establishes and guarantees the intelligibility and reasonableness of the natural order of things upon which scientists confidently depend, and who reveals himself <sic> as the Father of our Lord Jesus Christ. ... This unity of truth, natural and revealed, is embodied in a living and personal way in Christ..”² As a direct consequence of this theory of truth, John Paul II identifies three theological requirements which must be met by any adequate philosophy: 1) It must “recover its sapiential dimension as a search for the ultimate and overarching meaning of life.” 2) It must “verify the human capacity to know the truth...” 3) It must be of >genuinely metaphysical range, capable, that is, of transcending empirical data in order to attain something absolute, ultimate and foundational in its search for truth.”³ Pope John Paul II

concludes with a special appeal to scientists: "...I would urge them to continue their efforts without ever abandoning the *sapiential* horizon within which scientific and technological achievements are wedded to the philosophical and ethical values which are the distinctive and indelible mark of the human person."⁴

I welcome the Pope's profound insights found here. This Jubilee conference for scientists provides an excellent opportunity to place the ongoing discussions of cosmology, philosophy and theology squarely within the requirements and perspectives of *fides et ratio* and its insistence on the sapiential horizon which such discussions should take place. As we have seen, the conditions for a sapiential horizon flow from the unity of truth, and this in turn is based on the central theological assertion that the God of creation is the God of salvation history. The claim requires that: 1) nature must be interpretable as '>the creation of God', and 2) nature must be interpretable as the creation which, by God's act, will become God's '>new creation'. The first requirement leads us to fascinating, creative discussions which have been taking place internationally about Big Bang and quantum cosmology in relation to the doctrine of creation. Here we start with cosmology and ask in various ways about its theological relevance. I will treat this discussion in Part I below. The second, however, is much more challenging and relatively unexplored. Here Big Bang and quantum cosmology seem to resist any detailed theological interpretation while lending themselves easily to nihilistic and atheistic interpretations. This '>split' situation, in which the cosmos can be viewed theologically as creation but resists being viewed as the grounds for new creation, tends to undercut our ability to place cosmology within a unified sapiential horizon as called for by *fides et ratio* and weakens our ability as Christians to challenge such nihilistic and atheistic claims to the world. If we are to remedy this situation, we may need to approach the '>science/theology' interaction in a new way. I will treat this challenge in Part II below.

Part I: Nature as God's creation and scientific cosmology

1. Big Bang Cosmology

The doctrine of creation has been explored fruitfully in light of contemporary physical cosmology over the past four decades. The *ex nihilo* form of the doctrine has been placed in relation to two particular features of Big Bang cosmology: "t=0", which represents the beginning of time some 12 billion years ago (and thus

the age of the universe) and the so-called Anthropic Principle which suggests that the universe is fine-tuned for the evolution of life. I will limit my remarks here to the question of $t=0$.⁵ To what extent is $t=0$ relevant to the doctrine of creation *ex nihilo*, allowing us to view nature as God's creation? Responses have ranged widely from direct relevance to complete irrelevance.

a) Direct relevance of science to theology

For some, the scientific discovery of an absolute beginning of all things (including time) provides empirical confirmation, perhaps even proof, of the creation of the universe by God. There are a variety of well-known --- and highly debated --- theological precedents for such a position. One of the clearest is found in Book 11 of the *Confessions*, where Augustine argued that God created time along with the creation of the universe. Perhaps the *locus classicus* is that of Thomas Aquinas' five "Ways" by which reason can be in >accord' with the truth of the existence of God. Certainly an absolute beginning of time, if that is what science has discovered, would seem to provide empirical support Thomas' philosophical arguments. And of course there is Biblical precedent for an >absolute beginning', notably Genesis 1, though this, like its theological counterparts, is open to complex hermeneutical challenges and competing interpretations.

This rich matrix of ideas played a prominent role in the allocution by Pope Pius XII to the Pontifical Academy of Sciences in 1951.⁶ In his careful reading of the allocution, Ernan McMullin interprets Pope Pius' argument as stressing the theological implications not only of $t=0$ but also of the mutability of the universe and the irreversible decline of its thermodynamic processes. To quote McMullin, Pope Pius used such results as evidence from science as support for Thomas' arguments. Thus science can "testify to both a beginning in, and end of, the cosmos, thus confirming its contingency and the need to postulate for it a Creator."⁷ Though Pius is quite clear that science had not offered an "absolute proof of creation," it can come close. A number of Protestants have also defended the argument that $t=0$ provides strong, even convincing, support for belief in God. A sophisticated version has been developed by William Craig, who draws on the early Islamic debates over the finitude of the world in relation to the finite age of the Big Bang universe⁸. Others have given relatively unnuanced accounts of how science purportedly supports theology.⁹

Still for those still seeking a direct path from science and theology, recent history offers an important caution: the path, such as it is, is open to traffic in both directions, as we shall see below in Hoyle's eternally old steady state cosmology.

Moreover, the transitory nature of all scientific theories reminds one of the adage, '>married today, widowed tomorrow.' Finally, one must recognize that there are other aspects of Big Bang cosmology which threaten to undercut a close tie with Christian theology, such as the universe being actually infinite in size and its continuing to exist in the future far after the point at which all biological life will come to an end. Perhaps the direct route is simply one we should abandon.

b) Complete irrelevance:

There are, of course, a wide range of Christian theologians who endorse the complete separation of theology and science.¹⁰ What may seem surprising is that several of the most important scholars in the theology and science interaction agree that when it comes to $t=0$. For them, *creatio ex nihilo* is a strictly philosophical argument regarding the contingency of the universe for which any proffered empirical evidence, such as $t=0$, is irrelevant. Instead, the contingency of the universe consists entirely in its sheer existence. Georges Lemaitre¹¹, Arthur Peacocke¹², John Polkinghorne¹³, Steven Baldner and William Carroll have defended this position on the basis of Thomistic metaphysics.¹⁴ Ian Barbour took this position in his earlier writings¹⁵ but has since shifted to what I call '>indirect relevance.' Bill Stoeger¹⁶ stresses caution for empirical reasons as well, including the tentative status of any scientific cosmology and our inability in principle to gain direct evidence of $t=0$ or to rule out the possibility of a prior universe.¹⁷ But need we be this circumspect?

c) Indirect relevance

There are a variety of positions that one can take between the two extremes of direct relevancy and complete irrelevancy. Those assuming what I call the '>indirect relevance' approach include Ian Barbour (in his recent work)¹⁸, Walter Hearne¹⁹, Nancey Murphy and George Ellis²⁰, Howard van Till²¹, and Mark Worthing²².

One of the clearest indications of how we might proceed here comes from Ernan McMullin.²³ If we believe in divine creation, McMullin writes, we would expect the universe to look "something like the Big Bang", but we cannot go further to claim that direct support can be found either for cosmology from Christian theology or vice versa.²⁴ We should view theology and science as being in a relation he described as "consonance":

The Christian cannot separate his (sic) science from his theology as though

they were in principle incapable of interrelation. On the other hand, he has learned to distrust the simpler pathways from one to the other. He has to aim at some sort of coherence of world-view, a coherence to which science and theology, and indeed many other sorts of human construction like history, politics, and literature, must contribute. He may, indeed, *must* strive to make his theology and his cosmology consonant in the contributions they make to this world-view. But his consonance (as history shows) is a tentative relation, constantly under scrutiny, in constant slight shift.²⁵

I have developed McMullin's idea of consonance in several directions. I have suggested that the contingency of the universe can be categorized in three ways: global contingency, local contingency and nomological contingency, and each of these, in turn, can be differentiated further.²⁶ Global contingency includes both the sheer existence of the universe as such (which I call its '>global ontological contingency') as well as contingent theoretical or empirical aspects of the universe as a whole (its '>global existential contingency'). $t=0$ would come under the latter; it is a form of past temporal finitude, and this is a form of temporal finitude, and this of finitude, and thus finally of global existential contingency. Thus its sheer existence, which scholars in the second group stress, and its beginning at $t=0$, which those in the first group emphasize, relate to different strands or layers of global contingency.²⁷ The existence of the universe is always a basis for (ontological) contingency, regardless of temporal origins, but a finite beginning would add '>confirmation' of its having been created (existential contingency): to use a legal metaphor, $t=0$ would act as a character witness, but not an eyewitness, to creation theology.

I agree, then, with what Ted Peters calls '>hypothetical consonance'.²⁸ Here consonance is a "treasure" we seek but in reality we have not yet found, though we have discovered common domains of inquiry. We are encouraged to search for additional modes of consonance by these discoveries, but to explore them theologians as well as scientists must hold at least some of their views as fallible hypotheses, not as inviolable truths. Such openness to the new is essential to move us forward.²⁹ But I have also stressed that the infinities in size and future of the flat and open models argue against contingency. Drawing on Sallie McFague's approach which she calls "metaphorical theology"³⁰, I have suggested that if $t=0$ is '>consonant' with creation theology then these infinities are '>dissonant' with both creation and eschatology. Finally, by allowing philosophy to mediate between

cosmology and theology, we have an ongoing method by which the conversation with theology can continue to take scientific results seriously when scientific cosmologies change, as they already have with the development of inflationary and quantum cosmologies, and thus theology can continue to provide a sapiential horizon of meaning for these changing cosmologies.

2. Inflationary Big Bang and quantum cosmologies.

Since the 1970s, a variety of problems in the standard Big Bang model have led scientists to pursue '>inflationary Big Bang' and beyond that '>quantum cosmology'. These included technical problems as well as the need to introduce quantum physics into the conversation, both because the universe at its earliest epochs was arbitrarily small (and thus subject as a whole to quantum physics) and because physicists were searching to unify gravity theoretically with the other physical forces (i.e., the electroweak and strong nuclear forces).³¹

Given the speculative status of quantum cosmology, some scholars have kept the theological conversation focused on the standard Big Bang model³². Others, though, have asked what effects quantum cosmology might have on their theology of creation. John Lucas has defended the temporality of God against the difficulties raised by special relativity and quantum cosmology³³. Ted Peters recognizes the "anti-theological" implications to his project by Hawking's quantum cosmology, but draws on Chris Isham's argument that even without an initial singularity, God is present to and active in all events in the universe³⁴. Wim Drees has argued that the challenge from special relativity to those arguing for God's involvement in '>flowing time' is much more severe than anything raised by the lack of $t=0$ in quantum cosmology³⁵.

I have suggested that the Hawking/Hartle model reminds us that the concept of finitude need not entail a boundary. This simple insight can lead to new ways to describe the universe as God's creation. For example, it may well be that the finitude of the past of *our* universe as such, and not the additional requirement of its having a boundary at $t=0$, will illuminate the real meaning of ontological contingency within the doctrine of *creatio ex nihilo*. I have also emphasized that the '>nothing' (i.e., the superspace) out of which our universe arises in the Hartle/Hawking scenario is more like Platonic *me on* (>relative nothing') than it is like Platonic *ouk on* (>absolute nothing'). Thus our universes arises out of a relative '>nothing' including, in some sense at least, quantum fields governed by the laws of physics (both of which are needed to give a '>scientific' account of the '>quantum creation of the universe'). But the Christian view of *creatio ex nihilo* relies

predominantly (i.e., for Tillich³⁶) if not entirely (as most theologians insist) on the meaning of '>nothingness' as *ouk on*. In essence, neither the Hartle/Hawking creation scenario, or any other I know of, can claim to be '>scientific' and at the same time limit itself strictly to *ouk on*.³⁷ A very similar argument has been developed in detail by Joseph Mlyciński.³⁸

We should close this section by noting that Hawking, too, seems to draw on the ontological argument. In his Introduction to Hawking's *A Brief History of Time*, Carl Sagan writes about the '>absence of God' in his book, even if "the word God fills these pages." Hawking may seek to know '>the mind of God', Sagan admits, but if there is no $t=0$ --- and Hawking himself has done away with it --- then there is "nothing for a Creator to do."³⁹ My response, of course, is that Sagan is attacking Enlightenment deism, not Christian theism. At times in the book Hawking seems to agree with Sagan,⁴⁰ but not at the end, for he also writes: "even if there is only one possible unified theory, it is just a set of rules and equations. What is it that breathes fire into the equations and makes a universe for them to describe? The usual approach of science ... cannot answer the question of why there should be a universe for the model to describe."⁴¹

Part II: Nature as God's new creation and scientific cosmology

As we have seen above, the conditions for a sapiential horizon flow from the unity of truth, and this in turn is based on the central theological assertion that the God of creation is the God of salvation history. This assertion, in turn, entails two requirements: 1) nature must be interpretable as '>the creation of God', and 2) nature must be interpretable as the creation which will become God's '>new creation'. We have been studying the first requirement in the context of ongoing research into the ways Big Bang and quantum cosmology can be in relation to the doctrine of creation. These included the claim that we can move directly from cosmology to its impact on theology, an argument within natural theology, and we can view theology as indirectly confirmed by cosmology, a move which represents constructive work in systematic theology. We turn now to the second requirement. It will lead us to the edge of current research in theology and science where both Big Bang and quantum cosmology pose a fundamental challenge to theology.

The working premise here is that, if it is *the universe* that theologians describe as the creation of God, it is therefore *the universe* which must become '>the New Creation.' But according to Big Bang cosmology, the future of the universe is either

>freeze or fry', and long before either, all biological life will be extinguished from the universe. Can Christian eschatology be seen as consistent with either of these scientific scenarios?⁴² At first glance, the answer would seem an alarming, "no!"

Of course theologians could simply declare that speculations about the far future are off-limits to scientists. According to Karl Rahner, "Just as (natural scientists) have no right or obligation to >inquire beyond' (i.e., >before') the big bang, so too it is not their part to speculate about an absolute end of all material reality."⁴³ But the challenge cannot be dismissed so easily. Scientific descriptions of the far future are no more speculative than are statements about the present or past based on the same, Big Bang, model. The problem is deeper: we can interpret the Big Bang model in terms of the doctrine of creation in ways that are simply impossible in terms of the doctrine of eschatology. According to Wolfhart Pannenberg, all Christian theology depends on the future coming of God.⁴⁴ Eschatology thus involves "one of the most obvious conflicts between a worldview based on modern science and the Christian faith".⁴⁵ John Macquarrie, too, wrote that "...if it were shown that the universe is indeed headed for an all-enveloping death, then this might seem to constitute a state of affairs so negative that it might be held to falsify Christian faith and abolish Christian hope."⁴⁶ Peacocke clearly recognized that the inevitable end of life in the universe "undermines any intelligible grounds for hope being generated from within the purely scientific prospect itself... The Revelation of John is but a pale document compared with these modern scientific apocalypses!"⁴⁷

Many atheistic scientists, too, from Bertrand Russell⁴⁸ to Steven Weinberg⁴⁹, have given a thoroughly pessimistic, >dysteleological' reading of scientific cosmology⁵⁰, readings which clearly run counter to *fides et ratio*. A sign of hope, though, is that in 1979 Freeman Dyson worked out a partial response to cosmic pessimism by showing how life could survive forever in the open >freeze' model.⁵¹ In 1986, Frank Tipler and John Barrow took up Dyson's arguments in detail and extended them to the >fry' scenario of a closed universe.⁵² More recently, Tipler developed them in detail in his "Omega point theory."⁵³ In both cases, however, life is understood reductively within physics as >information processing', and >eternal life' as the endless processing of new information along a given worldline. The scientific details of Dyson's work are fascinating, and his challenge to Weinberg's pessimistic evaluation of the meaning of life in the universe is profound.⁵⁴ But reaction to these arguments has been mixed. Drees has given a careful but critical analysis of both Dyson and Tipler's works.⁵⁵ Tipler and Pannenberg have engaged in an interesting and constructive interaction⁵⁶ to which

Drees, myself and others have replied⁵⁷. But, Tipler's scientific claims have been attacked aggressively by other scientists⁵⁸ while both Dyson's and Tipler's theological proposals and their reductionist assumptions have been widely criticized by scholars including Polkinghorne, Barbour, Peacocke, Clayton and Worthing, and they would clearly be contrary to the spirit of *fides et ratio*.⁵⁹

If this alternative is not to be taken, what options are left? Polkinghorne is representative of most theological views when reminding us that "an ultimate hope will have to rest in an ultimate reality, that is to say, in the eternal God himself, and not in his creation."⁶⁰ The act of raising Jesus from the grave begins a process whose fulfillment beyond history will join the destiny of humanity and the destiny of the universe. The new creation, a new heaven and a new earth, is not a "second attempt by God at what he had first tried to do in the old creation. It is a different kind of divine action altogether...the first creation was *ex nihilo* while the new creation will be *ex vetera*..."⁶¹. In his *Systematic Theology*, Pannenberg argues that the Christian claim that the world will have an end can neither be supported by science, nor need it be in opposition to it. The scenario of a universe finite in space and time is "undoubtedly more compatible with the biblical view" than an infinite, imperishable scenario. Still the Biblical view of an imminent end, and the scientific view of a remote end, may not even "relate to the same event... Even if they do, it is only in the sense of very different forms of imminence."⁶² Ted Peters has developed the Trinitarian theology with particular attention to the implications of Big Bang and quantum cosmology. What we need is "temporal holism" in which the cosmos as a unity of time and space is both created proleptically from the future and redeemed eschatologically by God's future initiative which we know proleptically in Jesus Christ. Prolepsis ties together *futurum*, the ordinary sense of future resulting from present causes, and *adventus*, the appearance of something absolutely new, namely the kingdom of God, the renewal of creation. The creation, from alpha to omega, will be consummated and transformed into the eschatological future which lies beyond, but which will include, this creation as a whole."⁶³

I believe the approaches suggested by Pannenberg, Polkinghorne, and Peters are promising theologically. Still, the challenge remains of making them intelligible in light of the 'freeze or fry' far future scenarios of current scientific cosmology. Peters is ruthlessly honest about the challenge from science. "Should the final future as forecasted by (scientific cosmology) come to pass...then we would have proof that our faith has been in vain. It would turn out to be that there is no God, at least not the God in whom followers of Jesus have put their faith."⁶⁴

We may need to engage with science at another level, that in which

philosophical and theological factors might play a suggestive though indirect role in the construction of, and criteria for choosing between, scientific models, theories and paradigms. Such '>extra-scientific factors', as they are called in current philosophy of science, often play a role in the '>context of discovery', although the resulting theories must be tested strictly by the scientific community, that is the '>context of justification', without regard to their role in theory construction. It is conceivable, at least, that an explicit commitment to a cosmology that would be interpretable in terms of Christian eschatology could lead to the development of new scientific cosmologies which would be compatible with all known empirical evidence, even generate surplus content, and yet would not explicitly undercut an eschatological interpretation by theologians in the way current Big Bang scenarios seem to. In the process we would have brought the field of '>theology and science' into a genuine mutual interaction, so that the theologian's task is not only to interpret science as it is, but to make fruitful suggestions which might be attractive to scientists. Two examples serve to illustrate this possibility:

Extra scientific factors' the generation of a competitor to Big Bang cosmology .

In the 1940s, Fred Hoyle, an outspoken atheist, together with colleagues Hermann Bondi and Thomas Gold, constructed a cosmology that would have no temporal beginning or end. Their "steady state cosmology" depicted the universe as eternally old and expanding exponentially forever. For two decades, the Big Bang and the steady state models seemed equally viable given the empirical evidence then available. By the mid 1960s, however, the Big Bang model was vindicated, at least in most scientists' minds, by the discovery of the microwave background radiation and the successful prediction of the cosmological abundances of hydrogen and helium in the 1960's.⁶⁵

What is important here, however, is that at least in principle Hoyle's work represents the effect of Extra scientific factors in science. Now Hoyle's explicit reason for constructing the steady state model was his claim that a temporal singularity like $t=0$ was irrational on both scientific and philosophical grounds. But Hoyle's strident and public opposition to Christianity suggests it played at least a secondary role in motivating his construction of the steady state model. Indeed, McMullin takes Hoyle as representing "our most colorful example of the potential relevance of *anti*-religious views in the choice of cosmological models."⁶⁶ It is also crucial to emphasize that Hoyle did not, of course, impose his views about the existence of God directly into science per se, but merely undercut the factor in Big

Bang cosmology which others claimed to support belief in God.⁶⁷ Nevertheless the Hoyle scenario, and similar ones drawn from the history of 20th century cosmology⁶⁸, demonstrate that very fruitful ideas can come from >extra scientific' disciplines, such as philosophy and theology, and lead to scientific theories with testable consequences.

Extra-scientific' factors in quantum cosmology.

It is also possible to see, in the debates over approaches to quantum cosmology, the striking presence of >extra-scientific' factors. A fascinating example occurs in comparing proposals by Roger Penrose and Hawking/Hartle. In Penrose's view, our universe arises as an arbitrary quantum fluctuation in a homogeneous background superspace filled with quantum fields. But why should any point in superspace be singled out as creating a universe like ours; why isn't there an infinity of universes varying in all ways possible --- which there is not. As Chris Isham puts it, the problem was "pre-empted" by Augustine's response to the question of what God was doing before God made the universe. Augustine's answer was that God did not create the universe in time, since the decision as to which point in time to create it would be arbitrary and would imply that God's will is mutable. Instead Augustine claimed that God created time along with the creation of the universe. But as Isham points out, the same reasoning leads us to reject Penrose's approach: it is thoroughly arbitrary to pick a creation point in superspace. The Hawking/Hartle model, on the other hand, circumvents the need for such a point. Thus "it is singularly striking that, sixteen centuries later, theoretical physicists have considered precisely the same subterfuge" to avoid questions like >before creation'.⁶⁹ I think this is a striking example of the potentially positive role theology could play in stimulating new insights and directions of inquiry within the natural sciences.⁷⁰

As these examples suggest, constructive exchanges may be possible in both directions between science, philosophy and theology if we are extremely careful about the legitimate autonomy of, and indirect influences between, these fields. I am currently engaged in a project to reformulate Trinitarian theology in light of relativity and quantum mechanics, and then to see whether such a reformulated theology would shed light on ways to revise scientific cosmology making it more amendable to an eschatological interpretation.⁷¹

Conclusions

And so we return to that remarkable document, *fides et ratio*, and its urging of

scientists to place their work in the wider context of a worldview imbued with wisdom. According to *fides et ratio*, the conditions for this sapiential horizon flow from the central theological claim that the God of creation is the God of salvation history.

I hope I have shown how this theological claim can play a remarkable role in challenging us to bring together topics which are normally separated in the ongoing research in '>science and theology'. The claim requires that 1) nature must be interpretable as '>the creation of God', and 2) nature must be interpretable as the creation which, by God's act, will become God's '>new creation'. The first requirement led us to fascinating ongoing discussions about Big Bang and quantum cosmology in relation to the doctrine of creation. Here we start with cosmology and ask about its potential theological relevance. The second requirement, however, is much more challenging and, to date, relatively unexplored. Big Bang and quantum cosmology seem to resist any detailed theological interpretation. They forecast the future of the universe to be fundamentally inhospitable to biological life, and even more so, as contradicting the eschatological hope for a radical transformation of the universe into the '>new creation.'

With this in mind, I have suggested that our theological and philosophical convictions might, indirectly at least, inspire the construction of alternative, empirically adequate, scientific cosmologies which could be open to theological interpretation, cosmologies which at the same time have to be accepted by the scientific community according to its own, autonomous standards. Such a project might not be possible. However if it succeeded to any degree it would allow us to begin to view the universe as both God's old and new creation. This in turn is needed for theology to offer a sapiential horizon for all our scientific research and to provide a contrasting voice to nihilistic and atheistic readings of science that so pervade our age.

I hope to attempt such a project in the near future. I would be honored to remember this magnificent Jubilee for Scientists at the Vatican as marking its beginning, through the grace of God in Christ Jesus and the power and wisdom of God's Holy Spirit.

ENDNOTES

1. John Paul II, *Encyclical Letter Fides et Ratio of the Supreme Pontiff John Paul II to the Bishops of the Catholic Church on the Relationship Between Faith and Reason* (Washington, D. C.: United States Catholic Conference, 1998), III/30.

2. John Paul II, *Fides et Ratio*, III/34.

3. These requirements can be formulated conversely as rejections of three kinds of philosophies: 1) those which deny the possibility of an ultimate meaning; 2) those which are radically phenomenalist or relativist; and 3) those which are inherently antimetaphysical. See John Paul II, *Fides et Ratio*, IV/81-83.

4. John Paul II, *Fides et Ratio*, 106.

5. Science minisummary: Big Bang cosmology. During the decade following the publication of his special theory of relativity, Einstein worked on applying it to a dynamical theory of gravity. His basic insight was to reconceptualize gravity as the curvature of spacetime instead of as a (Newtonian) force in space. Rather than being deflecting from their otherwise linear motion in a Euclidean space with three dimensions, masses would move along geodesics describing the shortest possible path in curved spacetime. Their motion, in turn, would alter the curvature of spacetime, thus giving the field equations General Theory of Relativity (GR) their highly non-linear form aptly described as: >spacetime tells mass how to move; mass tells spacetime how to curve=. (See Charles W. Misner, Kip S. Thorne and John Archibald Wheeler, *Gravitation* (San Francisco: W. H. Freeman and Company, 1973), 5.).

Shortly after the discovery of GR, solutions to Einstein's equations were developed for two distinct classes of problems: i) point masses, which when applied to the solar system led to several key tests of the theory and their eventual confirmation (including the deflection of starlight by the sun and the precession in the perihelion of the orbit of Mercury), and ii) dust, which when eventually applied to the distribution of galaxies and galactic clusters described the universe as expanding in time. During the 1920s, telescopic observations by Edwin Hubble showed that galaxies were indeed receding from us and at a velocity proportional to their distance. In essence, the expansion of the universe had been discovered!

There are in fact three types of expansion possible . i) Closed model: spherical. In one model the universe has the shape of a 3-dimensional sphere of finite size. It expands up to a maximum size, approximately 100 billion years from now, then recontracts, eventually recollapsing to a singularity that mirrors $t=0$ with infinite temperatures and densities. ii) Open model 1: >flat= and iii) open model 2: >saddle-shaped=. Both the >flat= and >saddle-shaped= models are infinite in size *and* expanding in time. In both cases the universe will expand forever and cool indefinitely towards absolute zero. (The >flat= model is pseudo-Euclidean like the geometry of special relativity. The >saddle-shaped= model has negative curvature and cannot therefore be embedded in Euclidean space, so it is harder to picture: it is shaped something like a

saddle at each event in spacetime.) The future of these models is often used to characterize them as >freeze= (open, both cases) or >fry= (closed).

All three came to be called "Big Bang" models because they describe the universe as having a finite past life of 10-20 billion years and beginning in an event of infinite temperature and density, and zero volume. Since the age of the universe, t , is calculated as starting here, it is convenient to label it " $t=0$ "; technically this event is referred to as an "essential singularity." A singularity is an event in which physical parameters go infinite; an essential singularity is one which we believe actually describes a phenomena in nature, and is not merely the artificial result of using a particular model. In the 1960s, Stephen Hawking, Roger Penrose, and Robert Geroch proved key theorems which showed that the existence of an essential singularity, $t=0$, given Einstein's GR, was unavoidable. (For a technical introduction see {MTW 1973: Ch. 34, esp. 34.4, 34.6}; see also {Penrose 1965}, {Hawking & Penrose 1969}; {Hawking & Ellis 1973}.) These theorems only apply if certain reasonable conditions hold for the model, namely $3+\dot{p}/c > 0$. These conditions are violated in many inflationary models (see below).

One might wonder why we can talk about the universe expanding in time given that GR is based on SR: given relativity's challenge to the idea of "the present=", how can there be a unique "present=" which defines "the universe=" and allows it to be described as an "object=" expanding in time? The answer involves two facts: 1) The mathematical equations of GR can be factored into a "space plus time=" form, i.e., a 3-geometry whose characteristic size is a function of time, if the distribution of matter in the 3-geometry is uniform. 2) Hubble's observations show that, at large enough distances, galaxies at the same distance are uniformly distributed in space. One can appeal to this idea theologically by claiming that the "present=" of the universe which God experiences is defined by its uniform mass distribution and expansion in time. However, it should be kept in mind that the underlying equations of GR are even more complex than those of SR, and the distinctive meaning of space and of time in GR is correspondingly more problematic. See for example {Isham 1993: Section 3}; {Drees 1990: Appendix 5}.

For a non-technical introduction, see {Trefil & Hazen 2000: Ch. 15}, {Goldsmith 1995: Chs. 1-9}, {Trefil 1983: Chs. 1-9}, {Drees 1990: Appendix 1}; {Ellis & Stoeger 1993}; {Stoeger 1996}; {Southgate 1999: p. 35-39}. For a technical introduction, see {North 1965}; {MTW 1973: Part VI}; {Weinberg 1972: Part V}.

6. Ernan McMullin, "How Should Cosmology Relate to Theology?" in *The Sciences and Theology in the Twentieth Century*, ed. A. R. Peacocke (Notre Dame: University of Notre Dame Press, 1981), 17-57. According to McMullin, the Pope later refrained from this claim after being cautioned by Georges Lemaitre. Though a Roman Catholic Priest and one of the founders of Big Bang cosmology, Lemaitre's view was "two worlds": keep theology and science entirely separate. See also Christopher Southgate, Celia Deane-Drummond, et al., eds., *God, Humanity and the Cosmos: A Textbook in Science and Religion* (Harrisburg: Trinity Press International, 1999), 122-23.

7. McMullin, "How Should Cosmology Relate to Theology?" 31-32.

8. William Lane Craig and Quentin Smith, *Theism, Atheism, and Big Bang Cosmology* (New

York: Oxford University Press, 1993).

9. See for example Hugh Ross, *The Creator and the Cosmos: How the Greatest Scientific Discoveries of the Century Reveal God* (Colorado Springs: NavPress Publishing Group, 1993).

10. An example from Protestant neo-orthodoxy is the early writings of Langdon Gilkey. See for example Langdon Gilkey, *Maker of Heaven and Earth: The Christian Doctrine of Creation in the Light of Modern Knowledge* (Lanham: University Press of America (originally published: Garden City: Doubleday, 1959), 1959), Ch. 9, esp. 309-18. Gilkey has since changed his view somewhat.

11. According to McMullin, the Pope later refrained from this claim after being cautioned by Georges Lemaitre. Though a Roman Catholic Priest and one of the founders of Big Bang cosmology, Lemaitre's view was "two worlds": keep theology and science entirely separate. See also

12. A. R. Peacocke, *Creation and the World of Science: The Bampton Lectures, 1979* (Oxford: Clarendon Press, 1979), p. 78-79.

13. John C. Polkinghorne, *The Faith of a Physicist: Reflections of a Bottom-up Thinker*, Theology and the Sciences Series (Minneapolis, Minn.: Fortress, 1994), Ch. 4, esp. p. 73.

14. William E. Carroll, "Big Bang Cosmology, Quantum Tunneling from Nothing, and Creation," *Laval Theologique et Philosophique* 44.1 (February 1998). See also Thomas Aquinas, *Aquinas on Creation*, ed. Steven E. Baldner and William E. Carroll (Toronto: Pontifical Institute of Mediaeval Studies, 1997).

15. Ian G. Barbour, *Issues in Science and Religion* (New York: Harper & Row, 1971 (originally published in 1966 by Prentice-Hall)), esp. 366-68. For an analysis of Barbour's dependence on Gilkey and the eventual shift in his position see Robert John Russell, "Finite Creation Without a Beginning: The Doctrine of Creation in Relation to Big Bang and Quantum Cosmologies," in *Quantum Cosmology and the Laws of Nature: Scientific Perspectives on Divine Action*, ed. Robert J. Russell, Nancey C. Murphy and Chris J. Isham, Scientific Perspectives on Divine Action Series (Vatican City State; Berkeley, Calif.: Vatican Observatory Publications; Center for Theology and the Natural Sciences, 1993), esp. 300-03.

16. William R. Stoeger, S.J., "Contemporary Cosmology and Its Implications for the Science-Religion Dialogue," in *Physics, Philosophy, and Theology: A Common Quest for Understanding*, ed. Robert J. Russell, William R. Stoeger, S.J. and George V. Coyne, S.J. (Vatican City State: Vatican Observatory Publications, 1988), esp. p. 240, where Stoeger makes an interesting claim about the limitations of science and $t=0$. See also Paul Davies, "Is the Universe Absurd?" in *Science and Theology: The New Consonance*, ed. Ted Peters (Boulder: Westview Press, 1998), esp. p. 70.

17. McMullin gives a marvelous account of a very similar reaction by Georges Lemaitre. See

Note #25.

18. Barbour's recent position has shifted from what it was in the 1960s, when in the context of two rival models (steady state and Big Bang) he stressed the neutrality of theology to such specific aspects of cosmology as $t=0$. In his 1990 Gifford Lectures he suggested that if a clear scientific consensus should emerge on the issue of $t=0$, it would be relevant to theology. Compare Barbour, *Issues in science and religion*, 366-68, 377, 380, 414, 458. with Ian G. Barbour, *Religion in an Age of Science*, Gifford Lectures; 1989-1990. (San Francisco: Harper & Row, 1990), 128-29. For a detailed analysis of Barbour's position, see Russell, "Finite Creation Without a Beginning," 300-03.

19. David Price, John L. Wiester and Walter R. Hearn, *Teaching Science in a Climate of Controversy: A View from the American Scientific Affiliation* (Ipswich: American Scientific Affiliation, 1986), 24-28.

20. Nancey Murphy and George F. Ellis, *On the Moral Nature of the Universe: Theology, Cosmology, and Ethics*, Theology and the Sciences Series (Minneapolis, Minn.: Fortress Press, 1996), Ch. 3.

21. (ref)

22. Worthing gives a particularly careful analysis of the many issues related here. See Mark W. Worthing, *God, Creation, and Contemporary Physics*, Theology and the Sciences Series (Minneapolis: Fortress Press, 1996), esp. p. 85-90.

23. McMullin, "How Should Cosmology Relate to Theology?"

24. McMullin, "How Should Cosmology Relate to Theology?" esp. p. 39.

25. McMullin, "How Should Cosmology Relate to Theology?" esp. p. 52.

26. Robert John Russell, "Cosmology, Creation, and Contingency," in *Cosmos as Creation: Theology and Science in Consonance*, ed. Ted Peters (Nashville: Abingdon Press, 1989), 177-210; Russell, "Finite Creation Without a Beginning."; Robert John Russell, "T=0: Is It Theologically Significant?" in *Religion and Science: History, Method, Dialogue*, ed. W. Mark Richardson and Wesley J. Wildman (New York: Routledge, 1996), 201-26; Robert John Russell, "Did God Create Our Universe? Theological Reflections on Big Bang, Inflation and Quantum Cosmologies," in *Cosmic Questions Conference Proceedings*, ed. Jim Miller (American Association for the Advancement of Science, to be published, 1999). The categorization of contingency can be found in Robert John Russell, "Contingency in Physics and Cosmology: A Critique of the Theology of Wolfhard Pannenberg," *Zygon: Journal of Religion and Science* 23.1(March 1988).

27. The contingency of the universe can then play a role in theology: it is a >prediction= of

systematic theology (i.e., the datum of the world=s contingency is >explained= in terms of the theology of creation) as well as a philosophical >datum= for natural theology (i.e., the datum of the world=s contingency serves as a basis for an >argument for God=). t=0 can thus play a helpful, if indirect, role in both systematic theology and natural theology, for it gives concrete empirical content to the much more diffuse philosophical meaning of contingency at work in these theologies.

28. Ted Peters, Ed., *Science & Theology: The New Consonance* (Boulder, Colorado: Westview Press, 1998), p. 13-22.

29. Ted Peters, "Cosmos as Creation," in *Cosmos as Creation: Theology and Science in Consonance*, ed. Ted Peters (Nashville: Abingdon Press, 1989), 45-114. See also Ted Peters, "On Creating the Cosmos," in *Physics, Philosophy, and Theology: A Common Quest for Understanding*, ed. Robert J. Russell, William R. Stoeger, S.J. and George V. Coyne, S.J. (Vatican City State: Vatican Observatory Publications, 1988), esp. p. 288-91. For a critical response see Russell, "Finite Creation Without a Beginning," esp. 303-04. Interestingly, Peters combines this with >temporal holism=, an insistence that the perfection of creation lies in the future, not the past, particularly in its eschatological fulfillment. See Ted Peters, *God as Trinity: Relationality and Temporality in the Divine Life* (Louisville, Ky.: Westminster/John Knox Press, 1993), esp. p. 163-70.

30. Sallie McFague, *Metaphorical Theology: Models of God in Religious Language* (Philadelphia: Fortress Press, 1982).

31. Science minisummary: Inflationary Big Bang and quantum cosmologies.

With the introduction of the inflationary Big Bang@ scenario by Alan Guth and colleagues in the 1970s and further developments in this direction in the 1980s, these problems were basically solved. (These include the absence of antimatter in our universe, the formation of galaxies, the uniformity of the background radiation, and the flatness of the universe. See James S. Trefil, *The Moment of Creation: Big Bang Physics from Before the First Millisecond to the Present Universe* (New York: MacMillan Publishing Company, 1983), Chs. 3, 11.) According to inflation, the extremely early universe (roughly the Planck time 10^{-43} seconds) expands extremely rapidly, then quickly settles down to the expansion rates of the standard Big Bang model. During inflation, countless domains may arise, separating the overall universe into huge portions of spacetime in which the natural constants and even the specific laws of physics can vary.

The effect of inflation on the problem of t=0, however, is fascinating. In some inflationary cosmologies, the Hawking-Penrose theorems don=t apply during the inflationary epoch. In these cosmologies we may never know whether or not an essential singularity exists, even if it does. (See especially John D. Barrow, *Impossibility: The Limits of Science and the Science of Limits* (Oxford: Oxford University Press, 1998), Ch. 6, esp. p. 181.). Recently, attempts have been made to unify quantum physics and gravity and apply the results to cosmology. Proposals by Hawking and Hartle, Linde, Isham, Guth, Hawking and Turek, 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. (Some of the original papers include J. B. Hartle and S. W. Hawking, A Wave Function of the Universe, @ *Phys. Rev. D* 28:2960-2975, and A. D. Linde, A Particle Physics and Inflationary Cosmology, @ *Physics Today* 40 (9): 61-68) In most quantum cosmologies, our universe is just a part of an eternally expanding, infinitely complex megauniverse.

Quantum cosmology, however, is a highly speculative field. Theories involving quantum gravity, which underlie quantum cosmology, are notoriously hard to test empirically, and they lift the philosophical issues already associated with quantum mechanics to a much more complex level since the domain is now >the universe=.

For a non-technical introduction see Donald Goldsmith, *Einstein's Greatest Blunder? The Cosmological Constant and Other Fudge Factors in the Physics of the Universe* (Cambridge, Massachusetts: Harvard University Press, 1995), Chs 10 on, Trefil, *The Moment of Creation*, Chs. 10 on, Willem B. Drees, *Beyond the Big Bang: Quantum Cosmologies and God* (La Salle, Ill.: Open Court, 1990), Appendices 3, 4. For a more technical introduction see Chris J. Isham, "Creation of the Universe as a Quantum Process," in *Physics, Philosophy, and Theology: A Common Quest for Understanding*, ed. Robert J. Russell, William R. Stoeger, S.J. and George V. Coyne, S.J. (Vatican City State: Vatican Observatory Publications, 1988), 375-408; Chris J. Isham, "Quantum Theories of the Creation of the Universe," in *Quantum Cosmology and the Laws of Nature: Scientific Perspectives on Divine Action*, ed. Robert J. Russell, Nancey C. Murphy and Chris J. Isham, Scientific Perspectives on Divine Action Series (Vatican City State; Berkeley, Calif.: Vatican Observatory Publications; Center for Theology and the Natural Sciences, 1993), 49-90; Edward W. and Michael S. Turner Kolb, *The Early Universe* (Reading: Addison-Wesley Publishing Company, 1994).

32. For example, Murphy and Ellis, *On the Moral Nature of the Universe*.

33. J. R. Lucas, "The Temporality of God," in *Quantum Cosmology and the Laws of Nature: Scientific Perspectives on Divine Action*, ed. Robert J. Russell, Nancey C. Murphy and Chris J. Isham, Scientific Perspectives on Divine Action Series (Vatican City State; Berkeley, Calif.: Vatican Observatory Publications; Center for Theology and the Natural Sciences, 1993), 235-46.

34. Ted Peters, "The Trinity in and Beyond Time," in *Quantum Cosmology and the Laws of Nature: Scientific Perspectives on Divine Action*, ed. Robert J. Russell, Nancey C. Murphy and Chris J. Isham, Scientific Perspectives on Divine Action Series (Vatican City State; Berkeley, Calif.: Vatican Observatory Publications; Center for Theology and the Natural Sciences, 1993), 263-92; see also Peters, *God as Trinity*, 163-66.

35. Willem B. Drees, "A Case Against Temporal Critical Realism? Consequences of Quantum Cosmology for Theology," in *Quantum Cosmology and the Laws of Nature: Scientific Perspectives on Divine Action*, ed. Robert J. Russell, Nancey C. Murphy and Chris J. Isham, Scientific Perspectives on Divine Action Series (Vatican City State; Berkeley, Calif.: Vatican

Observatory Publications; Center for Theology and the Natural Sciences, 1993), 331-66.

36. Paul Tillich, *Systematic Theology*, 300 pp (Chicago: University of Chicago Press, 1951), 1:188, 253.

37. Russell, "Finite Creation Without a Beginning," 319-29.

38. Joseph M. Zycinski, "Metaphysics and Epistemology in Stephen Hawking's Theory of the Creation of the Universe," *Zygon: Journal of Religion and Science* 31.2(June 1996). See also Willem B. Drees, "Quantum Cosmologies and the "Beginning", " *Zygon: Journal of Religion and Science* 26.3(September 1991); Robert J. Deltete, "Hawking on God and Creation," *Zygon: Journal of Religion and Science* 28.4(December 1993).

39. Stephen W. Hawking, *A Brief History of Time: From the Big Bang to Black Holes* (New York: Bantam Books, 1988), x.

40. Hawking, *A brief history of time*. For example, cf. 140-141. Note, too: the word "God" does not appear in the index. More significantly, an interventionist version of divine action seems to be Hawking's presupposition, thus ignoring views of God as continuous creator, the God of process theism, generic pantheism, Trinitarian theism, and so on: cf. p. 9, 122. Final note: Hawking's comments about the Vatican, unfortunately, are not consistent with the actual events at the time. cf. p. 116, 136

41. Hawking, *A brief history of time*, 174.

42. Science minisummary: Big Bang and the far future: freeze or fry. There are two scenarios for the far future of the universe according to Big Bang cosmology: >freeze or fry.= If the universe is open (or flat), it will expand forever and continue to cool from its present temperature (about 2.7⁰K), asymptotically approaching absolute zero. If it is closed, it will expand to a maximum size in another hundred billion years or so, then recollapse to arbitrarily small size and unendingly higher temperatures somewhat like a mirror image of its past expansion. In inflationary and quantum scenarios, the present expansion may be accelerating due to the presence of the >cosmological constant=, but the overall picture of these two options holds. In either case, the universe will become inhospitable to biological life in the nearer future, after stars nova and planetary systems decay. Life as we know it will, apparently, be untenable for more than a few tens of billions of years in the universe. Moreover, the future of the universe is predictable here using physics alone.

43. Karl Rahner, "Natural Science and Reasonable Faith," trans. Karl-H. Kruger, in *Theological Investigations 21* (Baltimore: Helicon Press, 1961-92), p. 55.

44. Wolfhart Pannenberg, *Systematic Theology*, 713 pp, trans. G. W. Bromiley (Grand Rapids, Mich.: Eerdmans, 1998), 3:Ch. 15, esp. section 1, p. 531. Pannenberg claims that the future of God's reign is already present in the ministry of Christ and the church, but this claim anticipates

and depends crucially on its eschatological confirmation. Throughout his writings Pannenberg will insist that Christian theology must not be in contrast to or conflict with natural science, and that the deity of God depends on the eschatological consummation of the world.

45. Wolfhart Pannenberg, "Theological Questions to Scientists," in *The Sciences and Theology in the Twentieth Century*, ed. A. R. Peacocke (Notre Dame: University of Notre Dame Press, 1981). See his last and most challenging question: "Is the Christian affirmation of an imminent end of this world that is some way invades the present even now, reconcilable with scientific extrapolations of the continuing existence of the universe for billions of years ahead?"

46. John Macquarrie, *Principles of Christian Theology*, Second Edition (New York: Charles Scribner's Sons, 1977 (1966)), Ch. 15, esp. 351-62.

47. Peacocke, *Creation and the World of Science*, 329. Instead, Peacocke affirms that Christian hope is based on Jesus' Resurrection and its connection with eschatology. In earlier work he explored three schools of thought which might help relate eschatology and cosmology: the theologians of hope, the Teilhardians, and process theologians. For all three, hope actually consists in our movement towards and into God beginning *in the present* but it transcends any literal sense of the future. Instead, our End will be our Beginning --- God's own self. Arthur Peacocke, *Theology for a Scientific Age: Being and Becoming --- Natural, Divine and Human*, Enlarged Edition (Minneapolis: Fortress Press, 1993), 344-45. Our hope, then, ultimately lies in a fulfillment beyond space and time within the very being of God. Peacocke, *Creation and the World of Science*, 353. For a recent approach to theology and evolution somewhat indebted to Teilhard see S. J. Mooney, Christopher F., *Theology and Scientific Knowledge: Changing Models of God's Presence in the World* (Notre Dame: University of Notre Dame Press, 1996), Ch. 4.

48. Bertrand Russell, "A Free Man's Worship," in *Mysticism and Logic, and Other Essays*, 1963 edition (London: Allen & Unwin, 1903), p. 41.

49. Steven Weinberg, *The First Three Minutes: A Modern View of the Origin of the Universe* (New York: Basic Books, Inc., 1977), 154-55.

50. Are these conclusions avoidable? Not easily, if we play fair by the methodological rules adopted by the field. Recall that a specific methodological framework made scholarly work in theology and science possible for the past four decades. This framework includes an epistemological hierarchy of constraints and emergence which requires that theology not ignore the results of physics or hope that higher levels, such as evolutionary biology, will simply overturn the predictions of physics. Since scientific cosmology (i.e., Big Bang cosmology, inflationary Big Bang, quantum cosmology, etc.) is part of physics (i.e., relativistically correct theories of gravity applied to the universe), the predictions of freeze or fry --- or their scientific replacements in the future --- must place constraints on and challenge what theology can claim eschatologically just like the presence of death in evolutionary biology challenged the traditional connection

between sin and death. No easy appeal to contingency, chaos theory, unpredictability, novelty, emergence, the future, or metaphysics alone will be sufficient to solve this problem. (The only alternative is truly radical: to pursue the possibility that a commitment to eschatology will lead to an alternative *scientific* cosmology (see Part 3, C, below).)

51. Freeman Dyson, "Time Without End: Physics and Biology in an Open Universe," *Reviews of Modern Physics* 51 (1979): 447-60.

52. John D. Barrow and Frank J. Tipler, *The Anthropic Cosmological Principle* (Oxford: Clarendon Press, 1986). Although the writings of Dyson and Tipler are recent examples and have received wide discussion, they actually represent recent variations on a century-long series of proposals that follow on similar questions. See Barrow and Frank J. Tipler, *The Anthropic Cosmological Principle*, Chs. 2-4. for an excellent introduction. See also Worthing, *God, Creation, and Contemporary Physics*, Ch. 6. for a briefer summary.

53. Frank J. Tipler, *The Physics of Immortality: Modern Cosmology, God, and the Resurrection of the Dead* (New York: Doubleday, 1994). For an earlier reflections see Frank J. Tipler, "The Omega Point Theory: A Model of an Evolving God," in *Physics, Philosophy, and Theology: A Common Quest for Understanding*, ed. Robert J. Russell, William R. Stoeger, S.J. and George V. Coyne, S.J. (Vatican City State: Vatican Observatory Publications, 1988), 313-32.

54. Freeman Dyson, *Disturbing the Universe* (New York: Harper and Row, 1979), Ch. 23. Freeman Dyson, *Infinite in All Directions* (New York: Harper and Row, 1988), Ch. 6.

55. Drees, *Beyond the big bang*, Ch. 4. See also Fred W. Hallberg, "Barrow and Tipler's Anthropic Cosmological Principle," *Zygon: Journal of Religion and Science* 23.2 (June 1988).

56. Frank J. Tipler, "The Omega Point as Eschaton: Answers to Pannenberg's Questions for Scientists," *Zygon: Journal of Religion & Science* 24.2 (June 1989): 217-53. Wolfhart Pannenberg, "Theological Appropriation of Scientific Understandings: Response to Hefner, Wicken, Eaves, and Tipler," *Zygon: Journal of Religion & Science* 24.2 (June 1989): 255-71.

57. Willem B. Drees, "Contingency, Time, and the Theological Ambiguity of Science," in *Beginning with the End..God, Science, and Wolfhart Pannenberg*, ed. Carol Rausch Albright and Joel Haugen (Chicago: Open Court, 1997). (Russell 1997). See also Russell, "Cosmology, Creation, and Contingency," 201-04. Robert John Russell, "Cosmology from Alpha to Omega," *Zygon: Journal of Religion & Science* 29.4(December 1994): 570-72. See also the responses in the March, 1999 issue of *Zygon*.

58. Hyung Sup Choi, "A Physicist Comments on Tipler's "The Physics of Immortality"," *CTNS Bulletin* 15.2(Spring 1995); W. R. Stoeger and G. F. R. Ellis, "A Response to Tipler's Omega-Point Theory," *Science and Christian Belief* 7.2(October 1995).

59. John C. Polkinghorne, *Science and Providence: God's Interaction with the World*, 1st

Shambhala ed. (Boston: Shambhala Publications, 1989), 96; Barbour, *Religion in an age of science*, 151-52; Peacocke, *Theology for a Scientific Age*, 345; Clayton 1997: 132-136}; Worthing, *God, Creation, and Contemporary Physics*, Ch. 5. See also the Book Symposium in the June, 1995 and September, 1995 issues of *Zygon: Journal of Religion and Science*, 30.2, 30.3.

60. Polkinghorne, *The faith of a physicist*, 163.

61. Polkinghorne, *The faith of a physicist*, 162-70. He thus supports eschatological panentheism. One can find a hint of this in Paul Tillich, *Systematic Theology*, 434 pp (Chicago: University of Chicago Press, 1963), 3:421.

62. Pannenberg, *Systematic theology*, 3:589-90. Pannenberg is apparently referring to the closed Big Bang model and not the open model, which, though possessing a finite past, is infinite in size and will continue forever into the future. Mark Worthing has proposed that we take up Pannenberg's distinction between theological and scientific apocalyptic visions. Rather than equate the *parousia* with the remote future end of the universe, Worthing suggests we understand it as a renewal or transformation of the universe as a whole. The Biblical *end* is not a cosmic end, since it allows for a bodily resurrection and creation of a new heaven and new earth. Worthing, *God, Creation, and Contemporary Physics*, 177-78. This, in turn, shifts the discussion from the end of the world to the concept of eternity as the real issue in relating science and theology. We are led to consider the future of the universe... (as) taken up into the eternity of the Creator --- an eternity of a decisively different order from that which the physical universe could potentially possess... Worthing, *God, Creation, and Contemporary Physics*, 198.

63. Peters, *God as Trinity*, 168-70; Ted Peters, *God--the World's Future: Systematic Theology for a Postmodern Era* (Minneapolis, Minn.: Fortress Press, 1992), 134-39, esp. 134. A My hypothesis, then, is the following principle of proleptic creation: God creates from the future, not the past. Peters, *God as Trinity*, 173; Peters, *God--the world's future*, 308-09; Peters, *God--the world's future*, 308-09.

64. Peters, *God as Trinity*, 175-76. See also George L. Murphy, "Cosmology and Christology," *Science and Christian Belief* 6.2 (October 1994).

65. The *demise* of steady state cosmology may well be premature, since a number of cosmologists continue to construct models whose roots can be traced back to Hoyle's early work. See for example H. C. Arp, G. Burbidge, F. Hoyle, J. V. Narlikar & N. C. Wickramasinghe, "The extragalactic Universe: an alternative view," *Nature* 346 (30 August, 1990), 807-812.

66. McMullin, "How Should Cosmology Relate to Theology?" 24. According to historian of science Helge Kragh there can be little doubt that the discussions among Hoyle, Gold, and Bondi, which led to a tentative formulation of the steady-state theory in 1947, were colored negatively by the views expounded by Whittaker, Milne, and other religious scientists...Although the motives behind the steady-state model were not ... antireligious, it must surely have added to their satisfaction that it was possible to design a universe in which there allegedly was no room for a Creator. © Helge Kragh, *Cosmology and Controversy: The Historical Development of Two Theories of the Universe* (Princeton: Princeton University Press, 1996), 253.

67. I would argue that the position represented by Hoyle is, in at least a formal sense, that theology can play a role not only in theory choice but in theory construction, even if for Hoyle personally the motivation was only implicitly theological. That it is >theological= might be disputed, since Hoyle is an atheist, but I would argue that both an affirmation or denial of the existence of God are by definition theological (and, of course, also philosophical) assertions. That it functioned in the construction of theories might be disputed, because Bondi and Gold had already worked out much of the steady state model which Hoyle used, but it is also important to recall that Hoyle made foundational contributions to an alternative theory of gravity in its support.

68. A similar example comes from the early development of GR. Initially Einstein actually changed the field equations to allow for a universe that did not change in time by adding to it the famous >cosmological constant= Λ , but withdrew it after Hubble's discovery of the expansion of the universe, calling it his *greatest blunder*. Misner, Kip S. Thorne and John Archibald Wheeler, *Gravitation*, 409-11. I think it is another illuminating example of the way philosophical and theological concepts can influence the development of scientific theories. See Russell, "Did God Create Our Universe?"

69. Isham, "Creation of the Universe.". See also Russell, "Finite Creation Without a Beginning," 318-9. and Drees, *Beyond the big bang*.

70. Russell, "Finite Creation Without a Beginning," 319-29.

71. The project involves the following steps: first, Trinitarian conceptions about time and eternity would have to be reformulated in light of relativity (here science puts constraints on theology); second, in light of this reformulation, the assumptions on which current physics (and thus cosmology as a part of physics) are based would be inspected (tracing back to the rise of modern science). They may, in fact, be the root of the problem by leading to an insufficiently rich cosmology for theological appropriation. This, in turn, would suggest that a more complex view of nature as creation might be sought, and its implications for revising contemporary scientific cosmology be considered. Finally, if such a revision were formulated in scientifically testable fashion, it would be entirely the province of secular physics to decide whether it had any empirical merit. At least, though, the conversation would be genuinely two-way.