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Since Collins and Hawking described the need for an unimaginably precise flatness in the early universe, many have argued that the cosmos thereby requires design. This essay traces the developments of these design speculations from the Collins-Hawking discovery in 1973 to the present, and describes the four possible responses that are available to the apparent fine-tuning of the universe.

Anthropic explanation is commonplace in some parts of the human sciences: in archaeology, physical anthropology, and paleontology, for example. To identify a piece of flint found in a riverbed as an arrowhead, i.e., as the product of human agency, calls for specifically "anthropic" explanation, that is, one that refers directly or indirectly to human agency or to human presence more generally. In the first attempts at a cosmology consonant with the new "mechanical philosophy" of the seventeenth century, there was a tension between the Cartesian goal of constructing such a cosmology utilizing mechanistic modes of explanations only and the efforts of Christian scholars like Bentley, who in reaction against the Cartesian program insisted on involving the Creator in a more evident way in the formation of the cosmos, often invoking an "anthropic" element, human flourishing, as the Creator's motive for ensuring, for example, the stability of the solar system.

Descartes believed that his new mechanics was, in principle, sufficient to explain how the present universe in all its complexity could originate over the course of time from an initial "chaos" of particles in motion. By specifying a "chaos" as a sufficient starting-point, he was implicitly taking for granted a Principle of Indifference, meaning that no constraint had to be set on the original configuration for the present-day cosmic complexity to develop from it.[1] *Any* configuration would be sufficient, as would the most general laws of mechanics as Descartes had derived them. An implicit regulative principle of this kind would dispense with the possibility that a *special* initial configuration of some sort might be required in order to arrive at the later complexities of our world; in that case, the cosmologist would be faced with the additional task of explaining why *this* configuration, rather than others, distinguished the initial cosmic state, a task that obviously transcended the capacities of the mechanical philosophy.

Descartes simply took this simplifying idealization for granted. But in later cosmology it would crystallize into a quite explicit regulative princi-

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ple, as we shall see. For one thing it would serve to exclude anthropic elements from the issue of cosmic origins. And this is just what, unexpectedly, came into question in twentieth-century cosmology, once that issue came within the actual reach of the cosmologist with the appearance of so-called "Big Bang" theory.

1. *Getting "our" universe started*

The anthropic flurry so much in evidence in cosmology today began in the early 1970s when quantum theorists began to investigate the novel field of research opened up by the extension of the postulated Big Bang expansion back to its first moments, when the immense energies would involve all sorts of quantum effects. In 1973, Collins and Hawking came up with a most unexpected, and to them most unwelcome, entailment.[2] The only way, they said, for our universe to be as isotropic as ours is after so long a period of expansion is for its initial energy-density to be at the borderline between values that would lead to a runaway expansion and values that would lead to rapid collapse. The cosmic geometry would have to be "flat" to begin with to an almost unimaginably precise degree.

This finding was unwelcome because it challenged the Cartesian principle of indifference that had implicitly informed cosmology for so long. Were "chaos" to be sufficient to give rise to the sort of universe we now have, no question would arise about why its parameters had the evidently contingent initial values they had. But if the present universe severely *constrains* the range of possibilities for a plausible starting-point, a question about the significance of that constraint immediately presents itself, or so Collins and Hawking believed. Their guess was that the significance was anthropic in nature and that some sort of selection effect was responsible. The conditions necessary for the development of intelligent life: galaxies, planets, heavy elements etc. can only occur in a very long-lived universe. But a long-lived universe is the only kind that *we* could inhabit. The universe has to be long-lived because we are here!

But a necessary condition does not qualify as an explanation. A further premise is needed, and one immediately suggested itself to the authors. There had already been talk of "branching" worlds in attempts to understand wave-packet collapse in quantum theory. What if there was, not just one world, but a very large number of (actual) worlds characterized by, in effect, the widest range of possible initial conditions, specifically of energy-density? In that case, one could expect that there would be one or a small number in that ensemble of worlds satisfying the energy-condition that would give rise to our sort of long-lived world, thus permitting the evolution of humans.

The existence of a sufficient number of worlds to make this outcome unsurprising would "explain" why we find ourselves in a world whose initial conditions seem so finely tuned for our eventual appearance. The plurality of worlds possessing the requisite range of initial conditions is the explanation therefore, of what originally seemed puzzling. In another sense, it explains *away* the apparent fine-tuning. There *was* no fine-tuning after all, strictly speaking. Rather, there was a selection effect at work. The

kind of universe we find as *we* theorize back to cosmic beginnings is the one that our complex physical make-up effectively "selects" for us.

This pushes the Principle of Indifference up to a higher level. The unspecified initial condition (the "chaos") is now an ensemble of worlds, not of particles in motion within a single world. To get to "our" sort of world, once more we need not lay any special constraint on what the initial "given" should be like, in terms of energy-density at least. The constraint only enters when one asks which of the worlds within that "given" are suitable for the possible evolutionary development of intelligent life.

What is significant here is the constraint that the human presence places on the cosmic starting-point. Exactly the same constraint would be called for by the presence of beetles or oak trees. But there would be no selection effect in their case: they do not pose questions that implicitly assume a selection effect on the part of the questioner. The explanation afforded by postulating a selection over a multiplicity of worlds is thus properly anthropic. But is there an anthropic *principle* here?

2. *Carter's "anthropic principle"*

The anthropic reasoning involved in the Collins-Hawking argument was dignified by Brandon Carter the following year with the label, "anthropic principle":[3] "What we can expect to observe must be restricted by the conditions necessary for our existence as observers." As it stands, this is, of course, quite trivial-sounding. And Carter complicated matters by introducing also a "strong" version of the principle: "The Universe must be such as to admit the creation of observers within it at some stage." This either reduces to the first ("weak") form or makes an implausible claim, depending on the force given the term, 'must.'[4] The ambiguities of the Carter article have given rise to an abundant literature. It may be best to dispense with the notion of a "principle" here; it promises too much. Or if one must have one: "in an expanding universe, watch out for selection effects!"

Finding an initial cosmic parameter constraint where none was expected led physicists to ask: was there a *reason* for it? And a selection effect gives an elegant answer. But, of course, the postulate on which it depends is highly speculative. The vigor with which it was propounded in the 1970s by Hawking, Carter, and many others testifies as nothing else could do to their commitment to the principle of indifference: in the absence of even the slightest independent theoretical reason to suppose that the ensemble of worlds displaying the requisite range of the relevant parameter actually exists, they propounded the many-world scenario as though the solution it offered of the apparent "fine tuning" puzzle was evidence enough in its support, despite its extraordinary ontological extravagance.

What prompted Collins and Hawking to propose their many-world scenario in the first place was the extreme constraint required for a single parameter, an initial condition: the energy-density. But Carter pointed to another source of constraints of a significantly different sort. The energy-density seemed, to all intents and purposes, to be an entirely contingent matter: so far as one could tell, it could have the widest possible finite range that theory allowed over a multiplicity of "worlds" that constituted a

single "universe," the universe itself remaining the same kind of universe. But what if the many worlds of the anthropic solution vary in a more fundamental way, exhibiting different basic constants, different "laws of nature"?

Here came the second great surprise, the second challenge to the cherished principle of indifference. If the strong nuclear force binding nucleons into nuclei were only very slightly weaker relative to the other three fundamental forces, Carter notes, hydrogen would be the only element. If the gravitational force were slightly stronger, planets might not form. If the fine-structure constant were "increased by only a very small amount," likewise planets might not form. So it begins to seem that there is a much more fundamental set of cosmic constraints imposed by the anthropic requirement. Carter was more interested in explaining in this way why the gravitational force should be so extraordinarily weak, relative to the other three forces. (He leads into his article by recalling Dicke's invocation of a selection effect in the context of the large-number coincidences.) But his implication was clear: one may well find that there are all sorts of *nomic* constraints, constraints on the laws of physics themselves, for a universe to develop in a potentially life-bearing way.

And find such nomic constraints physicists did. Indeed over the next decade it became almost a parlor game to juggle with the balance between the four forces to see what would happen in the ensuing cosmic scenario: only helium if the strong nuclear force were as little as 2% stronger; only hydrogen if it were 5% weaker. The existence of supernovas, of planets, of carbon, was shown to depend fairly sensitively on the values the constants actually have in our universe.[5] An appeal to an anthropic selection effect once again suggested itself.

This time, however, the requisite many-world postulate was much more problematic. It was one thing to conjure up worlds differing only in their contingent energy-densities. It was at least conceivable that an overarching theory might be found in which a single universe might give rise to such a multiplicity of component worlds, causally linked, say, at their origin and hence, in principle at least, theoretically accessible. But *nomic* variation was another matter. Was it even permissible? Might not the relationships between the physical constants be *necessarily* what they are? What sort of super-theory could be imagined that would govern the sorts of variation that this new appeal to the anthropic entailed?

3. *The teleological alternative*

The physicists who discovered the different sorts of initial parameter constraint that are implicit in the development of the long-lived, planet-bearing, heavy-element-forming universe we know, saw those constraints as significant and dealt with the consequent demand for explanation by invoking the anthropic dimension of the universe. The constraints are a logical consequence of that dimension, if the many-world postulates were granted. But might not the constraints be significant in a quite different sense, one more familiar than a selection effect, when tracing a reason for an earlier in a later. Might they not be a *teleological* consequence instead?

It was not hard to see how this might be. The familiar story of creation shared by all three Abrahamic faiths postulates a Creator on whom the existence and nature of the world depends.[6] The Biblical story describes a universe whose contents are of the Creator's shaping that is brought into existence at a moment of time. Medieval Christian theologians elaborated on this metaphysical theme and argued, for example, that time itself was the creation of a Being who existed beyond time (Augustine), and that even were the universe to be eternal, as Aristotle had held, it would still need a Creator-cause to account for its existence and nature (Aquinas).

But a second premise is also needed, a more specifically theological one. Human beings play a special role in the universe story as this unrolls in the Bible and the Koran. They are said to be made in the Creator's image; they appear to be the object of the Creator's special concern. Their abilities set them apart from the rest of the creation: their combination of reason and freewill makes them capable of a response to the Creator (of love, of acknowledgement, of denial) that no other beings can claim. The sacred books of all three faiths tell of a God who is intimately involved in the doings of His people. There is a third premise implicit in all this too; that the Creator is not just an impersonal force or energy of some unimaginable sort but a being capable of concern whose creative agency is guided in some sense by an analogue to what humans would call purpose.

If these three premises are granted, then cosmic constraints are easily explained. To the extent that the advent of the human plays a significant part in the Creator's purposes, it was to be expected that whatever constraints on the original shaping were necessary for that purpose to be fulfilled would in fact have been incorporated by the Creator. If the universe is regarded as a Creation, then the characteristic ways of acting (the "laws of nature") and the initial conditions (e.g. initial energy-density) would be set by the Creator's agency. And if the universe were to be "anthropic," capable of evolving to the level of the human, the Creator would simply elect those constraints on the limitless possibilities of creation that would make this outcome possible.

This is an anthropic explanation but in yet another sense. It does not appeal directly to human agency as an archaeological explanation might. It does not see the constraints as a selection effect attributable simply to the anthropic involvement in the posing of the original question. The anthropic dimension appears rather, in the purposes of the Creator: the act of Creation is deemed to have been guided by purpose and the capacity of the universe to be human-bearing was part of that purpose. This conforms to the familiar model of teleological explanation, but of course the context is a far from familiar one, one where the very notion of purpose stretches the limits of analogy.

An important feature of this way of understanding the problematic initial constraints is that, unlike most "Design" arguments of past natural theology, this does not involve any sort of miraculous intervention of the Creator in natural process, no momentary setting aside of the normal operations of the laws of nature. If the notion of a purposive Creator is admitted in the first place, this automatically entails a choice on the Creator's part of the sort of universe that conforms to the Divine purpose. Electing

the constraints that in this respect allow the universe to conform is thus simply implicit in the very Creation postulate itself.

In this perspective, the metaphor of "fine-tuning," with its implication of a Tuner, is entirely appropriate. Not surprisingly, critics of the theistic alternative,[7] object to it as implicitly begging the question. I have used the neutral term, 'initial parameter constraints,' deliberately here and there in order to avoid any misunderstanding. A further reason for this choice is that it focuses attention on the essential element: the constraint on values that according to the principle of indifference one would expect to be unconstrained. The *degree* of constraint makes a difference to the motivation for seeking an explanation: the tighter the constraint, the greater the motivation, as Collins and Hawking recognized.

The teleological alternative is clearly not scientific. It relies on both metaphysical and theological considerations. Those who rule out such considerations and limit explanation in the cosmological domain to natural science alone will, of course, rule out the teleological alternative also. Those who are led to postulate a Creator on traditional metaphysical grounds might still balk at the anthropic move that relies rather more on theological supplementation. But for those who already accept the view of creation implicit in the Jewish, Christian, or Islamic traditions, the teleological alternative could seem a plausible choice; given their background beliefs, the anthropic solution could neatly account for initial cosmic constraints. The overall explanation is, of course, a theistic one. But it is the tie to the *anthropic* dimension of the universe that makes it work.

Many philosophers of religion were intrigued by these unexpected developments in cosmology and debate began as to the weight that should be given them. Some took the opportunity to advance a full-scale natural theology centering on cosmology and emphasizing the anthropic-theistic dimension of the new scientific findings.[8] Others were more hesitant; arguments from design: singling out features of the world that could best (or only) is explained by invoking the action of a Creator/Designer has not had a good record. Proponents of the new argument responded that it did not, as the earlier arguments had done, rely on an explanatory gap on the side of science, something that science *ought* to be able to explain but apparently cannot. The anthropic argument was in fact prompted in the first instance by scientific findings and continues to rest on those. It proposes an agent-causal explanation of the origin of physical laws and initial cosmic conditions, a topic that lies outside the scope of physical science to begin with.

But what if the original *scientific* claim had been in error or at least premature? What if the alleged constraints were, in fact, not necessary? What if the cosmologists could provide not just a possible non-teleological alternative explanation (the anthropic selection effect did not have many defenders at the time) but also a reason to believe that there was nothing to explain?

4. *Inflation and after*

In 1980, Alan Guth proposed an ingenious, if highly speculative, way of accounting for the present "flatness" of the universe, the problem from

which the whole anthropic discussion had begun in 1973, without requiring the almost unimaginably precise "flat" setting of the initial energy-density. His proposal affected only the first fraction of a second of the cosmic expansion, leaving the standard Big Bang theory to handle the rest. Suppose a phase transition occurred that brought about a gigantic expansion, multiplying the diameter of the point-like universe by a mind-boggling factor of the order of 10^{50} and then stopping as suddenly as it began. The effect of this would be to force the energy-density, no matter what its initial value might have been, towards the desired "flat" value that would then be maintained. No need, then, for any constraint on the initial value: the principle of indifference is once more in command.

Guth's "inflation" model was prompted in the first instance by the apparent parameter constraint that the initial state required. He regarded this latter as a "peculiar situation" that could not be left to stand. And the many-world alternative evidently did not appeal to him. What is interesting is to note how the strong the motivation was on his part and on that of many other leading cosmologists, to get rid of the troublesome initial constraints that gave rise to such strange anthropic fancies. Guth's model, like any first try, faced a number of serious technical difficulties, most of which have been overcome in the years since then by introducing a number of major modifications. Vigorous attempts have been made to find independent observational support for the inflation hypothesis; some success is claimed, for example, in it's predicting the amplitudes of the tiny fluctuations in the cosmic microwave background.[9] Its major promise is to offer hope of explaining how in such an isotropic universe the galaxies could have begun to form: the inflation ratio is so great that quantum fluctuations could have been enormously amplified to form the galactic seeds.

The notion of inflation has itself meanwhile been inflating: once inflation be admitted, some theorists have argued that it can happen over and over in separate domains, generating new "bubble" universes at no time causally connected with one another. The ensemble of such universes (now "universes," no longer "worlds") has been called a "multiverse." Thus, inflation, originally proposed as a way of *avoiding* the anthropic line of argument has, rather ironically, given fresh life to it. The most speculative of the multiverse theorists, the Russian physicist Andrei Linde, would have every other sort of universe out there somewhere, popping endlessly in and out of existence in an infinite space-time. These universes would exhibit the widest variety of basic constants; their laws, even their space-time dimensionality, would range as far as the theorist's imagination might let them.

It must be emphasized that these last theoretical forays are still not much more than imaginative constructions, a series of ever more daring "what-ifs." But they do bear on the second form of parameter constraint discussed above: the tight constraints on the basic constraints of nature that the development of an anthropic universe calls for. Even if the energy-density issue were to be explained away by inflation in our own universe, the more significant parameter constraints are assuredly the "nomic" ones, those embodied in the laws of physics themselves.

The multiverse scenario would once again restore the principle of indifference, now at an even higher level, that of an ensemble of universes, each

displaying a different nomic configuration. And the anthropic selection effect would once again come into play: we are in a unique universe among the vast ensemble of "bubble" universes out there, the one that has the "right" mix of physical constants. But for the moment, this is no more than the hand-waving of a very bright physicist. Our own universe, even if inflation is added in, still displays the tight nomic constraints that have seemed to many to call out for explanation of some sort. To handle these by invoking a selection effect, a multiverse of the Linde kind would be needed. And that price would seem, at the present juncture at least, to be too high. But its in-principle possibility must be kept in mind.

5. *Four alternatives*

In the light of the developments in cosmology of the last thirty years, there would seem to be four, and only four, alternative ways of dealing with the cosmic parameter constraints that have recently come to light. And adjudicating between them is extraordinarily difficult, given the lack of agreement on the proper criteria to employ and given also that cosmology itself is in such a state of explosive development. Still, to finish, it may be worth summing up the prospects for each of the four alternatives.

a. *Happenstance*: The constraints on initial cosmic conditions and on the law of physics themselves imposed by the anthropic requirements are taken to be real. But they are declared to be just a matter of chance. The universe just *happens* to be that way: why not? If it were to be at all, it had to be *some* way. And, lucky for us, that is just the way it is.

This is perhaps the least favored of the alternatives. Most scientists are uneasy about this dismissive way of dealing with coincidence, even in a world where quantum chance seems pervasive. Time and again, ever since the original constraint on initial energy-density came to light, cosmologists have devised highly speculative theoretical constructions either to show that the supposed parameter constraint is in fact illusory (Guth), or to provide an anthropic means of restoring the valued principle of indifference (Collins and Hawking). They *could* have said: well, that is just the way it was: a matter of chance like the moment at which a radioactive atom disintegrates. But they didn't . . .

What struck them was, of course, not the initial state alone: considered in isolation, one specification of that state would seem as likely as another. It was the apparently tight correlation between that state and a later history that to all appearances would have been altogether different had the initial state been only *slightly* different on the scale of the parameter itself. Was *this* significant or not? Was there some feature of that later history that might help to explain the correlation? One could argue that this is to push the demand for explanation too far. But physicists are wont to push that demand as far as it will go.

b. *Are the constraints real*?: A different response would be to question whether the supposed constraints are themselves real. What if they reflect merely a temporary stage in theory-development? If history is any guide, how can one be confident that constraints of this sort will survive theory-change? Might there not be a return to the traditionally bland indifference of the initial cosmic state?

In a sense, of course, this has in fact happened, or at the very least a route to it has been opened. The inflation hypothesis was devised in the first place precisely to eliminate the supposed "fine-tuning" as well as to respond to the so-called "horizon" problem. Highly speculative originally, the hypothesis now has attained a degree of respectability. It has had to be extensively reworked along the way, and still faces some difficult challenges. And it is not clear that it has entirely eliminated the need for "fine-tuning" on its own account. But the degree of success that the inflation hypothesis has in fact enjoyed should make one very cautious indeed in claiming the need for parameter constraints in the context of such contingent-seeming parameters as energy-density.

The nomic constraints, however, obviously have a quite different status. The basic constraints have been measured with an impressive degree of accuracy. The process, which, say, forms carbon by helium fusion, is reasonably well understood and the consequent parameter constraint is straightforward to formulate. The basic constraints are, of course, theory-dependent in numerous ways. But it seems safe to say that later theory, no matter how different it may be, will turn up approximately the same dimensionless numbers. And the numerous constraints that have to be imposed on these numbers if a complex long-lived universe is to be allowed to develop within the framework they define seem both too specific and too numerous to evaporate entirely, as may well happen with the original "fine-tuning" claim for energy-density. Take a typical example: "A change of only half a percent in the strong force would stop the helium fusion on which the formation of carbon depends. . .".[10] It might happen, of course, that an alternative account of the formation of carbon will be devised, one that would dispense with the claimed constraint. But then a dozen or more other similar constraints have been pointed out, each dependent on a different theory of how a certain sort of physical transformation occurs. Might they *all* be replaced? Well, perhaps, but it surely seems a very long shot.

There are, however, several other quite different sorts of challenge to the reality of the "fine-tuning" claim. The first is that a later super-theory might well show that these constants, and the laws following from them, are interconnected, that they cannot, in principle, vary independently of one another. So that one could not vary the strong force by 5%, say, without invoking a cascade of other changes. Its present value might, in other words, be dependent on, or even necessitated by, the values of the remaining constants.

Might they not all vary together, then? Would some sort of "fine-tuning" persist in this case? We simply don't know. It is one thing to suppose that the initial cosmic energy-density might have been different; it *seems*, at least, a contingent parameter. But the matter is otherwise with the laws of physics themselves and with the dimensionless constants that appear in them as pure numbers. Might they have been different? It is not clear that science has an answer to this. What sort of theory would tell us what the universe *might* have been like, even though it isn't that way?

A suggestion that has sometimes been made (by Hawking, among others) is that it may turn out that the present values of the basic constants *have* to be what they are, that a necessity binds the system as a whole. We are surely far from such a theory as matters now stand. But one could

point to the many unresolved issues in basic physics and cosmology right now: the lack of integration between gravitational and quantum effects, the growing "darkness" in cosmology, as "dark" energy has been added to "dark" matter as yet another troubling question-mark. But that the long-sought "final" theory that would bring all of these elements together would show that the constants *have* to have the values they do, that no other set is possible, raises a host of questions as to what that would even mean. And, of course, even though such a theory would explain, in a sense, why the constants have the values they have, it would leave open the further question: is this still not itself significant? Might not a *further* question be in order here?

A very different sort of objection to the whole idea of "fine-tuning" or significant cosmic parameter constraint is that for it to have any force, there would have to be a way to define the values of the probabilities involved. And this is impossible, it is urged, since for one thing the required measure function is non-normalizable. So the intuitions to which physicists like Hawking and philosophers like Leslie appeal in this context are no better than that: intuitions, and intuitions with nothing to back them.[11]

The issues here are complicated and I cannot do justice to them in short space. First, the critics are right in one regard. I do not think that numerical probabilities *can* be assigned here, even though physicists as eminent as Hawking and more recently Lee Smolin[12] have not hesitated to do so. It is important to distinguish here between the two types of possible constraint: on a parameter like initial energy-density which could take any one of a wide range of values as far as the relevant theories are concerned; or on a basic physical constant like the strength-ratio between one of the four fundamental forces and the other three. The notion of fine-tuning was originally attached to the first of these only. And in this case, the idea of a small constrained range compared to a much larger possible one might seem to offer a handhold for a probability estimate.

Some of the critics at this point assume that the larger range here would have to be infinite, and then have little difficulty in showing that this would lead to a zero probability for *any* finite range of the parameter.[13] But, of course, none of the physicists involved would want to allow the possible values of the energy-density to range to infinity. Their assumption is that the range is very large, so far as the relevant theories are concerned, large enough to make the postulated constraint significant. But this would not yield a numerical estimate for the probability. The further implicit assumption that each interval of the possible range is equally probable (required by normalizability in the absence of the alternative, a density function over the range) could also be problematic. Far more problematic, however, would be the application of probabilistic notions to possible variations in the fundamental physical constants. It is hard to see how this could be theoretically grounded, since we obviously have no theory as to how these constants *might* vary. Thus defenders of the necessity for "fine-tuning" would seem to be ill-advised to introduce numerical probability estimates of any sort here.

But who says that in the absence of a numerical estimate that Bayesians can work with, the notion of a required parameter constraint collapses?

Such a constraint violates the Principle of Indifference and the tighter the constraint that theory ordains relative to the plausible finite range of the parameter, the more pressing the question becomes: can there be an explanation for the fact that the initial cosmic state *was* so constrained relative to some later feature of the universe? No probability estimates are needed to make this question meaningful. It is enough that a variation of only a tiny percentage in the value of a dimensionless constant would exclude entirely some later cosmic development like the formation of helium. What fine-tuning amounts to in cases like this has nothing to do with probability estimates.

But there are as we have seen, serious questions about the direction future theory may take and about how to understand the idea of nomic variability that underlies the supposition that the fundamental constants might have had values other than those they actually do have. On the assumption, however, that the "fine-tuning" is real, two alternatives remain, both of them anthropic.

c. *Many-world*: Given a multiplicity of actual worlds over which the relevant parameter ranges sufficiently widely, an anthropic selection effect would, as we have seen, explain the fact that the parameter took on the constrained value it did. It would explain away the appearance of a deliberate fine-tuning on the part of a Maker. But there would have to be reason other than this alone to make such an ontologically extravagant postulate plausible. That is, there would have to be a physical theory implying the existence of this profusion of worlds, a theory for which there is independent evidence in the world we inhabit. If fine-tuning of the second kind, that is, of the basic constants, is in question, then one would need a theory requiring such a multiverse.

There are such theories, notable among them those of Andrei Linde. Their existence should at least make us pause. But whether sheer technical ingenuity in the absence of testable consequence is enough to confer plausibility is questionable. *If* a multiverse of the Linde type, displaying physical laws of all sorts in different bubbles of space-time, were to exist, an anthropic selection effect would assuredly operate. But this of itself is far from enough to warrant belief that we do inhabit such a bubble. Much more would be needed to make the multiverse alternative an appealing option.

d. *Purposive fine-tuning*: The remaining alternative, assuming the initial cosmic constraints to be real, is to suppose that they have been purposely "tuned" in this way in order to accomplish the ends of the Tuner, and these are further assumed to include the existence of humans. (Obviously a non-anthropic motive could also be postulated: there are many other possible reasons why a Tuner might want a universe of the sort that would also accommodate humans.)

Appeal to a *Creator* has a particular advantage over the multiverse alternative in the context of properly *nomic* constraints. As we have seen, asking how the basic constants might in principle vary and what sorts of limit one should impose on such a variation given the physics of the universe we have (our only source of scientific evidence) runs into all sorts of difficulty. There may be relations of necessity between the constants of which we remain unaware, though it would be very difficult to believe that no other physics than one featuring the present values of the basic constants is even

metaphysically possible. But even if there are internal limits of necessity on these constants in the context of the universe we have, we could ask: why a universe of *this* sort, one which makes the advent of the human possible, given that an entirely different universe, one governed by a quite different physics, seems metaphysically possible. Appeal to a *Creator* (not to a Maker constrained by the materials available) would provide an answer to this.

This is not a scientific hypothesis. Recalling the archaeologist who finds an incised bone deep in the earth that may or may not testify to a human presence in that location at a specific period, one would have to investigate the likelihood of such a Creator in the first place. And this would necessarily lead, as we have seen, in metaphysical and theological directions. There is no way that the natural sciences, on their own resources, could support, or for that matter exclude, such an hypothesis. Does this rule it out, as a good many of those who have entered the anthropic debate clearly assume? I would say not, but to hold this possibility open would, of course, need extended argument on its own account.

A Creator of the sort that informs the Western religious tradition would, as we have seen, explain fine-tuning, to the extent that such fine-tuning exists. Such a Creator according to this tradition is already held to be responsible for the existence and nature of the cosmos, and would therefore incorporate in the work of Creation whatever further constraints the Creator's purposes might include. This is not a challenge to the sciences; it supplements their findings by covering an issue of cosmic origins that can reasonably be said to lie outside their domain. (Again, argument is needed here in regard to recent claims about vacuum fluctuations and the like.) The crucial question here is the ancient metaphysical one: Ought we simply take the existence of the universe for granted, on the assumption that causal argument of the conventional sort fails at that level? Or ought we postulate a transcendent causal agency of some kind, one with an interest in human existence besides, for the anthropic argument to work?[14]

Suppose one were to pass over the difficulties in establishing the reality of the fine-tuning feature of cosmic origins itself, would the anthropic argument offer *independent* reason to believe in the existence of a Maker of the sort the argument would require? I am hesitant to answer this in the affirmative, even though the logic of theory-support might suggest that I should.[15] And the reason is the same as that already outlined in the case of the other anthropic argument, the many-world one. In both cases, a giant ontological leap is required. To confer some initial plausibility and to allay the suspicion that the proposed explanation is *ad hoc*, entirely contrived, one has to show that the hypothesis is coherent, that the entity being proposed by way of explanation is accessible to our theorizing, scientific in one case, metaphysical and theological in the other. With this assurance given, the anthropic explanation might be held to confer additional plausibility. But then we run into the other difficulty: how sure can we be of the explanation itself, the alleged *fact* of fine-tuning? All in all, then, the anthropic argument would seem a weak reed as a motive for belief in a Creator. It is *consonant* with such belief if that belief is already there. And that in it is enough, certainly, to commend it to our interest.

In the end, however, all four alternatives have to be kept in mind. And

balancing their relative likelihood, even in the roughest way, makes demands of an unusual epistemic sort. That is what has made this issue at once so fascinating and so incapable of agreed solution.

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NOTES

1. For a fuller discussion, see E. McMullin, "Indifference principle and anthropic principle in cosmology," *Studies in the History and Philosophy of Science*, 24, 1993, 359-389.
2. C. B. Collins and S. W. Hawking, "Why is the universe isotropic?" *Astrophysical Journal*, 180, 1973, 317-334.
3. Brandon Carter, "Large number coincidences and the anthropic principle in cosmology" (1973), reprinted in J. Leslie ed., *Physical Cosmology and Philosophy*, New York: Macmillan, 1990, 125-133.
4. McMullin, "Indifference principle…", pp. 372-377.
5. For a review, see Barrow and Tipler, *The Anthropic Cosmological Principle* (New York: Oxford University Press, 1986), still by far the best source for the technical minutiae of the anthropic arguments. See also John Leslie, *Universes*, London: Routledge, 1989.
6. See E. McMullin, "How should cosmology relate to theology?", in A. R. Peacocke ed., *The Sciences and Theology in the Twentieth Century*, Notre Dame: University of Notre Dame Press, 1981, 17-57; pp. 40-52.
7. Notably Adolf Grunbaum, in a series of publications. See, for example, "The pseduo-problem of creation in physical cosmology," reprinted in Leslie ed., *Physical Cosmology and Philosophy*, 92-112.
8. See, for example, M. A. Corey, *God and the New Cosmology: The Anthropic Design Argument*,, Lanham, MD: Rowman and Littlefield, 1993.
9. For a recent and thorough survey of the present state of the evidence regarding the inflation hypothesis, see A. Liddle and D. Lyth, *Cosmological Inflation and Large-Scale Structure*, Cambridge: Cambridge University Press, 2000.
10. To quote a recent estimate by Austrian physicist Heinz Oberhummer, reported in the *New York Times*, October 29, 2002.
11. See, for example, Neil A. Manson, "There is no adequate definition of 'fine-tuned for life'," *Inquiry*, 43, 2000, 341-352; Timothy McGrew, Lydia McGrew and Eric Vestrup, "Probabilities and the fine-tuning argument: A skeptical view," *Mind*, 110, 2001, 1027-1037.
12. Lee Smolin, *The Life of the Cosmos*, New York: Oxford University Press, 1997.
13. Manson infers that "McMullin's indifference principle" leads to this absurd conclusion, one that would make the probability of a life-permitting universe zero ("No adequate definition …", pp. 346-7). There is a multiple misunderstanding here. First, it is "my" principle, only in the sense that I defined and named it as an implicit regulative principle in modern cosmology (See McMullin, "Indifference principle" above) I do not myself defend it as a constitutive principle. Anthropic explanations violate the indifference principle, of course, because of the assumption of "fine-tuning" on which they are based. Second, the indifference principle does not (as Manson supposes) imply that the energy-density could take an infinity of possible values. All that the principle does is to *exclude* the possibility that a constraint would have to be

set on an initial parameter, like energy-density, in order to arrive at the sort of universe we now live in. This in no way implies that the parameter could take on any of an infinity of possible values.

14. Wes Morriston defends a negative answer to this last query in his "Must the beginning of the universe have a personal cause?" *Faith and Philosophy*, 17, 2000, 149-169. In a rejoinder William Craig proposes a positive one: *Faith and Philosophy*, 19, 2002, 94-105.

15. As some critics have urged. For an early defence of the view propounded here, see "How should cosmology relate to theology?" in A. Peacocke ed., *The Sciences and Theology in the Twentieth Century*, Notre Dame: University of Notre Dame Press, 1981, 17-57.