BARROW AND TIPLER'S ANTHROPIC COSMOLOGICAL PRINCIPLE

by Fred W. Hallberg

Abstract. John D. Barrow and Frank J. Tipler's recently published *Anthropic Cosmological Principle* is an encyclopedic defense of melioristic evolutionary cosmology. They review the history of the idea from ancient times to the present, and defend both a "weak" version, and two "strong" versions of the anthropic principle. I argue the weak version of the anthropic principle is true and important, but that neither of the two strong versions are well grounded in fact. Their "final" anthropic principle is a revision of Teilhard de Chardin's evolutionary cosmology. They rectify Teilhard's factual errors but commit even more serious psychological and religious errors of their own.

Keywords: anthropic principle; evolutionary cosmology; natural theology.

The "anthropic cosmological principle" is a new name for an ancient idea. John D. Barrow and Frank J. Tipler trace its origins back to the pre-Socratic Greek philosophers Protagoras and Anaxagoras (Barrow & Tipler 1986, 132, 556). Both Plato and Aristotle argued for a parallelism between the form of the human psyche and the form of the cosmos (Barrow & Tippler 1986, 28). All these ancient authorities agreed that human life and consciousness on the one hand, and the certain structural features of the cosmos on the other, are linked by so many manifest and subtle ties that neither could be supposed to be significantly different without supposing the other to be significantly different as well.

This ancient hypothesis was apparently refuted by the development of modern mechanics in the seventeenth century, which showed nature to be governed by principles that bore no obvious connection to the intentional and normative structures of human thought and action.

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Cartesian dualism thus became the ascendent consensual account of the place of mind in the world order. This anthropic principle challenges this central tenet of modern self-understanding and suggests the ancients had it right all along.

Robert Dicke proposed using the anthropic principle in 1961 to explain some puzzling coincidences among certain large numbers in cosmology (Dicke 1961, 440). However, his ideas did not attract much attention or comment. Much of the current interest in the idea may be traced to a series of lectures by the English mathematical physicist Brandon Carter, which appeared in print in 1974 (Barrow & Tipler 1986, 15; Gale 1981, 160). Carter baptized the idea with the name "anthropic principle" and distinguished two versions which he called the "weak" anthropic principle and the "strong" anthropic principle, respectively. Carter's aim, he said, was to "argue against (an) exaggerated subservience to the Copernican principle." He admitted Copernicus had demonstrated that we must not "assume gratuitously that we occupy a central position in the universe." However, it does not follow, he said, that the situation of human observers cannot be privileged in any way. At the least, our position as observers is special in that our existence places certain conditions, or constraints, of temperature and chemical environments on the world we can be expected to observe. Thus, our situation, while "not necessarily central, is inevitably privileged to some extent" (quoted by Gale 1981, 160).

Examples of Anthropic Arguments

What exactly is this anthropic principle which limits Copernicus's insight? We shall find there is no one anthropic principle, but a whole family of such principles. In addition to Carter's weak and strong versions, Barrow and Tipler distinguish two further versions which they call the "participatory anthropic principle" and the "final anthropic principle." Yet their taxonomy is a little confusing since in their hands the strong anthropic principle turns out to be a generic term which includes the participatory and final versions as specific instances. I think we can obtain a clearer picture of what is at stake if we consider some examples of the uses of the anthropic principle borrowed from John Wheeler, P. W. C. Davies, and Brandon Carter.

Cosmologists had every reason to be satisfied, Wheeler observed, with the theoretical edifice they had constructed by the mid-1970's. The standard "big bang" cosmology successfully predicted and explained first, the observed distribution of hydrogen and helium in the stars; second, the presence and distribution of elements heavier than helium; third, the existence and temperature of the universal background radiation; fourth, strange, counter-intuitive objects such as

neutron stars and black holes; and much more besides. This knowledge enables us to say some surprising things about the cosmos as a whole, such as its age (about eighteen billion years), its size (about eighteen billion light years in extent), and its mean temperature (about 2.8 degrees Kelvin). This knowledge also enables us to confidently affirm the universality of the laws of physics and chemistry. (The structure of the spectrum of light emitted by elements in the most distant galaxies is the same as that obtained from controlled experiments here on earth. Thus, chemistry works everywhere in the cosmos just as it does here on earth.)

Yet *why* does the cosmos exhibit just these features? Why, for example, is it as *old* as it is? Why should it not be just two or three billion years old?

We are able to ask such a question because we are articulately self-conscious beings. However, self-conscious beings only exist where there are elaborately organized biological systems such as human brains. The human brain is the product of three billion years of biological evolution, and perhaps a billion years of planetary and chemical evolution before that. Complex chemistry entails the existence of elements heavier than hydrogen and helium. These heavier elements have to be synthesized out of hydrogen and helium by means of thermonuclear fusion within the interiors of large stars. Once a sufficient proportion of the hydrogen and helium in these stars is "cooked" into heavier elements, the star becomes unstable and explodes, spewing its contents back into the cosmos where it is available for further star-making. So a star like our sun, with a planetary system comprised in part of heavier elements, must be at least a second or third generation star. If we allow time for pre-stellar and pre-galactic evolution, the minimum time necessary to produce self-conscious beings like ourselves is in the order of 10 to 100 billion years. So why is the universe so old? It is so old because we are here (Wheeler 1977, 18).

The age of the universe also constrains its size. It is as large as it is because its 10- to 100-billion-year age entails by the requirements of general relativity that it be 10 to 100 billion light years in extent. (Spatiality is defined in relativity theory by reference to the trajectory of the photon. It is axiomatic in that theory that a photon moves at a certain fixed velocity as measured by any observer. So the size of the universe is determined by its age times the speed of light.) So why is the universe so large? Because we are here (Wheeler 1977, 19).

Why is the universe so cool? Why is the temperature of the universal background radiation so close to absolute zero? (It is about 2.8 degrees Kelvin.) Why is it not closer to room temperature? The reason is because the expansion, together with a relativized correlative to the

classic gas laws, entails that it be so cool. (Just as the freon in your refrigerator cools as it expands, so too the universe cools when it expands. The only complication imposed by general relativity is that cosmic expansion creates *new space*, whereas the size of the expansion chamber in your refrigerator is fixed and determinate.) So why is the universe so cool? It is so cool because it is so old and so large, and it is so old and so large because we are here. So the universe is so cool because we are here (Davies 1977, 214).

Carter constructed similar arguments as to why two constants of nature, the gravitational constant and the nuclear coupling constant, have the specific numerical values they in fact have. The gravitational constant has a very small magnitude, in the order of ten to the minus eleven when expressed in the units of meters, kilograms, and seconds. Carter observed that the formation and evolutionary behavior of stars is very sensitive to this quantity. Specifically, the formation of abundant "main sequence" stars like our sun, which are both bright and stable for billions of years, seems to depend on this quantity being very nearly what it in fact is. Were it an order of magnitude *larger* than it in fact is, most stars would have become "blue giants," which would have rapidly exhausted their nuclear fuel long before life had a chance to evolve; if it were an order of magnitude *smaller* than it in fact is, many fewer stars would have formed, and the preponderance of these would have been dim "red dwarfs," which last long enough, but which are too cool to support life. Thus, our presence explains why the gravitational constant has (within a narrow range) the value it in fact has (Gale 1981, 167-68).

The nuclear coupling constant, which binds the protons and neutrons together in the nucleus of the atom, is very much larger than the gravitational constant. However, the force it represents is only marginally strong enough to bind protons and neutrons together. This close balance of forces within the nucleus turns out to be necessary condition for the existence of complex chemistry, and is thus a necessary condition for life. Were it much *smaller* than it in fact is, hydrogen would be the only stable element. Complex chemistry and life would be excluded. Were it much *larger* than it in fact is, all matter would consist of a peculiar element consisting of proton-proton pairs. Thus complex chemistry would again be impossible, and life would be excluded. Therefore, the nuclear coupling constant must have very nearly the value it in fact has, for there to be chemistry, life, and consciousness (Gale 1981, 168).

The upshot is that our very existence as self-conscious, biological beings places strong constraints on the kind of universe we can inhabit. Thus, our existence has a kind of cosmic significance we have only recently come to appreciate.

Weak and Strong Versions of the Principle

The arguments I have been discussing are all instances of Carter's weak version of the anthropic principle because they merely show that a universe containing biological observers such as ourselves must have the large scale and fine grain structures it in fact has for us to exist. These arguments do nothing to exclude other "possible worlds," with different large scale and fine grain structures, but with no conscious beings like ourselves to observe and record that fact. Carter's strong version of the anthropic principle provides the logical compliment to the weak version. He proposed that the cosmos may be such that it must produce life and consciousness somewhere in its history, if it is to be realized at all. The strong version is the claim that the other "alternative worlds" of his weak version are somehow conceptually defective, so that only one of them, namely *our* world, can in fact be realized.

Wheeler's Participatory Anthropic Principle

The only serious attempt to defend the truth of the strong anthropic principle on the basis of currently accessible empirical evidence, is an argument by Wheeler which Barrow and Tipler call the "participatory" anthropic principle. Wheeler's argument is based on a peculiar consequence of quantum mechanics, namely, that the outcome of certain kinds of physical processes, such as light interference effects demonstrated by slit spectroscope experiments, are not entirely definite or individuated until after they are observed. (Wheeler denies that an "observation" in this context means being the object of an act of awareness. It is rather constituted by the quantum mechanical processes in question having a definite, irreversible effect on a standard drygoods-sized object that *could be* observed by an ordinary person were that person to check out the results [see Wheeler 1980, 354 and note 91]. Wheeler's ideosyncratic account of what constitutes an observation generates a number of conceptual difficulties and has recently been criticized by Abner Shimony, 1988, 52-53.) In such experimental situations where very small entities such as photons or electrons produce observable human-sized effects, quantum mechanics entails that, prior to the observation, the entity or process in question was not in one definite state or another but is instead in a hybrid "superposition" of all possibly observed outcomes. This hybrid superposed state does not "collapse," that is, it does not take on some specific determinate value, until it is observed in the sense described above (Barrow & Tipler 1986, 459-64; Wheeler 1980, 341-62; Schlegel 1980, 24-55). Since all radiation and particulate matter is describable by the sorts of quantum mechanical formalisms which entail this peculiar consequence, we may

conclude all such entities *are not fully individuated until they are observed.* Since consciousness itself developed through an evolutionary process, Wheeler supposes the universe and its "participant observers" *grew up together* toward fully actual existence (Wheeler 1980, 354-58). Before we observed cosmic processes they were stuck in an indefinite, superposed collection of quantum mechanical states (Wheeler 1980, 352-54). Since only an observed world can be fully individuated, and since he assumes that to be real is to be unambigously individuated, Wheeler concludes that only a world which produces "observership" at some time in its history can be fully real. (For a rigorous exposition of the means by which to test for the sort of results Wheeler is describing, see d'Espagnat 1979, 158-81. For a description of the apparent confirmation of these predicted results see Mermin 1985, 38-47.)

I have one large problem with this "participatory" version of the anthropic principle. Wheeler emphasizes that life and consciousness entails both biological evolution, and prebiological physical and chemical evolution (Wheeler 1977, 3, 5). Yet all these forms of evolution involve very specific interactions among highly individuated molecules. So his story seems to require specific, individuated events and entities before consciousness is present to individuate them. Wheeler might avoid this paradoxical anachronism by providing a worked-out "degrees of reality" thesis, with respect to which unobserved atoms and molecules would be sufficiently individuated to partake of specific physical and chemical reactions. These events would then not be as individuated as they would be were they to be observed. However, no detailed account of such a degrees of reality thesis is provided by Wheeler or as far as I can tell by anyone else (Barrow & Tipler 1986, 469).

The idea that reality comes in gradations, or degrees, is at least as old as Barrow and Tipler claim the idea of the anthropic principle itself to be. Plato articulated the concept of the cosmos as a hierarchy of more or less real entities in his *Republic*, and his innovation endured until the Renaissance as various forms of Christian and non-Christian neoplatonism. St. Anselm's "ontological" argument for the existence of God depended on the idea of a hierarchy of more or less real entities. Yet this "degrees of reality" thesis was presumably killed and buried by David Hume's and Immanuel Kant's trenchant criticisms of the ontological argument. One of the most widely accepted and apparently secure features of modern logic is its assumption that existence is a matter of "either/or" rather than "more or less." A substance or state of affairs either exists or it does not exist. There is no place in modern logic for the partially real. Quantum mechanics may force us to overthrow this foundational assumption of modernity and return to some-

thing like Plato's "Great Chain of Being." Until such a radical proposal is worked out in detail and articulately related to all the things we currently believe we know by means of modern logic, we simply have no idea what to make of the so-called *paradoxes* of quantum mechanics. Until this new synthesis is achieved, they will remain an undigested anomaly at the fringes of our system of knowledge. They will play a role not unlike reports of extrasensory perception. Their existence is well documented. They appear to be incompatible with our commonsense understanding of what is possible or impossible. We have absolutely no idea how to integrate them with the rest of our functioning world-picture. Wheeler's participatory anthropic principle must therefore be judged to be inconsistent or else to be insufficiently developed to permit its epistemological merits to be adequately assessed.

Virtues of the Weak Anthropic Principle

A number of critics of the anthropic principle such as Heinz Pagels and Martin Gardner have objected that the strong versions of it are unscientific speculations, and the weak version is an empty tautology (Pagels 1985, 37; Gardner 1986, 22). I too have problems with all versions of the strong anthropic principle. However, I think it is simply an error to reject the weak anthropic principle on the grounds that it is an empty tautology or redundancy.

No one has attempted to establish the tautologous or redundant character of the weak anthropic principle by, for example, representing it in the lower functional calculus and demonstrating that it comes out true for all possible substitution instances. It clearly is not tautologous in that strong sense of the term. No one would seriously attempt such a proof, because the principle does not exhibit anything like the logical form of a tautology. Neither does it exhibit the logical form of a simple redundancy. It has, rather, the logical form of a *presuppositional* analysis, and is in many ways similar to the "transcendental" deductions employed by Kant in his *Critique of Pure Reason*.

Kant faced a problem in the theory of knowledge similar to that faced by contemporary cosmologists. Hume had shown Kant that we could not use empirical observation to ground certain basic assumptions about the knowing situation, such as whether objects exist unobserved, or whether concomitancies regularly observed in the past are the result of real causal connections that can be confidently projected into the future. Thus, Kant proposed that we taken our basic capacity to cognize and to *re*-cognize events and entities *as given*. He then shifted the question from what objects of observation are basic to the very different issue of what restrictions, or presuppositions, our assumed cognitive capacities lay on the objects of experience within our

existing system of knowledge. What the act of perceiving an object presupposes, he argued, is that there are persons, and there are things, both of which endure within a spatial manifold and are linked by real causal connections (Kant [1787] 1958, 220-21, 245-52).

Analogously, cosmologists like Dicke and Carter had run up against the fact that they could not explain the initial conditions and constants of the cosmos *causally*. (They could not get "behind" the original singularity to determine what "caused" it.) They turned to an explanation of a different kind. How does our existence as incarnate conscious beings constrain the kind of world we could possibly inhabit? Their answer has the same form as Kant's transcendental deductions, only the inferential dependencies in question are *causal* rather than conceptual in character. (That is, our existence depends *causally* on the earth being situated between the hot, stable sun and the cool night sky. Whereas our ability to *re*-cognize objects depends *conceptually* on the stable persistence of persons and things in space and time.)

Since Kant's transcendental deductions were neither tautologous nor circular, neither is the analogous weak version of the anthropic principle. This conclusion may be irritating to those, similar to Heinz Pagels, who insist on identifying "real" scientific understanding with the attainment of causal explanations potentially applicable for purposes of manipulation and control (Pagels 1985, 36-37). The irritation stems, I submit, from an unwillingness to acknowledge that inquiry may realize values other than those realizable by the extension of our power to manipulate and control events. Inquiry can also realize the purely contemplative value of appreciation of the amazing intricacy and subtlety of creation. Plainly, the kinds of questions the various forms of the anthropic principle are intended to address are of this contemplative sort, rather than having any sort of practical application.

The weak anthropic principle has one final virtue that is often overlooked. It makes plain that the question of whether our ultimate origins stem from chance or design cannot be answered by scientific investigation. We are thus cognitively free to view our ultimate origins in either of these two ways.

Carter proposed an "ensemble of universes," of which only one (or a small number) might contain the conditions of life and consciousness. So all those "other" universes would exist unobserved (Gale 1981, 168). The existence of our special life-enhancing universe would be the inevitable result of chance within this larger ensemble of universes. Of course this entire supposition of an ensemble of universes is a purely speculative idea beyond any conceivable scientific determination. An equally valid alternative supposition, that our universe expresses an *intention* that life and consciousness be realized, also takes us beyond

what could be conceivably determined by scientific experimentation. If, however, this second supposition were true, it would be appropriate for me to have an attitude of gratitude or thanksgiving toward that something, I know not what, from which the very special life-enhancing bounties of this particular universe are derived. On the other hand, were I to affirm the conjecture of a purely chance origin of this cosmos, a very different attitude would be appropriate, more like the attitude of cosmic alienation and despair expressed by Bertrand Russell in his "A Free Man's Worship" (Russell [1903], 1929, 46-57).

Stephen Jay Gould has discussed these two views, and has asserted that only the supposition of an origin in blind chance is rational and scientific. He railed against the alternative supposition as being "both patently ill-founded and quaint in its failure to avoid that age-old pitfall of Western civilization—the representation of raw hope gussied up as rationalized reality" (Gould 1983, 36). As I understand the weak anthropic principle, *neither* choice can be accused of factual error. We are free to adopt Russell's view, and to cling to a very negative account of our relation to our ultimate context, or to adopt the more affirmative account with respect to which the attitude of gratitude or thanksgiving would be appropriate (Mayeroff 1977, 85-87). Despite Gould's fulminations, neither choice is more factual, or realistic, than the other. If I may continue my Kantian parallel, the weak anthropic principle limits reason in a way that leaves room for faith (Kant [1787] 1958, 29).

Barrow and Tipler's Final Anthropic Principle

I have saved my analysis of Barrow and Tipler's "final" anthropic principle for the last. It is the most obstreperously and outrageously speculative of any version of the anthropic principle. It consists of a chain of at least nine speculative inferences, each of which goes far beyond what can be said to be confidently known today. Their conclusion at the end of this chain of inferences is that the cosmos has an ultimate telos, or "omega Point" as they call it, at which "life" or consciousness will have gained control over all matter in the universe (Barrow & Tipler 1986, 677). Barrow and Tipler have a fondness for acronyms, and call their strongest of strong anthropic principles "FAP" (for "Final Anthropic Principle"). Martin Gardner was moved by their grandiose claims to rename FAP "the completely ridiculous anthropic principle, or CRAP" (Gardner 1986, 25). My final assessment of Barrow and Tipler's final anthropic principle will be somewhat more favorable than Gardner's. However, I can certainly understand his sentiments.

Barrow and Tipler's final anthropic principle is similar in many ways to the thesis defended by the French Jesuit Pierre Teilhard de Chardin

in his book, *The Phenomenon of Man* (Barrow & Tipler 1986, 203). Both parties portray cosmic evolution as an inherently teleological process in which higher and higher levels of life and consciousness are realized until everything finally culminates in the final Omega Point. The *Omega Point* was Teilhard's term of art for God and eternity in which all value would be realized and all life reconciled with itself (Barrow & Tipler 1986, 201). Barrow and Tipler are fully as eschatological as was Teilhard in their description of this final Omega Point. I quote from the last paragraph of their book. (My interpolations are in brackets. Their references to the "many universes" of "quantum cosmology" are about the parallel universes postulated by Hugh Everett to avoid the paradoxes of the participatory anthropic principle. The reiterated, italicized, *all* is their own. See Barrow & Tipler 1986, 468-88.)

> From our discussion in Chapter 7 [on quantum mechanics], and from figure 7.2 [representing Everett's "parallel worlds"], we see that if life evolves in all of the many worlds of quantum cosmology, and if life continues to exist in all of these universes, then *all* of these universes, which include *all* possible histories among them, will approach the Omega Point. At the instant the Omega Point is reached, life will have gained control of *all* matter and forces not only in a single universe, but in all universes whose existence is logically possible; life will have spread to *all* spatial regions in all universes which could logically exist, and will have stored an infinite amount of information, including *all* bits of knowledge which it is logically possible to know (Barrow & Tipler 1986, 676-77).

Just in case you missed the connection between their Omega Point and Teilhard's, they add a final footnote to their final paragraph. "A modern-day theologian might wish to say that the totality of life at the Omega Point is omnipotent, omnipresent, and omniscient!" (Barrow & Tipler 1986, 682).

This is supposed to be the culminating endpoint of our history and of all histories. Yet how do we get from here to there? That conceptual journey involves a series of at least nine inferential steps, each of which involves taking a strong stand about an issue which is either controversial or uncertain at the present time.

First, they assume, and argue against other well-informed scientists such as Carl Sagan, that life and consciousness is exceedingly rare in the cosmos, and that ours may be the only instance of a technologically advanced society in the entire galaxy (Barrow & Tipler 1986, 576-77). This assumption entails that we bear an especially heavy responsibility for helping the Omega Point (God?) realize the final purposes of creation.

Second, they argue that the link between curiosity and intelligence is such that all life and consciousness is inherently expansive. A settled existence of ecological balance contradicts this allegedly fundamental imperative to transcend existing boundaries and to explore and master

new worlds. They thus confidently predict we will get busy and invest in planetary and stellar exploration and colonization, and that we will have completed the job of exploring and colonizing the entire galaxy by about 300 million years from now (Barrow & Tipler 1986, 577, 593).

Third, they identify a hypothetical type of machine, a "Von Neumann machine," with "life." Back in the 1950's, John Von Neumann proposed that digital computers would permit us to take machines that would make other machines, that is, machines that would be automated factories. Second, Von Neumann proposed that such automated factories could be made to *replicate themselves*, as a preprogrammed task. Third, he proposed that small, random variations be introduced into each generation of taped instructions that told the new factory how to replicate itself so that successive factories would all be slightly different from each other. Finally, he proposed that we put these factories in a large pen with limited amounts of fuel, vacuum tubes, nuts and bolts, and so on, so that these automated factories would have to compete for limited resources. Then these factories would evolve by natural selection into ever more efficient and capable self-replicators (Barrow & Tipler 1986, 517-19).

Of course no such fully functional self-replicating machine has ever been built, and we do not really know whether it *could* be built out of ordinary electronic machinery that did not avail itself of feedback structures going all the way down to the molecular level as occurs in the case of *biological* life. Yet Barrow and Tipler simply assume there are no significant barriers to the practical realization of Von Neumann's conjecture. This assumption enables them to overcome the problem of the time required for interstellar travel which greatly exceeds the span of a human life. *We* need not travel to the stars, they argue. We need only send Von Neumann machines in our place as our supposedly "living" progeny (Barrow & Tipler 1986, 579-83).

Fourth, they assume the "Turing test" for consciousness is conceptually satisfactory, and that it will be met by ordinary digital computers in the near future. In 1950 Alan Turing proposed that the question of whether computers "think" or are "conscious" be approached in the following way. Prepare a *Y*-shaped telephone line, with a human interrogator at a terminal on the bottom of the *Y*, and another human at a terminal on one of the upper forks, and a computer on the other upper fork. If all three were equipped with suitable input devices, the human interrogator at the bottom could undertake to determine which of the upper two branches was operated by a human, and which was operated by a computer by engaging each in a series of dialogues. In 1950 it would have been easy to distinguish the person from the computer. However, Turing predicted that as computer hardware and

software became increasingly sophisticated and capable, it would take the interrogator longer and longer periods of time to make the distinction. When it came to pass that he could never do better than chance, we could confidently assert that the computer was as "conscious" as the human (Barrow & Tipler 1986, 523).

This proposed operational definition of consciousness has been strongly criticized on philosophical grounds by Hurbert Dreyfus and John Searle, among others. Dreyfus argues that human consciousness can only be embodied by beings which share the biological and cultural "lifeworld" of human beings (Dreyfus 1972, 168-83). Searle argues that the proposed definition is covertly contradictory and hence unrealizable. By identifying the simulation with what is to be simulated, it collapses the distinction on which it nevertheless depends, between a description and what that description describes, or to which it refers. He thus concludes the proposed criterion is a semantic illusion, or word-trick, which proves nothing (Searle 1984, 28-40). Barrow and Tipler exhibit at least some awareness of these sorts of objections (Barrow & Tipler 1986, 154-55). Yet they plow doggedly ahead without worrying overmuch about them.

Fifth, they assume a continuous upward trend in the amount of disposable income for future human beings, with no "limits to growth" imposed by shortages of resources or other sorts of difficulties. They reveal themselves quite candidly as extreme technological optimists. This optimism permits them to project that an interstellar probe (necessary to get the process of galaxy-colonization underway) which would cost between 30 billion and 200 billion dollars at the present, would cost no more than the present equivalent of a personal computer or a used car 800 years in the future (Barrow & Tipler 1986, 579-83).

Sixth, building on certain suggestions by Freeman Dyson concerning the fate of life in the far future of the cosmos (Dyson 1979; Frautschi 1982), they project that life and consciousness could be embodied in such large scale structures as interstellar plasmas and fields rather than in small molecular structures as is now the case. They need this assumption because one prediction of current particle physics (as yet unconfirmed), is that protons will spontaneously decay into radiant energy in the far future. Thus, if life is to expand continuously to the Omega Point, it must eventually transcend its current dependence on molecular matter (Barrow & Tipler 1986, 659-60).

Seventh, they assume it will be possible for such large and diaphanous "living" beings to maintain themselves by utilizing exotic (and as yet poorly understood) energy sources such as gravitational shear and other sorts of gravitational asymmetries they assume will arise as the universe recollapses back towards its final future singularity (Barrow & Tipler 1986, 625, 631, 646, 665).

Eighth, they assume despite the entirely ambiguous status of the current observational evidence on the matter, that the universe is "closed" in the sense that the rate of Hubble expansion is less than the escape velocity imposed by the current mean density of matter. If the universe *is* closed in this sense, the color of distant galaxies will shift in the far future from red to blue, and then the whole system will finally recollapse into what John Wheeler once called the "big crunch" (Barrow & Tipler 1986, 620-21, 666). They speculate as to how their account of the final realization of the Omega Point might be accommodated to a flat universe (in which the rate of cosmic expansion exactly equals the cosmic escape velocity). However, they do not develop that possibility in any detail. They concede that a "runaway" universe (which is expanding significantly faster than its own escape velocity) is incompatible with their final anthropic principle (Barrow & Tipler 1986, 670).

Ninth, and finally, they assert that phenomenal or experienced time is dependent on the *rate* at which information is being processed by the subject whose experience it is. The faster a subject is processing information, the slower that subject will experience time as "passing." Since their hypothetical future large-scale diaphanous beings would have more and more gravitational shear energy at their disposal as they approached closer and closer to the final singularity, the rate at which these beings processed information would increase exponentially near the end. So, *from their point of view*, time would pass more and more slowly. At the limit, these beings would experience time as passing infinitely slowly, so they would have effectively attained personal immortality (Barrow & Tipler 1986, 636, 666). It is at this point that the final meaning of creation is realized (Barrow & Tipler 1987, 674-77).

Conclusion

What can one say about this baroque conceptual edifice? It was obviously a labor of love for the authors. Yet it seems equally obvious no one would be attracted to their system because of the great weight of empirical evidence in favor of its truth. The range of empirically plausible alternatives to their particular speculative system is enormous. Thus, what sorts of principles of selection, *other* than the weight of empirical evidence, guided them to their final result?

I believe I found the answer to that question in their very favorable treatment of Teilhard and in their emphasis on certain crucial similarities between his system and their own (Barrow & Tipler 1986, 195-204, 639, 674-77). They admire Teilhard for what he tried to do in his *The Phenomenon of Man*. They diagnose his failure as being due to some rather simple and easily repaired errors concerning matters of fact. Teilhard, on their account, simply failed to anticipate the concep-

tual opportunities opened up by recent developments in cosmology. Therefore, they are attempting to realize Teilhard's goals by correcting his detailed errors of fact.

If my interpretation is correct, it generates a second question. Why was what Teilhard was trying to do in *The Phenomenon of Man* so attractive to Barrow and Tipler? It was attractive, I believe, because Teilhard was attempting nothing less than a recasting of the entire Christian myth of humankind's sin, fall, and redemption in modern evolutionary dress. His aims were not obviously absurd. The "salvation history" to be found in Paul's Epistle to the Romans and in Augustine's *The City of God* was at least a quasi-evolutionary one. Teilhard, like Paul and Augustine, saw cosmic process as bounded by a beginning and an end of time, and as culminating in a final state in which spirit and the world are reconciled with each other. If Teilhard's constructive aims were plausible, so too was his understanding of the common "problem" to be solved, namely, that the traditional Christian myth *needs* to be modified or replaced by a new system which more accurately addresses the self-understanding and concerns of the contemporary world.

The traditional Christian myth served admirably for almost two millenia, as a framework of interpretation within which Western men and women could come to terms with their finitude, and locate their personal aspirations within a cosmic context. Yet the traditional Christian myth has been losing its power to provide a believable basis for culture since at least the time of the Enlightenment. The traditional myth has been losing its effectiveness because of the history of violent schisms within the Christian community, because of a growing tension between its factual and historical claims and the scientific world-picture, and because of skeptical attacks by philosophers such as Voltaire, Hume, and Kant. A number of contemporary critics of culture have diagnosed the decline in the power of the traditional myth to illuminate and guide our lives as a "dis-ease" that can only be cured by a "new revelation," that is, by a new mythic structure which would perform the functions of the traditional system without being vulnerable to sectarian abuse, factual error, and skeptical attack (Keen 1969, 139-40, 149, 201-12; Jung 1961, 140, 302, 339-40).

Barrow and Tipler apparently believe Teilhard pointed the way toward how such a reform could be successfully accomplished. His system of cosmic evolution preserved at least the broad outlines of the traditional myth, and even provided a role for the risen Christ as the future Omega Point. They apparently also believed these features alone would preserve the system's spiritual efficacy, if only the problems of conceptual coherence and conformity to well-confirmed scientific fact could be resolved.

The main shortcoming of Teilhard's system in Barrow and Tipler's eyes was that it failed to conform to the well-confirmed requirements of the laws of thermodynamics, and that it did not avail itself of the possibilities of interstellar space travel to project the world of culture and consciousness (Teilhard's "noosphere") into the cosmos beyond the solar system.

Concerning the first point, Teilhard could not square the prediction of an inevitable future "heat death" of the universe with his system of progressive evolution. This prediction, which was fashionable in his day, was derived from Ludwig Boltzmann's "H-theorem" (pronounced "Eta-theorem"). Boltzmann's theorem proved that the entropy of any thermodynamically closed system would increase to a maximum, at which point life in that system would become physically impossible (Barrow & Tipler 1986, 174-76; Davies 1977, 67-70). To avoid this decidedly nonmelioristic consequence, Teilhard postulated two types of energy. There is, he said, "tangential" energy which conforms to the usual rules of thermodynamics, including Boltzmann's H-theorem. And there is in addition, "radial" energy which is spiritual in nature, and which operates cumulatively in a way that circumvents the deleterious effects of the increasing entropy of tangetial energy (Barrow & Tipler 1986, 197-201).

Barrow and Tipler see this entire component of Teilhard's system as unnecessary, because contemporary cosmology provides scenarios in which life can flourish into the far future without having to postulate any sort of nonempirical alternative to ordinary thermodynamic processes. (Boltzmann's H-theorem presupposes an enclosed system of gases in which the effects of gravity and of cosmic expansion can be safely ignored. However, the fact of cosmic expansion entails that the cosmos as a while cannot be treated as an unambiguously "closed" system in the sense required by Boltzmann's H-theorem. See Layzer 1975, 56-69; Davies 1983, 52-54.)

Concerning the second point, Teilhard disbelieved in the possibilities of space travel for two reasons. First, from his pre-World War II vantage point this did not appear to be a very realistic possibility. Second and more important, he needed a physically closed arena for the evolution of consciousness, so the "compression" effects of ever greater interaction and communication would drive the noosphere toward a "vertical" unification with the Omega Point (Barrow & Tipler 1986, 201-03). Barrow and Tipler, writing after the successes of the Apollo and Voyager programs, are much more sanguine than was Teilhard about the technical feasibility of extra-terrestrial colonization. Yet they *retain* Teilhard's requirement of a finite amount of space to compress future conscious life toward the Omega Point. That is why

they insist the rate of cosmic expansion is less than the cosmic escape velocity. That claim provides a finite amount of space bounded by the "big bang" at one end, and the "big crunch" at the other (Barrow & Tipler 1986, 203, 639, 676). Thus, Barrow and Tipler's scenario amounts to a rewrite of the drama which Teilhard projected to occur on the surface of the earth. However, Barrow and Tipler's drama is to be enacted on a cosmic, rather than on a merely terrestrial, stage.

Barrow and Tipler are evidently confident that there is nothing in their system which flatly contradicts either well confirmed scientific fact, or real technological possibilities. They are therefore also confident their system will not be vulnerable to the sort of critical demolition job Peter Medawar performed on Teilhard's *The Phenomenon of Man* (Medawar 1961).

Why patch up, and hence save, a functional equivalent to the traditional Christian salvation history? Why not simply replace it with a purely scientific account of the world and humanity's place in it? René Descartes articulated a scientific replacement for the Christian myth in Part Six of his *Discourse on Method*. He proposed that the old myth be replaced by a new religion of scientific rationality. This new way of thinking and being would yield certain benefits, Descartes promised, that would amount to a man-made paradise on earth. Limitless power over nature and limitless personal wealth would be provided by applied agricultural and manufacturing technology. Personal happiness and contentment would be provided through applied pharmacology. Personal immortality would be guaranteed through medical control of the aging process. All we would need to do, to achieve this New Jerusalem, would be to invest sufficient funds in Descartes' research projects (Descartes [1637], 1960, 45-48).

This sort of technologically based salvation history has been one of the main contemporary competitors with traditional Christianity. Yet it has proven to be an abject failure in practice. It is incapable of providing the sort of personal orientation and satisfactions available within the traditional system. Modern medicine has not touched the problem of aging and death. The average upper limit on the span of life today for persons who escape premature death due to childhood disease, accident, and war, is between seventy and eighty years. That is just about what it was in biblical times (Psalms 90:10). Citizens in the industrialized nations have far greater personal wealth than did their forebears. However, this increase in wealth has not touched the sources of human misery described in modern literature and drama. For example Willy Loman, the hero of Arthur Miller's play *The Death of a Salesman*, is fairly well off in a material sense compared to a commoner in Descartes' day. Yet his adherence to the values of external possession

and control leave him helpless before the unpleasant facts of his finitude. The absence of any sort of interpretive framework that would enable him to affirm and accept his increasingly limited circumstances causes his own destruction, as well as damaging his sons (Miller 1949). What was it the traditional Pauline-Augustinian myth did we well that the modern Enlightment myth incorporated by Willy Loman does so poorly, or not at all?

If we are going to live and die well, we need some way to get beyond the values of our vigorous youth, when we could honestly believe "the sky is the limit" and that everything is possible. We must somehow internalize and affirm the increasingly inescapable fact of our dependency and creatureliness. If we are to affirm the *whole* of our life (which includes our senescence and death), we must become willing at some point to surrender the will to control entirely, and to say as did Jesus at Gethsemane, "Not my will, but Thine be done" (Luke 22:42).

The link between the youthful (and archetypically masculine) virtues of personal autonomy and power on the one hand, and the more mature (and archetypically feminine) virtues of receptivity, resignation, and acceptance on the other, was provided in the Pauline-Augustinian system by the image of the living Christ, who acted in the recesses of one's own heart as well as on a cosmic scale. There was thus no problem within the traditional system as to why I should care about the future realization of the Omega Point. The concerns of the cosmic Christ, and the concerns of the Christ experienced within, were one and the same (Jung 1959, 36-69).

There are of course other mythic symbol systems which men and women have utilized to make the transition from alienated and self-centered ways of being to more integrated and affirmative reality-centered ways of being. Jews employ the myths of the covenant and the Exodus. Buddhists internalize the idea of Buddha-consciousness. The essential element in all these traditional systems seems to be a combination of relevant symbols and practices, which both motivates individuals to undertake this process of personal transformation, and guides them through it. Once an individual has made the transition, he or she can apparently find a sense of fulfillment and belonging in virtually any sort of cosmic scheme. Marcus Aurelius found it in the Aristotelian system of cosmic teleology. Barich Spinoza found it within the Cartesian-Newtonian system of deterministic mechanism. It is evidently the processes of self-transformation that provide the essential ingredient of any livable mythic system, not the factual details of whatever background cosmology is being employed.

This is where both Teilhard, and Barrow and Tipler, fail. Teilhard's system is heretical, in my view, because it removes the locus of the

encounter with Christ from present experience to the remote future. He did appeal to the dogma of the immortality of the soul (mind) to provide some link between the world of our lives and the final realization of the Omega Point (Barrow & Tipler 1986, 201-03). However, Barrow and Tipler reject even this tenuous link between personal experience and the larger cosmic drama (Barrow & Tipler 1986, 202). Without such a link, their system cannot perform the sort of integrative, life-affirming functions traditionally provided by the Pauline-Augustinian salvation history.

This general deficiency is exacerbated by the second assumption on which their system rests, namely, that life and consciousness is inherently restless and expansive, and inevitably relates to the "other" with the ultimate aim of occupation and control (Barrow & Tipler 1986, 593). They reported that Carl Sagan and William I. Newman, among others, have objected that this amounts to a policy of "imperialism" toward the cosmos. Barrow and Tipler responded rather pedantically to the criticism by quoting an encyclopedia definition of imperialism, and enumerating the ways in which their proposal failed to conform to that definition (Barrow & Tipler 1986, 594, 610). Of course Sagan and Newman were using the term in a metaphorical sense to convey an objection very similar to my own. Barrow and Tipler's view of the goals of life is too narrow and simplistic to encompass the full range of interests and achievements that constitute a complete and integrated human existence. Their perspective, to use Jungian terminology, is too exclusively manipulative and "masculine" to provide a cosmic home for the full range of affirmative human possibilities. They thus leave themselves, and those who would buy into their interpretive system, vulnerable to the sort of experiences of futility and defeat which destroyed Miller's hero Willy Loman.

I do not feel the sense of exasperation Gardner expressed concerning Barrow and Tipler's speculative excesses. I can only admire the ingenuity and energy they have devoted to the elaboration and defense of their system. I have learned too much from them about contemporary physics and cosmology to be anything but grateful for their efforts. However, I must admit I do feel exasperated at times by the enormity of their psychological and religious naivete. They have apparently set out to save a modified version of Christianity from the nihilistic consequences of the Enlightenment. Yet they end up affirming the most shallow and loveless aspects of Enlightenment ideology without betraying the slightest understanding of the psychological and religious aspects of the problem they have undertaken so solve.

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