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GENERAL REVELATION AND THE ANTHROPIC COSMOLOGICAL PRINCIPLE: REASONS FOR OPTIMISM THAT GOD HAS MADE HIMSELF "KNOWN" TO EVERYONE

by Hal N. Ostrander, Ph.D.

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INTRODUCTION

The last quarter of the twentieth century is producing an increasing number of scholars characterized by a growing concern for ultimate questions, particularly with respect to those addressing the origin and destiny of the universe. These scholars include philosophers, theologians, and scientists alike, some demonstrating a surprising richness of proficiency in all three disciplines. With the entire cosmos as the object of their intense scrutiny, both on microcosmic and macrocosmic scales, a plethora of penetrating questions is raised at the bidding of these contemporary *metacosmologists*.[1] Why is the universe the way it is? Why does it appear to be finite? Why does it even exist at all? What are the driving forces behind space, time, matter, energy, and consciousness, and why are they so delicately balanced that the slightest difference in their fundamental makeup would prevent both the creation and perpetuation of life? Furthermore, what cosmic ingredients are necessary for a universe to exist, and how has it, been enabled to support intelligent life? Could there be a range of conceivable universes, each with its own potential for giving rise to special states of existence for various forms of conscious life? Is it possible to construct universes with different sets of natural laws in which life, intelligence, and self-consciousness could exist? And the questions go on interminably.

The purpose of the present study is not to provide answers to the above questions but to emphasize the fact that *the very createdness of the universe itself* can serve us well as the impetus for exploring such matters within theistic frameworks. The universe, then, insofar as it displays its "createdness" aspects by way of general revelation and by virtue of the kinds of questions it rightfully engenders as a result, gives us a number of reasons to be optimistic about the fact that God has indeed made himself "known" to us naturally, and this has always been the case.[2] But if

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[1] The term *metacosmologist* is meant as an all-inclusive term, signifying a person of broad scientific interests, namely, someone engaged in the study of metaphysics, cosmology, philosophy of science, physics and nature. Perhaps the best synonym for it is *quantum cosmologist*.

[2] Realize that the study's operative assumption agrees in principle with the overall approach taken by one of general revelation's finest advocates--Bruce Demarest. See Bruce Demarest, *General Revelation: Historical Views and Contemporary Issues* (Grand Rapids: Zondervan, 1982), 238-41. In brief, Demarest sets forth three comprehensive assertions with respect to general revelation: 1) human beings can properly perceive truth about God

the revelatory insights normally attributed to general revelation *per se* are viewed from the perspective of a single overarching, metacosmological rubric of sorts--that of the *anthropic cosmological principle*--they seem to take on a collective cogency far more energetic and effectual than at any previous time in the history of theological, philosophical and scientific trialogues.

The Anthropic Cosmological Principle

As fascinating as the above questions are, perhaps the supreme metacosmological question, cutting to the heart of all previous matters, is expressed in the philosophically familiar words, "Why is there something rather than nothing?" When such a question is placed before today's scientific community at large, it is usually examined within the paradigmatic confines of cosmic and/or biological evolution. Hence, it is appropriate to note that a relatively new interpretive approach is making its mark within the overarching paradigm of cosmic evolutionary studies.

As this new proposal attempts to answer the "Why is there something rather than nothing?" question, some believe that the solutions it provides are actually gaining the ascendancy, at least with respect to how the human race could have come to inhabit a cosmos initially and how the cosmos itself could have come to be instantiated so perfectly with a view to our continued existence. Others believe, however, that it by no means deserves being titled and touted so axiomatically as the "anthropic cosmological principle."3

Assuming the validity of its given designation, there are four recognized formulations of the ACP,4 but only two will be investigated for present purposes: the weak *anthropic principle* and the *strong anthropic principle.* These two versions of the ACP are defined as follows:

(1) The *weak anthropic principle* (WAP): "The observed values of all physical and cosmological quantities are not equally probable but they take on values restricted by the requirement that there exist sites where carbon-based life can develop and the requirement that the Universe be old enough for it to have already done so."

(2) The *strong anthropic principle* (SAP): "The Universe must have those properties which allow life to develop within it at some stage in its history."[5]

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from nature; 2) knowledge of God is mediated by general revelation; and 3) human beings consistently suppress all forms of general revelation in both nature and history.

[3] See especially John D. Barrow and Frank J. Tipler, *The Anthropic Cosmological Principle* (New York, Oxford University Press, 1989). This exhaustive work is interpreted by many as the 20th century's superior replacement to William Paley's 19th century classic text, *Natural Theology*. As Martin Gardner asks: "Just what is this anthropic principle that has become so fashionable among a minority of cosmologists, and is arousing such passionate controversy?" Martin Gardner, "WAP, SAP, PAP, and FAP," Review of *The Anthropic Cosmological Principle,* by John D. Barrow and Frank J. Tipler, *The New York Review of Books,* 8 May 1986, 22.

[4]As an acronym for the "anthropic cosmological principle," "ACP" will be used frequently throughout the study.

[5] Barrow and Tipler, 16, 21. Cf. John D. Barrow, "Anthropic Definitions," *Quarterly Journal of the Royal Astronomical Society* 24 (1983): 146-50. Barrow and Tipler, 22-23, define the other two formulations of the ACP as the *participatory anthropic principle (PAP):* "Observers are necessary to bring the Universe into being"; and the

This two-fold definition of the ACP, however, involves more than a simple cataloging of the invariant physical constants it seeks to outline. A number of metacosmologists are beginning to understand this, contending that certain ontological, cosmological, and teleological implications are more intrinsic to the ACP definitions than previously recognized, primarily the WAP and SAP.[6]

Historically, the first in-depth versions of anthropic principles committed to print can be traced back to R. H. Dicke's seminal article written in 1961,[7] but it was first given its said designation by physicist Brandon Carter in 1974.[8] Prior to instituting the Carter nomenclature, "anthropic" lines of reasoning had been applied for decades by such scientific notables as Alfred R. Wallace, Lawrence Henderson, George Wald, G. J. Whitrow, Sir Arthur Eddington, Paul Dirac, Sir Fred Hoyle, Edward R. Harrison, J. B. S. Haldane, Carl Sagan, *et al*., all of whom contributed to its "cosmic coincidences" line of argumentation and its growing list of physical properties seemingly intrinsic to the universe.[9] Since Carter's time, however, many thinkers have dismissed the ACP as "a mere curiosity,"[10] or have equated it with a "bootstrap" principle of sorts (an idea going back as far as the Greek philosopher Anaxagoras),[11] or have placed it within agnostic

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final anthropic principle (FAP): "Intelligent information-processing must come into existence in the Universe, and, once it comes into existence, it will never die out."

[6] Rather than continually referring to the Barrow/Tipler definitions, less technical explanations of the WAP and SAP will suffice at this point. When the weak and strong principles are subsequently referred to, the following definitions should be consulted: the weak version should be considered simply as the pure variables, the straight numbers that seem to have extremely improbable coincidental relations to the observed properties of the universe. In contrast, the strong version should be denoted as the organizing principle for why the fundamental constants and parameters of the universe *must* exist as they do.

Further clarification is provided by Milton Munitz who explains the SAP in this way: "The strong anthropic principle deals exclusively with *fundamental constants.* It seeks to show that the presence of life in the Universe is linked, in an explanatory way, with these constants. It seeks to explain the constants themselves by reference to the presence of life in the Universe." Milton K. Munitz, *Cosmic Understanding: Philosophy and Science of the Universe* (Princeton: Princeton University Press, 1986), 252-53 (emphasis original).

[7] See R. H. Dicke, "Dirac's Cosmology and Mach's Principle," *Nature* 192 (1961): 440-41. Cf. Paul A. M. Dirac, "The Evolution of the Physicist's Picture of Nature," *Scientific American,* May 1963, 45-53.

[8] See Brandon Carter, "Large Number Coincidences and the Anthropic Principle in Cosmology," in M. S. Longair, ed., *Confrontation of Cosmological Theories with Observational Data* (Dordrecht, Holland: D. Reidel, 1974), 291-98. Carter admits elsewhere that a better name for the overall principle would be "cognizability principle" rather than the already entrenched term "anthropic principle." Brandon Carter, "The Anthropic Principle and Its Implications for Biological Evolution," *Philosophical Transactions of the Royal Society of London* A 310:1512 (December 1983): 352.

[9] For a concise history of the ACP, see Patrick A. Wilson, "The Anthropic Cosmological Principle," Ph.D. diss., University of Notre Dame, 1989, 1-19.

[10] David A. Shotwell, "Is the Universe Improbable?" *The Skeptical Inquirer* 11:4 (Summer 1987): 380. B. J. Carr and Martin J. Rees state that the "[anthropic principle] may never aspire to being much more than a philosophical curiosity." B. J. Carr and Martin J. Rees, "The Anthropic Principle and the Structure of the Physical World," *Nature,* 12 April 1979, 612.

[11] "Today, the Bootstrap Principle says the universe operates on a sort of inner push-pull, inner necessity, inner knowledge principle, wherein progressive internal relations and operations tend to pull it up by its own bootstraps." Allen R. Utke, "The Cosmic Holism Concept: An Interdisciplinary Tool in the Quest for Ultimate Reality and Meaning," *Ultimate Reality and Meaning* 9:2 (June 1986): 150-51.

frameworks.[12] Regardless of how the ACP has been sketched out historically, a growing body of metacosmologists believes that "it's virtually impossible to avoid it in discussing the major issues of modem physics."[13]

Quantum Cosmology

Quantum cosmology is not only in search of what could be described as the "origination event" of the universe, but as the most sophisticated branch of theoretical physics it is equally concerned with how the universe has developed and maintained itself since its initially created time-frame. By way of investigation, today's quantum cosmologists often conduct their initial-moment-of-creation research on the level of quantum reality, as perplexing a microcosm as it is. The preeminent challenge faced by researchers on this level is that of identifying and measuring the stuff of which reality is made and determining why its microphysical constants are precise enough to hold the quantum world together (quite literally).

On the other hand, researchers at the cosmic level proceed to delve as deeply as possible into the complexities of how the universe developed into its present-day, large-scale structure, as vast a macrocosm as it is. The challenge here is not only accounting for the extraordinary vastness of the universe but also for the phenomenal accuracy of the physical cosmological constants and parameters that enables it to exist and sustain sentient life. The essential vision of quantum cosmology, then, is to account for these cosmic events and forces on both microcosmic and macrocosmic scales of reality, implying that a knowable theory of the entire universe will someday be achieved via the unification of all physics.[14]

A number of today's physicists and mathematicians are boldly seeking to establish such a theory of the universe, one that is simple and complete and in which the difficulties of quantum theory (Niels Bohr *et al.*) and relativity theory (Albert Einstein) will be synthesized mathematically to formulate what has been dubbed a *quantum theory of gravity,* the alleged missing component to a unified theory of the cosmos. Their eventual goal, which for some seems rather peremptory in nature, is to compile not only a reliable but a final recipe for the cosmos as well.

On the quantum level the ingredients for the recipe to date include four fundamental forces gravity, electromagnetism, and the subatomic strong and weak forces--which interact continuously with hundreds of atomic/subatomic particles in bizarre and unpredictable ways. At this level the recipe for reality is fuzzy and difficult to decipher; the quantum uncertainty built

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[12] John Barrow holds the position that "strong anthropic coincidences cannot be the basis of a cogent argument for God's existence from apparent anthropocentric design in the universe, although they are consistent with such a conclusion." John D. Barrow, "Life, the Universe, and the Anthropic Principle," *The World and 12* (August 1987): 186. As he develops his position further, 187, he concludes: "There cannot be an inevitable logical proof of God's existence, nor one of his nonexistence either. There will always be a choice about the credibility of assumptions."

[13] Tony Rothman, "A 'What You See Is What You Beget' Theory," *Discover*, May 1987, 90-99.

[14] "Humanity's deepest desire for knowledge is justification enough for our continuing quest. And our goal is nothing less than a complete description of the universe we live in." Stephen W. Hawking, *A Brief History of Time: From the Big Bang to Black Holes* (New York: Bantam Books, 1988), 13.

into these subatomic interactions often yield strange phenomena. The cumulative outcome, then, of all this curious quantum activity over a timescale, of apparently ten to fifteen billion years is nothing less than the universe as it appears today in all its astronomical grandeur.[15]

For the most part, metacosmologists agree that whatever cosmic evolutionary processes are in fact at work assembling the universe into its present form must not only be depicted in terms of having originated from a primeval cosmic explosion--the "big bang"--but must also be portrayed in terms of a continuous, law-sustaining cosmic nexus. In other words out of big bang cosmology emerges a universe of almost unfathomable axial dimensions as well as an equally unfathomable richness and diversity of life (at least on this one planet), and out of continuous law-like, nexal activity a universe of endless teleological diversity is cosmically extended.

The Anthropic Cosmological Principle and Quantum Cosmology

The present discussion, then, takes the position that the weak and strong versions of the ACP not only give us a stimulus to reflect upon the laws of nature that oversee the cosmos but also the opportunity to see our humanity in light of beneficent anthropic privileges. Simply put, did God create the universe in such a way that human beings, made expressly in his image, could enjoy a prominent contingency role in his cosmic undertakings?[16] Many theorists answer the question with a confirmed, "Yes!"

If such is the case, the ACP may be legitimately and actively engaged to reinterpret theories of universal origins in terms of what will be called a *theistic quantum cosmology,* the kind of cosmology that understands more fully the exceptional significance of the cosmic/anthropic constants and parameters than does its more naturalistic counterpart, quantum cosmology *per se.* Insofar, then, as the ACP may be construed as the operative or regulative principle for defining and propagating a theistically-based quantum cosmology, any new cosmology based on its redefining capacities could then serve as a theistic alternative to the now dominant cosmic/biological evolutionary paradigm, based as it is on the tenets of *methodological naturalism.*[17]

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[15] For a sweeping survey of how the universe is thought to be constructed, see Herbert Friedman, *The Astronomer's Universe: Stars, Galaxies, and Cosmos* (New York: Ballantine Books, 1990).

[16] As Eman McMullin states, "if the universe is taken to be the work of a Creator who wills that conscious life should develop in it, then the presence of such life would in this sense 'explain' the co-presence in the universe of whatever physical features are necessary as means to that end. In the traditional Christian perspective, the act of Divine Creation has man as its focus." Eman McMullin in Arthur R. Peacocke, ed., "How Should Cosmology Relate to Theology?" in *The Sciences and Theology in the Twentieth Century* (Notre Dame: University of Notre Dame Press, 1981), 44.

[17] According to John Newport, naturalism takes on several forms, but naturalism *per se* "consider[s] the natural world to be the whole of reality. It also . . . see[s] its method as the only valid approach to understanding reality." John P. Newport, *Life's Ultimate Questions*: *A Contemporary Philosophy of Religion* (Dallas: Word, 1989), 137. In keeping with Newport's interpretation, naturalism manifests an inflexible closed-mindedness to the supernatural. For a thorough analysis of "methodological naturalism," see J. P. Moreland, "Theistic Science & Methodological Naturalism," in J. P. Moreland, ed., *The Creation Hypothesis: Scientific Evidence for an Intelligent Designer* (Downer's Grove, Illinois: InterVarsity Press, 1994), 41-66.

Cosmic Coincidences and Anthropic Cosmology[18]

En route to a more comprehensive interpretation of the ACP, trained mathematicians are more likely than the average person to understand mathematical expressions of the universal constants and parameters *per se,* but theologians and philosophers at least make attempts to explore their many and varied implications. As a consequence, efforts are being launched to develop and promote anthropic cosmologies that use the cosmic coincidences and their apparent "design" characteristics to best advantage, the advantage of a theistically-interpreted universe. For instance, on the one hand, theist Patrick Wilson believes "there must be some hard-to-define features of human beings that . . . are what make the possibility of *our* presence in the universe significant enough to call for an anthropic sort of explanation,"[19] even as more overtly Christian positions are being espoused by others.[20]

On the other hand, certain well-known opponents to Christian faith also perceive the import of the anthropic constants and parameters.[21] In view of all the possibilities, arguments for the ACP's validity are beginning to emerge out of interpretive contexts fraught with religious implications, resulting in a synthesizing perspective that sees the ever-growing number of verified constants and parameters as having been cosmically engineered into the overall operation of the universe with a mathematical precision nearing that of sheer perfection.[22] For many, the collective forcefulness of their delicate values points convincingly to a divinely instantiated anthropic design for the universe.

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[18] See Appendices One and Two.

[19] Patrick A. Wilson, "What is the Explanadum of the Anthropic Principle?" *American Philosophical Quarterly* 28:2 (April 1991): 169-70. Wilson's greater concern, however, is for establishing permanent criteria by which certain of these features (e.g., intelligence, morality, consciousness, etc.) may be adjudged valuable enough for inclusion in the ACP's claim to being an *ipso facto* principle. Wilson also demonstrates, 168, that the ACP, in all of its versions corporately, betrays both teleological and anthropocentric concerns: the teleological, "insofar as the very notion of fine tuning is intimately linked to a person or principle responsible for the tuning," and the anthropocentric to the degree that the necessary conditions for galaxies and stars, and even cats and dogs, "can . . . be seen as fine tuning just as much for these objects as for human beings."

[20] For instance, W. Jim Neidhardt transforms the various anthropic principles into what he calls the "extended theistic principle," arguing that it "represents a comprehensive integration of the 'anthropic evidence' and biblical revelation. But this . . . principle will only be accepted as knowledge in communities that acknowledge the validity of all experience, including religious experience, and that, furthermore, perceive all reality to be open-ended in structure always pointing beyond to a transcendent order that provides its meaning." W. Jim Neidhardt, "The Anthropic Principle: A Religious Response," *Journal of the American Scientific Affiliation* 36:4 (December 1984): 206.

[21] Atheist J. L. Mackie affirms: "There is only one actual universe, with a unique set of basic materials and physical constants, and it is therefore surprising that the elements of this unique set-up are just right for life when they might easily have been wrong." J. L. Mackie, *The Miracle of Theism: Arguments For and Against the Existence of God* (Oxford: Clarendon Press, 1982), 141.

[22] Vincent Cronin refers to these constants and parameters as those "knife-edge factors prerequisite for life built in to the cosmos." Vincent Cronin, *The* View *from Planet Earth: Man Looks at the Cosmos* (New York: William Morrow, 1981), 10. Cronin concludes, 305, that these factors would "have had to intermesh in space and time in order to provide those narrow margins within which [the] living . . . can exist."

THE ANTHROPIC COSMOLOGICAL PRINCIPLE AND QUANTUM COSMOGENESIS

Even in light of what contemporary science has ascertained with respect to the secret machinery of the cosmos and its uniform operation, the question--"Why is there something rather than nothing?"--is still undoubtedly the ultimate question lying back of a cosmic genesis, a question suggesting the fact that the existence of the cosmos is by no means self-explanatory.[23] In addition, it is a question that must be addressed directly.

A working definition of the term *quantum cosmogenesis* is therefore in order. An obvious synonym is simply that of the word *creation,* but a fuller definition is more difficult to come by and will always sacrifice its definitional clarity on the altar of lack of completeness, an incompleteness intrinsic to the very universality of the concept. Beginning with the definition of *quantum cosmology* provided by James Hartle, quantum cosmogenesis may be said to focus in on the self-same following elements:

> We aim, in quantum cosmology, to provide a theory of the initial condition of the universe which will predict testable correlations among observations today . . . . These include the large scale homogeneity and isotropy of the universe, its approximate spatial flatness, the spectrum of density fluctuations that produced the galaxies, the homogeneity of the thermodynamic arrow of time, and the existence of classical spacetime.[24]

In other words, the more familiar definition of quantum cosmology can be utilized as the basis for determining the definitional boundaries of quantum cosmogenesis, the major difference between the two concepts only being a shift in emphasis. Quantum cosmogenesis, then, requires something of an increase in focus, one that not only takes the elements of quantum cosmology into account but also sharpens its vision more in the direction of the very moment of creation itself. How that singular moment affects subsequent spacetime events can be explained best by incorporating a set of insights derived only from the triune sharing of philosophy, theology and science as disciplines.[25] The moment of creation, therefore, involves both the realm of the quantum world and the realm of the cosmos at large, hence the term -*quantum cosmogenesis.*[26] In turn, quantum cosmogenesis must be examined in terms of the interpretive framework for creation it has produced--"big bang" cosmology.

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[23] Howard J. Van Till, Robert E. Snow, John H. Stek, and Davis A. Young, *Portraits of Creation: Biblical and Scientific Perspectives on the World's Formation* (Grand Rapids: Eerdmans, 1990), 122.

[24] James B. Hartle, "The Quantum Mechanics of Cosmology," in S. Coleman, ed., *Quantum Cosmology and Baby Universes* (Teaneck, New Jersey: World Scientific, 1991), 67.

[25] "Theoretical cosmology is but the starting point fro deeper philosophical inquiries." E. A. Milne, *Relativity, Gravitation and World Structure* (Oxford: Clarendon Press, 1935), 140.

[26] "The very largest structures of nature appear to be inextricably linked to the very smallest. Because of this symbiotic relationship between the sciences of the macro- and micro-worlds cosmologists and elementary particle physicists have joined forces in their quest to elucidate the earliest moments." John D. Barrow and Joseph Silk, *The Left Hand of Creation: The Origin and Evolution of the Expanding Universe* (New York: Basic Books, 1983), 214.

Big Bang Cosmology

By way of introduction, big bang cosmology is a catch-all term for models of the universe that reason backward from the speed at which countless galaxies are presently moving apart to postulate a time--or better, a beginning of time--when all matter and energy were contained in a superdense, primeval mass which has come to be known as a "singularity." For some reason this singularity (or "cosmic egg" in less scientific nomenclature) eventually exploded cataclysmically, with the cosmic blast apparently emerging out of a set of unknown initial conditions within the singularity to create the very set of manifest spacetime conditions necessary for galaxies, stars, and planets to form.[27]

Adherents of such a cosmology believe that the big bang explosion occurred anywhere from eight to twenty billion years ago, with either limit of the spectrum accounting in different ways for the time needed to structure the still-expanding universe into its present large-scale form. Contemporary metacosmologists seek to describe the whole process mathematically by constructing frameworks of explanation broad enough to support the big bang theory's credibility. With regard to the universe having had a beginning, an actual creation moment in spacetime, the mathematics involved becomes so ingenious and complicated that many of the world's top theoretical physicists are challenged by the deductive sequences they present. In large measure these mathematical sequences stem primarily from Einstein's relativity theories and their consequent field equations.

The Initial Moment of Creation

Questions surrounding the initial moment of creation from the perspective of big bang cosmologies are bound up necessarily with both the theoretical and observational sides of quantum cosmology, each of which attempts to explore the subsequent unfolding and ultimate fate of the universe in terms of what transpired post-quantum cosmogenesisly, that is, within a few milliseconds of the creation event itself.[28] But this does not preclude, from the theoretical side at least, the possibility of pursuing cosmological models featuring a first-moment-in-time

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[27] As Jayant Narlikar formulates it: "So we have the following description of a big bang Universe. At an epoch, which we may denote by $t = 0$, the Universe explodes into existence. . . . The epoch $t = 0$ is taken as the event of 'creation.' Prior to this there existed no Universe, no observers, no physical laws. Everything suddenly appeared at $t = 0$. The 'age' of the Universe is defined as the cosmic time which has elapsed since this event. . . . Although scientists are not in the habit of discussing the creation event or the situation prior to it, a lot of research has gone into the discussion of what the Unvierse was like immediately after its creation." Jayant V. Narlikar, *The Structure of the Universe* (Oxford: Oxford University Press, 1977), 125. Interestingly, Narlikar makes it clear elsewhere that "the $t = 0$ instant does not warrant 'miracles' or 'divine intervention'." Jayant V. Narliker, "The Concepts of 'Beginning' and 'Creation' in Cosmology," *Philosophy of Science* 59:3 (September 1992): 366.

[28] Narlikar, one of the big bang's most ardent opponents, complains that too many cosmologists are ignoring the real creation event for the sake of focusing in on the sequence of spacetime events immediately following it, i.e., post-creation events. He remarks: "The most fundamental question in cosmology is, 'Where did the matter we see around us originate in the first place?' This point has never been dealt with in the big bang cosmologies in which, at $t = 0$, there occurs a sudden and fantastic violation of the law of conservation of matter and energy. After $t = 0$ there is no such violation. By ignoring the primary creation event most cosmologists turn a blind eye to the above question." Narlikar, *The Structure of the Universe,* 136-37.

construct, "an instant that has no temporal predecessor," although the observational side of such primordial constructs lacks indisputable empirical support.[29]

A Spacetime Singularity Creation

Inasmuch as the spacetime singularity creation event allowed the present configuration of the spacetime cosmos to arise and take shape within a set of seemingly prearranged mathematical parameters, it is viewed by some as the perfect mathematical event. Created human realities, as finitudinally and temporally ensconced as they are by three dimensions of space and one of time, are mirrored clearly by a certain indispensableness of contingency within creation, the kind of necessity that calls for a series of anthropic restraints to work out the preconditions for our existence within a spacetime dimensionality, the actual *place* of our existence.

In addition, a set of creation parameters manufactured and laid out for the very possibility of importing human existence *into* a four dimensional universe, more specifically a nine to ten planet solar system, is required for the eventual creation of a habitat for humankind. Some metacosmologists purport that both sets of creation parameters, when considered *in toto* statistically, border on one chance in infinity of having been constructed to such levels of anthropic near-perfection; the window for human existence in the cosmos/solar system is indeed narrow. If any other set of universal conditions (i.e., other than those listed in Appendices One and Two) had prevailed at the singularity, "the cosmos would have winked out of existence the instant after it had been created."[30]

This raises a serious question: How did the initial conditions of the singularity, characterized by particular ACP-parameters, get so prearranged prior to the big bang explosion, so much so that they virtually guaranteed the continued existence of the universe after the blast, much less sending it on its way to becoming the future home of the human species? And how did the singularity's initial conditions determine (predetermine?) the configuration of the cosmos during those exceedingly important post-creation micromoments? However these questions are eventually answered in the future, responses will not be found in the notion that the naked singularity itself qualifies as deity but the answers reasonably point in the direction of God's existence.

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[29] Adolf Grünbaum, "The Pseudo-Problem of Creation in Physical Cosmology," *Philosophy of Science* 56:3 (September 19889): 380 (emphasis original). As Hawking once affirmed: "If, as is the case, we know only what has happened since the big bang, we could not determine what happened beforehand. As far as we are concerned, events before the big bang can have no consequences, so they should not form part of a scientific model of the universe. We should therefore cut them out of the model and say that time had a beginning at the big bang." Hawking, *A Brief History of Time*, 46.

[30] George Greenstein, *The Symbiotic Universe: Life and Mind in the Cosmos* (New York: William Morrow, 1988), 135.

The Planck Era Barrier

Named after Max Planck,[31] *Planck time is* defined as that infinitesimally small moment of time (10^{-43} second) after the big bang in which, as far as the operational laws of physics are concerned, the cosmos was born. It is the smallest quantity of time imaginable with any intracosmic signification, a time when there was no earlier time, at least that can be defined meaningfully. Theoretically, then, the Planck era was that incomprehensibly small time frame from the actual big bang creation moment, $t = 0$ up to 10^{-43} second, a time represented mathematically by the inequality, $[\, t \,] < t_p$.

The initial conditions of the cosmos during the Planck era are almost entirely unknown, but there is unanimity among cosmologists that regardless of what conditions did in fact prevail at the time, the Newtonian-framed law of conservation of matter and energy and the accepted rules of general relativity were explicitly violated.[32] Then, an instant after 10^{-43} second after the big bang, the universe would have then begun following conventional laws of physics. Hence, the Planck era may not be spelled out comprehensively enough by researchers until a theory of quantum gravity is achieved, and if the theory is brought to light at all, it will come through yet simpler mathematical theories as well as further quantal experiment.[33]

Closely associated with Planck time is the concept of *Planck length.* Planck length is defined as the distance light can travel in 10^{-43} second; it is that tiny stretch of spacetime (10^{-33} cm) into which the entirety of the mass-energy of the universe was once compressed so that the tremendous gravitational forces at work had to be counterbalanced almost exactly with the force of the big bang's outward expansion rate.[34] Planck length, then, is the complement to Planck time in that it also demands a theory of quantum gravity in order for it to be a workable unit of spacetime measurement so close to $t = 0$, the ultimate creation moment.

In summary, the Planck barrier represents a very important aspect of quantum cosmology, serving to drive cosmologists in the direction of formulating theories of quantum gravity. But, in turn, theories of quantum gravity incite at least some quantum cosmologists to acknowledge the very existence of God. Anthropic parameters, then, somehow embedded deep inside the initial

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[31] Max Planck was the German physicist (1858-1947) who discovered that radiation in its various forms is emitted in discrete bundles or packets of energy called *quanta*. His story is told in Leon Lederman, *The God Particle: If the Universe Is the Answer, What Is the Question?* (New York: Houghton Mifflin, 1993), 146-49.

[32] It is believed that the initial gravity of the universe at the Planck era (10^{-43} second) was 1027 times greater than the present gravity of the earth. No *natural* force of conventional physics, says Mark Mahin, would have been sufficient to overcome even a tenth of this gravitational pull in order to allow the cosmic expansion to proceed. Mark Mahin, *The New Scientific Case for God's Existence* (Boston: Mindlifter Press, 1985), 36.

[33] "We need a theory of quantum gravity instead of classical general relativity to extrapolate our model to epochs earlier than t_p." Narlikar, "The Concepts of 'Beginning' and 'Creation' in Cosmology," 369. Other scientists agree: "Although physicists have devised quantum theories that unite three of the forces [electromagnetism, the weak nuclear force, and the strong nuclear force], one by one, through eras going back to the Planck Time, they have so far not been able to bring gravity into the fold. To do so, they must reconcile the laws of quantum mechanics, which operate at microcosmic scales, and Einstein's theory of gravitation." George Constable and Ellen Phillips, eds., *Voyage Through the Universe--The Cosmos* (Richmond, Virginia: Time-Life Books, 1988), 105.

[34] Gribbin, *In the Beginning*, 166.

conditions of the singularity, seem to take on the robust status normally accorded only to laws of nature. As Corey states: "[T]he laws of Nature had to have been in existence prior to the initial unfolding of the Big Bang," that is, they "must have in some sense *preceded* the actual Big Bang itself" so that when the explosion did in fact take place "[the singularity] would . . . have been able to explode in such a precise and coherent manner as to produce our miraculous life-supporting universe."[35] Subsequently, those same laws of nature would have begun to coalesce and stabilize themselves into the conventional laws of physics known to be operative today.

Briefly, then, the 10^{-43} second Planck era and the 10^{-33} cm Planck length are prime examples of fundamental constants that must have in some sense existed prior to the big bang in order to have later become essential ingredients for the exploding singularity, for cosmogenesis itself. What still needs to be explained, however, is how the cosmic egg singularity came into existence in the first place, simply to be there awaiting its chance explosion. Not only this, but how could the singularity have been imparted its existence in a way that insured the ACP parameters/laws of nature/fundamental constants having been embedded deeply within it as part of its primordial characteristics, as elemental pieces of its "cosmic eggishness"? The answer compels the serious thinker toward considering the reasonableness of God's existence.

CONCLUSION

On the SAP and the WAP

Concerning the strong anthropic principle, there is a sense in which it is already a theistic form of the ACP, because it can be defined and implemented as such from the outset. But it is not simply a matter of definitional perspective operating here; it is also a matter of ideological ground motive, a factor that comes into play openly when it becomes necessary to begin interpreting the *must* aspect of the SAP definition. There are two options for interpreting the *must*: either the *must* must connote a cosmic evolutionary force at work within a coincidentally ACP-parametered universe, or it must have a theistic connotation for the same, with the ACP parameters taking on intentioned aspects over against coincidental ones. Granted the universe *must* possess those characteristics which enable it to support human life (since we are actually here), the question then becomes, "Who or what drives the *must*, God or chance cosmic evolution?"

Theistic versions of the ACP provide an answer to the question of how an emerging universe came to be so poised initially for a fine-tuning process of sorts, that is, for an anthropically-guided quantum cosmogenesis. In order for the ACP to instantiate its anthropic-driven constants into the proto-spacetime universe at $t = 0$, the principle must be assumed to have been fully in place and quantumly operative at the creation moment itself, the very moment of quantum cosmogenesis. As this organizing principle for the cosmos awaited its

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[35] M. A. Corey, *God and the New Cosmology: The Anthropic Design Argument* (Lanham, Maryland: Rowman & Littlefield, 1993), 129-30 (emphasis original).

appointed emergence from deep within the naked singularity, the SAP became mediately responsible for the optimal arrangement of fundamental constants and WAP descriptive variables now seen to be universally extant.

With this optimal arrangement being built into the cosmic blueprint from the very beginning, ACP constants seem to achieve a *maximal triadic consonance* in their outworking: 1) they obeyed God's originating, spoken command (as recorded in Gen. 1:3); 2) they brought the infant cosmos into being by way of a *creatio ex nihilo modus operandi;* and 3) they configured the whole of the geospatial cosmos over the course of some unascertained period of time. The universe, then, *must* be seen to have been anthropically engineered by God for the sake of the eventual creation of human beings, which, of course, also had its appointed time. It is as if anthropic principles take on the accouterments of a deeper physical mechanism whose purpose it is to fix the apparent parameters of the constants so that human beings can exist within the cosmos.

TOWARD A THEISTIC QUANTUM COSMOGENESIS

Quantum Cosmogenesis as Biblically Warranted

In the context of present concerns, because the cosmos is finite though unbounded (as the equations of Einstein, Hawking, Roger Penrose, *et al.* have established), it is reasonable to see the universe as something within the purview of the comprehensible, as being within reach of the discriminable. It is something the human mind can in fact delineate.[36] In keeping, then with the spirit of the incisive statement--"We have no reason to suppose that the rationality of the world is a human artifact"[37]--it becomes legitimate to compare and contrast, if not openly equate, the statement of Genesis 1:1--"In the beginning God created the heavens and earth"--to the whole of things described by cosmology proper.[38] One noted scientist even affirms that the stress placed by Genesis, chapter one, on "a 'beginning' and the initial roles of 'void,' 'light,' and a 'structureless' state, may be uncannily close to the verified evidence with which modern science has already supplied us."[39] In short, the pursuit of quantum cosmogenesis is biblically warranted and may be explored, modified, and redefined as warranted within theistic frameworks only.

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[36] Hugo Meynell places this notion within an apologetics context saying: "Where theism at least is concerned, the stress in apologetics. . . is an explanation for the intelligibility of the world, rather than. . . accounting for the gaps in that intelligibility." Hugo Meynell, "More Gaps for God?" in John M. Robson, ed., *Origin and Evolumtion of the Universe: Evidence for Design?* (Kingston: McGill-Queen's University Press, 1987), 253.

[37] John Polkinghorne, *Science and Creation*, 26.

[38] T. F. Torrance, ed., *Theology and Science at the Frontiers of Knowledge*, vol. 10, *Creation and Scientific Explanation*, by W. P. Carvin (Edinburgh: Scottish Academic Press, 1988), 99.

[39] Benjamin Gal-Or, *Cosmology, Physics, and Philosophy* (New York: Springer-Verlag, 1981), 5. Gal-Or is a physicist employed by the Jet Propulsion Laboratory, Technion-Israel Institute of Technology, Haifa, Israel.

Supracosmic Transcendence

If an ACP model is designated, in turn, as the basis for reinterpreting what scientific disclosures of naturalistic quantum cosmologies bring to us--transforming them logically and empirically into arguments for a theistic quantum cosmogenesis by virtue and permission of the apologetic mandate established in 1 Pet. 3:15), then the ACP variables (as outlined by its weak version) and the ACP constants (as supplied by the stronger version) may be understood to have been creationally and cosmically instantiated *ex nihilo* at $t = 0$, and to have unfolded accordingly and subsequently via an ACP-delineated, God-sanctioned process seemingly spanning aeons of cosmic time. If this is the true cosmic picture, then an ACP-eventuality of such magnitude and universal consequence should be understood as *the defining moment for the cosmos and human race*; it is the point at which the manifold structural objectives of the universe were first introduced and set in motion, even as they are now being carried through to completion as if the cosmic drama had no other alternatives available to it for playing. Moreover, if this kind of an ACP-defined, spacetime inaugural event came about at the instigating hands of a Being transcendent to the material universe, then big bang cosmology has just entered (unknowingly for many of its adherents) the jurisdiction of metaphysics. It suddenly becomes bare cosmogenesis laying hold of theistic explanatory opportunity, only to regard the existence of something or someone *before* the big bang as an undeniable cosmogonic possibility. Insofar, then, as ancient-to-current cosmic structures were instantiated (instanced?) and developed across epochal time according to God's will and power, they were also simultaneously and operationally defined by a universal set of theistically-devised ACP constants and parameters, the very ones necessary for human beings to have a place to live someday on the grand scale of a universe.

Insofar, then, as it is recognized that the cosmos itself provides no self-caused cause for its own ACP parameters, it must be understood to have received its humanity-engendering variables and constants for human *being,* both ontologically and materially, from something transcendent to it. Hence, to conclude that such a *supracosmic transcendence* is capable of being expressed to some extent in quantum cosmological terms is to attempt to resolve the difficult issues associated with it by moving either above, or beyond, or perhaps behind the Planck era itself to postulate a time of sorts (an omnitime?) even before the big bang, before $t = 0$.[40]

In brief this is the direction theistic quantum cosmology must now take, with a biblically legitimized anthropic cosmological principle as its traveling companion. True, there is a sense in which our current milieu is taking place within a post-Einsteinian paradigm chock-full of ACP-interpretive material, and perhaps realizing this should lead us to agree with Stanley Jaki,

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[40] "To say that 'before the Planck era there is the wall of ignorance, beyond which we can say nothing' is a mental self-castration which is the typical outcome of that laziness of intelligence called skepticism." Giancarlo Cavalleri, "The Finite Past Life of the Universe Demands Its Creation Thus Lending Support to the Anthropic Principle," in Francesco Bertola and Umberto Curi, eds., Venice Conference of Cosmology and Philosophy, *The Anthropic Principle: Proceedings of the Second Venice Conference on Cosmology and Philosophy*, November 18-19, 1988 (New York: Cambridge University Press, 1989), 221.

the Hungarian physicist-priest, that "Everything is fully dependent on [God] and the dictum '*creatio ex nihilo*' will merely reveal the very fullness of that dependence."[41]

A Final Word

If David as psalmist could say--"When I look up at thy heavens, the work of thy fingers, the moon and the stars set in their place by thee, what is man that thou shouldst remember him, mortal man that thou shouldst care for him?" (Psalm 8:3-4)--how much more then can we empathize with such sentiments here at the dawn of the new millennium. Reasons for optimism, then, abound with respect to the validity of general revelation's ability to reveal the depths of created reality, only to pass on its insights into God's power, intelligence and creativity to us in ways previously unimaginable.

Anthropic cosmological principles are perhaps only the tip of the iceberg as far as mechanisms for unlocking the mysteries of the universe are concerned. There are undoubtedly further cosmic enigmas to be explored by way of the ACP or some such other yet-to-be-discovered principle, and if these enigmas are locked up deep inside the regulatory rules of created reality itself, a transcendent key of sorts will seemingly be required to unlatch them successfully.[42] But if general revelation keeps on keeping on, keeps on revealing the mind of God, if you will, as it has to date, then general revelation is clearly metascientific, even metaconceptual or metatheoretical, in scope--something to be optimistic about, if for no other reason than the fact it still gives us something to do!

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[41] Jaki, Cosmos and Creator, 63.

[42] As Steven Weinberg notes: "There are mysteries at the outer boundaries of our science, matters that we cannot hope to explain in terms of what we already know. When we explain everything we observe, it is in terms of scientific principles that are themselves explained in terms of deeper principles. Following this chain of explanations, we are led at last to laws of nature that cannot be explained within the boundaries of contemporary science." Steven Weinberg, "Life in the Universe," *Scientific American*, October 1994, 45.

APPENDIX ONE[43]

EVIDENCE FOR THE FINE TUNING OF THE UNIVERSE

More than two dozen parameters for the universe must have values falling within narrowly defined ranges for life of any kind to exist.

1. strong nuclear force constant
   if larger: no hydrogen; nuclei essential for life would be unstable
   if smaller: no elements other than hydrogen

2. weak nuclear force constant
   if larger: too much hydrogen converted to helium in big bang, hence too much heavy element material made by star burning; no expulsion of heavy elements from stars
   if smaller: too little helium produced from big bang, hence too little heavy element material made by star burning; no expulsion of heavy elements from stars

3. gravitational force constant
   if larger: stars would be too hot and would burn up too quickly and to unevenly
   if smaller: stars would remain so cool that nuclear fusion would never ignite, hence no heavy element production

4. electromagnetic force constant
   if larger: insufficient chemical bonding; elements more massive than boron would be too unstable for fission
   if smaller: insufficient chemical bonding

5. ratio of electromagnetic force constant to gravitational force constant
   if larger: no stars less than 1.4 solar masses, hence short stellar life spans and uneven stellar luminosities
   if smaller: no stars more than 0.8 solar masses, hence no heavy element production

6. ratio of electron to proton mass
   if larger: insufficient chemical bonding
   if smaller: insufficient chemical bonding

7. ratio of numbers of protons to electrons
   if larger: electromagnetism would dominate gravity, preventing galaxy, star, and planet formation
   if smaller: electromagnetism would dominate gravity, preventing galaxy, star, and planet formation

8. expansion rate of the universe
   if larger: no galaxy formation
   if smaller: universe would collapse prior to star formation

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[43] The entirety of Appendix One is taken from Hugh Ross, *The Creator and the Cosmos: How the Greatest Scientific Discoveries of the Century Reveal God*, 2d ed. (Colorado Springs: Navpress, 1995), 118-21.

9. entropy level of the universe
   if larger: no star condensation within the proto-galaxies
   if smaller: no proto-galaxy formation

10. mass density of the universe
    if larger: too much deuterium from big bang, hence stars burn too rapidly
    if smaller: insufficient helium from big bang, hence too few heavy elements forming

11. velocity of light
    if faster: stars would be too luminous
    if slower: stars would not be luminous enough

12. age of the universe
    if older: no solar-type stars in a stable burning phase in the right part of the galaxy
    if younger: solar-type stars in a stable burning phase would not yet have formed

13. initial uniformity of radiation
    if smoother: stars, star dusters, and galaxies would not have formed
    if coarser: universe by now would be mostly black holes and empty space

14. fine structure constant (a number used to describe the fine structure splitting of spectral lines)
    if larger: DNA would be unable to function; no stars more than 0.7 solar masses
    if smaller: DNA would be unable to function; no stars less than 1.8 solar masses

15. average distance between galaxies
    if larger: insufficient gas would be infused into our galaxy to sustain star formation over an adequate time span
    if smaller: the sun's orbit would be too radically disturbed

16. average distance between stars
    if larger: heavy element density too thin for rocky planets to form
    if smaller: planetary orbits would become destabilized

17. decay rate of the proton
    if greater: life would be exterminated by the release of radiation
    if smaller: insufficient matter in the universe for life

18. ^{12}Carbon (^{12}C) to ^{16}Oxygen (^{16}O) energy level ratio
    if larger: insufficient oxygen
    if smaller: insufficient carbon ground state energy level for ^{4}Helium (^{4}He)
    if larger: insufficient carbon and oxygen
    if smaller: insufficient carbon and oxygen

20. decay rate of ^{8}Beryllium (^{8}Be)
    if slower: heavy element fusion would generate catastrophic explosions in all the stars
    if faster: no element production beyond beryllium and, hence, no life chemistry possible

21. mass excess of the neutron over the proton
    if greater: neutron decay would leave too few neutrons to form the heavy elements essential

for life
if smaller: proton decay would cause all stars to collapse rapidly into neutron stars or black holes

22. initial excess of nucleons over anti-nucleons
if greater: too much radiation for planets to form
if smaller: not enough matter for galaxies or stars to form

23. polarity of the water molecule
if greater: heat of fusion and vaporization would be too great for life to exist
if smaller: heat of fusion and vaporization would be too small for life's existence; liquid water would become too inferior a solvent for life chemistry to proceed; ice would not float, leading to a runaway freeze-up

24. supernovae eruptions
if too close: radiation would exterminate life on the planet
if too far: not enough heavy element ashes for the formation of rocky planets
if too frequent: life on the planet would be exterminated
if too infrequent: not enough heavy element ashes for the formation of rocky planets
if too late: life on the planet would be exterminated by radiation
if too soon: not enough heavy element ashes for the formation of rocky planets

25. white dwarf binaries
if too few: insufficient fluorine produced for life chemistry to proceed
if too many: disruption of planetary orbits from stellar density; life on the planet would be exterminated
if too soon: not enough heavy elements made for efficient fluorine production
if too late: fluorine made too late for incorporation in proto-planet

26. ratio of exotic to ordinary matter
if smaller: galaxies would not form
if larger: universe would collapse before solar type stars could form

APPENDIX TWO[44]

EVIDENCE FOR THE DESIGN OF THE GALAXY-SUN-EARTH-MOON SYSTEM FOR LIFE SUPPORT

The following parameters of a planet, its moon, its star, and its galaxy must have values falling within narrowly defined ranges for life of any kind to exist. Characteristics 2 and 3 have been repeated from Appendix One since these apply to both the universe and the galaxy.

1 . galaxy type
if too elliptical: star formation would cease before sufficient heavy element build-up for life chemistry
if too irregular: radiation exposure on occasion would be too severe and heavy elements for life chemistry would not be available

2. supernova. eruptions
if too close: life on the planet would be exterminated by radiation
if too far: not enough heavy element ashes would exist for the formation of rocky planets
if too frequent: life on the planet would be exterminated
if too infrequent: not enough heavy element ashes would be present for the formation of rocky planets
if too late: life on the planet would be exterminated by radiation
if too soon: not enough heavy element ashes would exist for the formation of rocky planets

3. white dwarf binaries
if too few: insufficient fluorine would be produced for life chemistry to proceed
if too many: planetary orbits would be disrupted by stellar density; life on the planet would be exterminated
if too soon: not enough heavy elements would be made for efficient fluorine production
if too late: fluorine would be made too late for incorporation in protoplanet

4. parent star distance from center of galaxy
if farther: quantity of heavy elements would be insufficient to make rocky planets
if closer: galactic radiation would be too great, stellar density would disturb planetary orbits out of life support zones

5. number of stars in the planetary system
if more than one: tidal interactions would disrupt planetary orbits
if less than one: heat produced would be insufficient for life

6. parent star birth date
if more recent: star would not yet have reached stable burning phase; stellar system would

[44] The entirety of Appendix Two is taken from Ross, *The Creator and the Cosmos,* 138-41.

contain too many heavy elements
if less recent: stellar system would not contain enough heavy elements

7. parent star age
   if older: luminosity of star would change too quickly
   if younger: luminosity of star would change too quickly
8. parent star mass
   if greater: luminosity of star would change too quickly; star would bum too rapidly
   if less: range of distances appropriate for life would be too narrow; tidal forces would disrupt the rotational period for a planet of the right distance; uv radiation would be inadequate for plants to make sugars and oxygen
9. parent star color
   if redder: photosynthetic response would be insufficient
   if bluer: photosynthetic response would be insufficient
10. parent star luminosity relative to speciation
    if increases too soon: would develop runaway greenhouse effect
    if increases too late: would develop runaway glaciation
11. surface gravity (escape velocity)
    if stronger: planet's atmosphere would retain too much ammonia and methane
    if weaker: planet's atmosphere would lose too much water
12. distance from parent star
    if farther: planet would be too cool for a stable water cycle
    if closer: planet would be too warm for a stable water cycle
13. inclination of orbit
    if too great: temperature differences on the planet would be too extreme
14. orbital eccentricity
    if too great: seasonal temperature differences would be too extreme
15. axial tilt
    if greater: surface temperature differences would be too great
    if less: surface temperature differences would be too great
16. rotation period
    if longer: diurnal temperature differences would be too great
    if shorter: atmospheric wind velocities would be too great
17. rate of change in rotation period
    if larger: surface temperature range necessary for life would not be sustained
    if smaller: surface temperature range necessary for life would not be sustained
18. age
    if too young: planet would rotate too rapidly
    if too old: planet would rotate too slowly

19. magnetic field
    if stronger: electromagnetic storms would be too severe
    if weaker: ozone shield and life on the land would be inadequately protected from hard stellar and solar radiation
20. thickness of crust
    if thicker: too much oxygen would be transferred from the atmosphere to the crust
    if thinner: volcanic and tectonic activity would be too great
21. albedo (ratio of reflected light to total amount falling on surface)
    if greater: runaway glaciation would develop
    if less: runaway greenhouse effect would develop
22. collision rate with asteroids and comets
    if greater: too many species would become extinct
    if less: crust would be too depleted of materials essential for life
23. oxygen to nitrogen ratio in atmosphere
    if larger: advanced life function, would proceed too quickly
    if smaller: advanced life functions would proceed too slowly
24. carbon dioxide level in atmosphere
    if greater: runaway greenhouse effect would develop
    if less: plants would be unable to maintain efficient photosynthesis
25. water vapor level in atmosphere
    if greater: runaway greenhouse effect would develop
    if less: rainfall would be too meager for advanced life on the land
26. atmospheric electric discharge rate
    if greater: too much fire destruction would occur
    if less: too little nitrogen would be fixed in the atmosphere
27. ozone level in atmosphere
    if greater: surface temperatures would be too low
    if less: surface temperatures would be too high; there would be too much uv radiation at the surface
28. oxygen quantity in atmosphere
    if greater: plants and hydrocarbons would bum up too easily
    if less: advanced animals would have too little to breathe
29. tectonic plate activity
    if greater: too many life forms would be destroyed
    if less: nutrients on ocean floors (from river run off) would not be recycled to the continents through tectonic uplift

30. oceans-to-continents ratio
    if greater: diversity and complexity of life forms would be limited
    if smaller: diversity and complexity of life forms would be limited
31. global distribution of continents (for Earth)
    if too much in the southern hemisphere: seasonal temperature differences would be too severe for advanced life
32. soil mineralization
    if too nutrient poor: diversity and complexity of life forms would be limited
    if too nutrient rich: diversity and complexity of life forms would be limited
33. gravitational interaction with a moon
    if greater: tidal effects on the oceans, atmosphere, and rotational period would be too severe
    if less: orbital obliquity changes would cause climatic instabilities; movement of nutrients and life from the oceans to the continents and continents to the oceans would be insufficient; magnetic field would be too weak