ARTICLES AND ESSAYS

Eternal Progression in a Multiverse: An Explorative Mormon Cosmology

Kirk D. Hagen

This article is an examination of the Mormon doctrine of eternal progression within the context of big-bang cosmology, a description of a finite universe that appears to contradict that doctrine. I argue that a multiverse cosmology, a theory that posits a multiplicity of universes, resolves many of the problems posed by big-bang cosmology.

The doctrine of eternal progression is the centerpiece of Mormon theology. This principle "cannot be precisely defined or comprehended, yet it is fundamental to the LDS worldview."[1] While the phrase "eternal progression" is absent from the canon of scripture, it first occurs in the discourses of Brigham Young, who said, "I wish to urge upon the people the necessity of knowing what to do with their present life, which pertains more particularly to temporalities. The very object of our existence here is to handle the temporal elements of this world and subdue the earth, multiplying those organisms of plants and animals God has designed shall dwell upon it. When we have learned to live according to the full value of the life we now possess, we are prepared for further advancement in the scale of eternal progression—for a more glorious and exalted sphere."[2] Statements on eternal progression by Brigham Young and his successors embrace the substance of the doctrine taught by Joseph Smith in his King Follett discourse, in which Joseph declared that "God himself was once as we are now, and is an exalted man" and that "you have got to learn how to be gods yourselves."[3] Echoing this idea, John Taylor remarked, "What is man, that thou are mindful of him? He is not only the Son of man, but he is the Son of God also. He is a God in embryo."[4]

The doctrine of eternal progression—that the ultimate human potential is to become like God himself—has been reiterated by numerous modern-day Church authorities. Apostle John A. Widtsoe stated: "In short, man is a god in embryo. He comes of a race of gods, and as his eternal growth is continued, he will approach more nearly the point which to us is Godhood, and which is everlasting in its power over the elements of the universe."[5] Widtsoe also declared, "What then is eternal progress? It is an eternity of active life, increasing in all good things, toward the likeness of the Lord. It is the highest conceivable form of growth." Although viewed as heresy by the Christian world at large, this uniquely LDS doctrine "was a tremendous addition to Christian belief and thought . . . that gave heaven, often conceived as a static psalm-singing place, a new and desirable definition."[6]

Responding to the criticism that the doctrine deflates the position of God, Apostle Hugh B. Brown rejoined: "We do not mean to humanize God, but rather to deify man—not as he now is but as he may become. The difference between us is indescribably great, but it is one of degree rather than of kind."[7] Speaking of the distinctive views on intelligence espoused by Mormonism, Apostle Stephen L Richards remarked, "In what does the joy of man consist? There are two things: first, an eternal progression in intelligence, knowledge and power that leads to perfection, even as Christ is perfect; and second, companionship with God in his presence and in the presence of his Son."[8]

In contrast to the firm doctrinal tone of earlier sermons on the subject, recent commentaries by Church authorities on eternal progression have taken on a more "family friendly" feel. For example, Apostle Joseph B. Wirthlin stated that "this very moment is part of our eternal progression towards returning with our families to the presence of our Father in Heaven."[9] Elder M. Russell Ballard, also of the Quorum of the Twelve, declared, "There is no greater expression of love than the heroic Atonement performed by the Son of God. Were it not for the plan of our Heavenly Father, . . . all mankind would have been left without the hope of eternal progression."[10] Referring to the untimely death of his sister by a childhood disease, Boyd K. Packer, acting president of the Quorum of the Twelve, observed, "She will not be denied anything essential for her eternal progression."[11]

From one of Joseph Smith's last revelations we learn that Abraham, Isaac, and Jacob "have entered into their exaltation, according to the promises, and sit upon thrones, and are not angels but are gods" (D&C 132:37). Indeed, in the same revelation an equivalent status is promised to all who abide by "the new and everlasting covenant," for "then shall they be gods, because they have no end; therefore shall they be from everlasting to everlasting, because they continue; then shall they be above all, because all things are subject unto them. Then shall they be gods, because they have all power, and the angels are subject unto them" (D&C 132:19, 20).

If, by obedience to the laws and ordinances of the gospel, the ultimate future status of the children of God is godhood itself, the question naturally arises, where are these gods? What is the domain of their habitation? Mormon doctrine asserts that they are eternal beings, "from everlasting to everlasting," so how can the universe spatially or temporally accommodate them? Or, for that matter, where is there space or time for the innumerable "intelligences" or "spirits" that have already acquired, or will acquire at some point in their eternal sojourn, a tabernacle of clay? Do *all* these beings exist in our universe, and does Jesus Christ have dominion over just this world or the entire universe? Teachings of latter-day Church leaders indicate that Jesus Christ is, indeed, Lord of the universe. John A. Widtsoe taught that, to determine the relationship between God and man, it is necessary to know "why the Lord is the supreme intelligent Being in the universe, with the greatest knowledge and the most perfected will, and who, therefore, possesses infinite power over the forces of the universe."[12] Marion G. Romney, a counselor in the First Presidency, stated: "Jesus Christ, in the sense of being its Creator and Redeemer, is Lord of the whole universe. Except for his mortal ministry accomplished on this earth, his service and relationship to other worlds and their inhabitants are the same as his service and relationship to this earth and its inhabitants."[13] That Jesus Christ's dominion extends to the universe at large can be inferred from the Lord's teachings to Moses when he declared that "worlds without number have I created," and by revelations to Joseph Smith that "by him, and through him, and of him, the worlds are and were created, and the inhabitants thereof are begotten sons and daughters unto God" (Moses 1:33; D&C 76:24, 93:10). Apostle Neal A. Maxwell, speaking from the Lick Observatory on Mount Hamilton in California proclaimed, "Way back then, under the direction of the Father, Christ was the Lord of the universe, who created worlds without number—of which ours is only one. Yet in the vastness of His creations, the Lord of the universe, who notices the fall of every sparrow, is our personal Savior."[14]

The term *universe* in these references presumably alludes to a singular cosmos, the universe in which we live, viz., *our* universe with which the non-astronomer is casually familiar. Similarly, the term *worlds* refers to planets or other celestial bodies, conceivably inhabited by God's children, within that universe. Given this apparent "one Lord, one universe" paradigm, how are Latter-day Saints to frame a "plurality of gods" doctrine within a modern cosmological context of the big-bang model of the universe? Do the gods share a common universe, having dominion over only a fraction of the whole cosmic realm? Do they exist in different dimensions? Different universes?

Referring to big-bang cosmology and claiming that "Mormon doctrine now seems to be a relic of the nineteenth century," Keith Norman states, "Turning our gaze forward in time, science paints a bleak picture of the ultimate fate of the cosmos, in contrast to the optimistic Mormon doctrine of eternal progression. Where is there room or time for a limitless series of exalted beings to organize and people new worlds by natural means, presumably without end? How will such gods operate, let alone exist, in a dead and cold universe, or even a violently expanding and contracting one? Mormons cannot appeal to God to get them out of this fix."[15] More recently, philosophers Paul Copan and William Craig argue that the big bang "is irreconcilable with the traditional Mormon understanding of God as a temporal, material being immanent in the universe. Not only must God, [i]n the Mormon conception, have a beginning, but he must also come to an end, either being swallowed up and crushed into oblivion in the Big Crunch or else literally disintegrated into the cold, dark recesses of outer space—a pitiable deity indeed!"[16]

Is Mormonism's doctrine of eternal progression at odds with the big bang? Does the big bang really imply that the "temporal, material" god of Mormonism has an end of existence coincident with the demise of the universe? Can we find harmony between the central tenet of Mormonism and the crowning achievement of twentieth-century cosmology? To more fully answer these questions, let's briefly examine the history of the big-bang cosmological model and describe its salient points.

The Big-Bang Model of the Universe

According to the noted cosmologist Joseph Silk, "Cosmology is the study of the large-scale structure and evolution of the universe. The study of the origin of observable structures in the universe, ranging from the huge clusters of galaxies down to the solar system, falls in the realm of cosmogony."[17] Astronomical observational evidence, bolstered by theoretical considerations from general relativity and quantum mechanics gathered during the last seventy-five years, has precipitated a single model that addresses the central questions of cosmology and cosmogony. This model is called the big bang. The big bang may be narrowly defined "as a moment in the *finite* past at which our universe had [a] very high density and a very high temperature."[18] From this basic definition, we glean two obvious but very important conclusions: the universe is *not* infinitely old, and the universe has *changed*. Because the big bang is a "moment" in the finite past, the universe must have an age, and because today's universe does not have a high density or a high temperature, the universe must have evolved from one state to the state we observe now. According to the big-bang model, the universe began in an exceedingly hot and dense state and has been expanding and cooling ever since.

Big-bang cosmology owes its beginnings to no single individual or scientific discovery, but two key events early in the twentieth century stand out in the history of its development. The first event was a consequence of Albert Einstein's general theory of relativity. Developed in 1915, general relativity is integral to cosmology because it is a theory of gravity, one of the four fundamental forces of nature. Unlike Newtonian gravity, Einsteinian gravity couples the geometry of space to the distribution of matter and energy within it. Solutions of Einstein's general field equations showed that the universe is either expanding or contracting. But based on his observational belief that the cosmos must be static and unchanging, Einstein introduced a proportionality constant, which soon became known as the cosmological constant, into his original field equations. The cosmological constant is a mathematical term that represents a cosmic repulsion that is proportional to distance, and the evolution of the universe is determined by the competition between the repulsive force and the attractive force of Newtonian gravity. In Einstein's static universe the two forces are in balance. While the cosmological constant is not necessarily ad hoc, it makes the field equations more complicated and less appealing from the standpoint of mathematical elegance and beauty. Such aesthetic considerations made Einstein initially doubt if the constant could be justified. According to Helge Kragh, professor of the history of science at the University of Oslo, in 1919 Einstein described the introduction of the constant as "gravely detrimental to the formal beauty of the theory."[19] Twelve years passed before Einstein decided that the introduction of the cosmological term had been a mistake.

In 1917 Dutch astronomer Willem de Sitter extended Einstein's analysis by showing that, contrary to Einstein's contention, the static matter-filled cosmological model was not the only solution to the field equations. De Sitter's model was an empty universe; but he showed that, if a particle of matter was introduced at a distance from the origin of a coordinate system, it would appear to move away from the observer, thereby causing a red shift in the light frequencies.[20] But de Sitter described the velocity associated with this motion as "spurious" and not a real velocity caused by the expansion of space. Thus, in spite of the red shift phenomenon built into his model, the de Sitter universe, like Einstein's, was static.[21]

The static models of Einstein and de Sitter stood as the primary cosmological models until 1922 when the Russian mathematician Alexander Friedmann showed that Einstein's field equations included nonstatic solutions. Friedmann's analysis proved that the solutions of Einstein and de Sitter were special cases of a more general solution that included the possibility of a universe with a finite age. With Friedmann's work, we have, for the first time, the idea of an expanding universe originating in a singularity, a big-bang universe. But, as emphasized by Kragh, Friedmann's model was primarily mathematical rather than physical in nature, and he did not attempt to connect his results with astronomical observations of the red shift, which were made as early as 1912 by astronomer Vesto Slipher. Furthermore, Friedmann did not predict or argue that the actual universe is of the expanding type. Thus, while we see the germ of the big-bang universe in Friedmann's model, to credit him with the "discovery" of the big-bang universe would be going too far.[22] Even though Friedmann's work was published in the world's leading journal of physics, his cosmological model was virtually ignored by astronomers, perhaps because it lacked information about observational consequences. Friedmann died prematurely in 1925, and the expanding universe model was promptly forgotten.

In 1927, Georges Lemaître, a Belgian priest and physicist, reproduced Freidmann's cosmology and found that Einstein's static universe model was unstable, i.e., that the slightest perturbation of the cosmological constant from a special value caused a rapid collapse or a runaway expansion of the universe.[23] In subsequent improvements to the model, Lemaître theorized an expanding universe in which the velocities of galaxies varied in proportion to their distances, the same proportionality relationship discovered experimentally by American astronomer Edwin Hubble a few years later.

Unlike Friedmann, whose cosmological model was a mathematical exercise in general relativity, Lemaître made a serious attempt to develop a physically realistic model. But Lemaître's prediction of an expanding universe suffered the same fate as Friedmann's, but for different reasons. Lemaître published his results in an obscure Belgian journal; and as Kragh notes, "he did not care very much for international reputation and he may have had second thoughts about the soundness of the expanding universe and for that reason did not press the point."[24] But things drastically changed in 1930. With the belated recognition and endorsement of Lemaître's work by the distinguished British astronomer Arthur Eddington, Lemaître's cosmology was "rediscovered" and given its due credit. The Belgian priest suddenly rose to celebrity status in the world of science.

The second key event that helped usher in big-bang cosmology was announced by Edwin Hubble in 1929.[25] Using the 100-inch telescope at Mount Wilson in California, Hubble showed that the nearest spiral nebulae were galaxies of stars like the Milky Way, and he was able to measure the distance to the Andromeda Nebulae and other spiral nebulae. With these measurements, Hubble determined that the frequencies of light emitted by these nebulae were shifted toward the red end of the spectrum, indicating that these distant celestial objects were receding from our galaxy at very high velocities. Using the amount of red shift, Hubble was able to calculate the recession velocities, and his calculations showed that the recession velocity of a distant object increased in proportion to its distance away, a relation now known as Hubble's law. Thus, Hubble discovered what the models of Friedmann and Lemaître predicted years earlier: that the universe is expanding. There was now a fusion of theory and astronomical observation that made the expanding universe a widely accepted concept in the scientific community.

Prepared by his earlier work, Lemaître used Hubble's experimental data in 1931 to produce the first cosmological model based on actual measurements. His model had a constant term that represented a cosmological repulsion effect that predicted a universe entering its rapid expansion phase at the present time. Contrary to Einstein, Lemaître believed that the cosmological constant was not a mistake or a superfluous mathematical term but a natural and indispensable part of relativistic cosmology. His model also predicted a "singularity" at a finite time in the past, a high density initial state that Lemaître called the "primeval atom." He even referred to the exit from this initial state as a "bang," but he did not couple this adjective with the word "big." The phrase "big bang" was a nickname coined in 1950 by British astronomer Fred Hoyle, a staunch advocate of the steady-state theory of the universe, who used the phrase as a pejorative connotation for the big-bang model.[26] To Hoyle's chagrin, his derisive label ultimately became the official name for the very cosmology he spent much of his life unsuccessfully trying to debunk.

It is critical to emphasize at this point that the big bang should not be considered as an explosion of a hot dense cosmic mass somewhere *in* space that hurled matter in all directions *though* space. On the contrary, the big bang is the "event" that defines the birth of the universe itself—i.e., the big bang marks the origin *of* space and *of* time. The big bang occurred everywhere at once. According to the theory, before the big bang there was no space, and there was no time. As far as the big-bang model is concerned, the word "before" is meaningless. Asking what came before the big bang is like asking what is north of the north pole. As physicist Paul Davies explains, "People often ask: Where did the big bang occur? The big bang did not occur at a point in space at all. Space itself came into existence with the big bang. There is a similar difficulty with the question: What happened before the big bang? The answer is, there was no 'before.' Time itself began at the big bang."[27]

Furthermore, the expansion predicted by Friedmann and Lemaître and experimentally confirmed by Hubble should not be envisioned as the hurtling of celestial objects *through* space but the expansion *of* space, a phenomenon that may be compared to an inflating balloon whose surface contains a collection of dots corresponding to the celestial objects in the universe. As the balloon fills with air, the surface of the balloon (space) stretches, moving the dots (celestial objects) farther from one another. From the point of view of an observer on *any* dot on the balloon's surface, the other dots move away as the surface stretches. As Hubble observed, light from distant galaxies is red shifted, indicating that these galaxies are being conveyed, as it were, by the "fabric" of expanding space. This is the correct interpretation of the expansion of the universe according to the big-bang model.

The singularity predicted by Lemaître is a region of space-time where the known laws of physics break down because the curvature of space is infinite. Known laws of physics (Einstein's general theory of relativity) take us back to the so-called Planck time, which is 10^{-43} seconds after the big bang. To understand what happened before this time, a theory that combines gravity and quantum mechanics is required. Presently, no such theory has been successfully developed, but a fairly recent concept called "string theory" may hold some promise.

By the late 1930s, nuclear astrophysics had developed into an advanced theory, and by late 1942 the big-bang model had gained significant momentum among nuclear physicists. In 1946 the Russian-born nuclear physicist George Gamow published a short paper which is regarded by some as the foundation of modern big-bang cosmology. In this landmark paper, Gamow combined two perspectives, the relativistic cosmology of Friedmann and Lemaître and the idea that a process of an explosive character was necessary to account for the existence of the heavy elements (elements other than hydrogen and helium) in the universe.[28]

By the late 1940s, big-bang cosmology had developed into a proper scientific theory with quantitative estimates of how the universe has evolved with time. Around this time cosmologists postulated that the energy released by the big bang should have left a remnant thermal signature, a cosmic "afterglow," in the present universe. They calculated that the temperature of this "background" radiation from the primeval cosmic fireball would today be about 5 K.[29] This thermal signature was finally measured in 1964 by astronomers Arno Penzias and Robert Wilson at the Bell Laboratories in New Jersey. Using a radio telescope,[30] Penzias and Wilson found a strong signal at one particular wavelength of the microwave band emanating from all directions in the sky. After months of measurements and consultations with other astronomers, they concluded that their signal was the cosmic microwave background radiation predicted by the big-bang model.[31] They eventually refined their temperature measurement to 2.7 K.

Within a few years after the discovery of the cosmic background radiation, scientists utilized the temperature measurement of Penzias and Wilson, together with improved knowledge of nuclear reactions that convert hydrogen into helium and heavier elements, to show that everything in the universe was created out of primordial protons and electrons in a two-stage process.[32] First, the light elements were "cooked" in the big bang, and second, the heavier elements were cooked more slowly inside stars. The predicted proportions of hydrogen, helium, and other light elements in the universe were found to be in excellent agreement with measurements taken by astronomers, thereby corroborating the big-bang model.

The next major development in big-bang cosmology came in 1974 when astrophysicist J. R. Gott and his associates showed that the matter density of the universe is less than one tenth of the value required for the universe to be "closed."[33] In cosmology, the geometrical "shape" of the universe is described as either "closed," "open," or "flat." These geometries refer to the "curvature" of space and may be visualized as a sphere (positive curvature), a saddle (negative curvature) and a plane (zero curvature), respectively. Cosmologists use the Greek letter Ω (omega) to denote the ratio of the actual density of the universe to the critical density of the universe. If Ω is greater than 1, the universe is closed, and will some day stop expanding and contract back to a singularity. This event is referred to as the "big crunch." If Ω is less than 1, the universe is open and will expand forever, eventually cooling to absolute zero, resulting in a "big freeze." If Ω equals 1, the universe is flat, precisely balanced between closed and open. A flat universe will stop expanding after an infinite amount of time. The findings of Gott and his colleagues showed that only flat and open universes could be seriously considered at the time.

The year 1980 saw the emergence of a crucial piece to the big-bang cosmological puzzle, a theory called *inflation.* Inflation says that, during the first split second of the life of the universe, a tiny "seed" containing all the mass and energy in the universe was blown up from a size smaller than that of a proton to about that of a basketball. Pioneered by physicist Alan Guth, inflation theory explained or refined several key aspects of the "standard" big-bang cosmological model.[34]

First, inflation explains how the number of particles in the universe grew from a small number to around 10^{90} today. The standard model does not postulate any numbers so large.

Second, inflation addresses the flatness problem, which, as discussed earlier, relates to the closeness of the actual density of the universe to the critical density of the universe. While the issue is not completely settled, there is growing evidence that Ω is very close to 1, so the universe is flat or very nearly so. The standard big-bang model offers no rationale to prefer one value of Ω over another, but $\Omega = 1$ is a natural consequence of inflation theory.

Third, the standard big-bang model predicts an abundance of "magnetic monopoles" (particles that have only a south or north pole but not both) in the universe, but these extraordinarily heavy particles are nowhere to be found in the cosmos. Inflation theory posits that the number of monopoles was effectively reduced to zero by the enormous expansion associated with inflation.

Fourth, inflation helps explain the uniformity of the universe, which is observed most clearly by measuring the temperature of the cosmic background radiation. The effective temperature is the same in every direction to an accuracy of one part in a hundred thousand, but the standard big-bang model does not contain an explanation for this uniformity.

Fifth and finally, inflation predicts that, while the universe is very uniform, there should be very small deviations from that uniformity due to quantum uncertainties. These deviations were detected by NASA's Cosmic Background Explorer (COBE) satellite launched in 1989, and the findings were announced in 1992. The radiometers aboard COBE confirmed the small temperature deviations predicted by the inflation theory and measured an overall temperature of the cosmic background radiation at 2.735 K. The temperature deviations were validated in 2000 by the BOOMERANG experiment, a balloon-borne telescope operating around the Antarctic, and by other balloon-based and ground-based experiments.

In 2003 the first data from the Wilkinson Microwave Anisotropy Probe (WMAP) were released. The mission of WMAP, a space probe launched in 2001 and positioned approximately one million miles from earth in a direction opposite to the sun, was to provide a higher resolution map of the cosmic background radiation than COBE could provide. To a very high degree of measurement accuracy, WMAP validated the COBE results, providing even stronger observational evidence for inflation. Furthermore, WMAP measurements showed that the universe is flat to within a 2 percent margin of error. Using precise WMAP measurements and other information, cosmologists have also determined that the universe is 13.7 billion years old, plus or minus 200 million years.[35] By combining data from cosmic background radiation measurements and results from the Sloan Digital Sky Survey (SDSS), cosmologists determined early in 2005 that $\Omega = 1.01$, plus or minus 0.009.[36] This finding strengthens the case for a flat universe but suggests that the universe could be closed since Ω ranges from 1.001 to 1.019.

Big-bang cosmology is a tribute to the mathematical brilliance, experimental adeptness, and laborious observational efforts of numerous individuals who pioneered this extraordinary model over the better part of the past hundred years. According to physicist Simon Singh:

> The big-bang model of the universe is arguably the most important and glorious scientific achievement of the twentieth century. Just like many other areas of science, cosmology started by attempting to explain things that had previously been in the domain of myth or religion. Developing, testing, revising and proving the complete big-bang model required a number of theoretical, experimental and observational stages. Yet this does not mean that the model is polished and complete, because there will always be some outstanding issues and some details that need to be filled in.[37]

So firmly established is big-bang cosmology as a scientific reality that noted cosmologist James Peebles stated, "The big-bang theory is no longer seriously questioned; it fits together too well."[38]

Even though the big-bang theory "fits together well," some baffling phenomena have emerged in recent years. In 1998 cosmologists found that the rate of expansion of the universe is increasing, not decreasing as previously thought.[39] Moreover, they have discovered that ordinary matter—the kind of which stars, planets, comets, dust, and other celestial objects consist—constitutes only 4 percent of the ingredients of the universe. The other 96 percent consists of two mysterious entities that astronomers have not yet identified. Approximately 23 percent of the universe is composed of "dark matter," and approximately 73 percent consists of "dark energy," the bizarre energy that is believed to be responsible for the recently discovered accelerated expansion. Scientists know very little about dark matter and even less about dark energy, which is currently being associated with the cosmological constant that Einstein argued was a blunder. A version of this constant now seems necessary to account for the accelerated expansion. According to cosmologists Lawrence Krauss and Michael Turner, "The cosmological constant has reemerged to play a central role in 21st century physics."[40] Martin Rees, the United Kingdom's Astronomer Royal, acknowledges, "It is embarrassing to admit, but astronomers still don't know what our universe is made of."[41]

Rival Cosmologies

The current scientific consensus is that the big-bang model correctly describes the structure and evolution of our universe. But this has not always been so. In 1948 three young physicists from Cambridge University, Hermann Bondi, Thomas Gold, and Fred Hoyle, introduced the modern "steady-state" theory of the universe.[42] The steady-state model consists of two interrelated postulates. First, the universe has always and will always look the same to any observer, regardless of that observer's location in space and time. This postulate is called the "perfect cosmological principle," a name coined by Gold. Second, matter is continuously created throughout the universe, emerging spontaneously out of apparently nothing. Most cosmologists disdained the idea that matter could be created out of nothing, but the steady-state theorists claimed that it was no more bizarre than the notion of matter creation from nothing in the big bang. The steady-state model recognizes cosmic expansion but contains a continuous creation of matter that counterbalances the expansion, resulting in a steady-state universe. The steady-state cosmology of Bondi, Gold, and Hoyle was the primary cosmological rival to the big-bang model; and in addition to being an important theory in its own right, it provoked a major controversy in cosmology by questioning the standard assumptions of the evolutionary theory. The steady-state model forced cosmologists to think more deeply and critically about the foundations of cosmology, and the model was instrumental in the emergence of new observational methods and practices. [43]

After a decade of controversial existence, the steady-state theory was still alive at the end of the 1950s. But the theory failed to harmonize with several astronomical observations, particularly the cosmic background radiation discovered by Penzias and Wilson in 1965, so by 1970 the theory was considered dead by virtually all astronomers except two (Gold and Hoyle) of its three developers and a few steady-state converts who continued the resistance to big-bang cosmology by developing extensions and revisions to the original steady-state theory, such as the quasi-steady state theory introduced by Fred Hoyle, Geoffrey Burbidge, and Jayant Narlikar in 1993.[44]

Among the most energetic opponents of big-bang cosmology was Hannes Alfvén, the Swedish physicist and 1970 Nobel Prize winner for his work in plasma physics. Alfvén rejected the big-bang theory, which he found unscientific and mythical. Alfvén's cosmology was a "plasma universe" that could be described by the laws of electromagnetism, thermodynamics and particle physics. "Instead of working forward from a theoretically conceived beginning of time, plasma cosmology works backwards from the present universe. . . . It arrives at a universe without a big bang, without any beginning at all, a universe that has always existed, is always evolving, and will always evolve, with no limits of any sort."[45] Alfvén's cosmology received some support from other plasma physicists but was ignored by most astronomers and cosmologists. Eric Lerner has attempted to keep Alfvén's plasma model alive, but serious errors in the model have been identified.[46]

The handful of steady-state and plasma cosmology partisans are not the only big-bang antagonists. In an open letter to the scientific community, more than a hundred scientists from around the world signed a statement by Lerner proclaiming that the big-bang theory "relies on a growing number of hypothetical entities" such as "inflation, dark matter and dark energy" without which there would be "fatal contradictions between the observations made by astronomers and the predictions of the big-bang theory." The letter further asserts that "doubt and dissent are not tolerated" and that "those who doubt the big-bang fear that saying so will cost them their funding."[47]

Mormonism and the Big Bang

Notwithstanding the vocal few who adhere to steady-state, quasi-steady state, plasma, or some other type of cosmology, the big-bang model has passed wide-ranging scientific scrutiny for the last seventy-five years. The big-bang model owes its birth to Einstein's general theory of relativity, which itself has passed numerous experimental tests and is therefore no longer considered merely a "theory." Moreover, the big-bang model has passed every major astronomical test that it has been subjected to, something that rival cosmologies have failed to do. These findings do not imply that the big-bang model is complete, but rather confirm that the model has been sufficiently verified experimentally that there is little doubt about its validity. Science, according to Karl Popper, a philosopher of science, is about theories that are subject to falsification.[48] For a theory to be falsifiable, it must be possible to make an observation that shows the theory to be false. For example, the theory that "all crows are black" could be falsified by observing one white crow. No number of experiments can prove a theory correct, but a single experiment can disprove one. Thus far, no aspects of the big-bang model have been experimentally falsified. So, if the big bang truly describes our universe, the nature of space and time and perhaps even existence itself, then an examination of the Mormon doctrine of eternal progression within the context of big-bang cosmology may be worthwhile.

Throughout the history of the LDS Church, many authorities have boldly asserted that there should, in actual fact, be no contradictions between science and religion. "Two truths are never at variance," declared Frederick Pack, a University of Utah geologist.[49] John A. Widtsoe, who was academically trained as a chemist, echoed the same thesis when he said, "Truth is truth forever. Scientific truth cannot be theological lie. To the sane mind, theology and philosophy must harmonize. They have the common ground of truth on which to meet."[50] He was expressing a tenet that has been articulated in various words throughout the history of the Church by a number of authorities.

Of the early Church leaders, Brigham Young was probably the most dynamic individual when it came to championing the consonance of science and religion. "My religion is natural philosophy," he said.[51] "In these respects we differ from the Christian world, for our religion will not clash with or contradict the facts of science in any particular."[52] Young emphasized that "every art and science known and studied by the children of men is comprised within the Gospel."[53] In the same vein, Apostle Orson Pratt advocated, "The study of science is the study of something eternal. If we study astronomy, we study the works of God. It is truth that exists throughout universal nature; and God is the dispenser of all truth—scientific, religious, and political."[54]

Of course, the "pro-science" stance is only one of two principal viewpoints currently active in the Church, the second viewpoint ranging from mild to severe "anti-science." Whenever there is an appearance of discord between a Church doctrine and science, the first impulse of many Church members is to immediately dismiss the science. The inaction fostered by this impulse, besides retarding a potentially fruitful dialogue on the science-religion interface, is contrary to the Lord's instruction to

> teach ye diligently and my grace shall attend you, that you may be instructed more perfectly in theory, in principle, in doctrine, in the law of the gospel, in all things that pertain unto the kingdom of God, that are expedient for you to understand;
>
> Of things both in heaven and in the earth; things which have been,

> things which are, things which must shortly come to pass. (D&C 88:78, 79)

Moreover, it is clear that the Lord desires that we study the natural world, for "all things are created and made to bear record of me, both things which are temporal, and things which are spiritual; things which are in the heavens above, and things which are on the earth, and things which are in the earth, and things which are under the earth, both above and beneath: all things bear record of me" (Moses 6:63).

As pointed out by mathematician and LDS author David H. Bailey, the anti-science viewpoint gained considerable momentum in the 1950s following the publication of Joseph Fielding Smith's book, *Man: His Origin and Destiny* (Salt Lake City: Deseret Book, 1954). In this book and other publications, Smith promoted a highly literal interpretation of the scriptures that was predominant in the Church for several decades.[55] In spite of the doctrinal literalism that has impeded the science-religion dialogue in the Church during the last fifty years, the compatibility of science and Mormonism is still addressed by Church leaders from time to time. In 1953, Apostle Harold B. Lee stated, "True religion and true science are in harmony. I have always thought it to be a dangerous assumption that there was a clash or warfare between the fundamental teachings of the truths of science and the teachings of true religion. If there is a disagreement, it is because one or the other has not attained to the truth."[56] Apostle Russell M. Nelson, a physician, has stated more recently: "From generation to generation, God has given additional light. Whether truth comes from a laboratory of science or directly by revelation, truth is embraced by the gospel."[57]

Is big-bang cosmology compatible with Mormonism; and more specifically, is it compatible with the centerpiece of Mormon theology: the doctrine of eternal progression? Have one or both of these ideas "not attained to the truth"? Before addressing that question, let's briefly summarize the conclusions of big-bang cosmology, which, for the purposes of this article, may be condensed to six principal points:

1. The universe is expanding and, according to recent discoveries, doing so at an accelerated rate.

2. The universe is nearly flat, but its ultimate fate is unknown.

3. Current laws of physics are inadequate for investigating the very early universe.

4. Our universe has a finite age, approximately 13.7 billion years.

5. The big bang marked the inception of space and time.

6. Approximately 96 percent of the constituents of the universe are unknown.

Concerning the first point, there do not appear to be any doctrines in Mormonism that are at odds with an expanding universe per se. In fact, one may even claim that Mormonism supports the idea by arguing that an expanding universe is required to accommodate the growing "race of gods" spoken of by Widtsoe. This argument assumes, of course, that these gods actually *need* the expanded space. Proponents of the compatibility of the first point would more likely maintain that an expanding universe is required to accommodate a growing number of life-sustaining worlds and therefore a growing number of God's spirit children who have taken on mortality. But star and planet formation, which is required for life, occurs within existing galaxies and is independent of the expansion. God may exist outside of our universe, i.e., outside of our space-time, but assuredly operates, as he sees fit, within it. This issue will be addressed in more detail later in connection with the fourth and fifth points.

As for the second point concerning the ultimate fate of the universe, big-bang cosmology proffers three possible outcomes for the universe, each one corresponding to a different "shape" of space-time. The first outcome is a closed universe ($\Omega > 1$). This outcome is characterized by a universe that eventually stops expanding and then collapses into an infinitely dense hot region, a state reminiscent of the primordial fireball that defined the beginning of the universe. In a closed universe, all cosmic structure is destroyed, thereby destroying all life; and what happens afterward is beyond our current knowledge of physics. However, subsequent big bangs, which result in an "oscillatory" universe, have been hypothesized. The second outcome is an open universe ($\Omega < 1$). This outcome is characterized by a universe that expands forever, ultimately cooling to a temperature of absolute zero. In an open universe, space is infinite, completely black and cold, and therefore lifeless. The third outcome is a flat universe ($\Omega = 1$). This outcome is characterized by a universe that is perfectly balanced between closed and open. A flat universe will stop expanding after an infinite amount of time. The end result in a flat universe is basically the same as an open one—it just takes an infinite amount of time to achieve. As discussed earlier, cosmologists have determined that our universe is very close to being flat. Further studies and measurements are required to ascertain whether this is actually the case.

The ultimate fate of the big-bang universe in *any* of the three possible outcomes spells doom for humans who live in that universe. Within a more limited scientific context, however, this point is meaningless for humans—at least, for those who live on this earth—since long before the demise of the universe, the earth will be scorched by an increasingly hot sun as it transforms into a red giant in the next few billion years. Assuming that we are still here, survival will require that we find a way to protect ourselves by altering the sun somehow or leaving the solar system. Presumably, our work on earth in the mortality phase of our eternal sojourn will have been completed long before this perilous event.

The claim by Copan and Craig that God would be "swallowed up and crushed into oblivion in the Big Crunch or else literally disintegrated into the cold, dark recesses of outer space" arises from the false notion that God, having a tangible body, is susceptible to the same external physical effects as human beings. As modern revelation states, God has a tangible body of flesh and bones, but God is a *resurrected* being with a "glorified" body whose physical properties we know almost nothing about. The suggestion that God is subject to destruction in a "big crunch" or a "big freeze" is based on a misunderstanding or misinterpretation of God's materiality in Mormon doctrine.

The third point stated above concerning the inadequacy of contemporary physics illustrates that "the universe is full of magical things, patiently waiting for our wits to grow sharper."[58] Einstein's general theory of relativity is enormously successful in describing gravity. Likewise, quantum mechanics is enormously successful in describing the behavior of subatomic particles. What is lacking, however, is a theory that incorporates or unifies gravity and quantum mechanics into a single consistent theory capable of describing the universe prior to the Planck time. Some scientists believe that string theory is the key to uniting gravity with quantum mechanics.[59] In any event, our inability to describe the universe before 10^{-43} seconds after its birth simply says that our physics is a work in progress and does not suggest any discord between Mormonism and big-bang cosmology.

The fourth point, that our universe has a finite age, is problematic for Mormonism. The big-bang model postulates a cosmos with a *beginning,* a cosmos whose birth occurred approximately 13.7 billion years ago by current estimates. In Mormonism, there is *no* ultimate beginning, but an eternity, which is endless time. The definition of "eternal" here is an infinitely long "time line" and not a contracted definition of a "very long" period of time or an appellative reference to God. Eternity, or eternal existence, means that existence has no beginning and no end. Existence just *is*. Joseph Smith taught: "Is it logical to say that the intelligence of spirits is immortal, and yet that it has a beginning? The intelligence of spirits had no beginning, neither will it have an end. That is good logic. That which has a beginning may have an end. There never was a time when there were not spirits; for they are co-equal [co-eternal] with our Father in heaven."[60]

According to modern-day scripture, God is eternal. "For, behold, the mystery of godliness, how great is it! For, behold, I am endless, and the punishment which is given from my hand is endless punishment, for Endless is my name" (D&C 19:10). Also, Doctrine and Covenants 20:17 reads: "By these things we know that there is a God in heaven, who is infinite and eternal, from everlasting to everlasting." And again, we read, " . . . which Father, Son, and Holy Ghost are one God, infinite and eternal, without end" (D&C 20:28). Moses 1:3 states: "And God spake unto Moses, saying: Behold I am the Lord God Almighty, and Endless is my name; for I am without beginning of days or end of years; and is not this endless?"

These verses are to be understood within a broad doctrinal context of eternal progression, which claims that God is a progressive, eternal being. God has always existed, but not always as a god. Joseph Smith taught, "God himself was once as we are now, and is an exalted man, and sits enthroned in yonder heavens! That is the great secret. We say that God Himself is a self-existing being. Who told you so? It is correct enough; but how did you get it into your heads?"[61] Joseph Smith also taught, "Man was also in the beginning with God. Intelligence, or the light of truth, was not created or made, neither indeed can be" (D&C 93:29).

If man and God, who used to be a man, are eternal beings, where were they prior to the birth of the universe? Did they exist outside of time that came into being with the big bang? How can Mormonism claim the existence of eternal uncreated intelligences when big-bang cosmology purports a universe that is 13.7 billion years old? By human standards, 13.7 billion years is a very long period of time, but it is not an infinitely long period of time and hence does not describe the endless existence of intelligences and gods posited by Mormonism.

Is the difficulty posed by the fourth point concerning the finite age of our universe relieved if premortal and postmortal entities exist outside of time? Does God exist outside of time? According to Kent Robson, "Scriptural passages that ascribe eternity to God do not say or imply that God is independent of, or outside of, or beyond time. Nor do they say, with Augustine, that God created time out of nothing."[62] Verses in the LDS canon of scripture that refer to time do not provide a conclusive answer. Doctrine and Covenants 130:4 reads, "In answer to the question—Is not the reckoning of God's time, angel's time, prophet's time, and man's time, according to the planet on which they reside?" This verse suggests that God operates within or is associated with *a* time but apparently not angel's, prophet's, or man's.

From Abraham we read, "And the Lord said unto me, by the Urim and Thummim, that Kolob was after the manner of the Lord, according to its times and seasons in the revolutions thereof; that one revolution was a day unto the Lord, after his manner of reckoning, it being one thousand years according to the time appointed unto that whereon thou standest. This is the reckoning of the Lord's time, according to the reckoning of Kolob" (Abr. 3:4). Again, a time of some sort is associated with the Lord, but the Lord's time, or at least the reckoning of it, is described as being vastly different than Abraham's. Similarly, Figure 1 of Facsimile 2 in the Book of Abraham refers to Kolob as the "last pertaining to the measurement of time." Contrast these words with those of Alma, who said, "Now whether there is more than one time appointed for men to rise it mattereth not; for all do not die at once, and this mattereth not; all is as one day with God, and time only is measured unto men" (Alma 40:8). The last part of this verse implies that the measurement of time is not associated with God at all. (But it seems that the word "only" should follow the word "men" instead of the word "time" if the implied interpretation is to be strictly conveyed.)

It is interesting to note that, in each of these scriptures, time is discussed in the context of its reckoning or measurement. All the verses, with the exception of Alma, suggest that God does indeed measure time, but that God's measurement is somehow unique. The verses even suggest, as do other verses in the Bible, that one thousand years for man is equivalent to one day for God (Ps. 90:4; 2 Pet. 3:8). Whether we should interpret this man-to-God "equivalency" of time literally is questionable. The large disparity in time spans may be symbolic of the enormous difference between God's time and man's time, or it may be a symbol for the "timelessness" of God. After all, when Jesus exhorted his disciples to forgive "seventy times seven," he did not mean that they should forgive their brother exactly 490 times (Matt. 18:22).

Perhaps God always exists within *a* time, but the time in question may or may not be *our* time, depending on the divine activity in which God is involved. If true, this suggests that God's power transcends time in the sense that God is not restricted within one temporal system. In this way, God can be outside of time because God can be outside of *our* time, the only time with which we are familiar. From the scriptural record, our understanding of God's relationship to time is unclear. The relationship to time for premortal and postmortal spirits is likewise unclear.

Another difficulty posed by the fourth point is the doctrine that attests to the eternal nature of the elements. Doctrine and Covenants 93:33 states, "For man is spirit. The elements are eternal, and spirit and element inseparably connected, receive a fulness of joy." In both mortal and resurrected states, a human being is a dual entity consisting of two kinds of "matter," spirit and element. The first kind of matter refers to the kind that "can only be discerned by purer eyes" (D&C 131:7).

The second kind of matter refers to common stuff, the materials of which stars, planets, dust, and other objects in the cosmos, including us, consist. For a resurrected being, however, the second kind of matter is "glorified," having physical properties beyond our present level of understanding. According to big-bang cosmology, the second kind of matter arose from the primordial fireball a finite time ago. Light elements were cooked in the big bang, and the heavy elements were forged later by nuclear fusion processes inside stars. Assuming that these elements are the same as those referred to in this verse, it is difficult to see how they can be eternal unless we extend their identity infinitely backward in time, through the singularity, to other realms of existence. Joseph Smith said, "Anything created cannot be eternal; and earth, water, etc., had their existence in an elementary state, from eternity."[63] If the elements have existed in an elementary state, from eternity, the big-bang model alone is inadequate to explain it.

The difficulty posed by the fifth point, that the big bang marked the inception of space and time, is similar to that posed by the fourth point. Physicist Paul Davies explains, "The universe did not always exist. . . . Just as the big bang represents the creation of space, so it represents the creation of time."[64] Because the universe has a finite age, it also has a finite size.[65] This fact, too, may pose a dilemma for a theology that embraces "a vast society of eternal beings."[66] If the big bang marked the inception of space and time, what of the endless gods of Mormonism? "Before" the big bang, where/when were these gods? And what of *our* God, the father of Jesus Christ? Was God *created* in the big bang, or did God *cause* the big bang? The first notion seems repugnant and subverts the very meaning of a divine omnipotent being. But if God caused the big bang, he must have operated from within a separate space-time because the big bang marked the inception of our universe, the space-time that God created. According to the Mormon doctrine of eternal progression, God was created by a prior god, and that god was created by a still prior god, and so on into the infinite past. How could this endless chain of deities, and their associated innumerable worlds inhabited by mortal children, be facilitated by a single universe of finite size and age?

The big bang gave birth to a single universe, the universe that *we* occupy, the universe over which Jesus Christ, as LDS Church authorities have stated, has dominion. What is the domain of the other gods posited by the doctrine of eternal progression? If our universe is the only one, the gods must have established a subdivision of or hierarchical structure to the universe in which each god has dominion over his own parcel of the cosmic real estate. Because the big bang produced a single universe, every god must share it, and the cosmic parcels are too small to accommodate "worlds without number" (Moses 1:33). The idea of a single finite universe occupied by a multitude, perhaps an infinite number, of gods and other eternal beings seems untenable.

The sixth point, that 96 percent of the constituents of the universe are unknown, is like the third point in that it illustrates that science is a human activity that methodically advances, revealing new knowledge along the way. Cosmologists anticipate that the mysterious entities called dark matter and dark energy will eventually be identified and incorporated into the big-bang model. Inasmuch as we do not even know what these entities are, it is difficult, if not impossible, to associate them with Mormon doctrine in any meaningful way at present.

Another point, not mentioned above, that some people affiliate with the big bang is *creatio ex nihilo,* the doctrine that the universe was created out of nothing. While traditional Christian theologians and some philosophers subscribe to this doctrine, Mormonism flatly rejects it.[67] The logical essence underlying this rejection is perhaps best summed up by Apostle James E. Talmage, trained as a geologist, who said, "Man's consciousness tells him of his own existence; his observation proves the existence of others of this kind and of uncounted orders of organized beings. From this we conclude that something must have existed always, for had there been a time of no existence, a period of nothingness, existence could have never begun, for from nothing, nothing can be derived."[68] Likewise, astronomer Hollis Johnson explains that "it is difficult to imagine that nothing exists anywhere. Creation from nothing is clearly a fantasy devised by certain theologians, perhaps in a misguided attempt to glorify God by making of him a fantastic magician."[69] Cosmologists theorize that the universe arose from a quantum vacuum, an entity seething with energy and elementary particles, which, as Martin Rees advises, is not "nothing." He states, "Indeed some physicists already claim that our universe evolved essentially from nothing. But they should watch their language, especially when talking to philosophers. The physicist's vacuum is a far richer construct than the philosopher's 'nothing': latent in it are all the particles and fields described by the equations of physics."[70] Similarly, in a review of Copan and Craig's book, Blake Ostler, a theologian and attorney, makes an extensive refutation of their *creatio ex nihilo* thesis.[71]

While the Mormon doctrine of eternal progression is not at odds with most aspects of big-bang cosmology, there are difficulties in harmonizing the doctrine with a single universe that is spatially and temporally finite. Interestingly, the steady-state theories discussed earlier harmonize better with the Mormon doctrine of eternal progression for the simple reason that the universe posited by these theories is eternal. Furthermore, the continuous creation of matter in these models could provide the mechanism whereby "worlds without number" are formed to facilitate the introduction of the children of the gods into mortality, but the steady-state theories subsume *ex nihilo* matter creation. But even putting the *creatio ex nihilo* issue aside, the steady-state theories, through failures to harmonize with astronomical observations, have been scientifically dismissed, leaving the big bang as the only viable cosmological model.

How then to best reconcile Mormon doctrine with big-bang cosmology? In his refutation of Copan and Craig's *creatio ex nihilo* thesis already mentioned, Ostler appeals, in part, to a multiverse proposal, a cosmological theory that might relieve the difficulties posed by big-bang cosmology. The rest of this article explores some of the promising solutions that the concept of a multiverse provides.

Multiverse Alternatives

Mormons may not have to, as Norman says, "appeal to God to get them out of this fix." On the contrary, science may supply the answers. Incongruities that exist between the Mormon doctrine of eternal progression and big-bang cosmology may be mitigated if we frame the doctrine within a multiverse cosmological model. The term *multiverse* originated in 1960 with Andy Nimmo who was then vice chair of the British Interplanetary Society, Scottish Branch. His definition was "an apparent universe, a multiplicity of which go to make up the whole universe."[72] This original version of the term was based on a specific dictionary definition of the word "universe," which means "all that there is." Over a period of misuse in scientific and science fiction circles, cosmologists and astronomers have largely redefined the term "multiverse" as "the set of all possible universes throughout time, including our observable universe."[73] Although this current definition is the opposite of its original one, the new definition has become entrenched in the literature and is the definition used here.[74]

Recent developments in cosmology suggest that *this* universe—the universe in which we live, the universe generated in the primordial fireball known as the big bang—may not be the only one. What we conventionally call "the universe" could be just one member of an ensemble of "universes." Some cosmologists have even intimated that there may be an infinite number of members in the ensemble. Martin Rees explains: "Our entire universe may be just one element—one atom, as it were—in an infinite ensemble: a cosmic archipelago. Each universe starts with its own big bang, acquires a distinctive imprint (and its individual physical laws) as it cools, and traces out its own cosmic cycle. The big bang that triggered our entire universe is, in this grander perspective, an infinitesimal part of an elaborate structure."[75]

The multiverse thesis may be the most profound idea in cosmology since the big bang itself and would therefore possess penetrating scientific ramifications. Theoretical physicist Steven Weinberg, in a conversation with colleague Michio Kaku, stated, "I find this an attractive picture and certainly worth thinking about very seriously. An important implication is that there wasn't a beginning; that there were increasingly larger big bangs, so that the [multiverse] goes on forever—one doesn't have to grapple with the question of it before the big bang. The [multiverse] has just been here all along. I find that a very satisfying picture."[76] Martin Rees elaborates, "It now seems an attractive idea that our big bang is just one of many: just as our earth is a planet that happens to have the right conditions for life, among the many, many planets that exist, so our universe, and our big bang, is the one out of many which happens to allow life to emerge, to allow complexity."[77]

At first thought, one might suppose that the idea of multiple universes is the product of science fiction or a wild conjecture, a version of "cosmology gone wild." Referring to multiverse theories as "frivolous fantasies," mathematician Martin Gardner remarks: "Many top physicists and cosmologists now defend the wild notion that not only are universes as common as blackberries, but even *more* common. Indeed, there may be an infinity of them!"[78] In defense of multiverse theories, Paul Davies states, "The multiverse is not an idle speculation, but a natural consequence of developments in fundamental physics and cosmology."[79]

Different individuals have proposed their own version of a multiverse theory. Each version reflects a different physical mechanism, but they all hypothesize a type of "universe" or "parallel world" that lies outside our own. Three multiverse theories, advocated by different cosmologists, hold some prominence in the current multiverse milieu:

1. The "eternal inflation" theory of Alexander Vilenkin and Andrei Linde
2. The "ekpyrotic" theory of Paul Steinhardt and Neil Turok
3. The "cosmological natural selection" theory of Lee Smolin

Before elaborating on the implications of a multiverse for Mormonism, let's briefly describe these three multiverse theories.

At present, the most prominent multiverse theory is an extension of Guth's inflation concept incorporated in the big-bang model that was introduced by Alexander Vilenkin and Andrei Linde.[80] Their multiverse theory is called the "eternal inflation" or "chaotic inflation" theory. Especially championed by Linde in recent years, the theory states that our universe is just one particular "pocket universe" that was randomly spawned as an "inflationary bubble" by a fluctuation of the quantum vacuum. One inflationary universe sprouts other inflationary bubbles, which in turn produce other inflationary bubbles that become universes. The result, according to Linde, "is a chain reaction, producing a fractal-like pattern of universes. In this scenario the universe as a whole is immortal. Each particular part of the universe may stem from a singularity somewhere in the past, and it may end up in a singularity somewhere in the future. There is, however, no end for the evolution of the entire universe."[81]

The ekpyrotic theory of the multiverse, recently introduced by Paul Steinhardt and Neil Turok, proposes that our universe arose from a collision of two three-dimensional worlds or "membranes" ("branes" for short) in a space with a fourth spatial dimension.[82] The name for their model comes from the Greek word "ekpyrosis," which means "conflagration." Unlike the big-bang universe, which begins with nearly infinite density and temperature, the ekpyrotic universe begins cold and nearly vacuous. According to the model, which is based on recent ideas from string theory, the collision of two branes ignited the hot big bang, and the universe evolved from that point as we observe it today. The big bang "is just the latest in a cycle of cosmic collisions stretching infinitely into the past and into the future. Each collision creates the universe anew. The 13.7 billion-year history of our cosmos is just a moment in this endless expanse of time."[83]

The cosmological natural selection theory of Lee Smolin suggests that "baby" universes can sprout from existing ones through the gravitational collapse of black holes.[84] When a star implodes to form a black hole, a space-time singularity occurs inside the hole. Smolin proposes that a quantum description of this phenomenon leads to the nucleation of a tiny new region of space that is connected to our space by a wormhole. The wormhole is eventually severed, thereby disconnecting the baby universe from its "parent" universe. The baby universe inherits the physical laws of its parent but with random variations, similar to genetic drift in biological systems. This process continues ad infinitum, with baby universes cosmically evolving to produce their own progeny. Smolin suggests that our universe is the product of this "cosmic Darwinism" and that "our universe is creating new universes through the mechanism of black hole production."[85] In Smolin's model, the big bang is the outcome of the collapse of a black hole in a previous universe, and every black hole in our universe is giving rise to a new universe.

While each of these multiverse theories has a rational basis in physics, they possess a common underpinning in biology. Davies explains that the "principal observational support for the multiverse hypothesis comes from a consideration of biology. The universe we observe is biofriendly, or we would not be observing it. This tautology develops some force when account is taken of the sensitivity of biology to the form of the laws of physics and the cosmological initial conditions—the so-called fine tuning problem."[86] Our existence depends on our universe being rather special, a "Goldilocks universe" if you will, where the physical constants of nature are "just right" to admit and sustain life. If the values of the physical constants were only fractionally different from what they are, the universe would have either immediately collapsed or expanded so rapidly that stars could not have formed. In short, had the recipe imprinted at the time of the big bang been even slightly different, we could not exist.

Martin Rees offers three interpretations for the fine-tuning of our cosmos. The first interpretation is simply that our universe is a coincidence, a "happy accident." This interpretation, according to Rees, is unsatisfying because "we still wonder why the unique recipe for the physical world permits consequences as interesting as those we see around us." The second interpretation is divine providence, i.e., that the universe was "designed" by God. Our universe is fine-tuned because God willed that it should be so. The third interpretation is based on the idea that there are many universes of which ours is just one. Rees explains that "the cosmos maybe has something in common with an 'off-the-shelf' clothes shop: if the shop has a large stock, we're not surprised to find one suit that fits. Likewise, if our universe is selected from a multiverse, its seemingly designed or fine-tuned features wouldn't be surprising."[87]

In the context of Mormonism, the first interpretation parallels a hypothesis claiming that the earth and human beings are accidents, products of random cosmic and biological processes; it would therefore have to be rejected. The second interpretation is entirely consistent with the Mormon worldview that God organized a place for his children who kept their "first estate" (Abr. 3:26). If God organized the earth and countless other worlds within the universe, it seems reasonable that God framed the universe itself. The creation accounts in the scriptures, however, describe the organization of the earth and its immediate environs only but not the universe as a whole (Moses 1:35). For those who do not believe in providential design but still think that fine-tuning demands an explanation, the third interpretation becomes an attractive alternative. But to the believer in a cosmic designer, the second and third interpretations do not have to be mutually exclusive. In Mormonism, the third interpretation is not a circumvention of the second but rather an explanation of how the doctrine of eternal progression harmonizes with a multiverse cosmology. The multiverse hypothesis still admits God as the architect of the universe while mitigating the inconsistencies between the doctrine and the big-bang model. For science, a compelling reason to consider a multiverse cosmology is to avoid a theistic implication of fine tuning. For Mormonism, a compelling reason to consider a multiverse cosmology is to attempt a reconciliation of modern cosmological ideas and the central tenet of Mormon doctrine.

Scientific circles regard the multiverse hypothesis strictly from a nontheistic perspective, as a possible explanatory hypothesis for a universe that is extraordinarily fine-tuned for life. The multiverse hypothesis has thereby become another plank in the scientists' platform on which they can argue that the origin of the universe can be explained by science without invoking a "god of the gaps." But philosopher Robin Collins of Messiah College argues that contemporary cosmology might not only be compatible with theism but might even suggest a theistic explanation of the multiverse. Collins claims that theism is perfectly compatible with the multiverse hypothesis because "God is infinitely creative," so it makes sense that a physical reality much larger than a single universe would reflect this attribute of God. Collins also maintains that an infinitely creative God might create these universes by means of some sort of universe-generator, since such a creation would be more elegant and ingenious than simple *ex nihilo.* Furthermore, God would be glorified, not in just one universe, but in countless others.[88]

This non-Mormon assessment of the multiverse hypothesis conveys a parallel to one of God's statements to Moses, when he said, "The heavens, they are many, and they cannot be numbered unto man; but they are numbered unto me, for they are mine" (Moses 1:37). In a Mormon multiverse cosmology, God does indeed manifest his infinite creative prowess in the respect that God (any god along the infinite chain of gods) creates children, some of whom progress to become gods, who in turn create their own universes and children, some of whom progress to become gods, and so on, forever. Each universe in the ensemble of universes becomes an extension and continuation of the creativity of every "ancestral god" in an eternal family of deities. The creativity and glory of each god increases exponentially with the production of new universes. In this cosmology, the multiverse is a hallmark and witness of the infinite work and glory of God and the dwelling place for an infinite number of eternal progressing beings.

The multiverse is eternal, but, consistent with the big-bang model, each member of that multiverse is not. As Linde remarks, "In thinking about the process of self-reproduction of the universe, one cannot avoid drawing analogies. . . . One may wonder, Is not this process similar to what happens to all of us? Some time ago we were born. Eventually we will die . . . but . . . humanity as a whole . . . may live for a long time."[89] One must admit that, in the context of the Mormon eternal family paradigm, Linde's analogy is striking. A human being, like the multiverse in which he or she exists, is a member of an eternal family, an endlessly progressing and improving society. In a multiverse cosmology, the whole of existence conforms to the same familial pattern. Even universes are born, live, and eventually die, but the multiverse continues. The essence of a Mormon multiverse cosmology is beautifully captured in the Lord's statement to Moses: "And as one earth shall pass away, and the heavens thereof even so shall another come; and there is no end to my works, neither to my words" (Moses 1:38).

In a Mormon multiverse, a being who progresses to godhood brings about a universe for which that god has dominion. To provide suitable worlds for their children, the gods endow their universes with the required physical properties (constants of physics) to sustain life. In Mormon theology, gods exist "simultaneously," so separate universes coexist in the eternal multiverse. In a given multiverse "epoch," each universe in the ensemble may be anthropomorphically characterized as a "newborn," a "child," an "adolescent," an "adult," or a "senior citizen," depending on its age–i.e., the time that has passed since its own big-bang "birth" into the multiverse "family." A universe may even be characterized as "deceased" if the universe has experienced the big crunch or big freeze and is therefore no longer capable of sustaining life. The spirit children of the god of a given universe presumably must finish their mortal probation, progressing to the degree of glory prepared for them, long before their universe fulfills its purpose. The children who achieve the highest degree of glory–those who achieve godhood–eventually bring about their own universes and populate them with their children. And the cycle continues, eternally.

Multiverse Muddle?

Multiverse theories are not without problems and criticisms. Both scientific and philosophical arguments have been employed against the multiverse hypothesis. Paul Davies enumerates six arguments against the multiverse concept, but for the sake of brevity, I will summarize only his three principal ones.[90] The first argument is that a multiverse cosmology is not science because the "other universes" cannot be observed; thus, their existence cannot be considered a proper scientific hypothesis. After all, we are unable to observe all of *our* universe, let alone *other* universes. However, Davies cautions that, while direct confirmation of other universes may be precluded, other indirect tests may be utilized. For example, Smolin's cosmological natural selection theory, which predicts that universes are produced via black holes, could be indirectly tested in cases where physical conditions favor black hole production.

Incidentally, Smolin points out that his multiverse theory is falsifiable (and therefore real science), while criticizing Linde's eternal inflation theory as "an interesting speculation."[91] Whereas the first argument asserts that a multiverse cosmology is not science at all, the second argument asserts that it is *bad* science. Some physicists argue that the job of scientists is to provide fundamental explanations for observed phenomena without making reference to observers, i.e., without resorting to anthropic reasoning to explain the fine-tuning of our cosmos.

The third argument says that a multiverse merely shifts the problem up one level. Multiverse proponents are often vague about how the values of the constants of physics are selected across the ensemble of universes. If there is a "law of laws" or "meta-law" describing how these values are assigned from one universe to another, then we have only shifted the problem of cosmic bio-friendliness up one level because we then need to explain where the meta-law comes from. Moreover, the set of such meta-laws is infinite, so we have replaced the problem of "why this universe?" with "why this meta-law?"

Other problems with the multiverse hypothesis have been advanced, including an objection based on Ockham's Razor, which, in its original form, says that "entities are not to be multiplied beyond necessity."[92] A modern variant of Ockham's Razor states: "Of two competing theories or explanations, all other things being equal, the simpler one is to be preferred." Some argue that the multiverse hypothesis is a blatant violation of Ockham's Razor for the basic reason that one universe is simpler than two or more universes. Along with Gardner, they claim: "Surely the conjecture that there is just one universe and its Creator is infinitely simpler and easier to believe than that there are countless billions upon billions of worlds, constantly increasing in number."[93]

Ockham's Razor is an interesting philosophical injunction, and many phenomena may meet the condition stipulated therein, but Ockham's Razor is not a law of physics nor is it equivalent to the notion that simplicity is truth or perfection. The Lord apparently ignored Ockham's Razor in the design of the universe, for the muon, an elementary particle, "exists for no known reason and has no known function."[94] Our cosmos is simpler without it, and yet it exists. Ockham's Razor is a heuristic argument that does not necessarily provide correct results, a loose guide for choosing a scientific hypothesis that contains the fewest unproven assumptions. Hence, its forcefulness against a multiverse thesis is uncompelling.

One of the most serious and potentially damaging objections to the multiverse hypothesis is that it posits an infinite set of actually existing universes. Can there really be an infinite set of actually existing "objects" of any kind, particularly entire universes? According to mathematicians George Ellis, U. Kirchner, and W. R. Stoeger, "We suggest that, on the basis of well-known philosophical arguments, the answer is no. Because we can assign a symbol to represent 'infinity' and can manipulate that symbol according to specified rules, we assume corresponding entities can exist in practice. This is highly questionable." Quoting mathematician David Hilbert, Ellis, Kirchner, and Stoeger write, "Our principal result is that the infinite is nowhere to be found in reality. It neither exists in nature nor provides a legitimate basis for rational thought." They continue:

> This is why, for example, a realized past infinity in time is not considered possible from this standpoint—because it involves an infinite set of completed events or moments. There is no way of constructing such a realized set, or actualizing it. Future infinite time is also never realized; rather, the situation is that whatever time we reach, there is always more time available. Much the same applies to the claim of a past infinity of time; there may be unbounded time available in the past in principle, but in what sense can it be attained in practice? The arguments against an infinite past time are strong—it is simply not constructible in terms of events or instants of time, besides being conceptually indefinite.[95]

Notwithstanding the apparent strength of the philosophical argument against an infinite set of actually existing universes, Ellis, Kirchner, and Stoeger provide (in a footnote) a possible way out of the problem by invoking quantum cosmology "to have time originating or emerging from the quantum-gravity dominated primordial substrate only 'later.' In other words, there would have been a 'time' or an epoch before time as such emerged. Past time would then be finite, as seems to be demanded by philosophical arguments, and yet the timeless primordial state could have lasted 'forever,' whatever that would mean. This possibility avoids the problem of constructibility."[96]

In his refutation of Copan and Craig's *creatio ex nihilo* thesis, Ostler contends that the "infinity arguments . . . do not apply" to multiverse chaotic inflationary theories "because they posit realities that are temporally discontinuous." He argues that, because "there is no continuous time metric between two space-time epochs" in a chaotic inflationary multiverse, the infinity arguments brought to bear on an eternally existing multiverse consisting of separate bubble universes do not apply. Each bubble universe has its own time metric that is not shared with the others, so each bubble universe is finite in the past, but the multiverse is eternal.[97] Ellis, Kirchner, and Stoeger echo this point, explaining that "in the case of a true multiverse, there is not even any possibility of any indirect causal connection of any kind—the universes are then completely disjoint and nothing that happens in any one of them is causally linked to what happens in any other one."[98] Ostler further points out that the quantum vacuum, from which bubble universes chaotically arise according to Linde's chaotic inflationary model, is quiescent in the sense that it does not "causally" initiate the bubbles. Thus, our concept of cause and effect does not apply, rendering the infinity argument illegitimate.[99]

The timelessness of quantum events pointed out by Ostler and Davies qualitatively parallels the statement of Ellis, Kirchner, and Stoeger that time as we know it may have emerged from the "primordial substrate" only after an epoch of some kind had passed. The primordial quantum vacuum cannot be characterized spatio-temporally, so until a big bang is quantum mechanically initiated, neither space nor time can be associated with the quantum vacuum in any way. In other words, time does not "start" until a big bang occurs. "Before" that event, there is no time because the primordial quantum vacuum cannot be temporally characterized; quantum events have no causal properties. This explanation points to a possible way for "local" universes to have a finite age and for the multiverse to be eternal without running into the argument of an actual past infinity of time.

But, contrary to Ostler, Ellis, Kirchner, and Stoeger assert that universes generated via chaotic inflation *are* causally connected, which would indicate that the argument of an actual past infinity of time may still apply. A "true" multiverse, they claim, is a "completely causally disconnected multiverse," and not a multiverse generated by chaotic inflation, which Ellis, Kirchner, and Stoeger call a "multidomain universe." Speaking of universes with regularities in their properties, they contend that they "are, instead, products of a single process, as in the case of chaotic inflation. A common generating mechanism is clearly a causal connection, even if not situated in a single connected space-time—and some such mechanism is needed if all the universes in an ensemble have the same class of properties, e.g., being governed by the same physical laws or meta-laws." They also state that "the idea of a completely disconnected multiverse with regular properties but without a common causal mechanism of some kind is not viable. What are claimed to be totally disjoint universes must in some sense indeed be causally connected together, albeit in some pre-physics or meta-physical domain that is causally effective in determining the common properties of the universes in the multiverse." Ellis, Kirchner, and Stoeger conclude that the "existence of the hypothesized ensemble remains a matter of faith rather than proof. Furthermore, in the end it simply represents a regress of causation. Ultimate questions remain."[100]

Whether universes generated through chaotic inflation (or by any other quantum-mechanical mechanism for that matter) are "caused" by quantum events and are therefore causally connected deserves closer examination. Despite the stochastic properties of quantum events, one could argue that a quantum event can still be the cause of an observed phenomenon. Because a quantum event is random and unpredictable does not mean that it does not constitute the cause of an effect. It may be much easier to argue that a quantum event, owing to its intrinsic random and chaotic character, cannot be classified as an effect than it is to argue that a quantum event cannot be classified as a cause.[101] Indeed, Davies explains that "quantum events are not determined absolutely by preceding causes."[102]

Radioactive decay is an example of a quantum event. If we constructed a device that detonated a bomb by the random decay of an alpha particle, would we conclude that the detonation had no cause simply because it resulted from a quantum event? Quantum events are not determined by preceding causes, as Davies points out, but quantum events can themselves be causes.

But what about an actual infinity of universes? Ostler does not specifically discuss the infinity argument in the context of "objects" but only of time. If a multiverse consists of an infinite number of universes and if we assume that we could satisfactorily address the infinity of time problem, we still run into the argument against an actually existing infinity of "things." More importantly, if the claim made by mathematicians and philosophers that an actual infinity of things is impossible, is the entire doctrinal superstructure of eternal progression dashed? If the claim is true, how can there be an infinite number of progressing beings? How can there be an infinite number of worlds? Perhaps the argument does not apply to the multiverse as a whole. Universes in the multiverse are not observable by inhabitants of other universes, so other universes cannot be counted by them. Thus, the number of objects could still be finite because each local universe has a finite size and thus a finite number of objects within it. This explanation may or may not relieve the tension, but short of some other interpretation or mathematical/philosophical loophole that abates the contradiction, we may have to wait for an acceptable answer.

Primarily because inflation is a scientific concept more fully developed and supported by astronomical observations, the eternal inflation or chaotic inflationary theory of Linde is the prevailing multiverse model.[103] According to Linde's model, bubble universes are spawned *ad infinitum* into the future, but he admits that the "situation with the very beginning is less certain."[104] The jury is still out on whether Linde's multiverse is truly in a state of eternal inflation without a beginning. Cosmologists Arvind Borde and Alexander Vilenkin claim that a "universe . . . in a state of eternal inflation without a beginning . . . is in fact not possible in future-eternal inflationary spacetimes as long as they obey some reasonable physical conditions." In their analysis, Borde and Vilenkin show that eternal inflation "does not seem to avoid the problem of the initial singularity (although it does move it back into the indefinite past)." They admit, however, that this conclusion primarily rests on an a central physical assumption and that "it would be interesting to . . . determine the exact conditions of [the] assumption and to investigate the possibility of relaxing it."[105] Consequently, the doctrine of eternal progression is conceivably in harmony with Linde's eternal inflation theory, albeit the question of a multiverse without a beginning is still open to scientific analysis.

What about the ekpyrotic theory of Steinhardt and Turok and the cosmological natural-selection theory of Smolin? The ekpyrotic theory was introduced more recently and is therefore less developed than Linde's eternal inflation theory. Unlike the eternal inflation model, the ekpyrotic model is an outgrowth of superstring theory, which posits that space has up to ten spatial dimensions. Steinhardt and Turok describe our universe as a "brane" (membrane) flapping in the "breezes" of the ten-dimensional cosmos. Using the complex equations of string theory, their model shows that the big bang resulted from the collision of two branes that reside less than the width of a proton away from each other. In the moment just before a collision, the forces between the branes cause them to ripple. As a result, the two branes do not collide all at once, but instead the peaks of the ripples collide first. This uneven collision generates the small variations in the cosmic background radiation we observe today. The stupendous fireball (big bang) generated by the collision drives the branes apart, causing them to cool, resulting in a phase transition that unleashes a force that makes the universe expand. This force is still at work today and is, in fact, responsible, they suggest, for the mysterious dark energy that cosmologists hypothesize is responsible for the accelerated expansion. In the ekpyrotic model, the cycle of brane collisions, which produces the universes, is eternal. The big bang "is just the latest in a cycle of cosmic collisions stretching infinitely into the past and into the future." Other calculations by Steinhardt and Turok suggest that we are "at the beginning of a very long process that will eventually result in what appears to be an empty universe."[106]

The ekpyrotic theory, like any theory that postulates an eternal multiverse, runs into the same infinity argument discussed earlier. It is interesting to note, however, that the ekpyrotic theory predicts an endless expansion that results in an empty universe, a universe that cannot sustain life. Such a universe could only facilitate the progression of eternal beings in their mortal phase until matter in that universe becomes too tenuous. Whether an empty universe could serve any purpose for intelligences, spirits, or gods is another matter.

The cosmological natural selection theory of Smolin is patterned after the model of natural selection in biology. His theory was originally motivated by asking the question, "Where in science is there a successful solution to a problem of explaining improbable complexity?" Smolin hypothesizes that certain universes in the multiverse population are reproductively active. He suggests that, in those universes where black holes form, a child universe is created inside the event horizon of the black hole.

In this multiverse model, a child universe inherits almost the same values of the physical constants possessed by its parent, where slight variations of the values are akin to genetic drift in biological systems. Smolin asserts that the values of the physical constants that maximize black hole production (and therefore the birth rate of child universes) are also the values that permit the existence of life. He also suggests that the reproduction is not perfect but that random changes occur in the values of the constants. Thus, Smolin's model postulates reproduction with inheritance and mutation. Furthermore, Smolin claims that his theory "explains the values of all the parameters that determine low energy physics and chemistry: the masses of the proton, neutron, electron and neutrino and the strengths of the strong, weak and electromagnetic interactions."[107]

In his paper pitting the cosmological natural selection theory against the anthropic principle, Smolin is critical of other multiverse theories, claiming that eternal inflation is "supported neither by observation nor by firm mathematical results within a well defined theory of quantum gravity." Comparing the structure of the eternal inflation multiverse with his "bouncing black hole" multiverse, he states that a multiverse fashioned after his theory "looks like a family tree. Each universe has an ancestor, which is another universe." In contrast, in the eternal inflation multiverse, "each universe has the same ancestor, which is the primordial vacuum. Universes themselves have no descendants." In a critique of string theories, Smolin also claims that "a key problem has been constructing string theories that agree with the astronomical evidence that the vacuum energy (or cosmological constant) is positive."[108]

Smolin does not explicitly state whether his model posits a "first" universe or whether black holes have been producing child universes infinitely into the past because his model makes no assumption about what that "first" universe would have been. This means that "any universe in the collection, no matter what its own parameters are, is likely to spawn in time a vast family of descendants that after a while are dominated by those whose parameters are the most fit for producing black holes."[109]

The most striking aspect of a multiverse described by the cosmological natural selection theory is its structural resemblance to a biological system with parents and posterity, an earthly version of the "eternal family" structure in Mormonism. This aspect is attractive because the same familial structure found on earth and in the eternities is imitated in the multiverse itself. A form of this structure is present in the other multiverse theories too, but Smolin's theory seems to come closer to the mark in the respect that his theory even includes cosmological inheritance.

Concluding Remarks

The doctrine of eternal progression is the central tenet of Mormonism, a worldview that depicts the eternal existence of an infinite number of progressing beings who, by obedience to the laws and ordinances of the gospel, may ultimately become gods. The big-bang model is the currently accepted cosmological model of the universe, but some aspects of this model are inconsistent with the eternal progression doctrine. A single universe with a finite size and finite age cannot facilitate an infinite number of beings who have no beginning or end in time. An infinite spatial-temporal domain of some kind is required for an infinite number of eternal beings.

Recently developed multiverse theories, which hypothesize an ensemble of universes that could be eternal, may mitigate the situation. In a Mormon multiverse cosmology, a being who progresses to godhood brings about, either through one of the universe-generating processes described here or through some other process, a universe for which that deity has dominion and care. In this cosmology, our own universe is such a universe.

In fairness to Keith Norman, who underscores the conflict between Mormon doctrine and big-bang theory, he does allude to "other dimensions" and the possibility of "alternate universes existing in those other dimensions of reality" and claims, quite correctly, that "such ideas are highly speculative." He even says that "infinite universes could also allow for an endless regression of gods."[110] Norman made these comments twenty years ago when multiverse theories were in their infancy, or, in some cases, did not yet exist. Today these theories, while still speculative, are on firmer scientific ground.

As pointed out earlier, the primary tension between the eternal progression doctrine and a theory that hypothesizes an eternal multiverse is the mathematical/philosophical argument against an actual temporal infinity. While it is difficult to comprehend the notion of infinite time, it is even more difficult to comprehend how there can be an ultimate beginning, a time at which there was no existence. Clearly, there is *something* now, so how could there be a time when there was *nothing?* As Talmage said, "From nothing, nothing can be derived." Even though the concept of infinite existence is difficult to grasp, it seems vastly more reasonable and logical than the alternative that existence sprang from nonexistence. If the beginning of a thing is postulated, then the cause of that thing is demanded, and so on into the past, leading to an infinite regression, which naturally leads to the idea of endless existence captured by the doctrine of eternal progression.

The thesis that a multiverse theory is needed to harmonize the Mormon doctrine of eternal progression with cosmology is controversial and incomplete. Moreover, the physical and mathematical principles underlying multiverse theories are complex and, in the opinion of some scientists and philosophers, largely speculative. The major scientific challenge with any multiverse theory is *verifiability*, which ultimately means that the major challenge is *observability*. Scientists cannot authoritatively state that other universes exist without observing them. Particle physics, a branch of physics dealing with subatomic particles, has largely advanced by theorizing the existence of such particles and then detecting them later in carefully designed experiments. How does one design experiments to detect other universes? Perhaps we will never detect other universes directly but only infer their existence from indirect evidence.

If other universes are never detected (which is entirely possible), it does not mean, from a logical point of view, that they do not exist. The maxim, "absence of evidence is not evidence of absence" applies here. Astronomer Owen Gingerich states, "In science, then, as in life generally, we do our best to create a picture that makes sense even when we don't have all the pieces of the puzzle in hand. The same principle applies to religious faith."[111] Echoing this idea, Hollis Johnson states, "It is essential to realize that both the scientific and the religious canons of knowledge are incomplete, and it would be wrong to assume that either gives definitive answers about the other."[112] Archaeologists have not discovered any metal plates with reformed Egyptian characters in the Americas, but they could still exist in this region. Even if these relics are never found, the Mormon believer accepts the Book of Mormon, with its description of Nephites, Lamanites, and other ancient peoples, by faith.

If other universes are never found, the believer would have to take on faith the concept that an eternal domain of some kind exists to affirm a core Mormon doctrine. The Latter-day Saint who wrestles with the science-religion interface in any form (cosmology, organic evolution, cloning, etc.) may take some comfort in the words of Elder Neal A. Maxwell, who declared: "It would be unwise, of course, for the Church to tie itself to the provisional truths of science at any point in science's unfolding history. Ultimately, scientific truth will align with divinely revealed truth; meanwhile we can applaud genuine scientific advances, noting them without depending overly much upon them."[113]

In a Mormon multiverse cosmology, many questions remain open. Are there communication and movement of the gods and other premortal and postmortal beings between universes? When a universe experiences a big crunch or big freeze, does the god of that universe generate a new universe or "relocate" to another universe fit for carrying out the "great plan of happiness" for a new household of spirit children? Did God, our Father in Heaven, achieve godhood in this universe or a prior one? If God was exalted in a prior universe, how many universes has he governed? Jesus Christ is the redeemer for this universe, but is he the redeemer for others? Are some universes "stillborn" in the sense that they do not have the required values of the physical constants for a universe capable of sustaining life? Because the multiverse is infinite, are there replicas of us in other universes as postulated by the replication paradox?[114] Cosmologists speculate whether the physical laws are the same across the ensemble of universes, but what about the spiritual laws? Are the spiritual laws "multiversal" or just "universal"? As multiverse cosmologies develop scientifically, these questions and others will stimulate much discussion.

On some level, a Mormon multiverse cosmology is a beautiful construct that imbues even physical reality with familial relationships. That universes have "ancestors" and "progeny" like the progressing beings that inhabit them is wondrous to ponder. As Andrei Linde quips, "Universes can have babies—it's nice."[115]

Notes

1. Lisa R. Adams, "Eternal Progression," in *Encyclopedia of Mormonism,* 4 vols. (New York: Macmillan Publishing, 1992), 2:465–66.

2. Brigham Young, January 26, 1862, *Journal of Discourses,* 26 vols. (London and Liverpool: LDS Booksellers Depot, 1855–86), 9:168.

3. Joseph Smith, *The King Follett Discourse* (Salt Lake City: Magazine Printing Co., 1963), 8, 10.

4. John Taylor, February 19, 1860, *Journal of Discourses,* 8:3.

5. John A. Widtsoe, *A Rational Theology* (Salt Lake City: Presiding Bishop's Office, 1926), 25.

6. John A. Widtsoe, *Evidences and Reconciliations* (Salt Lake City: Bookcraft, 1987), 182–83.

7. Hugh B. Brown, *Conference Report* (Salt Lake City: Church of Jesus Christ of Latter-day Saints, semi-annual), April 1956, 103–6.

8. Stephen L Richards, *Conference Report*, April 1938, 20–26.

9. Joseph B. Wirthlin, "The Time to Prepare," *Ensign*, May 1998, 14.

10. M. Russell Ballard, "The Atonement and the Value of One Soul," *Ensign*, May 2004, 84.

11. Boyd K. Packer, "Do Not Fear," *Ensign*, May 2004, 77.

12. Widtsoe, *A Rational Theology*, 23.

13. Marion G. Romney, "Jesus Christ, Lord of the Universe," *Improvement Era*, November 1968, 46.

14. Neal A. Maxwell, "Special Witnesses of Christ," *Ensign*, April 2001, 4.

15. Keith E. Norman, "Mormon Cosmology–Can it Survive the Big Bang?" *Sunstone* 10, no. 9 (1985): 19–23.

16. Paul Copan and William Lane Craig, "Craftsman or Creator," in *The New Mormon Challenge*, edited by Francis J. Beckwith, Carl Mosser, and Paul Owen (Grand Rapids, Mich.: Zondervan, 2002), 95–152.

17. Joseph Silk, *The Big Bang* (New York: W. H. Freeman, 1989), 1.

18. S. M. Faber, "The Big Bang as Scientific Fact," in *Cosmic Questions*, Vol. 950 of the *Annals of the New York Academy of Sciences* (New York: New York Academy of Sciences, 2001), 39.

19. Helge Kragh, *Cosmology and Controversy* (Princeton, N.J.: Princeton University Press, 1996), 10.

20. The red shift phenomenon is similar to the Doppler effect in which the frequency or pitch of a sound wave is lowered or raised as the observer moves away from or toward the source.

21. Kragh, *Cosmology and Controversy*, 11–12.

22. Ibid., 24–27.

23. Georges Lemaître, "Un univers homogène de masse constante et de rayon croissant rendant compte de la vitesse radiale des nébuleuses extra-galactiques," *Annales de Société Scientifique de Bruxelles* 47 (1927): 49.

24. Kragh, *Cosmology and Controversy*, 31.

25. Edwin Hubble, "A Relation between Distance and Radial Velocity among Extra-galactic Nebulae," *Proceedings of the National Academy of Sciences of the USA* 15 (1929): 168–73.

26. From Fred Hoyle's radio program on cosmology for the BBC in 1949. Scripts from this program were published in the monograph *The Nature of the Universe* (Oxford, Eng.: Blackwell, 1951).

27. Paul Davies, *The Mind of God: The Scientific Basis for a Rational World* (New York: Simon & Schuster, 1992), 50.

28. G. Gamow, "Expanding Universe and the Origin of Elements," *Physical Review* 70 (1946): 572–73.

29. A temperature of 5 K denotes a temperature of five degrees above absolute zero on the kelvin (K) scale. Absolute zero, 0 K, is the lowest temperature possible.

30. A radio telescope is an antenna that detects electromagnetic radiation in the radio band of wavelengths, while an optical telescope detects electromagnetic radiation in the visible band of wavelengths.

31. A. A. Penzias and R. W. Wilson, "A Measurement of Excess Antenna Temperature at 4080 mc/s. (Effective Zenith Noise Temperature of Horn-Reflector Antenna at 4080 mc Due to Cosmic Black Body Radiation, Atmospheric Absorption, etc.)," *Astrophysical Journal* 142 (1965): 419–21.

32. R. V. Wagoner, W. A. Fowler, and F. Hoyle, "On the Synthesis of Elements at Very High Temperatures," *Astrophysical Journal* 148 (1967): 3–49.

33. J. R. Gott III, J. E. Gunn, D. N. Schramm, and B. M. Tinsley, "An Unbound Universe?" *Astrophysical Journal* 194 (1974): 543–53.

34. Alan H. Guth, "Inflationary Universe: A Possible Solution to the Horizon and Flatness Problems," *Physical Review* 23 (1981): Part D, 347–56; Alan H. Guth, *The Inflationary Universe* (New York: Perseus Books, 1997).

35. A. MacRobert, "Turning a Corner on the New Cosmology," *Sky and Telescope* 105 (May 2003): 16–17.

36. Ned Wright's cosmology tutorial, posted January 11, 2005, retrieved in January 2005 from http://www.astro.ucla.edu/~wright/ cosmolog.htm#News.

37. Simon Singh, *Big Bang: The Origin of the Universe* (New York: HarperCollins, 2004), 469, 471, 476.

38. P. James E. Peebles, "Making Sense of Modern Cosmology," *Scientific American* 12, no. 2 (December 2002): 2–4.

39. A. G. Riess et al., "Observational Evidence from Supernovae for an Accelerating Universe and a Cosmological Constant," *Astronomical Journal* 11 (September 1998): 1009–38.

40. Lawrence M. Krauss and Michael S. Turner, "A Cosmic Conundrum," *Scientific American* 291, no. 3 (September 2004): 71.

41. Martin Rees, "Exploring Our Universe and Others," *Scientific American* 12, no. 2 (December 2002): 82–88.

42. H. Bondi and T. Gold, "The Steady-State Theory of the Expanding Universe," *Monthly Notices of the Royal Astronomical Society* 108 (1948): 252–70; F. Hoyle, "A New Model for the Expanding Universe," *Monthly Notices of the Royal Astronomical Society* 108 (1948): 372–82.

43. Kragh, *Cosmology and Controversy,* 142.

44. F. Hoyle, G. R. Burbidge, and J. V. Narlikar, "A Quasi-Steady State Cosmological Model with Creation of Matter," *Astrophysical Journal* 410 (1993): 437–57.

45. Eric J. Lerner, *The Big Bang Never Happened* (New York: Random House, 1991), 14.

46. Ned Wright's cosmology tutorial.

47. Eric J. Lerner, "Bucking the Big Bang," *New Scientist* 182, no. 2448 (May 22, 2004): 20.

48. Karl Popper, *The Logic of Scientific Discovery*, 15th ed. (New York: Routledge, 2002), 57–73.

49. Frederick J. Pack, *Science and Belief in God* (Salt Lake City: Deseret News, 1924), title page.

50. John A. Widtsoe, *Joseph Smith as Scientist* (Salt Lake City: General Board, Young Men's Mutual Improvement Association, 1908), 156.

51. Brigham Young, February 1, 1857, *Journal of Discourses*, 4:202.

52. Brigham Young, March 14, 1871, *Journal of Discourses*, 14:116.

53. Brigham Young, June 17, 1866, *Journal of Discourses*, 12:257.

54. Orson Pratt, February 12, 1860, *Journal of Discourses*, 7:157.

55. David H. Bailey, "Science and Mormonism: Past, Present, and Future," *Dialogue: A Journal of Mormon Thought* 29, no. 1 (Spring 1996): 80–96.

56. Harold B. Lee, "I Dare You to Believe," USAC Baccalaureate Address, May 31, 1953, *Church News*, June 6, 1953, 4–5, 19.

57. Russell M. Nelson, *Perfection Pending, and Other Favorite Discourses* (Salt Lake City: Deseret Book, 1998), 231.

58. Attributed to Eden Phillpotts, quoted in John D. Barrow, *The World within the World* (Oxford, Eng.: Oxford University Press, 1988), 300.

59. Stephen Battersby, "Are We Nearly There Yet?" *New Scientist*, April 30, 2005, 30–34.

60. Smith, *The King Follett Discourse*, 20.

61. Ibid., 8, 19.

62. Kent E. Robson, "Time and Eternity," in *Encyclopedia of Mormonism*, 4:1478.

63. Joseph Smith Jr. et al., *History of the Church of Jesus Christ of Latter-day Saints*, edited by B. H. Roberts, 2d ed. rev., 6 vols. (Salt Lake City: Deseret News Press, 1902–12; 1948 printing): 3:387.

64. Paul Davies, *God and the New Physics* (New York: Simon and Schuster, 1983), 11, 18.

65. A finite universe should not be confused with an "unbounded" universe. Our universe is finite but unbounded, much like the surface of the earth. The earth's surface has a finite area, but it is not bounded, meaning that if you keep going in any particular direction, you end up where you started.

66. Lowell L. Bennion, *Introduction to the Gospel*, Course of Study for the Sunday Schools of the Church of Jesus Christ of Latter-day Saints (Salt Lake City: Deseret Sunday School Union Board, 1955), 47.

67. Paul Copan and William L. Craig, *Creation out of Nothing* (Grand Rapids, Mich.: Baker Academic, 2004), 9–10, 14–15.

68. James E. Talmage, *The Articles of Faith,* 42nd ed. (Salt Lake City: Deseret News Press, 1968), 33, 34.

69. Hollis R. Johnson, "The Big Bang: What Does It Mean for Us?" *FARMS Review* 16, no. 2 (2004): 296.

70. Martin Rees, *Before the Beginning: Our Universe and Others* (Reading, Mass.: Addison-Wesley, 1997), 161.

71. Blake T. Ostler, "The Doctrine of Creatio Ex Nihilo Is a Big Fuss Over Nothing. Part II: The Inductive Argument," a review of Copan and Craig's *The New Mormon Challenge,* retrieved from the Foundation for Apologetic Information and Research (FAIR) website in January 2005 from http://www.fairlds.org/apol/TNMC.

72. "Multiverse," *Reference.com.* Lexico Publishing Group, LL. (2005), retrieved January 29, 2005, from http://www.reference.com/browse/ wiki/multiverse.

73. Iona Miller and Richard A. Miller, "The Universe Is Obsolete," a paper prepared for *Nexus Magazine* (2003), retrieved in January 2005 from http://nwbotanicals.org/oak/newphysics/parauniverses.htm.

74. Martin Rees, *Our Cosmic Habitat* (Princeton, N.J.: Princeton University Press, 2001), 165, states: "There is a risk of semantic confusion here. The usual definition of 'universe' is of course 'everything there is.' It would be neater to redefine the whole enlarged ensemble as 'the universe' and then introduce some new term—for instance, 'the metagalaxy'—for the domain that cosmologists and astronomers can directly observe."

75. Rees, *Before the Beginning,* 3.

76. Michio Kaku, "What Happened before the Big Bang?" *Astronomy* 24, no. 5 (May 1996): 34–42.

77. Martin Rees, "In the Matrix," *Edge* 116 (May 19, 2003); available on http://www.edge.org/documents/archive/edge116.html.

78. Martin Gardner, "Multiverses and Blackberries," in his *Are Universes Thicker than Blackberries?* (New York: W. W. Norton & Company, 2003), 3, 9.

79. Paul Davies, "Chance or Creation? Only the Multiverse Knows for Sure," *Science and Theology News,* January 2005, 35.

80. Alexander Vilenkin, "Birth of Inflationary Universes," *Physical Review* 27 (1983): Part D, 2848–55; Andrei Linde, "Eternal Chaotic Inflation," *Modern Physics Letters* 1 (1986): Part A, 81–88.

81. Andrei Linde, "The Self-Reproducing Inflationary Universe," *Scientific American,* November 1994, 48–55.

82. Paul J. Steinhardt, "A Brief Introduction to the Ekpyrotic Universe," per-

sonal website, Department of Physics, Princeton University; retrieved in January 2005 from http://www.phy.princeton.edu/~steinh/ npr.

83. Michael D. Lemonick, "Before the Big Bang," *Discover,* February 2004, 35–41.

84. Lee Smolin, *The Life of the Cosmos* (New York: Oxford University Press, 1997), 92–106.

85. Lee Smolin, "Scientific Alternatives to the Anthropic Principle," July 29, 2004, retrieved in January 2005 from http://www.edge.org/ 3rd_culture/ smolin_susskind04/smolin_susskin.html.

86. Paul Davies, "Multiverse Cosmological Models," *Modern Physics Letters* 19 (March 2004): Part A, 727–44.

87. Martin Rees, "Living in a Multiverse," in *The Far-Future Universe: Eschatology from a Cosmic Perspective,* edited by George F. R. Ellis (Philadelpha: Templeton Foundation Press, 2002), 65–85.

88. Robin Collins, "Universe or Multiverse? A Theistic Perspective," retrieved in January 2005 from http://home.messiah.edu/~rcollins/ finetune/stanford%20multiverse%20talk.htm.

89. Linde, "The Self-Reproducing Inflationary Universe," 55.

90. Davies, "Multiverse Cosmological Models," 735–41.

91. Smolin, "Scientific Alternatives to the Anthropic Principle," 6, 15.

92. Simon Blackburn, *The Oxford Dictionary of Philosophy* (Oxford, Eng.: Oxford University Press, 1994), 268.

93. Gardner, "Multiverses and Blackberries," 9.

94. Robert P. Crease and Charles C. Mann, *The Second Creation* (New York: Macmillan, 1986), 168–69.

95. G. F. R. Ellis, U. Kirchner, and W. R. Stoeger, "Multiverses and Physical Cosmology," *Monthly Notices of the Royal Astronomical Society* 347, no. 3 (January 2004): 921–37.

96. Ibid.

97. Blake T. Ostler, "Do Kalam Infinity Arguments Apply to the Infinite Past?" Review of Copan and Craig's *The New Mormon Challenge,* on the website of the Foundation for Apologetic Information and Research (FAIR); retrieved on January 2005 from http://www.fairlds.org/apol/ TNMC/TNMC01.html.

98. Ellis, Kirchner, and Stoeger, "Multiverses and Physical Cosmology," 934.

99. Ostler, "Do Kalam Infinity Arguments Apply to the Infinite Past?"

100. Ellis, Kirchner, and Stoeger, "Multiverses and Physical Cosmology," 935.

101. In Linde's chaotic inflationary theory, the quantum vacuum gives rise to bubble universes through quantum events. But, as Rees explains, the quantum vacuum is a far richer construct than the "nothing" of the philosopher because it consists of particles and fields described by the equations of physics. If the quantum vacuum is not the absolute nothing of the philosopher, it must be some-

thing, even if only a set of physical laws. This leads one to wonder, "Where did the laws come from? Are the laws of the multiverse eternal? Can we say that the laws just *are?*"

102. Davies, *The Mind of God,* 61.

103. During a symposium sponsored by the John Templeton Foundation at Stanford, California, in 2003, Martin Rees quipped that he would stake his dog that a multiverse exists. After Paul Davies rejoined with a similar statement, Andrei Linde exclaimed, "I'd bet my life! That's what I've been doing all these years!"

104. Linde, "The Self-Reproducing Inflationary Universe," 54.

105. Arvind Borde and Alexander Valenkin, "Eternal Inflation and the Initial Singularity," *Physical Review Letters* 72, no. 21 (May 23, 1994): 3305–08.

106. Lemonick, "Before the Big Bang," 40.

107. Smolin, "Scientific Alternatives to the Anthropic Principle," 32.

108. Ibid.

109. Ibid., 100.

110. Norman, "Mormon Cosmology," 23.

111. Owen Gingerich, "Do the Heavens Declare?," in *The Book of the Cosmos,* edited by Dennis R. Richard (New York: HarperCollins Publishers, 2000), 527.

112. Johnson, "The Big Bang," 283–84.

113. Neal A. Maxwell, *Men and Women of Christ* (Salt Lake City: Bookcraft, 1991), 87–91.

114. John D. Barrow, *The Infinite Book* (New York: Pantheon Books, 2005), 155–76.

115. Andrei Linde, "Universe or Multiverse?" Paper presented at a symposium sponsored by the John Templeton Foundation held at Stanford University, March 26, 2003.