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John D. Barrow and Frank J. Tipler: *The Anthropic Cosmological Principle*[1]

Barrow and Tipler's treatment of the anthropic principle is briefly discussed, and a critique is given of their claim that the 'strong' anthropic principle is verifiable without appealing to theological presuppositions.

Key Words: weak and strong anthropic principles, many-worlds interpretation, quantum mechanics, theological presuppositions.

The central aim of this work is to articulate the role of various forms of the anthropic principle in the science of the origins of life, particularly in modern cosmological research. The Weak Anthropic Principle (WAP), the least controversial, amounts to the assertion that the physical universe we happen to observe around us has a structure permitting the evolved existence of ourselves as observers within it. The WAP serves as a kind of sieve to rule out those cosmological theories which can't account for the fundamental empirical datum at our disposal—our own living presence in the cosmos. An instructive way to conceptualize the WAP is by imagining an ensemble of alternative possible worlds to our own each with a different permutation of values for initial cosmological data, the fundamental constants of nature, the dimensionality of space-time and each with alternative possible laws of physics. The WAP selects out that subset of 'worlds' in this ensemble compatible with the evolved existence of human life. Clearly one member of this subset models the *actual* world we inhabit!

Despite the admirable comprehensiveness of this book, it is surprising the authors overlook the modern study of modal logic which has succeeded in making precise reasoning involving the conceptualization of an ensemble of 'possible worlds'. This conceptual tool can be successfully applied to analyse a range of problems (from the meaning of counterfactual statements to the validity of the ontological 'proof' of the existence of God) and it is indispensible, in my view, to the correct comprehension of the anthropic principles. Further, although this book contains exhaustive chapters on the design argument and teleological ideas in philosophy and science to the present, the authors disappointingly omit discussion about any teleological aspects of the universe's intelligibility (e.g. one view is that the universe was preconditioned by a transcendant Creator to be susceptible to reason so that man can productively 'live and learn'). On this they are satisfied in simply commenting: 'The scientific theories that prove to be most effective

1 J. D. Barrow and F. J. Tipler, *The Anthropic Cosmological Principle*, Clarendon Press, Oxford, (1986).

descriptions of the physical world are invariably mathematical. It is an interesting question, although not one that concerns us here, as to why this should be the case' (p. 408).

A main thesis appearing throughout the book is that there are very few possible physical structures of the universe compatible with our existence. For example, all other factors remaining constant, if the ratio of the number of photons to protons in the universe were altered only slightly, cosmic conditions would not have allowed carbon-based life to arise. The authors' reasoning for the most part is compelling; periodically however it is unconvincing. For example, if we assume that the structure of the laws of physics, in particular the Schrödinger equation, would remain unchanged in a world with N spatial dimensions, it can be shown that there are no stable bound orbits for $N>3$ in the hydrogen atom. They conclude 'Thus we see that the dimensionality of the universe is a reason for the existence of chemistry and therefore, most probably, for chemists also' (p. 265). Now there is a sense in which this is correct, especially if one professes to be an ontological reductionist (i.e. whereby the world is seen as wholly reducible to the particles and forces studied by physicists) as the authors claim to be (p. 138). However, this statement also somewhat begs the question. For had the laws of physics not been quantum mechanical, life (albeit not 'human' in the sense to which we are accustomed) may have emerged based upon a drastically different periodic table of elements than we currently know. (And, as a Christian, I am not convinced God, through Whom all things are possible, could not have chosen such an alternative way of bringing forth His creation.)

Nevertheless, the most intriguing aspect of this book is that it increases the plausibility that conditions in the universe were, to a certain extent, 'fine-tuned' by a Creator for the purpose of permitting life's emergence and sustenance. This theological interpretation of the Strong Anthropic Principle (SAP), which the authors define as the statement that the universe *must* have those properties which allow the possibility for life to emerge within it, is unfortunately not treated seriously by the authors who relegate it to the category of those ideas not '. . . open either to proof or disproof . . .' (p. 22). In fact throughout the book the authors noticeably circumvent any theological implications of their work in favour of pursuing only those ideas which they see as physically motivated. For example, after mentioning Arthur Peacocke's argument that the *continual* operation of physical laws in the universe can only be justified by committing oneself to some form of cosmic teleology, they remark 'This sort of argument is so general that it would be consistent with *any* scientific result, and so, although interesting, it is completely useless' (p. 183). Their attitude towards the theological is well represented by their comment: 'Whereas philosophers and theologians appear to possess an emotional attachment to their theories and ideas which requires them to believe them, scientists tend to regard their ideas differently . . . leaving any judgement regarding their truth to observation' (p. 15). On this, I suggest the authors reread Thomas Kuhn's *The Structure*

of Scientific Revolutions (which they quote from at length on p. 142!) and reassess the human elements in scientific progress.

In preference to a theological interpretation, the authors argue that a Many Worlds Interpretation (MWI) should be applied to the SAP which they then claim will become testable. The MWI alleges that when a physical observable of some quantum system is measured all quantum mechanically possible magnitudes for the observable become actualized—each in a separate *real* universe. Although this interpretation solves the longstanding quantum 'measurement problem' and does not require (as the orthodox Copenhagen interpretation would) an observer external to the universe observing its quantum properties, the MWI involves an extreme violation of Ockam's Razor which physicists typically wish to avoid. The authors are no exception responding, rather curiously, that the Razor only *seems* to be violated and that the MWI, while enlarging our ontology, actually economizes on physical laws. For in their view this interpretation solves the open problem of why it is that a certain set of initial conditions for our universe (out of infinitely many possible conditions) have reality. Within classical cosmology the authors assert that the only way to solve this problem is by promoting our universe's initial conditions to the status of a physical law. But surely there is nothing special about the label 'physical law' which embodies or entails an explanation for its own presence in our physical world. In the long run we are still left to account for why some particular law, among other possible laws, has reality. Oblivious to this objection, the author's portray the MWI as economically avoiding such a law since all possible initial conditions *actually* occur each in a seperate real universe. They triumphantly conclude 'The question of why does this universe rather than that universe exist is answered by saying that *all* logically possible universes exist' (p. 495). Although they do not consider a theological interpretation which would view cosmological initial conditions as somehow preordained (which, to me, conforms to Ockam's Razor *most* adequately considering the breadth of its explanatory power in many other aspects of life), they do confess that if one could argue that all possible worlds, other than our own, could not arise '. . . then the result would be a version of the Design argument remarkably similar to that proposed by Paley' (p. 289). The MWI apparently allows them to bypass resorting to such an argument.[2]

Briefly I want to argue that the authors are misguided in their motivation for adopting the MWI and in their subsequent claims that the SAP is testable without invoking a theological interpretation. Firstly, they are simply incorrect in repeatedly claiming that the ensemble of universes associated with the MWI corresponds to all *logically* possible universes.

2 On this, Craig remarks (p. 394): 'In order to stave off the conclusion of a Designer, the Anthropic philosopher must take the metaphysically speculative step of embracing a special kind of multiple universe scenario. That will hardly commend itself to some as any less objectionable than theism'. Cf. W. I. Craig, 'Barrow and Tippler on the Anthropic Principle vs. Divine Design', British Journal for the Philosophy of Science (1988), **39**, pp. 389–395.

For each universe with which they are concerned is governed by quantum mechanical laws (making the description that each is *physically* possible more appropriate) while the set of logically possible (or conceivable) universes also includes those 'universes' which are governed fundamentally by classical mechanics, those in which the Ptolemaic system is an adequate basis for astronomy, etc. (Here I take the standard view that what is not inherently self-contradictory is logically possible.) This point undermines their conclusion, at best merely a conjecture (unverifiable *in principle* because we have no observational access to universes other than our own), that the universes postulated by the MWI are free to take up all logically possible values for cosmological initial conditions. We can certainly *imagine* that they do take up all possible values, but it is *not* true that the MWI *per se* demands that there exist *real* universes (not just imaginary or logically possible) parallel to our own in which this is in fact the case! To put it another way, what the authors require is an infinite ensemble of real universes which exhausts the various possibilities for the universe's initial conditions. If the ensemble of all logically possible universes exists, then this ensemble would suffice. But this is not the same ensemble as the more restricted one which the MWI delivers. Indeed, as the authors well know, the MWI says nothing at all about initial conditions in the classical sense, for *boundary* conditions are what determine the Universal wavefunction; indeed a *single* boundary condition is sufficient to do the job![3]

Secondly, the authors' attempt to empirically test the assertion that all actual universes postulated by the MWI 'must' have been endowed with properties allowing the possibility for life to exist (i.e. the SAP!) would require that these universes be shown to *necessarily* possess the following properties: P1) Physical law is fundamentally quantum mechanical. P2) The wavefunction describing the physical evolution of the universe is constrained in order to enable the possibility for life to evolve. Clearly if P1) and P2) are necessary properties of each actual universe then they jointly imply that the SAP is true. My first point against this is that the authors make no attempt to show that P1 *must* be satisfied in all universes. Indeed the attempt would be futile because, again, it is perfectly conceivable that we might have found ourselves living in a world governed solely by Newtonian mechanics, even in the domain of microphysics. Thus it is not logically

3 McMullin makes a similar criticism but on differing grounds. He claims that 'Because observation can only occur in a universe with observers' (p. 56), each universe in the MWI ensemble, which is created by a splitting of a universe at each measurement interaction, must contain at least one observer. But then this means, by the WAP, that the initial conditions in each of these universes must be restricted to a certain set compatible with these observers' existence and, thus, MWI cannot deliver the desired ensemble. However, it seems that a defender of the MWI can reply that 'observers' are not necessary for the event of measurement, and hence 'universe splitting', to come about. For a measurement, on the MWI, can be seen as merely a correlation between an inanimate measurement device and a measured system; and, in the quantum mechanical formalism, this is completely described (without reference to observers) by the joint state of the system and device undergoing a unitary time-evolution in Hilbert space. Cf. E. McMullin, 'How Should Cosmology Relate to Theology?', in Peacocke, A. ed. *The Sciences and Theology in the Twentieth Century*, Oriel Press, Stocksfield, (1981), pp. 17–57.

necessary for our universe to have been found to satisfy P1. (Here I adopt the standard definition that an assertion is logically necessary if and only if it is true in all logically possible or conceivable worlds.)

Further, the authors investigate whether or not P2 is satisfied in their many universes by applying a certain mathematical boundary condition (cf. their equation (7.50) on p. 503) to the Universal Wavefunction (capitalized to denote that, on the MWI, it is taken as simultaneously applicable to all actual universes). They argue (p. 505) that this boundary condition permits the possible evolution of life in all universes and, since different boundary conditions lead to differing observable structures of these universes, it is possible to empirically verify whether or not P2 holds. This, for them, would constitute a verification of the SAP. What they overlook is that even if equation (7.50) should turn out to be empirically verified, we still require an explanation of why one particular boundary condition (viz. eqn. (7.50)) has reality (in all the universes postulated by the MWI) over other possible boundary conditions; just as in classical cosmology there is a need (which the authors recognize) to explain why the universe had one set of initial conditions over some other set. Thus the very problem in classical cosmology which they claim motivates the adoption of the MWI has re-emerged only this time it is with regards to boundary conditions rather than initial conditions! It seems to me that if the SAP is really true, then a theological interpretation, that there is some divine purpose for the boundary conditions (or similarly initial-conditions) of these universes adopting one form or another, is superior to the MWI. This is because it supplies a basis for believing that properties found in these universes which allow the existence of life were necessary or 'inevitable' (in the sense required by the SAP) by their having been divinely preselected. (My motivation for this critique—which, incidentally, has not been to resurrect natural theology—is to cast doubt upon a statement made by one of the authors' in a seminar given at the Institute of Astronomy at Cambridge University which I attended. Roughly the suggestion was that cosmologists are now being able to investigate topics which were previously only within the province of theological speculation. As a counterexample I offer the above to demonstrate that the verifiability of principles such as the SAP remains outside the realm of scientific reason.)

With the foregoing critique I hope to have demonstrated the capacity this book has to provoke discussion. Despite its faults, this book will inevitably become a recognized standard in its field and a classic contribution to the dialogue between science and theology. It is clearly worth incorporating into the personal library of any serious follower of contemporary thought. To balance with this recommendation I offer a word of warning, especially concerning the speculation which engulfs the last chapter in which a detailed discussion is given about the possible validity of the Final Anthropic Principle (FAP) (which asserts that intelligent information-processing life *must* come into existence in the Universe and *continue* to exist forever). My caution is best summed up in the words of the physicist

Landau: 'Cosmologists are seldom right, but never in doubt'. To display the plausibility of this assertion, I conclude with a sketch of physical eschatology put forth by the authors:

> . . . if life evolves in all of the many universes in 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 into *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. And this is the end.

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