COSMOLOGY FROM ALPHA TO OMEGA

by Robert John Russell

Abstract. This paper focuses on four passages in the journey of the universe from beginning to end: its origin in the Big Bang, the production of heavy elements in first generation stars, the buzzing symphony of life on earth, and the distant future of the cosmos. As a physicist and a Christian theologian, I will ask how each of these passages casts light on the deepest questions of existence and our relation to God, and in turn how these questions are being explored through ongoing research into the interaction between Christian theology and the natural sciences.

Keywords: Ian Barbour; Big Bang; chaos theory; cosmology; creation; divine action; Freeman Dyson; evolution; evolutionary theism; far future; God; Stephen Hawking; Jacques Monod; Arthur Peacocke; John Polkinghorne; quantum gravity; quantum physics; Frank Tipler; Trinity.

Does the universe as a whole have a unique history, a single all-encompassing span of events never repeated, beginning at Alpha, the cosmic origin, and ending in the distant mists of a universal Omega? Can God be found not only in human life and history but also in the passages of the universe in its journey from Alpha to Omega? As a physicist and Christian, it is my joint calling to explore these questions in light of the discoveries and question marks which science brings to the mystery and glory of life in the universe. I will do so here by picking four passages in the journey of the universe. First, we will return to that most profound puzzle of all, the origin of the universe, the Alpha of cosmology. Then we will pause momentarily to watch the vital production of heavy elements in first-generation

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stars. Third, we will ponder the buzzing symphony of life on earth and ask two questions: Does life have cosmic significance? and Does chance veil the action of God in evolution? Finally, we will attempt to gaze outward toward the vast and distant future and the theme of a cosmic completion in Omega. In each case I will ask how the discoveries of science cast light on the deepest questions of existence and our relation to God. I will then develop in some detail some of the more technical aspects of the discussion to give a clearer sense of where I think the most interesting research in Christian theology and the natural sciences is taking place on these topics.[1]

Four Passages in the Cosmic Journey

1. FOAM, FIRE AND FINITUDE: ALPHA AS THE BEGINNING OF ALL THAT IS. Did the universe have a beginning? Was there a time before the beginning of the universe, or was time created "at the beginning"? This is the ancient question Augustine perused in his *Confessions* and in *The City of God.* Augustine rejected the notion of a pre-existent time before creation, arguing instead that time itself began with the creation of the universe. Can we too ask such a question in light of modern science and cosmology? The answer is, in my opinion, a cautious "yes"—and it has much in common with Augustine's insight about the creation of time by God.

Physical cosmology stands today squarely within the scientific academy, and yet it attempts to deal with just this sort of question. Cosmology is that branch of science which studies the universe as a whole—though it is extraordinarily difficult to give an adequate answer to the basic scientific and philosophical questions raised in the process.[2] According to our best theory, Albert Einstein's general theory of relativity, space and time are parts of a four-dimensional manifold called space-time. Moreover, space-time is a dynamic physical entity and not just an abstract mathematical construct. Space-time is responsive to the distribution of matter within it. As matter moves about, the geometry of space-time continuously changes, and these changes in turn alter the motion of matter. Einstein's field equations $R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = 8\pi T_{\mu\nu}$ describe this complex interaction.

To apply these abstract equations to the universe, we must turn to the empirical results of astronomical observations dating back to the work of Edwin Hubble in the mid 1920s. Hubble's observations and their subsequent confirmation on much broader scales show us that the universe, on the large scale, is remarkably uniform: the distribution of clusters of galaxies is homogeneous and isotropic. Given this,

Einstein's theory predicts that the universe is expanding from an arbitrarily small size and tremendous temperatures in what is called the "Hot Big Bang," an event labeled as the beginning of time, or "$t = 0$." From there, three alternatives are possible: the universe might expand to a maximum size and then recollapse, returning to infinite temperatures in perhaps 100 billion years from now, the closed spherical Big Bang model; or it might expand and cool forever, either as a flat universe or as one shaped something like a saddle, the two open Big Bang models. So the options for the far future according to the Big Bang are "freeze or fry"! Astronomers remain uncertain about its future: most likely it will expand and cool forever, being either flat or marginally open.

Now there are technical problems with the Big Bang account: why the universe is essentially flat (or barely open); why there is apparently more matter than antimatter, why the universe is so seemingly homogeneous and isotropic (the "horizon" problem), and so on.[3] Inflationary cosmology, the invention of MIT physicist Alan Guth, showed the way toward answering many of these questions, but it did not solve the problem of $t = 0$.

So what are we to make of that beginning point? Because of the theoretical research of such cosmologists as Roger Penrose and Stephen Hawking, we know that if general relativity is correct and if we make some very reasonable assumptions about matter in the universe, then $t = 0$ is an "absolute singularity," and so standard cosmology cannot get "behind" it, so to speak. $t = 0$ poses what physicist John Wheeler calls the "biggest crisis on the books of physics," for how could science, based on the presupposition that every state of affairs is the result of a previous state of affairs, discuss an uncaused state, an effect which has no cause? Is it possible that Einstein's theory is wrong?

Meanwhile the Big Bang has received big attention from many quarters. Some, including Pope Pius XII, Robert Jastrow, head of NASA's Goddard Space Center, and more recently evangelical and conservative Christians as well as such mainstream theologians as Wolfhart Pannenberg and Ted Peters, take it as more or less *direct support* for Christian theology—that God indeed created the universe *ex nihilo*, that is, out of nothing previously existing. Others, including theologian George Lindbeck, Jesuit cosmologist William Stoeger of the Vatican Observatory, and Anglican biochemist Arthur Peacocke have seen *little if any theological significance* to $t = 0$, even though Peacocke, of course, and to a lesser extent Stoeger, find very important and extensive connections elsewhere between theology and science. Finally, a strictly "two worlds" position, that science and

religion in principle can have nothing in common, is assumed by many scientists and religious scholars alike. I, however, believe that a stronger, though more complicated, case can be made for the significance of what are really three distinct but intertwined issues: the finite past, an absolute beginning, and the ontological dependence of all that is on God.

Briefly, my argument is as follows. I agree that the central assertion of the biblical tradition, enshrined in the doctrine of Creation *ex nihilo* (out of nothing) is that God is the source of existence as such, that the sheer fact of existence receives its necessary and sufficient explanation in the concept of God—but I do not agree that this exhausts the meaning of the doctrine of Creation. Historically the doctrine of Creation *ex nihilo* arose out of the early Church's battles against neo-Platonism and the common belief in a demiurgic god who created by giving structure to preexisting matter (a view whose roots lie in Plato's *Timaeus*). A millennium later, Thomas Aquinas defended *ex nihilo* against both the Aristotelian insistence on an infinitely old universe and Christian apologists such as Bonaventure, who insisted that the universe had a finite age. Aquinas insisted that the basic meaning of *ex nihilo* is ontological dependence. Though I support Aquinas here, this need not negate the importance of the twentieth-century discovery that the universe has a finite age; it only means that this discovery cannot play a pivotal role in Christian theology. So I take the finite age of the Big Bang cosmology to contribute what might be considered *corroborating evidence,* suggesting that the doctrine of Creation is more likely than not, and adding an *empirical context* of interpretation to the central, philosophical context given by the sheer existence of the universe.[4] The *Big Bang acts like a character witness in a trial, but not an eyewitness.* Indeed, I would argue that nothing derived from science could rule entirely for or against the central assumptions and beliefs of any system of knowledge—including those upon which science itself is based. Science and theology, however, do share some basic expectations as they approach the world, and the contingency of nature is clearly central to these expectations. For science, this means that God cannot be an explicit "part of the equation," as it were, since this would introduce an entirely necessary element into what should be an entirely contingent argument. For Christian theology (as I see it), this means that nature is not to be equated with the divine, thereby protecting theology from the "heresy of idolatry." The Big Bang, with its absolute beginning, captures both of these aspects of contingency nicely (contra the "two worlds" arguments)—although not normatively or even uniquely (contra the "direct support" arguments) and gives to contingency an

empirical and historical interpretation (contra the "little relevance" arguments).

On the other hand, I also want to state up front that if we are thus to take cosmology on board, we must take all of it and not just what fits in advance. This means that the infinite size and infinite future of the open Big Bang model raise important challenges to Christian theology. Similarly, if the "consonance"[5] between theology and cosmology achieved via the Big Bang is heightened by further corroboration of Big Bang cosmology, such as the Big Bang received by recent evidence from the COBE satellite, then "dissonance" may also set in if the Big Bang scenarios are replaced with other cosmologies which assign to the universe an infinite age.

Now let us return to the changing scene in cosmological research, where this is in fact taking place. We have already seen the changes brought on by inflationary scenarios. Still, these do not directly overturn the problem of $t = 0$. One that might do so, however, arises in the application of what is called "quantum gravity," the combination of quantum physics and gravitation, to the problem of cosmology. Many approaches are being taken to "quantum cosmology"; all of them are still highly speculative and far from any kind of direct empirical testing. My focus shall be on the proposals by John Hartle and Stephen Hawking (1983).[6]

According to Hawking, the universe does indeed have a finite past of about 15 billion years, as it does in Big Bang models, but it has no beginning, no boundary at $t = 0$. Instead, the universe as we know it arises out of a domain in which quantum gravity becomes critically important. This domain is extraordinarily hard to study even with complex mathematics, let alone to picture in words, but we can get a glimpse of what the physics represents in the following way.

Our universe can be thought of as arising out of an infinite dimensional superspace. This superspace contains countless bubbles, each composed of a unique three-dimensional geometry and a set of matter and energy fields. Like foam on a seashore, the bubbles are scattered separately or in small clumps throughout superspace. Some of them are gradually connected together more and more smoothly to form a four-dimensional space-time, the universe as we know it. The extent of this four-dimensional space-time is finite in the past, but it never has an edge or boundary. Rather, it melts away into the foamy sea of disconnected bubbles. Thus, time is a property of the four-dimensional space-time we know as the universe and not a property of the overall superspace. Each bubble is like a frozen instant of time and is essentially timeless, having at most what physicists call "internal time."[7]

What is the significance for the theology-science discussion given the changes beginning to appear via quantum cosmology—and keeping in mind its still *highly speculative* nature? The position I am developing depends on three central conclusions arising from cosmology: (1) Both the Big Bang and the Hawking cosmology agree in viewing the *past* of the visible universe as *finite* although they disagree over whether it is *bounded*—Big Bang, yes, Hawking, no. (2) They also disagree over the *origin* of the universe: it is *unexplained* in Big Bang cosmology, where the origin is obscured by giving it the status of an essential singularity, whereas the origin of the universe is explained by a "previous" realm, superspace, in the Hawking model. (3) Neither the Big Bang model nor the Hawking proposal explains why there should be a universe as such, why there is something and not nothing, or why the laws of nature—which characterize the universe and, in the quantum case, its origin—exist.

Can we relate these conclusions—agreement over a finite past, disagreement over the status of the boundary of the past, disagreement over the explicability of the origin, and agreement over the inexplicability of the existence of the universe per se—to the theological discussion about creation? In my opinion, each one is of vital importance. Hawking has shown theologians that they can discuss the universe having a finite past, and thus the claim that the cosmos is *created,* without linking this with the *additional* claim that the past is bounded by an absolute singularity, $t = 0$. The disagreement over the status of the origin—whether it is open to scientific investigation—constitutes a topic of direct importance for theological discussion, especially as theologians attempt to distinguish God from nature while insisting that God is present to nature. In a similar way, the agreement over the inexplicability of the existence of the universe per se reflects the fundamental religious dimension of all scientific inquiry, the sheer mystery of the givenness of existence and its embeddedness in the divine life.[8]

We know so much from science, and yet we stand in awe of a nature the very existence of which confounds us with the ultimate question, Why? The ancient and enduring religions of the West seek to honor this mystery, to stay with the question of existence, with its power to evoke wonder and joy further strengthened by the astonishing discoveries of cosmology. Yet, the answer to that ultimate question can never, finally, come from human probings but only from that final source on which all things depend.

Is the universe the result of the Big Bang or a previous quantum past? Or will other models arise in science which transcend both of these accounts? These are some of the most important questions

arising out of the best science of our time. They point to the astonishing success of science and at the same time the humble poverty of what we humans can ever know about the ultimate mystery of life and existence, for they can never answer the question of existence itself. Absolute origin in a blinding flash or endless origination in a quantum sea? To me, the finite past of both Big Bang and Hawking cosmologies suggests the utter dependence of the universe upon a source which transcends it. Whether the origin of the universe as we know it involves a previous quantum superspace, or whether the universe had an absolute beginning 15 billion years ago, the universe is contingent: it does not seem to include the grounds for its own necessity, it does not offer an ultimate explanation of why anything at all exists in the first place, and therefore it points to that on which all beings necessarily exist—God.

As Hawking himself 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?" (Hawking 1988, 174). I am drawn to wonder with Hawking at this ultimate mystery and to use language drawn from the ancient traditions of Christian theology and reclaimed today by living faith: the mystery of existence grounded in the unoriginate divine Being, structured by the form of the divine Logos and Wisdom and moving with the energies of the divine Spirit. The cosmos proclaims the meaning and goal of existence: communion with this all-surpassing God whom we know through the infant swaddled in a simple manger and then hung on a tree outside an obscure town in the outlying districts of an ancient empire.

2. COOLING FIRE, CRACKING FORCES, AND TRANSFORMING STARS. As the universe cooled, it cracked: the single unified force of the primeval cosmos became differentiated into the gravitational, strong, and electro-weak forces. After some three hundred thousand years from the Big Bang, the hot plasma of elementary particles dissolved into a dust of hydrogen and helium atoms and a sea of racing photons, the remnants of which we now know as stars and the 2.7 degree background microwave radiation, respectively. In this period in which radiation and matter decoupled, the universe was highly symmetric: a perfect sphere expanding in time, with a uniform distribution of matter and radiation. Yet the evolution of galaxies and stars meant the puzzle of a further breaking of symmetry, for why should a clump of matter form here and not there to produce proto-galaxies? We are only now beginning to unlock this deep puzzle via the now famous data from the COBE satellite in

which we can detect slight inhomogeneity in the present microwave radiation. This suggests that even as matter and radiation decoupled long ago there were slight traces of structure and pattern which could serve, eventually, as the seeds to crystallize out the stuff of galaxies and stars.

Eventually matter indeed produced galaxies with their first generation of stellar furnaces, busy fusing hydrogen into helium. Still, the ordinary processes in the life of a star could not generate many of the heavy elements on which life would one day depend. It took those most spectacular of stellar deaths, the supernovas, to produce and scatter these rich elements throughout the local star clouds where new stars were being born. These second-generation stars would eventually have their own planetary systems and, occasionally, volcanic activity to produce atmospheres and—at least in one case—organic chemistry, marking the start of what Loren Eisley (1946) so poignantly called the "immense journey."

Once again we are at a critical phase transition in the history of the universe, a time and place which will never be repeated, a rite of passage for all of nature. For even at its inception, life depended on sacrifice, the production of matter out of the destruction of a now forgotten star. The dust of our flesh, the precious metals in the jewelry we wear to signify meaning and beauty in our relationships, the wet appetites we satisfy with proteins and liquids, the passions we rejoice in, mating and birthing, the very fabric of life, have their origin in, and connect us directly to, a distant stellar source whose form was broken and whose contents were transformed to become the natural world around us and the nature we know as ourselves. That star is now forever lost to the past, and yet it is present to us as us.

There is a mystery to life encoded in this secret gift from a star now gone, whose matter we now are: for that star became what it could never have been had it remained as it was—a plasma of scalding hydrogen and helium. Now the transformed materials of that star are caught up in the thoughts of a central nervous system which somehow knows, if dimly as with all human knowing, the vast tracks of its own origin and what is now the secret future beyond that star's death. We are in some unfathomable way the universe come to know itself through the process of being broken in form and being transformed in content, leading me to image nature through the metaphors of the New Testament: in being broken for us, stellar matter has become the bread of life and thus a symbol of the divine bread which sustains and transforms all life through the cruciform structure of redeeming sacrifice.

3. THE BUZZING SYMPHONY OF LIFE ON EARTH. We now come to the present epoch in our journey from Alpha to Omega, with life and mind and self-consciousness now an emergent new reality on this green and wet planet Earth and, perhaps, elsewhere in the cosmos. Throughout the cultures of humanity we find the phenomenon of religious experience. In the traditions of Jews, Christians, and Muslims, the numinous and transcendent God is communicated through the instrumentalities of history and nature, and this God, in self-communicating grace, makes Godself known to us and elicits our free response of faith. For Christians, the supreme instance of this forgiving self-communication is found in the person of Jesus the Christ. Somehow, although we understand it so very poorly, through his life and death the person of Jesus is "raised," is taken up into a reality so astonishingly new that language alludes us, vision blinds us, and we stammer the root confession of faith: Jesus died, Jesus rose from the dead, Jesus will come again. The rest we leave to the enfolding mystery of God.

Yet all of this takes place on one tiny planet circling a rather average star lost in a galaxy of several hundred billion stars, and even that is only one galaxy among countless others. I can recall as a young child standing in the Griffith Planetarium in Los Angeles, staring at a photograph of what appeared to be a sea of stars, overwhelmed by the unfathomable depth of nature, for this was a sea not of stars but of individual galaxies or "island universes" as we used to call them. In a universe so vast, how could humankind and the religions it has spawned really matter?

One possible answer is that we don't really matter, or at least very little. Certainly this kind of answer seems warranted from a statistical approach to the data: what could one in a billion mean? Many would give an answer like this. Indeed it is a talisman for the "world come of age" that we abandon our preoccupation with our selves, our "species-ism," and accept our place as a trifling part of nature as a whole. Many today are persuaded by arguments like these—not only because of the reductionism associated too often (and too unnuanced) with science, but simply because of the infinities of nature itself.

Yet one can take a different approach. If lost in a vast, dry desert, the spotting of a palm tree on the horizon would not be insignificant, no matter how isolated it might be. Rather, by its very scarcity it would be a signal discovery, leading the alert sojourner to discover a hidden spring of life-giving water lying at its roots and shade beneath its swaying branches. The oasis, with its signaling palm tree and its hidden treasure of water, takes on an immense meaning compared to the unending monotony and barrenness of the desert sands.

I feel this way about life on Earth. We needn't make this planet into a divine Gaia to appreciate its almost sacred meaning in the galaxy. Here nature, patiently at work through countless ages, has produced what may well be the most remarkable construction in the galaxy: the primate central nervous system. Through this complex organ, biological evolution has given rise to consciousness and self-consciousness, and through biocultural evolution it has produced culture, including the natural sciences and the world religions. The achievements of biocultural evolution arise out of the astonishing instrumentality of the human brain, whose neuronal interconnections outnumber the stars in our galaxy and make possible the almost unimaginable feat of knowing oneself as a conscious, free agent in the world. Out of this mystery arises the most profound questions of existence: Where did we come from? Where are we going? What are we to do? Why was I born? Why will I die? How should I live? Whom should I love? What must I do to be saved? These very *questions* are signs of the transcendent, arising through the depths of our religious experience of self, world, and God. They are the wavy palms signaling that here lies treasure: the presence of the numinous, the merging of the human spirit and the immanent Creator Spirit, the loving activity of Wisdom who, as the Psalmist sings, was there at the Creation, who knit us together in our mother's womb, and who comforts us in our terrible knowledge that we exist as finite creatures for whom exquisite life will one day surely end.

Does this depth of experience, does this encounter with the absolute mystery of our existence, have cosmic significance? I believe the answer can be found in the experience itself. For if it takes a thousand billion stars to produce the conditions for the possibility of a sea urchin, if it takes a billion years of tinkering with genetic dice to produce a hummingbird, and if it takes two million years of scratching on bark and vocalizing intentions to produce a child who can reach out through human artifacts and mental calculations and touch the edge of the visible universe, then the universe itself points to the value of life however rare, life, the pearl of great price. It is in living that we find—better, we are found by—the source of all existence, its guide and its goal: the living God, and this God invites us and all life into eternal communion and joy.

Chance, the Veil of Divine Action in Nature. Still the message modern culture too often takes science is that since nature is ruled by overwhelming chance, no agent, human or divine, could achieve a previsioned purpose if chance is rampantly at work in the intervening steps. Spin a roulette wheel—you might guess the outcome, but you

can't control it! Now spin it a thousand times, a million times, a billion times: how could anyone control the outcome of the entire series of spins? How could God? Unless God violates the laws of gambling and mischievously works in hidden ways to control the roulette wheel's motion. But this would not be the God of Western faith, only a god of puppets and playthings.

Modern science, which tells us that life arose by "blind chance," to use Jacques Monod's famous phrase, is said to be inimical to God's action in the world. We might interpret the world as loved by God, life as important to God, and our lives as touched by God's redeeming grace. But God could not really be at work in nature: perhaps our attempts to combine biological evolution by natural selection with theism, God working in the world, seems as wrong-headed as a square circle. But is this really so?

In one of the great achievements of contemporary religious scholarship, this challenge has been met, in my opinion.[9] Much of the credit goes to Arthur Peacocke and Ian Barbour for their reconstruction and defence of evolutionary theism.[10] As they and others have shown, not only is chance not inimical to God's continuous creative activity, it is essential to it. God creates through the interplay of chance and law, for it is precisely this interplay which characterizes the quantum, chemical, genetic, and evolutionary processes that have produced life in this world as the handiwork of God.

Given this as a basic position and starting point, a great deal of research is now under way by theologians and scientists in understanding how the kind of chance and law operative at each level in nature shapes the theological understanding of divine action of creating and redeeming. Here I can only indicate some of the directions in which that discussion is proceeding.

At the quantum level, chance seems the rule of the day, but it is a kind of chance strikingly different from our ordinary experience of accidents, statistical tables, and the weather. Science itself tells us that here there can never be a complete scientific explanation of just why specific quantum events happen as they do, either from quantum physics as we know it or from some future theory that may replace quantum physics. Nature is intrinsically open, ontologically indeterminate, authentically spontaneous. Thus many scholars have argued that we can conceive of God as free to act in these ontological indeterminacies of quantum nature. When a quantum event occurs, it occurs by God's direct and immediate action.[11] In other words, since quantum physics points not just to epistemic gaps in our theory that are about to be filled, but to ontological "bubbles" in the fabric of nature, one is free to stipulate that God acts immediately in nature

—and not just through secondary, instrumental causes. God may indeed work at higher levels in nature as well, such as the levels of chemistry, biology, neurophysiology, and so on, and God may act in a "top-down" way as well as in a "bottom-up" way, as Arthur Peacocke and John Polkinghorne—among others—suggest, but at least in this perspective, God can act providentially to determine the future course of the world through the openness of quantum reality.[12]

Dynamic Chaos. Next, let's turn to the rapidly developing research on dynamic chaos as found broadly in physical, chemical, and biological systems (for an overview, see Ford 1989)—and now popularized by the movie *Jurassic Park!* These processes are entirely "classical"; they occur in the simplest nonlinear equations of classical mechanics; thus, they can be studied without invoking quantum physics. In even the simplest of such processes, small differences in the initial conditions become rapidly amplified, as in the proverbial "butterfly effect," where the flight of a butterfly in Chicago affects the weather in Bombay two weeks later. Moreover, the future development of the systems is extraordinarily sensitive to even the most distant environmental factors. This gives chaotic systems their random appearance, since though their evolution is determined in principle it is almost impossible to predict.

Thus nature, at even the macroscopic level of rivers, weather, and biological populations, seems much more chaotic and random than was thought from centuries of living with a Newtonian view of a clockwork universe. Does this provide the grounds for a new understanding of God's action in the world? Some have suggested that this might be possible if we think of God as somehow altering the initial conditions ever so slightly to bring about large-scale effects in nature (Polkinghorne 1989). I think this puts the question wrongly, both for scientific and for theological reasons. Scientifically, the initial conditions are themselves presumably determined by previous states of the system—unless one invokes quantum physics, as is, of course, possible, though the great problem here is that quantum physics alone may not give rise to chaotic behavior (see Ford 1989). Theologically, should God act on the initial conditions, no matter how slight the action, it would require a finite input of energy, and this would seem to make God a secondary cause—just another natural cause among causes. Thus not only is this argument unacceptable scientifically, but to theologians it makes God into an idol.

There is, however, a different kind of lesson to be learned from chaotic systems, and it is based on an extremely simple, but generally overlooked fact, namely the epistemological limitation chaos imposes on our ability to know what is taking place in nature as such. We can

never know all of the factors constituting the initial conditions of, and the environmental effects on, a chaotic system and which in turn produce a specific, large-scale outcome since in principle we lack what would be required: infinite precision in our measurements and the ability to specify mathematically these measurements with infinite decimal expansions. Thus, since we can never gain complete knowledge of the initial conditions or the entire set of environmental factors, we can never decide, based on science, whether nature is acting, and has been acting all along, entirely on its own or whether God is acting and has been acting all along with and immediately within nature in every event. We can never decide between a strictly naturalistic and a modified theistic account of the workings of the world around us. We are equally free to choose the view that what confronts us as "nature" is God working with nature as we are free to accept the view that it is nature working autonomously on its own.

Thus chaos alone does not provide room for God to act, as it were; how God acts, how we wrestle with the problem of "double agency" and the "causal joint," to use Austin Farrer's phrases (1967, 65–66), remains an open question, and one to which I shall return in closing. Chaos does, however, challenge our "default" assumption that nature is "godless" and that God, in order to "do something," must somehow get into nature from outside. Instead, we may regard God as immediately present to nature, acting at every event, and chaos as blocking us from ever disproving this assumption. This gives new meaning to the well-worn phrase that God is immanent in nature and gives "teeth" to the panentheistic view of the world in God and God transcending the world, to which I subscribe.

What is particularly important about this argument is that it "cashes out" the evolutionary theists' promissory note that we can conceive of God as acting through the processes of variation and selection. To see this, we must return to the level of the chromosome and its genetic structure. We find ourselves in a realm small enough to be affected directly by quantum processes—mutations induced by radiation or quantum tunneling—and yet large enough to be treated via classical chaos. At the level of the gene, this means that the evolutionary history we describe through neo-Darwinian analysis is now open to an unequivocal interpretation via evolutionary theism.

So the phenomenon of life not only raises the question of the meaning of life, but it raises the challenge of chance to the meaning of the action of God. In response to this challenge, much current research in theology and science now suggests that this is precisely the kind of world we would expect God to create and in which God can continue to act as Creator and Redeemer. Let me be clear, however,

that this in turn leads to still other challenges to faith, none the more formidable than the problem of suffering, death, and finally, sin and evil. For the present, however, I leave this theme untouched and move to the final topic in our cosmological tour: the far future.

4. VISTAS OF THE FAR FUTURE: TOWARD THE COSMIC OMEGA POINT. We turn toward the far future. This wet, blue-green planet, too, will end someday—about five billion years from now—as the Sun goes nova, expanding its solar atmosphere out beyond the orbit of Mars and swallowing up all that we have changed about the Earth and Earth itself. Will the descendents of humanity have found their way by then to the stars—and what future is there for the myriads of species left behind, not to mention Earth itself? Will our descendents spread out into the almost unfathomable depths of the galaxy, making new homes on other hospitable planets, terraforming whole planetary systems into Dyson spheres to catch every last photon emitted from the remaining stars in an inevitably cooling universe? Constrained by the speed of light as an upper limit on migration to and communication between the stars, life will at best undergo a diaspora of unthinkable dimensions. As these stars too wink out, will life follow into the eternal night of the expanding universe or burn in the fiery ending of the recollapsing universe? Or will life ultimately transform the universe itself into something beyond imagining now? And have these distant futures been foreseen however dimly by the Earth's religions, in particular by the eschatological and apocalyptic visions of Jews and Christians with whom I take my place?

Perhaps it is not surprising that few if any of the world's religions have really faced the realities of the universe we actually live in, with its staggering scope and far future, or that the secular community has erected its own visions of the ultimate role of life in the universe. One form is the stoicism of a Bertrand Russell or a Stephen Weinberg. Recently, however, other voices are being added from within the scientific community. Freeman Dyson, Frank Tipler, and others depict a positive role for sentient life in the universe: such life might in fact succeed in "colonizing the universe," and it might undergo all possible experience and obtain all possible knowledge. The vision so raised is striking, given the stringencies of Big Bang cosmology and that these scientists have no personal ties to institutional religion. Still, it is the challenge of the far future which is most difficult to meet.

Freeman Dyson is well known for his outstanding contributions to theoretical physics. A decade ago, however, he turned his attention to the problem of the far future in Big Bang cosmology, making

the first contribution to what he and others now term "physical eschatology," with his ground-breaking paper, "Time without End: Physics and Biology in an Open Universe" (Dyson 1979). According to Dyson, life *can* continue indefinitely into the far future of the *open* universe, even though the temperature approaches absolute zero and the structures we know of—galaxies, stars, planets, atoms—eventually decay to fundamental particles. Dyson's scenario depends on accepting the premise that a living creature is (at least) a type of computer, imputing, processing, storing, and exporting information. Thus life is defined in terms of the organization of matter rather than some dualistic living force or material principle added to inanimate matter.[13] If this kind of organization can be achieved through *any* material substrate, not just that of terrestrial biochemistry, then computation by appropriately organized matter can beat the Second Law indefinitely.[14]

Frank Tipler concurs with Dyson, working under the general rubric of the "Final Anthropic Principle" (FAP): the universe must be such that intelligent life will continue to exist forever. Dyson and Tipler, however, base their research on different cosmological models. This leads to distinct and testable conclusions, as follows.

In Dyson's approach, the universe must be *open* spatially (that is, infinite in size) and it must *continue forever* in time. In contrast, Tipler's model depends on a *closed* universe, both finite in size and with a *finite future.* Tipler makes a crucial distinction, however, between the passage of physical time (in terms of which the future will be finite) and mental time (the rate at which information is processed by our minds or by a computer). He is able to show that, though the future physical time of the closed universe is finite, its mental time need not be. Indeed, in Tipler's model, life can process an infinite amount of information before the "Big Crunch." Thus he is able to make a striking prediction: our actual universe is in fact closed.

These scenarios may seem little more than "whistling in the dark." Still, two things should be borne in mind.

First, it was a scientist—Dyson—who squarely answered the pessimism of another scientist—Weinberg.[15] Second, we should remember instead that, until the work of Dyson and Tipler, the future prospects for life offered by cosmology to theological interpretation were dismal at best. In the end, I do not think that eschatology is reducible to unending life in *either* a closed[16] or an open universe as Dyson and Tipler imagine, since I think that the goal of life is not unending life but eternal life, and since I think that eternity does not mean timelessness but the full reality of divine time without separations and divisions, weeping and death. On the other hand, what I

especially like about Tipler and Dyson's arguments is that they take all of nature squarely on board, for it is *the cosmos* as such that is the domain of discussion and the subject of eschatological fulfillment and not just humanity against the barren stage of nature, as is often the case in traditional theology. Thus their attempts to honor and celebrate life in its cosmic perspective *should* prompt us in the church communities to rethink the cosmological implications of just what is at stake if we claim, as I for one would do, that the groaning of *all* of nature will be taken up in and healed by the transfiguration of the universe which has already begun with the Resurrection of Christ.[17]

Recently, I have begun to think through just what would be required to construct an adequate, applicable, consistent, and coherent understanding of Christian eschatology with these cosmological arguments in mind. Here I can only roughly indicate the direction I am taking. The approach I am developing brings together the renewal of the doctrine of the Trinity in current theology (drawing specifically on the writings of Karl Barth, Karl Rahner, Catherine LaCugna, Elizabeth Johnson, Jurgen Moltmann, Wolfhart Pannenberg and Ted Peters), the insistence that the New Testament is thoroughgoingly eschatological (and, specifically, that its eschatology is proleptic, drawing again on Pannenberg), the claim that what makes monotheism Christian is its commitment to the historicity of the Resurrection of Jesus and the cosmological entailments of the "scandal of particularity." A trinitarian framework provides the means to overcome the God-world problematic characterized by a false dichotomy between a godless world and a worldless god and leading to such problems as the "causal joint," "double agency," and the "interaction" model of divine action. Instead, Trinitarian thought places God within the world as the divine Spirit, yet allows God to ineffably transcend the world as its unoriginate source, and it combines these in a subtle Christology. The historicity of the Resurrection keeps Christianity from a Gnostic, world-denying tendency and opens the door to nature's relation to eschatology. New Testament eschatology combines the apocalyptic and prophetic threads in Hebrew scripture and orients them toward the reign of God announced by Jesus. It gives to contemporary commitments to social and ecological justice, thematized by the World Council of Churches' "integrity of creation," a cosmological vision of ultimate fulfillment for all of creation.

Together these lay out the basic framework for approaching the problem of the far future in cosmology and its significance for Christian theology. Thinking along these lines is only at a preliminary stage and beset with issues. The clearest is the "scandal of

particularity" as applied to the cosmos.[18] Does the claim that Jesus is the Savior of the world make sense if one considers the possibility that there are other (possibly *many* other) forms of life in the universe: self-conscious beings who experience moral choice in the context of free will, and who, presumably, sin? Does *Jesus* have cosmic significance? Or are there many incarnations of *the Christ* in the universe?[19]

The far future is not far off, then. It presses toward us and forces our hand theologically on the hardest questions Christian faith faces. We do not have answers, and perhaps we never will, but we must accept the reality of the question: if all things end in fire or in darkness, what is the final meaning of life in the universe? Perhaps the only response we can or should make is that its meaning is hidden within the ineffable mystery of life itself and its ultimate ground and goal, the God who saves.

CLOSING THOUGHTS

Whatever the future may bring, we are living in a special time in the journey of the universe: a time in which the primeval fireball with its blinding plasma is long gone, as is the time of the first generation of stars which produced the material basis for life. A time far down the laborious road of variation and selection which through blood and ecstasy produced the tree of species in which mammals and primates grew as one branch. A time in which more species have become extinct than there are stars in the galaxy, and a time in which one species on earth has achieved the complexity of a brain with more neurons than stars in many galaxies, a species which could think and be aware of itself as alive in this world. We are alive in the time of the second-generation stars, the greening of the galaxy. Ours is perhaps the last generation of stars, a time which, when gone, will be followed by countless ages of darkening cosmic expansion and an unknown ending. A time when the strange particles of matter created at the beginning have been involved in a process so complex that they find themselves caught in the irreducible terms of the "I." A time when this "I," this person, understands itself to be touched, created, and loved by the source of it all: the Lord God. Perhaps this is meaning enough. It certainly is a miraculous start.

NOTES

1. How ought one to move from science to philosophy and theology? There is, of course, no easy answer—at least not one worth discussing. The path is arduous. Since the mid-1960s, pioneering scholars such as Ian Barbour, Arthur Peacocke, Ralph Burhoe, Thomas Torrance, and Philip Hefner—to name just a few—have sought to give

a reasoned response out of their own faith tradition to such questions. To respond in this way for any of us means to recognize the decades of scholarship that have now, speaking in 1993, gone into this field, and to gain both literacy and competency in what is now a fairly vast literature on theology and science. It necessitates that we carefully and intentionally shift our discussion from the empirical flavor of scientific research to the languages of philosophy and theology. Such a shift requires enormous care, for a whole series of issues await us and can easily entrap the unsuspecting wanderer! In the context of this essay, I can only indicate in roughest outline what positions I and others have elaborated elsewhere in full realization of the issues involved here. I believe the shift requires taking a critical realist view of both scientific and theological epistemologies, recognizing their mutual use of metaphorical language and the hypothetical character of their theories (read "doctrines" in theology) that arise in relation to their relative kinds of data and criteria on theory choice. Our recognition should acknowledge the greater degree of subjectivity in theology than in science but still insist on the metaphysical elements and values implicit in theoretical science and its dimension of depth, numinous wonder, and boundary or limit questions. Ontologically, it means assuming what I call "emergent materialism," the claim that the more complex epistemologies of the cognitive and social sciences, for example, can never be fully reduced or explained by the simpler epistemologies of the natural sciences, though the latter impose quite specific rules of constraint on what can be asserted in the former. Such an emergence is fully compatible with, and even recommended by, an evolutionary view of nature in which new fields of study are geared to the emergence of more complex natural phenomena during the passages of the universe from matter to life to mind to the full emergence of person as self-conscious moral free agent created in the image and likeness of God. For a detailed exposition see, for example, the writings of Arthur Peacocke, including his *Creation and the World of Science* (1979), *God and the New Biology* (1986), and *Theology for a Scientific Age* (1993). The writings of Janet Soskice, Ernan McMullin, Sallie McFague, Philip Hefner, Ted Peters, and many others are of central importance to these questions.

2. For an excellent discussion of the philosophical issues in physical cosmology, see William Stoeger's article in Russell Stoeger, and Coyne (1988).

3. For a helpful introduction to these issues, see James Trefil, *The Moment of Creation* (1983).

4. I take this to be an articulation of what is implicit in Ernan McMullin's provocative suggestion that if we believe in the doctrine of Creation, the Big Bang is the sort of thing one would expect to see, although it does not directly support the doctrine. See Ernan McMullin's "How Should Cosmology Relate to Theology?" (1981).

5. This term was first introduced by Ernan McMullin in his insightful article "How Should Cosmology Relate to Theology?" (1981), and has been picked up by various authors, including Ted Peters and Willem Drees. Earlier on I developed it in some detail through the use of metaphor, following Ricoeur, Barbour, MacFague, and others in understanding metaphor to be an epistemic structure consisting of a simile and a dissimile in tension. My coining the term *dissonance* in these earlier articles was meant to suggest not only that we must "play fair" and recognize the limits of consonance (for the health of the metaphor is its dissimile) but that we can learn from the dissonance, too. See my article in Peters (1989) and in response to Pannenberg in *Zygon* 23 (March 1988), 23–43.

6. See Hawking's *Brief History of Time* (1988) for a popular account, as well as Drees's *Beyond the Big Bang* (1990), and Russell, Murphy, and Isham's *Quantum Cosmology* (1993).

7. Alternatively, quantum cosmology is sometimes pictured as a set of funnels emerging out of a bowl: one funnel, our space-time universe, tapers back but, unlike a cone, never reaches an apex. Instead, the funnel blends into a bowl a finite "distance" away (giving our universe a finite past). Out of the primordial bowl, other funnel universes arise. The separate funnel universes are no longer causally connected, but through their topological connection to the bowl, they all form a meta-universe. However we seek to picture it, what remains very important overall is that the Hartle/Hawking universe is finite in time but has no beginning: it lacks a past temporal boundary.

8. Each of these three conclusions requires careful discussion. For example, the

Hawking cosmology depends on the notion of a superspace in some sense preexisting our universe. If we take the Hawking cosmology as speculative, then its superspace can be evaded as a mathematical artifice, and the finitude of the past of the known universe can be highlighted. If, however, we take superspace to be an ontologically real part of the proposal, then the finite past of *our* universe becomes relatively trivial compared to the infinity of superspace. This speaks to the Platonic sense in which most cosmologists operate and leads to other problems, like the deletion of an arrow of time since no such arrow appears in fundamental physics, and so on, causing, ultimately, real problems for human experience, free will, and the divine/human interaction. It should be noted that even the Big Bang cosmology can be interpreted as leading to an eternal past, by simply changing the temporal coordinates.

9. (See especially Barbour 1990; Peacocke 1993.) Unfortunately, the victory has not been heard by creationists who still construct what amounts to a pseudoscience based on a literal interpretation of the Bible, all the while presupposing that science, with its insistence on chance, leads necessarily to atheism and must therefore be rejected by Christians. But this simply is not the case, although it is still not widely appreciated in the culture we live in, nor is a literal reading of Scripture authentic to the original sources of that same Scripture and the religious experience out of which it arose and to which it testifies.

10. One must also include here the diverse contributions to the problem by scholars including Ralph Burhoe, Gerd Theissen, Philip Hefner, D.J. Bartholomew, William Pollard, and John Polkinghorne.

11. This can easily lead to an occasionalist interpretation of divine action, which raises serious theological problems in turn (see Russell, Murphy, and Peacocke 1994).

12. Still a host of philosophical problems arise here. Quantum chance, or quantum statistics, is radically different from chance at even the molecular, let alone macroscopic, level, and it makes one think through very carefully what it means for God to act at the quantum level as compared with the meaning of divine action at the chemical, evolutionary, or biocultural levels. Classically, chance means the unexpected meeting of two causally determined paths or the jostling about of an object by subtle forces. Chance is a pseudonym for ignorance of what is really going on at a more detailed level. Quantum chance is entirely different. There are no well-defined paths, nor are there unseen forces. Instead, there is only the statistical distribution of events and the way these statistics produce the actual form of our experience of the natural world.

One kind of quantum statistics, Fermi-Dirac statistics, gives rise to the structure and incompressibility of matter and the chemical properties of compounds. Another kind of quantum statistics, Bose-Einstein statistics, governs the fundamental interactions in nature—light, gravitation, nuclear, and weak forces. Thus, quantum statistics produce both the most fundamental structures of nature and their interactions. Rather than being the result of fluctuations from an equilibrium value stemming from an unknown, hidden variable, quantum chance is the form or pattern of the structures and interactions of matter.

One more word should be added, although it, too, is complex: long-distance correlations in the behavior of elementary particles which once interacted suggest that matter cannot be understood, without remainder, as highly localized or completely unconnected. Instead, the material world is "nonlocal" and hence more holistic than atomistic, as Niels Bohr and, much later, John Bell, so keenly saw. (N.B.: This position assumes a realist interpretation of quantum physics.) If one rejects realism, the nonlocal implications can be marginalized and quantum physics is given a merely instrumentalist interpretation. I do not take such a view, but it is frequently defended in the field.

So, at the quantum level, God acts to produce structure and bonds them together by articulating the structure and bonding of chance itself—quantum chance. See my article, "Quantum Physics in Philosophical and Theological Perspective" (Russell, Stoeger, and Coyne 1988).

13. As Dyson puts it in his 1985 Gifford lectures: "Life resides in organization rather than in substance. I am assuming that my consciousness is inherent in the way the

molecules in my head are organized, not in the substance of the molecules themselves. If this assumption is true, that life is organization rather than substance, then it makes sense to imagine life detached from flesh and blood and embodied in networks of superconducting circuitry or in interstellar dust clouds" (Dyson 1988, 107).

14. Actually, an understanding of life as organization is held as a necessary and perhaps sufficient characterization by many who are active in relating science and theology.

15. Dyson specifically states his intention to reply to Weinberg: "The universe that I have explored in a preliminary way in this book is very different from the universe which Weinberg envisaged when he called it pointless. I have found a universe growing without limit in richness and complexity, a universe of life surviving forever and making itself known to its neighbors across unimaginable gulfs of space and time. Whether the details of my calculations turn out to be correct or not, there are good scientific reasons for taking seriously the possibility that life and intelligence can succeed in molding this universe of ours to their own purposes. Twentieth-century science, when it looks to the future, provides a solid foundation for a philosophy of hope" (Dyson 1988, 117).

16. It should be noted that Tipler, in particular, has aggressively pursued the theological implications of FAP both in *Anthropic* and elsewhere. I stand at a far distance from his theological conclusions, since in my opinion (1) he gives science much too normative a role in their foundations, (2) he is clearly a reductionist, and (3) he constructs them with a strongly (ex-) Protestant fundamentalist style. Nevertheless, as I have said (Russell et al. 1988), I respect that in his earlier work he attempted to take science very seriously in the theological discussion, unlike many professional theologians today. Unfortunately his most recent work is *highly* dubious, in my view.

17. Such theological reflections are indeed being undertaken today, as recently reflected in articles by Wolfhart Pannenberg and others. Cf. *Zygon: Journal of Religion and Science* 24 (June 1989), entire issue, and the upcoming book edited by Carol Albright and Joel Haugen. See also Drees (1990) and my article, "A Fresh Exploration of the Symbol of a Cosmic Christ: Eschatology and Scientific Cosmology" given at the annual meeting of the Catholic Theological Society of America, May 1993 (available through the Center for Theology and the Natural Sciences, 2400 Ridge Road, Berkeley, CA 94709).

18. The specific proposal I have in mind for such a "modest Christology" is made by Wesley Wildman in his recent doctoral dissertation.

19. Interestingly, it is clear that the challenge of world religions and the challenge of cosmology to classical Christology are intimately related. To put the questions crudely, could an inclusivist about Christianity in the context of world religions make a plausible case that Jesus is the *cosmic* Christ bearing cosmological soteriological significance? Alternatively, could an inclusivist about Christianity in the context of world religions be a pluralist when it comes to the universe of life, expecting there to be normative paths to salvation throughout the life forms in our universe? A recent book exploring the significance of the cosmic Christ with special attention to the theology of Karl Rahner is Denis Edwards's *Jesus and the Cosmos*. Again, Wildman has made these points clearly and forcefully in his criticisms of classical Christology.

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