John D. Barrow and Frank J. Tipler's

THE ANTHROPIC COSMOLOGICAL PRINCIPLE

FAITH, HOPE, AND CHARITY

> Our existence imposes a stringent selection effect upon the type of Universe we could ever expect to observe and document. Many observations of the natural world, although remarkable *a priori*, can be seen in this light as inevitable consequences of our own existence.
>
> J. D. Barrow and F. J. Tipler

So soon as one thinks *anthropic cosmology*, one thinks *teleology*. In *The Anthropic Cosmological Principle*, John D. Barrow and Frank J. Tipler have presented the most exhaustive explanation in recent years of the connection between teleological thinking and the construction and interpretation of scientific theory.

After sketching the meaning of "anthropic principle," the authors devote the first two hundred or so pages to a historical survey of thinkers who defended, attacked, or tacitly accepted teleology. The chronological scope is impressive, and most of the reporting is accurate. On occasion, informed readers will be startled, however, as when they are told that "Parmenides claimed that a 'many worlds' interpretation of nature is necessary because of the non-uniqueness of the subjective element in our perception and understanding of the world." (p. 34) Despite such mistakes, the authors will no doubt succeed in impressing upon most readers the idea that teleology in human thought is traditional and, perhaps for that reason, justified and noble. They thus set the stage for the acceptance of the anthropic principle as a current expression of that noble tradition. (p. 109)

The singular reference of the book's title is somewhat misleading, since the authors identify and discuss three different anthropic principles: the Weak Anthropic Principle (WAP), the Strong Anthropic Principle (SAP), and the Final Anthropic Principle (FAP). Moreover, SAP has three different interpretations. Common to these principles and their interpretations is the idea that human beings, aside from their being the makers of scientific theory, are crucial constituents in any coherent, empirically based and falsifiable cosmology that human beings can construct. The "empirically based and

Reason Papers No. 13 (Spring 1988) 217-223

falsifiable" is important; the authors are quite disdainful of theology and speculative philosophy for the lack of objectivity therein.

Barrow and Tipler divide 'purposive' arguments into two types, called teleological arguments and eutaxiological arguments. (p. 29) Teleological arguments are further divided into two kinds: those based on sheer anthropocentrism, and those based on finalism. Thus, arguments based on the anthropocentric assumption that each thing has our benefit as its purpose are called teleological arguments, and those based on the finalistic assumption that all entities (including human beings) have some ultimate purpose are also called teleological arguments. Eutaxiological arguments are the standard design arguments, such as "Paley's Watch." The division of 'purposive' arguments is not arbitrary; its purpose is harmony with the different kinds of anthropic argument that concern Barrow and Tipler.

'Purposive' arguments, for Barrow and Tipler, are connected with causality and causal order. To claim that there cannot be order without that order's having a cause that is itself planned is to argue eutaxiologically. And to claim that causal laws dictate that order has to have some resulting purpose is to argue teleologically. (p. 29) WAP is based on eutaxiological thinking, whereas SAP and FAP are based on teleological thinking. SAP arguments tend to be anthropocentric; FAP arguments tend to be finalistic. Gooey mixtures are not uncommon.

Of the three main anthropic principles, WAP is by far the most commonsensical. Barrow and Tipler give it this formulation:

> 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 evolve and by the requirement that the Universe be old enough for it to have already done so. (p. 160)

In short, there are certain necessary conditions that any satisfactory cosmology must accommodate, namely, those conditions that will account naturally for our being here.

Although it is not a tautology, WAP has the same sort of self-evidence that "I exist" has. It becomes immediately obvious that any account of the world must account for the accounters, since they are constituents of the world. WAP, then, is a sort of guiding principle for cosmological thinking. Hypotheses about the formation of starts and galaxies, about the development of the heavier elements from hydrogen and helium, about stellar lifetimes, about the age and the size of the universe, are all 'conditioned' by our being here.

The most convincing portion of the book, as far as an anthropic principle is concerned, is the explication of modern cosmology in terms of WAP. Barrow and Tipler brilliantly display the breadth of their knowledge of cosmology, and the careful reader is alert to their concern for his understanding of the labyrinth through which they are leading him. He is alert as well to their concern for the scientific status of WAP.

The authors seem eager to give scientific credence to WAP by making it appear crucial to *predictions*. For example, in calculating the stellar production of beryllium from helium, and of carbon from helium and beryllium, Hoyle realized that unless carbon resonated at about 7.7 MeV, much less carbon would have been produced than is now observed to exist (and carbon-based life could not have evolved). Hoyle and others then sought and found the

predicted resonance. By playing on the parenthetical addendum of the second sentence previous, Barrow and Tipler claim that the discovery of that resonance "confirmed an Anthropic Principle prediction." (pp. 252f) The anthropic principle is of course unnecessary to the making of that prediction. What's relevant is the existing carbon.

Such strained interpretations of scientific prediction (see also, e.g., pp. 165, 184, 673f.) may reveal an emotional commitment by the authors to the anthropic principle. Sentiment aside, however, WAP can function as a preliminary test of any theory of cosmic or biological development. As a test of any such theory, given ourselves as part of the data to be accounted for, WAP can be only a coherence test; it does not yield explicit, verifiable predictions.

In shifting our attention from WAP to SAP, we shift from an empirically based guiding principle to an article of faith. Barrow and Tipler give a general statement of the Strong Anthropic Principle in this way:

> The Universe must have those properties which allow life to develop within it at some stage in its history. (p. 21)

By one reading of that statement, it might seem but an innocuous restatement of WAP. Alas, telic 'arguments' just seem more palatable with a dash of ambiguity or metaphor. Reread the general statement of SAP, understanding that "must have" means cannot have been otherwise than to have"; and understand "allow" to be exactly as permissive as the "willing permission" of Augustine's omnipotent creator. This is the strongest reading of SAP, and it of course precludes all contingency.

There are, remember, three distinct interpretations of SAP. The first interpretation makes clearer than the general statement just what is at issue in the principle:

> There exists one possible Universe 'designed' with the goal of generating and sustaining 'observers.' (p. 22)

The 'scare quotes' may have been intended to exorcise the supernatural aura of SAP; indeed, Barrow and Tipler do concede that this interpretation of SAP is religious. Yet the religious import was concealed in the general statement of SAP. This interpretation is the only unnamed anthropic principle in the book. Let's call it RAP. Whereas Hoyle defends this interpretation, Barrow and Tipler seem much more comfortable with the other two interpretations, which really have no necessary religious implications and which are only remotely RAP-like.

The second and third interpretations of SAP both derive from construals of quantum mechanics. The second, the Participatory Anthropic Principle (PAP), says:

> Observers are necessary to bring the Universe into existence. (p. 22)

The third, the Many-Worlds Interpretation (MWI), says:

> An ensemble of other different universes is necessary for the existence of our Universe. (p. 22)

Although PAP and MWI seem unrelated, they are consequences of two different interpretations of the same equation in quantum physics.

In 1925, Schrödinger constructed a mathematical 'description' of electrons as *waves* around the atomic nucleus, rather than as the discrete particles of the Bohr atom. The following year, Bohr used Schrödinger's wave equation to construct (by squaring the amplitude) a probability wave equation expressing the probable position of a particle (electron, photon, etc.). The probability wave equation gives a neat 'description' of the light and dark bands in the double slit experiment using, say, a beam of photons. But consider a single particle. A single particle could be anywhere between any two adjacent nodes of the wave. Now, just where is the particle?

In an experiment to detect a single particle (say, by having a particle detector at each possible position designated by the wave equation) the particle will appear at one and only one place. But where was the particle *before* it was 'observed'? The two answers commonly given defy common sense: (1) the particle was literally nowhere, i.e., between each pair of adjacent nodes. Let's consider each answer in turn.

The first answer, that the particle is nowhere before detection, is based on Bohr's construal of quantum mechanics, and that construal is based on an outre epistemology. Barrow and Tipler quite correctly give Bohr's "empiricist principle" as "what cannot be measured, even in principle, cannot be said to exist." (p. 461) That statement is equivalent by transposition to saying: If we can say that a thing exists then we can, in principle, measure that thing.

That, of course, is the *reverse* of what is generally understood as the empiricist principle, which traces back to Aristotle's dictum that there is nothing in the intellect which was not first in sensation. Simply put, whatever we know of the world comes to us in experience. Thus, if we can measure (observe) something then we can say (claim knowledge) that it exists. This standard empiricist principle makes sense; Bohr's outre principle does not. The standard principle says that our knowledge derives from the world. The outre principle says that what we can know dictates what can be in the world. A poor epistemology here yields a dubious ontology.

That backward epistemology also transforms Heisenberg's uncertainty principle into an indeterminacy principle. Uncertainty is an epistemological condition. Indeterminacy is a metaphysical condition. Since the simultaneous position and momentum of, say, an electron cannot be *known* with certainty, the particle does not really *have* both. As Barrow and Tipler express it for Bohr, "these properties are 'real' only within the limits allowed by the uncertainty relations and the experimental apparatus chosen by the observer to measure them." (p. 461)

Barrow and Tipler use the "Schrödinger Cat Paradox" to help clarify what's at issue. (pp. 465ff) This clever fancy was concocted by Schrödinger in 1935. A cat is sealed inside a box containing an apparatus that will release cyanide gas upon activation by a single radioactive decay of a substance having a .5 probability of one decay per hour. For the sake of simplicity, assume that the activation of the apparatus, the release of the gas, and the death of the cat would be instantaneous. Now, at the end of one hour, is the cat dead or alive? Wave equations typically express numerous possibilities. Schrödinger's example is neat since there are but two possibilities: dead cat;

live cat. By Bohr's outre epistemology, the cat is neither dead nor alive until it is 'observed' to be one or the other.

The wave function, or psi function, 'describing' the hypothetical state of affairs:

$$\Psi = \frac{1}{\sqrt{2}} (\Psi \text{ dead} + \Psi \text{ alive}) \qquad \text{(p. 465)}$$

Each quantum state effect—the cat's being dead, the cat's being alive—is only a *possibility*; and one of the equiprobable possibilities will be actualized by the 'observer.' By opening the box and looking in, *we* actualize one possibility (probability = 1) and collapse the rest of the wave (probability = 0). Hence, we, as observers, bring reality into being. This interpretation gives us PAP. Without 'observers,' it's claimed, nothing is actualized as real and the rest of the wave doesn't get collapsed. But are we, human beings, really needed? Alternate claims are that (a) the cat is the 'observer' and that (b) the electronic detector is the 'observer.' It should be apparent that the adoption of either of these claims precludes any literally *anthropic* considerations. Perhaps only those who would be taken in by the backward empiricist principle would either accept the 'suicidal' cat option as anthropic or resort to considering an electronic detector to be an observer. As earlier noted, metaphor and equivocation are rife in these regions.

The psi function for Schrödinger's cat has yet another construal, one which conforms to the second answer to the question: Where is the particle 'described' by the wave equation? That answer was: At every possible position. Accordingly, Schrödinger's cat is both dead and alive, since the radioactive substance in the box both did and did not emit a particle within the hour. In more typical cases of the wave equation, each of the numerous possibilities is supposed under this construal to be real; but, since only one of the mutually exclusive possibilities can be actualized in this universe, there must be other universes in which those other real possibilities are actualized, i.e., a different world for each possibility. Hence, the Many-Words Interpretation of the Strong Anthropic Principle.

Common sense would have us back off for a moment to see what's going on. There seem to be at least two problems here. One is a matter of translation. Another is the ontologizing epistemology already discussed. And a possible third concerns, more generally, interpretation of what quantum mechanics is about.

The translation problem is one of getting from the operators of the formal language, mathematics, to those of a natural language, English. Just how do "x" and "+" translate into English? The best way to make the translation is through symbolic logic, since there is a clear correspondence between certain mathematical and logical operators, and the translation between logic and natural language is routine. The arithmetic "x" corresponds to the "·" (conjunction) of logic, and the arithmetic "+" corresponds to the "v" (disjunction) of logic. The "·" translates as "and" in English; the "v" translates as the weak disjunction of English, i.e., "either-or, but perhaps both."

The possibilities expressed in the wave equation are connected by "+" and should be understood disjunctively, not conjunctively as they are in MWI. Moreover, since those wave function possibilities are mutually exclusive, only

one can be satisfied. But if any one of them is satisfied, the whole equation is satisfied since the possibilities are disjunctive. Since this universe satisfies the equations, the positing of multiple worlds violates Ockham's Razor. Only by misconstruing "+" as "and" would MWI be plausible.

Of course, Barrow and Tipler are not themselves responsible for MWI. They simply present the historical case as it is. Indeed, they even see the propriety of translating "x" as "and"; but they immediately translate "+" as "and" as well, as though "+" and "x" have exactly the same meaning. (p. 467)

The second problem originates with the backward epistemology: what we can claim to know determines what must be in reality. The von Neumann formalism of quantum mechanics is beautifully laid out. Using it, given the initial state of a system, we can deduce the range within which subsequent states will lie. Now, applying the backward epistemology, since we know the theory, and we know that the theory is highly confirmed, the world must conform to the theory. This is dogmatic metaphysics. What's more, either an 'observer' is needed to collapse the wave in order to actualize reality (PAP) or else, wave-collapse being unnecessary for actualization, the wave generates many realities (MWI). This is speculative metaphysics.

The more general problem concerns what quantum mechanics is about. It is commonly presented to us laymen as a description of the entities and processes underlying the world of our experience, i.e., as metaphysics. Physicists may dislike the label, but that's what it comes down to if theory is taken literally as a description of an occult reality. It might promote a better understanding of what they are about if physicists were to make a shift from the metaphysical stance to an epistemological one. Theory could then be explained as a description of the *way* we might make inferences about the world, including the limitations on (or built into) that method of inference. Then, Heisenberg's uncertainty principle, for example, would remain a principle of knowledge and not become a principle of ontology. Then, perhaps, such nonsense as PAP and MWI would not even occur to anyone.

The Final Anthropic Principle, FAP, adds hope to the faith required for SAP. Barrow and Tipler state FAP as follows:

> Intelligent information-processing must come into existence in the Universe, and, once it comes into existence, it will never die out. (p. 23)

Alas, we are not the "*it*" that will never die out. We will be gone, as will the earth, the sun, and the galaxy, long before the long run of a large closed universe or of a flat universe. There is not even much hope for FAP in an open universe. (p. 670) Even in a flat- or closed universe, the information processors, if any, would not be based on the matter that we are familiar with, but on positronium, an ephemeral association of an electron and a positron (an anti-electron). Energy transfer within positronium is an 'unsolved problem,' as is the very possibility of the sort of organization of positronium 'atoms' that information processing would require. (p. 667) Hope alone seems to remain the 'justification' for FAP.

Despite the limitations of WAP and the failures of SAP, RAP, PAP, MWI, and FAP, Barrow and Tipler have written a fascinating book. The survey of twentieth century cosmology in Chapter 6 and the arguments against intelligent extraterrestrial life in Chapter 9 are excellent, and make the book

worth its price. There are, in addition, good discussions of interesting issues in biochemistry.

No-nonsense readers who expect straightforward clarity in what they read should approach *The Anthropic Cosmological Principle* with charity. The quotation at the beginning of this review is just one of many seemingly contrived lures in the book. Anthropic notions flourish in the compost of lax language and beguiled thought. With charity, we can consider the authors to be cunning storytellers who are not themselves seduced by their own figurative language.

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