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A Scientific Argument for the Existence of God: The Fine-Tuning Design Argument

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I. Introduction

The Evidence of Fine-Tuning

Suppose we went on a mission to Mars, and found a domed structure in which everything was set up just right for life to exist. The temperature, for example, was set around 70° F and the humidity was at 50 percent; moreover, there was an oxygen recycling system, an energy gathering system, and a whole system for the production of food. Put simply, the domed structure appeared to be a fully functioning biosphere. What conclusion would we draw from finding this structure? Would we draw the conclusion that it just happened to form by chance? Certainly not. Instead, we would unanimously conclude that it was designed by some intelligent being. Why would we draw this conclusion? Because an intelligent designer appears to be the only plausible explanation for the existence of the structure. That is, the only alternative explanation we can think of — that the structure was formed by some natural process — seems extremely unlikely. Of course, it is *possible* that, for example, through some volcanic eruption various metals and other compounds could have formed, and then separated out in just the right way to pro-

duce the "biosphere," but such a scenario strikes us as extraordinarily unlikely, thus making this alternative explanation unbelievable.

The universe is analogous to such a "biosphere," according to recent findings in physics. Almost everything about the basic structure of the universe — for example, the fundamental laws and parameters of physics and the initial distribution of matter and energy — is balanced on a razor's edge for life to occur. As the eminent Princeton physicist Freeman Dyson notes, "There are many . . . lucky accidents in physics. Without such accidents, water could not exist as liquid, chains of carbon atoms could not form complex organic molecules, and hydrogen atoms could not form breakable bridges between molecules"[1] — in short, life as we know it would be impossible.

Scientists call this extraordinary balancing of the parameters of physics and the initial conditions of the universe the "fine-tuning of the cosmos." It has been extensively discussed by philosophers, theologians, and scientists, especially since the early 1970s, with hundreds of articles and dozens of books written on the topic. Today, it is widely regarded as offering by far the most persuasive current argument for the existence of God. For example, theoretical physicist and popular science writer Paul Davies — whose early writings were not particularly sympathetic to theism — claims that with regard to basic structure of the universe, "the impression of design is overwhelming."[2] Similarly, in response to the life-permitting fine-tuning of the nuclear resonances responsible for the oxygen and carbon synthesis in stars, the famous astrophysicist Sir Fred Hoyle declares that

> I do not believe that any scientists who examined the evidence would fail to draw the inference that the laws of nuclear physics have been deliberately designed with regard to the consequences they produce inside stars. If this is so, then my apparently random quirks have become part of a deep-laid scheme. If not then we are back again at a monstrous sequence of accidents.[3]

1. Freeman Dyson, *Disturbing the Universe* (New York: Harper and Row, 1979), 251.

2. Paul Davies, *The Cosmic Blueprint: New Discoveries in Nature's Creative Ability to Order the Universe* (New York: Simon and Schuster, 1988), 203.

3. Fred Hoyle, in *Religion and the Scientists* (1959); quoted in *The Anthropic Cosmological Principle,* ed. John Barrow and Frank Tipler (Oxford: Oxford University Press, 1986), 22.

A few examples of this fine-tuning are listed below:

1. If the initial explosion of the big bang had differed in strength by as little as one part in 10^{60}, the universe would have either quickly collapsed back on itself, or expanded too rapidly for stars to form. In either case, life would be impossible. (As John Jefferson Davis points out, an accuracy of one part in 10^{60} can be compared to firing a bullet at a one-inch target on the other side of the observable universe, twenty billion light years away, and hitting the target.)[4]
2. Calculations indicate that if the strong nuclear force, the force that binds protons and neutrons together in an atom, had been stronger or weaker by as little as five percent, life would be impossible.[5]
3. Calculations by Brandon Carter show that if gravity had been stronger or weaker by one part in 10^{40}, then life-sustaining stars like the sun could not exist. This would most likely make life impossible.[6]
4. If the neutron were not about 1.001 times the mass of the proton, all protons would have decayed into neutrons or all neutrons would have decayed into protons, and thus life would not be possible.[7]
5. If the electromagnetic force were slightly stronger or weaker, life would be impossible, for a variety of different reasons.[8]

Imaginatively, one could think of each instance of fine-tuning as a radio dial: unless all the dials are set exactly right, life would be impossible. Or, one could think of the initial conditions of the universe and the fundamental parameters of physics as a dart board that fills the whole galaxy, and the conditions necessary for life to exist as a small one-foot wide target: unless the dart hits the target, life would be impossible. The fact that the dials are perfectly set, or that the dart has hit the target, strongly suggests that someone set the dials or aimed the dart, for it seems enor-

4. See Paul Davies, *The Accidental Universe* (Cambridge: Cambridge University Press, 1982), 90-91. John Jefferson Davis, "The Design Argument, Cosmic 'Fine-tuning,' and the Anthropic Principle," *The International Journal of Philosophy of Religion* 22 (1987): 140.

5. John Leslie, *Universes* (New York: Routledge, 1989), 4, 35; *Anthropic Cosmological Principle,* 322.

6. Paul Davies, *Superforce: The Search for a Grand Unified Theory of Nature* (New York: Simon and Schuster, 1984), 242.

7. Leslie, *Universes,* 39-40.

8. John Leslie, "How to Draw Conclusions from a Fine-Tuned Cosmos," in *Physics, Philosophy and Theology: A Common Quest for Understanding,* ed. Robert Russell et al. (Vatican City State: Vatican Observatory Press, 1988), 299.

mously improbable that such a coincidence could have happened by chance.

Although individual calculations of fine-tuning are only approximate and could be in error, the fact that the universe is fine-tuned for life is almost beyond question because of the large number of independent instances of apparent fine-tuning. As philosopher John Leslie has pointed out, "Clues heaped upon clues can constitute weighty evidence despite doubts about each element in the pile."[9] What is controversial, however, is the degree to which the fine-tuning provides evidence for the existence of God. As impressive as the argument from fine-tuning seems to be, atheists have raised several significant objections to it. Consequently, those who are aware of these objections, or have thought of them on their own, often will find the argument unconvincing. This is not only true of atheists, but also many theists. I have known, for instance, both a committed Christian Hollywood filmmaker and a committed Christian biochemist who remained unconvinced because of certain atheist objections to the argument. This is unfortunate, particularly since the fine-tuning argument is probably the most powerful current argument for the existence of God. My goal in this chapter, therefore, is to make the fine-tuning argument as strong as possible. This will involve developing the argument in as objective and rigorous a way as I can, and then answering the major atheist objections to it. Before launching into this, however, I will need to make a preliminary distinction.

A Preliminary Distinction

To develop the fine-tuning argument rigorously, it is useful to distinguish between what I shall call the *atheistic single-universe hypothesis* and the *atheistic many-universes hypothesis*. According to the atheistic single-universe hypothesis, there is only one universe, and it is ultimately an inexplicable, "brute" fact that the universe exists and is fine-tuned. Many atheists, however, advocate another hypothesis, one which attempts to explain how the seemingly improbable fine-tuning of the universe could be the result of chance. We will call this hypothesis the *atheistic many-worlds hypothesis,* or *the atheistic many-universes hypothesis*. According to this hypothesis, there exists what could be imaginatively thought of as a "universe generator" that produces a very large or infinite number of uni-

9. Leslie, "How to Draw Conclusions," 300.

verses, with each universe having a randomly selected set of initial conditions and values for the parameters of physics. Because this generator produces so many universes, just by chance it will eventually produce one that is fine-tuned for intelligent life to occur.

Plan of the Chapter

Below, we will use this distinction between the atheistic single-universe hypothesis and the atheistic many-universes hypothesis to present two separate arguments for theism based on the fine-tuning: one which argues that the fine-tuning provides strong reasons to prefer theism over the atheistic single-universe hypothesis and one which argues that we should prefer theism over the atheistic many-universes hypothesis. We will develop the argument against the atheistic single-universe hypothesis in section II below, referring to it as the *core* argument. Then we will answer objections to this core argument in section III, and finally develop the argument for preferring theism to the atheistic many-universes hypothesis in section IV. An appendix is also included that further elaborates and justifies one of the key premises of the core argument presented in section III.

II. Core Argument Rigorously Formulated

General Principle of Reasoning Used

The Principle Explained

We will formulate the fine-tuning argument against the atheistic single-universe hypothesis in terms of what I will call the *prime principle of confirmation*. The prime principle of confirmation is a general principle of reasoning which tells us when some observation counts as evidence in favor of one hypothesis over another. *Simply put, the principle says that whenever we are considering two competing hypotheses, an observation counts as evidence in favor of the hypothesis under which the observation has the highest probability (or is the least improbable).* (Or, put slightly differently, the principle says that whenever we are considering two competing hypotheses, H_1 and H_2, an observation, O, counts as evidence in favor of H_1 over H_2 if O is more probable under H_1 than it is under H_2.) Moreover, the degree to which the evidence counts in favor of one hy-

pothesis over another is proportional to the degree to which the observation is more probable under the one hypothesis than the other.[10] For example, the fine-tuning is much, much more probable under theism than under the atheistic single-universe hypothesis, so it counts as strong evidence for theism over this atheistic hypothesis. In the next major subsection, we will present a more formal and elaborated rendition of the fine-tuning argument in terms of the prime principle. First, however, let's look at a couple of illustrations of the principle and then present some support for it.

Additional Illustrations of the Principle

For our first illustration, suppose that I went hiking in the mountains, and found underneath a certain cliff a group of rocks arranged in a formation that clearly formed the pattern "Welcome to the mountains, Robin Collins." One hypothesis is that, by chance, the rocks just happened to be arranged in that pattern — ultimately, perhaps, because of certain initial conditions of the universe. Suppose the only viable alternative hypothesis is that my brother, who was in the mountains before me, arranged the rocks in this way. Most of us would immediately take the arrangements of rocks to be strong evidence in favor of the "brother" hypothesis over the "chance" hypothesis. Why? Because it strikes us as extremely *improbable* that the rocks would be arranged that way by chance, but *not improbable* at all that my brother would place them in that configuration. Thus, by the prime principle of confirmation we would conclude that the arrangement of rocks strongly supports the "brother" hypothesis over the chance hypothesis.

Or consider another case, that of finding the defendant's fingerprints on the murder weapon. Normally, we would take such a finding as strong evidence that the defendant was guilty. Why? Because we judge that it would be *unlikely* for these fingerprints to be on the murder weapon if the defendant was innocent, but *not unlikely* if the defendant was guilty. That is, we would go through the same sort of reasoning as in the above case.

10. For those familiar with the probability calculus, a precise statement of the degree to which evidence counts in favor of one hypothesis over another can be given in terms of the odds form of Bayes's Theorem: that is, $P(H_1/E)/P(H_2/E) = [P(H_1)/P(H_2)] \times [P(E/H_1)/P(E/H_2)]$. The general version of the principle stated here, however, does not require the applicability or truth of Bayes's Theorem.

Support for the Principle

Several things can be said in favor of the prime principle of confirmation. First, many philosophers think that this principle can be derived from what is known as the *probability calculus,* the set of mathematical rules that are typically assumed to govern probability. Second, there does not appear to be any case of recognizably good reasoning that violates this principle. Finally, the principle appears to have a wide range of applicability, undergirding much of our reasoning in science and everyday life, as the examples above illustrate. Indeed, some have even claimed that a slightly more general version of this principle undergirds all scientific reasoning. Because of all these reasons in favor of the principle, we can be very confident in it.

Further Development of Argument

To further develop the core version of the fine-tuning argument, we will summarize the argument by explicitly listing its two premises and its conclusion:

- *Premise 1.* The existence of the fine-tuning is not improbable under theism.
- *Premise 2.* The existence of the fine-tuning is very improbable under the atheistic single-universe hypothesis.
- *Conclusion:* From premises (1) and (2) and the prime principle of confirmation, it follows that the fine-tuning data provide strong evidence to favor the design hypothesis over the atheistic single-universe hypothesis.

At this point, we should pause to note two features of this argument. First, the argument does not say that the fine-tuning evidence proves that the universe was designed, or even that it is likely that the universe was designed. In order to justify these sorts of claims, we would have to look at the full range of evidence both for and against the design hypothesis, something we are not doing in this chapter. Rather, the argument merely concludes that the fine-tuning strongly *supports* theism *over* the atheistic single-universe hypothesis.

In this way, the evidence of the fine-tuning argument is much like fingerprints found on the gun: although they can provide strong evidence

that the defendant committed the murder, one could not conclude merely from them alone that the defendant is guilty; one would also have to look at all the other evidence offered. Perhaps, for instance, ten reliable witnesses claimed to see the defendant at a party at the time of the shooting. In this case, the fingerprints would still count as significant evidence of guilt, but this evidence would be counterbalanced by the testimony of the witnesses. Similarly the evidence of fine-tuning strongly supports theism over the atheistic single-universe hypothesis, though it does not itself show that, everything considered, theism is the most plausible explanation of the world. Nonetheless, as I argue in the conclusion of this chapter, the evidence of fine-tuning provides a much stronger and more objective argument for theism (over the atheistic single-universe hypothesis) than the strongest atheistic argument does against theism.

The second feature of the argument we should note is that, given the truth of *the prime principle of confirmation,* the conclusion of the argument follows from the premises. Specifically, if the premises of the argument are true, then we are guaranteed that the conclusion is true: that is, the argument is what philosophers call *valid.* Thus, insofar as we can show that the premises of the argument are true, we will have shown that the conclusion is true. Our next task, therefore, is to attempt to show that the premises are true, or at least that we have strong reasons to believe them.

Support for the Premises

Support for Premise (1)

Premise (1) is easy to support and fairly uncontroversial. One major argument in support of it can be simply stated as follows: *since God is an all good being, and it is good for intelligent, conscious beings to exist, it is not surprising or improbable that God would create a world that could support intelligent life.* Thus, the fine-tuning is not improbable under theism, as premise (1) asserts.

Support for Premise (2)

Upon looking at the data, many people find it very obvious that the fine-tuning is highly improbable under the atheistic single-universe hypothesis. And it is easy to see why when we think of the fine-tuning in terms of the analogies offered earlier. In the dart board analogy, for example, the

initial conditions of the universe and the fundamental parameters of physics are thought of as a dart board that fills the whole galaxy, and the conditions necessary for life to exist as a small one-foot wide target. Accordingly, from this analogy it seems obvious that it would be highly improbable for the fine-tuning to occur under the atheistic single-universe hypothesis — that is, for the dart to hit the target by chance.

Typically, advocates of the fine-tuning argument are satisfied with resting the justification of premise (2), or something like it, on this sort of analogy. Many atheists and theists, however, question the legitimacy of this sort of analogy, and thus find the argument unconvincing. For these people, the appendix to this chapter offers a rigorous and objective justification of premise (2) using standard principles of probabilistic reasoning. Among other things, in the process of rigorously justifying premise (2), we effectively answer the common objection to the fine-tuning argument that because the universe is a unique, unrepeatable event, we cannot meaningfully assign a probability to its being fine-tuned.

III. Some Objections to Core Version

As powerful as the core version of the fine-tuning argument is, several major objections have been raised to it by both atheists and theists. In this section, we will consider these objections in turn.

Objection 1: More Fundamental Law Objection

One criticism of the fine-tuning argument is that, as far as we know, there could be a more fundamental law under which the parameters of physics *must* have the values they do. Thus, given such a law, it is not improbable that the known parameters of physics fall within the life-permitting range.

Besides being entirely speculative, the problem with postulating such a law is that it simply moves the improbability of the fine-tuning up one level, to that of the postulated physical law itself. Under this hypothesis, what is improbable is that of all the conceivable fundamental physical laws there could be, the universe just happens to have the one that constrains the parameters of physics in a life-permitting way. Thus, trying to explain the fine-tuning by postulating this sort of fundamental law is like trying to explain why the pattern of rocks below a cliff spell "Welcome to the mountains, Robin Collins" by postulating that an earthquake oc-

curred and that all the rocks on the cliff face were arranged in just the right configuration to fall into the pattern in question. Clearly this explanation merely transfers the improbability up one level, since now it seems enormously improbable that of all the possible configurations the rocks could be in on the cliff face, they are in the one which results in the pattern "Welcome to the mountains, Robin Collins."

A similar sort of response can be given to the claim that the fine-tuning is not improbable because it might be *logically necessary* for the parameters of physics to have life-permitting values. That is, according to this claim, the parameters of physics must have life-permitting values in the same way 2 + 2 must equal 4, or the interior angles of a triangle must add up to 180 degrees in Euclidian geometry. Like the "more fundamental law" proposal above, however, this postulate simply transfers the improbability up one level: of all the laws and parameters of physics that conceivably could have been logically necessary, it seems highly improbable that it would be those that are life-permitting.[11]

Objection 2: Other Forms of Life Objection

Another objection people commonly raise to the fine-tuning argument is that as far as we know, other forms of life could exist even if the parameters of physics were different. So, it is claimed, the fine-tuning argument ends up presupposing that all forms of intelligent life must be like us. The answer to this objection is that most cases of fine-tuning do not make this presupposition. Consider, for instance, the case of the fine-tuning of the strong nuclear force. If it were slightly smaller, no atoms could exist other than hydrogen. Contrary to what one might see on *Star Trek*, an intelligent life-form cannot be composed merely of hydrogen gas: there is simply not enough stable complexity. So, in general the fine-tuning argument

11. Those with some training in probability theory will want to note that the kind of probability invoked here is what philosophers call *epistemic probability*, which is a measure of the rational degree of belief we should have in a proposition (see appendix, subsection iii). Since our rational degree of belief in a necessary truth can be less than 1, we can sensibly speak of it being improbable for a given law of nature to exist necessarily. For example, we can speak of an unproven mathematical hypothesis — such as Goldbach's conjecture that every even number greater than 6 is the sum of two odd primes — as being probably true or probably false given our current evidence, even though all mathematical hypotheses are either necessarily true or necessarily false.

merely presupposes that intelligent life requires some degree of stable, reproducible organized complexity. This is certainly a very reasonable assumption.

Objection 3. Anthropic Principle Objection

According to the weak version of the so-called *anthropic principle,* if the laws of nature were not fine-tuned, we would not be here to comment on the fact. Some have argued, therefore, that the fine-tuning is not really *improbable or surprising* at all under atheism, but simply follows from the fact that we exist. The response to this objection is to simply restate the argument in terms of our existence: our existence as embodied, intelligent beings is extremely unlikely under the atheistic single-universe hypothesis (since our existence requires fine-tuning), but not improbable under theism. Then, we simply apply the prime principle of confirmation to draw the conclusion that *our existence* strongly confirms theism over the atheistic single-universe hypothesis.

To further illustrate this response, consider the following "firing squad" analogy. As John Leslie points out, if fifty sharpshooters all miss me, the response "if they had not missed me I wouldn't be here to consider the fact" is not adequate. Instead, I would naturally conclude that there was some reason why they all missed, such as that they never really intended to kill me. Why would I conclude this? Because my continued existence would be very improbable under the hypothesis that they missed me by chance, but not improbable under the hypothesis that there was some reason why they missed me. Thus, by the prime principle of confirmation, my continued existence strongly confirms the latter hypothesis.[12]

Objection 4: The "Who Designed God?" Objection

Perhaps the most common objection that atheists raise to the argument from design, of which the fine-tuning argument is one instance, is that postulating the existence of God does not solve the problem of design, but merely transfers it up one level. Atheist George Smith, for example, claims that

12. Leslie, "How to Draw Conclusions," 304.

> If the universe is wonderfully designed, surely God is even more wonderfully designed. He must, therefore, have had a designer even more wonderful than He is. If *God* did not require a designer, then there is no reason why such a relatively less wonderful thing as the universe needed one.[13]

Or, as philosopher J. J. C. Smart states the objection:

> If we postulate God in addition to the created universe we increase the complexity of our hypothesis. We have all the complexity of the universe itself, and we have in addition the at least equal complexity of God. (The designer of an artifact must be at least as complex as the designed artifact). . . . *If the theist can show the atheist that postulating God actually reduces the complexity of one's total world view, then the atheist should be a theist.*[14]

The first response to the above atheist objection is to point out that the atheist claim that the designer of an artifact must be as complex as the artifact designed is certainly not obvious. But I do believe that their claim has some intuitive plausibility: for example, in the world we experience, organized complexity seems only to be produced by systems that already possess it, such as the human brain/mind, a factory, or an organism's biological parent.

The second, and better, response is to point out that, at most, the atheist objection only works against a version of the design argument that claims that all organized complexity needs an explanation, and that God is the best explanation of the organized complexity found in the world. The version of the argument I presented against the atheistic single-universe hypothesis, however, only required that the fine-tuning be more probable under theism than under the atheistic single-universe hypothesis. But this requirement is still met even if God exhibits tremendous internal complexity, far exceeding that of the universe. Thus, even if we were to grant the atheist assumption that the designer of an artifact must be as complex as the artifact, the fine-tuning would still give us strong reasons to prefer theism over the atheistic single-universe hypothesis.

To illustrate, consider the example of the "biosphere" on Mars presented at the beginning of this paper. As mentioned above, the existence

13. George Smith, "The Case Against God," reprinted in *An Anthology of Atheism and Rationalism,* ed. Gordon Stein (Buffalo: Prometheus Press, 1980), 56.

14. J. J. C. Smart, "Laws of Nature and Cosmic Coincidence," *The Philosophical Quarterly* 35 (July 1985): 275-76, italics added.

of the biosphere would be much more probable under the hypothesis that intelligent life once visited Mars than under the chance hypothesis. Thus, by the prime principle of confirmation, the existence of such a "biosphere" would constitute strong evidence that intelligent, extraterrestrial life had once been on Mars, even though this alien life would most likely have to be much more complex than the "biosphere" itself.

The final response theists can give to this objection is to show that a supermind such as God would *not* require a high degree of unexplained organized complexity to create the universe. Although I have presented this response elsewhere, presenting it here is beyond the scope of this chapter.

IV. The Atheistic Many-Universes Hypothesis

The Atheistic Many-Universes Hypothesis Explained

In response to the theistic explanation of fine-tuning of the cosmos, many atheists have offered an alternative explanation, what I will call the atheistic many-universes hypothesis. (In the literature it is more commonly referred to as the *many-worlds hypothesis,* though I believe this name is somewhat misleading.) According to this hypothesis, there are a very large — perhaps infinite — number of universes, with the fundamental parameters of physics varying from universe to universe.[15] Of course, in the vast majority of these universes the parameters of physics would not have life-permitting values. Nonetheless, in a small proportion of universes they would, and consequently it is no longer improbable that universes such as ours exist that are fine-tuned for life to occur.

Advocates of this hypothesis offer various types of models for where these universes came from. We will present what are probably the two most popular and plausible, the so-called *vacuum fluctuation* models and the *oscillating big bang* models. According to the vacuum fluctuation models, our universe, along with these other universes, were generated by quantum fluctuations in a preexisting superspace.[16] Imaginatively, one

15. I define a "universe" as any region of space-time that is disconnected from other regions in such a way that the parameters of physics in that region could differ significantly from the other regions.

16. Quentin Smith, "World Ensemble Explanations," *Pacific Philosophical Quarterly* 67 (1986): 82.

can think of this preexisting superspace as an infinitely extending ocean full of soap, and each universe generated out of this superspace as a soap bubble which spontaneously forms on the ocean.

The other model, the oscillating big bang model, is a version of the big bang theory. According to the big bang theory, the universe came into existence in an "explosion" (that is, a "bang") somewhere between ten and fifteen billion years ago. According to the *oscillating* big bang theory, our universe will eventually collapse back in on itself (what is called the "big crunch") and then from that "big crunch" will arise another "big bang," forming a new universe, which will in turn itself collapse, and so on. According to those who use this model to attempt to explain the fine-tuning, during every cycle, the parameters of physics and the initial conditions of the universe are reset at random. Since this process of collapse, explosion, collapse, and explosion has been going on for all eternity, eventually a fine-tuned universe will occur, indeed infinitely many of them.

In the next section, we will list several reasons for rejecting the atheistic many-universes hypothesis.

Reasons for Rejecting the Atheistic Many-Universes Hypothesis

First Reason

The first reason for rejecting the atheistic many-universes hypothesis, and preferring the theistic hypothesis, is the following general rule: *everything else being equal, we should prefer hypotheses for which we have independent evidence or that are natural extrapolations from what we already know.* Let's first illustrate and support this principle, and then apply it to the case of the fine-tuning.

Most of us take the existence of dinosaur bones to count as very strong evidence that dinosaurs existed in the past. But suppose a dinosaur skeptic claimed that she could explain the bones by postulating a "dinosaur-bone-producing-field" that simply materialized the bones out of thin air. Moreover, suppose further that, to avoid objections such as that there are no known physical laws that would allow for such a mechanism, the dinosaur skeptic simply postulated that we have not yet discovered these laws or detected these fields. Surely, none of us would let this skeptical hypothesis deter us from inferring the existence of dinosaurs. Why? Because although no one has directly observed dinosaurs, we do have expe-

rience of other animals leaving behind fossilized remains, and thus the dinosaur explanation is a *natural extrapolation* from our common experience. In contrast, to explain the dinosaur bones, the dinosaur skeptic has invented a set of physical laws, and a set of mechanisms that are *not* a natural extrapolation from anything we know or experience.

In the case of the fine-tuning, we already know that minds often produce fine-tuned devices, such as Swiss watches. Postulating God — a supermind — as the explanation of the fine-tuning, therefore, is a natural extrapolation from what we already observe minds to do. In contrast, it is difficult to see how the atheistic many-universes hypothesis could be considered a natural extrapolation from what we observe. Moreover, unlike the atheistic many-universes hypothesis, we have some experiential evidence for the existence of God, namely religious experience. Thus, by the above principle, we should prefer the theistic explanation of the fine-tuning over the atheistic many-universes explanation, everything else being equal.

Second Reason

A second reason for rejecting the atheistic many-universes hypothesis is that the "many-universes generator" seems like it would need to be designed. For instance, in all current worked-out proposals for what this "universe generator" could be — such as the oscillating big bang and the vacuum fluctuation models explained above — the "generator" itself is governed by a complex set of physical laws that allow it to produce the universes. It stands to reason, therefore, that if these laws were slightly different the generator probably would not be able to produce any universes that could sustain life. After all, even my bread machine has to be made just right in order to work properly, and it only produces loaves of bread, not universes! Or consider a device as simple as a mousetrap: it requires that all the parts, such as the spring and hammer, be arranged just right in order to function. It is doubtful, therefore, whether the atheistic many-universe theory can entirely eliminate the problem of design the atheist faces; rather, at least to some extent, it seems simply to move the problem of design up one level.[17]

17. Moreover, the advocate of the atheistic many-universes hypothesis could not avoid this problem by hypothesizing that the many universes always existed as a "brute fact" without being produced by a universe generator. This would simply add to the problem: it would not only leave unexplained the fine-tuning or our own universe, but would leave unexplained the existence of these other universes.

Third Reason

A third reason for rejecting the atheistic many-universes hypothesis is that the universe generator must not only select the parameters of physics at random, but must actually randomly create or select the very laws of physics themselves. This makes this hypothesis seem even more far-fetched since it is difficult to see what possible physical mechanism could select or create laws.

The reason the "many-universes generator" must randomly select the laws of physics is that, just as the right values for the parameters of physics are needed for life to occur, the right set of laws is also needed. If, for instance, certain laws of physics were missing, life would be impossible. For example, without the law of inertia, which guarantees that particles do not shoot off at high speeds, life would probably not be possible.[18] Another example is the law of gravity: if masses did not attract each other, there would be no planets or stars, and once again it seems that life would be impossible. Yet another example is the *Pauli Exclusion Principle,* the principle of quantum mechanics that says that no two fermions — such as electrons or protons — can share the same quantum state. As prominent Princeton physicist Freeman Dyson points out,[19] without this principle all electrons would collapse into the nucleus and thus atoms would be impossible.

Fourth Reason

The fourth reason for rejecting the atheistic many-universes hypothesis is that it cannot explain other features of the universe that seem to exhibit apparent design, whereas theism can. For example, many physicists, such as Albert Einstein, have observed that the basic laws of physics exhibit an extraordinary degree of beauty, elegance, harmony, and ingenuity. Nobel prize-winning physicist Steven Weinberg, for instance, devotes a whole chapter of his book *Dreams of a Final Theory*[20] explaining how the criteria of beauty and elegance are commonly used to guide physicists in formulating the right laws. Indeed, one of the most prominent theoretical physicists of this century, Paul Dirac, went so far as to claim that "it is more important to have beauty in one's equations than to have them fit experiment."[21]

18. Leslie, *Universes,* 59.

19. Dyson, *Disturbing the Universe,* 251.

20. Chapter 6, "Beautiful Theories."

21. Paul Dirac, "The Evolution of the Physicist's Picture of Nature," *Scientific American* (May 1963): 47.

Now such beauty, elegance, and ingenuity make sense if the universe was designed by God. Under the atheistic many-universes hypothesis, however, there is no reason to expect the fundamental laws to be elegant or beautiful. As theoretical physicist Paul Davies writes, "If nature is so 'clever' as to exploit mechanisms that amaze us with their ingenuity, is that not persuasive evidence for the existence of intelligent design behind the universe? If the world's finest minds can unravel only with difficulty the deeper workings of nature, how could it be supposed that those workings are merely a mindless accident, a product of blind chance?"[22]

Final Reason

This brings us to the final reason for rejecting the atheistic many-universes hypothesis, which may be the most difficult to grasp: namely, neither the atheistic many-universes hypothesis (nor the atheistic single-universe hypothesis) can at present adequately account for the improbable initial arrangement of matter in the universe required by the second law of thermodynamics. To see this, note that according to the second law of thermodynamics, the entropy of the universe is constantly increasing. The standard way of understanding this entropy increase is to say that the universe is going from a state of order to disorder. We observe this entropy increase all the time around us: things, such as a child's bedroom, that start out highly organized tend to "decay" and become disorganized unless something or someone intervenes to stop it.

Now, for purposes of illustration, we could think of the universe as a scrabble-board that initially starts out in a highly ordered state in which all the letters are arranged to form words, but which keeps getting randomly shaken. Slowly, the board, like the universe, moves from a state of order to disorder. The problem for the atheist is to explain how the universe could have started out in a highly ordered state, since it is extraordinarily improbable for such states to occur by chance.[23] If, for example, one were to dump a bunch of letters at random on a scrabble-board, it would be very unlikely for most of them to form into words. At best, we would expect groups of letters to form into words in a few places on the board.

Now our question is, Could the atheistic many-universes hypothesis

22. Davies, *Superforce,* 235-36.

23. This connection between order and probability, and the second law of thermodynamics in general, is given a precise formulation in a branch of fundamental physics called *statistical mechanics,* according to which a state of high order represents a very improbable state, and a state of disorder represents a highly probable state.

explain the high degree of initial order of our universe by claiming that given enough universes, eventually one will arise that is ordered and in which intelligent life occurs, and so it is no surprise that we find ourselves in an ordered universe? The problem with this explanation is that it is overwhelmingly more likely for local patches of order to form in one or two places than for the whole universe to be ordered, just as it is overwhelmingly more likely for a few words on the scrabble-board randomly to form words than for all the letters throughout the board randomly to form words. Thus, the overwhelming majority of universes in which intelligent life occurs will be ones in which the intelligent life will be surrounded by a small patch of order necessary for its existence, but in which the rest of the universe is disordered. Consequently, even under the atheistic many-universes hypothesis, it would still be enormously improbable for intelligent beings to find themselves in a universe such as ours which is highly ordered throughout.[24]

Conclusion

Even though the above criticisms do not definitively refute the atheistic many-universes hypothesis, they do show that it has some severe disadvantages relative to theism. This means that if atheists adopt the atheistic many-universes hypothesis to defend their position, then atheism has become much less plausible than it used to be. Modifying a turn of phrase coined by philosopher Fred Dretske: these are inflationary times, and the cost of atheism has just gone up.

V. Overall Conclusion

In the above sections I showed there are good, objective reasons for claiming that the fine-tuning provides strong evidence for theism. I first presented an argument for thinking that the fine-tuning provides strong evidence for preferring theism over the atheistic single-universe hypothesis, and then presented a variety of different reasons for rejecting the

24. See Lawrence Sklar, *Physics and Chance: Philosophical Issues in the Foundation of Statistical Mechanics* (Cambridge: Cambridge University Press, 1993), chapter 8, for a review of the nontheistic explanations for the ordered arrangement of the universe and the severe difficulties they face.

atheistic many-universes hypothesis as an explanation of the fine-tuning. In order to help one appreciate the strength of the arguments presented, I would like to end by comparing the strength of the *core* version of the argument from the fine-tuning to what is widely regarded as the strongest atheist argument against theism, the argument from evil.[25]

Typically, the atheist argument against God based on evil takes a similar form to the core version of the fine-tuning argument. Essentially, the atheist argues that the existence of the kinds of evil we find in the world is very improbable under theism, but not improbable under atheism. Thus, by the prime principle of confirmation, they conclude that the existence of evil provides strong reasons for preferring atheism over theism.

What makes this argument weak in comparison to the core version of the fine-tuning argument is that, unlike in the case of the fine-tuning, the atheist does not have a significant objective basis for claiming that the existence of the kinds of evil we find in the world is highly improbable under theism. In fact, their judgment that it is improbable seems largely to rest on a mistake in reasoning. To see this, note that in order to show that it is improbable, atheists would have to show that it is *unlikely* that the types of evils we find in the world are necessary for any morally good, greater purpose, since if they are, then it is clearly not at all unlikely that an all good, all powerful being would create a world in which those evils are allowed to occur. But how could atheists show this without first surveying all possible morally good purposes such a being might have, something they have clearly not done? *Consequently, it seems, at most the atheist could argue that since no one has come up with any adequate purpose yet, it is unlikely that there is such a purpose.* This argument, however, is very weak, as I will now show.

The first problem with this atheist argument is that it assumes that the various explanations people have offered for why an all good God would create evil — such as the free will theodicy — ultimately fail. But even if we grant that these theodicies fail, the argument is still very weak. To see why, consider an analogy. Suppose someone tells me that there is a rattlesnake in my garden, and I examine a portion of the garden and do not find the snake. I would only be justified in concluding that there was probably no snake in the garden if either: i) I had searched at least half the garden; or ii) I had good reason to believe that if the snake were in the garden, it would likely be in the portion of the garden that I examined. If,

25. A more thorough discussion of the atheist argument from evil is presented in Daniel Howard-Snyder's chapter (pp. 76-115), and a discussion of other atheistic arguments is given in John O'Leary-Hawthorn's chapter (pp. 116-34).

for instance, I were randomly to pick some small segment of the garden to search and did not find the snake, I would be unjustified in concluding from my search that there was probably no snake in the garden. Similarly, if I were blindfolded and did not have any idea of how large the garden was (e.g., whether it was ten square feet or several square miles), I would be unjustified in concluding that it was unlikely that there was a rattlesnake in the garden, even if I had searched for hours with my rattlesnake-detecting dogs. Why? Because I would not have any idea of what percentage of the garden I had searched.

As with the garden example, we have no idea of how large the realm is of possible greater purposes for evil that an all good, omnipotent being could have. Hence we do not know what proportion of this realm we have actually searched. Indeed, considering the finitude of our own minds, we have good reason to believe that we have so far only searched a small proportion, and we do not have significant reason to believe that all the purposes God might have for allowing evil would be in the proportion we searched. Thus, we have little objective basis for saying that the existence of the types of evil we find in the world is highly improbable under theism.

From the above discussion, therefore, it is clear that the relevant probability estimates in the case of the fine-tuning are much more secure than those estimates in the probabilistic version of the the atheist's argument from evil, since unlike the latter, we can provide a fairly rigorous, objective basis for them based on actual calculations of the relative range of life-permitting values for the parameters of physics. (See the appendix to this chapter for a rigorous derivation of the probability of the fine-tuning under the atheistic single-universe hypothesis.) *Thus, I conclude, the core argument for preferring theism over the probabilistic version of the atheistic single-universe hypothesis is much stronger than the atheist argument from evil.*[26]

Appendix

In this appendix, I offer a rigorous support for premise (2) of the main argument: that is, the claim that the fine-tuning is very improbable under the atheistic single-universe hypothesis. Support for premise (2) will involve three major subsections. The first subsection will be devoted to explicating the fine-tuning of gravity since we will often use this to illustrate

26. This work was made possible in part by a Discovery Institute grant for the fiscal year 1997-1998.

our arguments. Then, in our second subsection, we will show how the improbability of the fine-tuning under the atheistic single-universe hypothesis can be derived from a commonly used, objective principle of probabilistic reasoning called the *principle of indifference*. Finally, in our third subsection, we will explicate what it could mean to say that the fine-tuning is improbable given that the universe is a unique, unrepeatable event as assumed by the atheistic single-universe hypothesis. The appendix will in effect answer the common atheist objection that theists can neither *justify* the claim that the fine-tuning is improbable under the atheistic single-universe hypothesis, nor can they provide an account of what it could possibly *mean* to say that the fine-tuning is improbable.

i. The Example of Gravity

The force of gravity is determined by Newton's law $F = Gm_1m_2/r^2$. Here G is what is known as the *gravitational constant,* and is basically a number that determines the force of gravity in any given circumstance. For instance, the gravitational attraction between the moon and the earth is given by first multiplying the mass of the moon (m_1) times the mass of the earth (m_2), and then dividing by the distance between them squared (r^2). Finally, one multiplies this result by the number G to obtain the total force. Clearly the force is directly proportional to G: for example, if G were to double, the force between the moon and the earth would double.

In the previous section, we reported that some calculations indicate that the force of gravity must be fine-tuned to one part in 10^{40} in order for life to occur. What does such fine-tuning mean? To understand it, imagine a radio dial, going from 0 to $2G_0$, where G_0 represents the current value of the gravitational constant. Moreover, imagine the dial being broken up into 10^{40} — that is, ten thousand, billion, billion, billion, billion — evenly spaced tick marks. To claim that the strength of gravity must be fine-tuned to one part in 10^{40} is simply to claim that, in order for life to exist, the constant of gravity cannot vary by even one tick mark along the dial from its current value of G_0.

ii. The Principle of Indifference

In the following subsections, we will use the *principle of indifference* to justify the assertion that the fine-tuning is highly improbable under the atheistic single-universe hypothesis.

a. The Principle Stated

Applied to cases in which there is a finite number of alternatives, the principle of indifference can be formulated as the claim that we should assign the same probability to what are called *equipossible alternatives*, where two or more alternatives are said to be equipossible if we have no reason to prefer one of the alternatives over any of the others. (In another version of the principle, alternatives that are relevantly symmetrical are considered equipossible and hence the ones that should be assigned equal probability.) For instance, in the case of a standard two-sided coin, we have no more reason to think that the coin will land on heads than that it will land on tails, and so we assign them each an equal probability. Since the total probability must add up to one, this means that the coin has a 0.5 chance of landing on heads and a 0.5 chance of landing on tails. Similarly, in the case of a standard six-sided die, we have no more reason to think that it will land on one number, say a 6, than any of the other numbers, such as a 4. Thus, the principle of indifference tells us to assign each possible way of landing an equal probability — namely $\frac{1}{6}$.

The above explication of the principle applies only when there are a finite number of alternatives, for example six sides on a die. In the case of the fine-tuning, however, the alternatives are not finite but form a continuous magnitude. The value of G, for instance, conceivably could have been any number between 0 and infinity. Now, continuous magnitudes are usually thought of in terms of ranges, areas, or volumes depending on whether or not we are considering one, two, three, or more dimensions. For example, the amount of water in an 8 oz. glass could fall anywhere within the *range* 0 oz. to 8 oz., such as 6.012345645 oz. Or, the exact position that a dart hits a dart board can fall anywhere within the *area* of the dart board. With some qualifications to be discussed below, the principle of indifference becomes in the continuous case the principle that *when we have no reason to prefer any one value of a parameter over another, we should assign equal probabilities to equal ranges, areas, or volumes.* So, for instance, suppose one aimlessly throws a dart at a dart board. Assuming the dart hits the board, what is the probability it will hit within the bull's eye? Since the dart is thrown aimlessly, we have no more reason to believe it will hit one part of the dart board than any other part. The principle of indifference, therefore, tells us that the probability of its hitting the bull's eye is the same as the probability of hitting any other part of the dart board of equal area. This means that the probability of its hitting the bull's eye is simply the ratio of the area of the bull's eye to the rest of the dart board. So, for instance, if the

bull's eye forms only 5 percent of the total area of the board, then the probability of its hitting the bull's eye will be 5 percent.

b. Application to Fine-Tuning

In the case of the fine-tuning, we have no more reason to think that the parameters of physics will fall within the life-permitting range than within any other range, given the atheistic single-universe hypothesis. Thus according to the principle of indifference, equal ranges of these parameters should be assigned equal probabilities. As in the case of the dart board mentioned in the last section, this means that the probability of the parameters of physics falling within the life-permitting range under the atheistic single-universe hypothesis is simply the ratio of the range of life-permitting values (the "area of the bull's eye") to the total *relevant* range of possible values (the "relevant area of the dart board").

Now physicists can make rough estimates of the range of *life-permitting* values for the parameters of physics, as discussed above in the case of gravity, for instance. But what is the "total *relevant* range of possible values"? At first one might think that this range is infinite, since the values of the parameters could conceivably be anything. This, however, is not correct, for although the possible range of values could be infinite, for most of these values we have no way of estimating whether they are life-permitting or not. We do not truly know, for example, what would happen if gravity were 10^{60} times stronger than its current value: as far as we know, a new form of matter might come into existence that could sustain life. Thus, as far as we know, there could be other life-permitting ranges far removed from the actual values that the parameters have. Consequently, all we can say is that the life-permitting range is very, very small *relative* to the limited range of values for which we can make estimates, a range that we will hereafter refer to as the *"illuminated"* range.

Fortunately, however, this limitation does not effect the overall argument. The reason is that, based on the principle of indifference, we can still say that it is very improbable for the values for the parameters of physics to have fallen in the life-permitting range *instead* of some other part of the "illuminated" range.[27] And this *improbability* is all that is actu-

27. In the language of probability theory, this sort of probability is known as a conditional probability. In the case of G, calculations indicate that this conditional probability of the fine-tuning would be less than 10^{-40} since the life-permitting range is less than 10^{-40} of the range 0 to $2G_0$, the latter range being certainly smaller than the total "illuminated" range for G.

ally needed for our main argument to work. To see this, consider an analogy. Suppose a dart landed on the bull's eye at the center of a huge dart board. Further, suppose that this bull's eye is surrounded by a very large empty, bull's-eye-free, area. Even if there were many other bull's eyes on the dart board, we would still take the fact that the dart landed on the bull's eye instead of some other part of the large empty area surrounding the bull's eye as strong evidence that it was aimed. Why? Because we would reason that *given that the dart landed in the empty area,* it was very improbable for it to land in the bull's eye by chance but not improbable if it were aimed. Thus, by the prime principle of confirmation, we could conclude that the dart landing on the bull's eye strongly confirms the hypothesis that it was aimed over the chance hypothesis.

c. The Principle Qualified

Those who are familiar with the principle of indifference, and mathematics, will recognize that one important qualification needs to be made to the above account of how to apply the principle of indifference. (Those who are not mathematically adept might want to skip this and perhaps the next paragraph.) To understand the qualification, note that the ratio of ranges used in calculating the probability is dependent on how one parameterizes, or writes, the physical laws. For example, suppose for the sake of illustration that the range of life-permitting values for the gravitational constant is 0 to G_0, and the "illuminated" range of possible values for G is 0 to $2G_0$. Then, the ratio of life-permitting values to the range of "illuminated" possible values for the gravitational constant will be ½. Suppose, however, that one writes the law of gravity in the mathematically equivalent form of $F = \sqrt{U} m_1 m_2 / r^2$, instead of $F = G m_1 m_2 / r^2$, where $U = G^2$. (In this way of writing Newton's law, U becomes the new gravitational constant.) This means that $U_o = G_0^2$, where U_o, like G_0, represents the actual value of U in our universe. Then, the range of life-permitting values would be 0 to U_o, and the "illuminated" range of possible values would be 0 to $4U_o$ on the U scale (which is equivalent to 0 to $2G_0$ on the G scale). Hence, calculating the ratio of life-permitting values using the U scale instead of G scale yields a ratio of ¼ instead of ½. Indeed, for almost any ratio one chooses — such as one in which the life-permitting range is about the same size as the "illuminated" range — there exist mathematically equivalent forms of Newton's law that will yield that ratio. So, why choose the standard way of writing Newton's law to calculate the ratio instead of one in which the fine-tuning is not improbable at all?

The answer to this question is to require that the proportion used in calculating the probability be between *real* physical ranges, areas, or volumes, not merely mathematical representations of them. That is, the proportion given by the scale used in one's representation must directly correspond to the proportions actually existing in physical reality. As an illustration, consider how we might calculate the probability that a meteorite will fall in New York state instead of somewhere else in the northern, contiguous United States. One way of doing this is to take a standard map of the northern, contiguous United States, measure the area covered by New York on the map (say 2 square inches) and divide it by the total area of the map (say 30 square inches). If we were to do this, we would get approximately the right answer because the proportions on a standard map directly correspond to the actual proportions of land areas in the United States.[28] On the other hand, suppose we had a map made by some lover of the east coast in which, because of the scale used, the east coast took up half the map. If we used the proportions of areas as represented by this map we would get the wrong answer since the scale used would not correspond to real proportions of land areas. Applied to the fine-tuning, this means that our calculations of these proportions must be done using parameters that directly correspond to physical quantities in order to yield valid probabilities. In the case of gravity, for instance, the gravitational constant G directly corresponds to the force between two unit masses a unit distance apart, whereas U does not. (Instead, U corresponds to the square of the force.) Thus, G is the correct parameter to use in calculating the probability.[29]

28. I say "approximately right" because in this case the principle of indifference only applies to strips of land that are the same distance from the equator. The reason for this is that only strips of land equidistant from the equator are truly symmetrical with regard to the motion of the earth. Since the northern, contiguous United States are all about the same distance from the equator, equal land areas should be assigned approximately equal probabilities.

29. This solution will not always work since, as the well-known Bertrand Paradoxes illustrate (e.g., see Roy Weatherford, *Foundations of Probability Theory* [Boston: Routledge and Kegan Paul, 1982], 56), sometimes there are two equally good and conflicting parameters that directly correspond to a physical quantity and to which the principle of indifference applies. In these cases, at best we can say that the probability is somewhere between that given by the two conflicting parameters. This problem, however, typically does not seem to arise for most cases of fine-tuning. Also, it should be noted that the principle of indifference applies best to *classical* or *epistemic* probability, not other kinds of probability such as *relative frequency*. (See subsection iii below.)

d. Support for Principle

Finally, although the principle of indifference has been criticized on various grounds, several powerful reasons can be offered for its soundness if it is restricted in the ways explained in the last subsection. First, it has an extraordinarily wide range of applicability. As Roy Weatherford notes in his book, *Philosophical Foundations of Probability Theory,* "an astonishing number of extremely complex problems in probability theory have been solved, and usefully so, by calculations based entirely on the assumption of equiprobable alternatives [that is, the principle of indifference]."[30] Second, at least for the discrete case, the principle can be given a significant theoretical grounding in information theory, being derivable from Shannon's important and well-known measure of *information,* or *negative entropy.*[31] Finally, in certain everyday cases the principle of indifference seems the only justification we have for assigning probability. To illustrate, suppose that in the last ten minutes a factory produced the first fifty-sided die ever produced. Further suppose that every side of the die is (macroscopically) perfectly symmetrical with every other side, except for there being different numbers printed on each side. (The die we are imagining is like a fair six-sided die except that it has fifty sides instead of six.) Now, we all immediately know that upon being rolled the probability of the die coming up on any given side is one in fifty. Yet, we do not know this directly from experience with fifty-sided dice, since by hypothesis no one has yet rolled such dice to determine the relative frequency with which they come up on each side. Rather, it seems our only justification for assigning this probability is the principle of indifference: that is, given that every side of the die is relevantly macroscopically symmetrical with every other side, we have no reason to believe that the die will land on one side over any other side, and thus we assign them all an equal probability of one in fifty.[32]

30. Weatherford, *Probability Theory,* 35.

31. Sklar, *Physics and Chance,* 191; Bas van Fraassen, *Laws and Symmetry* (Oxford: Oxford University Press, 1989), 345.

32. Of course, one could claim that our experience with items such as coins and dice teaches us that whenever two alternatives are macroscopically symmetrical, we should assign them an equal probability, unless we have a particular reason not to. All this claim implies, however, is that we have experiential justification for the principle of indifference, and thus it does not take away from our main point that in certain practical situations we must rely on the principle of indifference to justify our assignment of probability.

iii. The Meaning of Probability

In the last section we used the principle of indifference to rigorously justify the claim that the fine-tuning is highly improbable under the atheistic single-universe hypothesis. We did not explain, however, what it could *mean* to say that it is improbable, especially given that the universe is a unique, unrepeatable event. To address this issue, we shall now show how the probability invoked in the fine-tuning argument can be straightforwardly understood either as what could be called *classical probability* or as what is known as *epistemic probability.*

Classical Probability

The *classical conception of probability* defines probability in terms of the ratio of number of "favorable cases" to the total number of equipossible cases.[33] Thus, for instance, to say the probability of a die coming up "4" is one out of six is simply to say that the number of ways a die could come up "4" is one-sixth the number of equipossible ways it could come up. Extending this definition to the continuous case, classical probability can be defined in terms of the relevant ratio of ranges, areas, or volumes over which the principle of indifference applies. Thus, under this extended definition, to say that the probability of the parameters of physics falling into the life-permitting value is very improbable simply *means* that the ratio of life-permitting values to the range of possible values is very, very small. Finally, notice that this definition of probability implies the principle of indifference, and thus we can be certain that the principle of indifference holds for classical probability.

Epistemic Probability

Epistemic probability is a widely recognized type of probability that applies to claims, statements, and hypotheses — that is, what philosophers call *propositions.*[34] (A proposition is any claim, assertion, statement, or hy-

33. See Weatherford, *Probability Theory,* ch. 2.

34. For an in-depth discussion of epistemic probability, see Richard Swinburne, *An Introduction to Confirmation Theory* (London: Methuen, 1973); Ian Hacking, *The Emergence of Probability: A Philosophical Study of Early Ideas About Probability, Induction and Statistical Inference* (Cambridge: Cambridge University Press, 1975); and Alvin Plantinga, *Warrant and Proper Function* (Oxford: Oxford University Press, 1993), chapters 8 and 9.

pothesis about the world.) Roughly, the epistemic probability of a proposition can be thought of as the degree of credence — that is, degree of confidence or belief — we rationally should have in the proposition. Put differently, epistemic probability is a measure of our rational degree of belief under a condition of ignorance concerning whether a proposition is true or false. For example, when one says that the special theory of relativity is probably true, one is making a statement of epistemic probability. After all, the theory is actually either true or false. But, we do not know for sure whether it is true or false, so we say it is probably true to indicate that we should put more confidence in its being true than in its being false. It is also commonly argued that the probability of a coin toss is best understood as a case of epistemic probability. Since the side the coin will land on is determined by the laws of physics, it is argued that our assignment of probability is simply a measure of our rational expectations concerning which side the coin will land on.

Besides epistemic probability simpliciter, philosophers also speak of what is known as the *conditional* epistemic probability of one proposition on another. The conditional epistemic probability of a proposition R on another proposition S — written as P(R/S) — can be defined as the degree to which the proposition S *of itself* should rationally lead us to expect that R is true. For example, there is a high conditional probability that it will rain today on the hypothesis that the weatherman has predicted a 100 percent chance of rain, whereas there is a low conditional probability that it will rain today on the hypothesis that the weatherman has predicted only a 2 percent chance of rain. That is, the hypothesis that the weatherman has predicted a 100 percent chance of rain today should strongly lead us to expect that it will rain, whereas the hypothesis that the weatherman has predicted a 2 percent chance should lead us to expect that it will not rain. Under the epistemic conception of probability, therefore, the statement that *the fine-tuning of the Cosmos is very improbable under the atheistic single-universe hypothesis* makes perfect sense: it is to be understood as making a statement about the degree to which the atheistic single-universe hypothesis would or should, *of itself,* rationally lead us to expect the cosmic fine-tuning.[35]

35. It should be noted here that this rational degree of expectation should not be confused with the degree to which one should expect the parameters of physics to fall within the life-permitting range if one believed the atheistic single-universe hypothesis. For even those who believe in this atheistic hypothesis should expect the parameters of physics to be life-permitting since this follows from the fact that we are alive. Rather,

Conclusion

The above discussion shows that we have at least two ways of understanding improbability invoked in our main argument: as classical probability or epistemic probability. This undercuts the common atheist objection that it is meaningless to speak of the probability of the fine-tuning under the atheistic single-universe hypothesis since under this hypothesis the universe is not a repeatable event.

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the conditional epistemic probability in this case is the degree to which the atheistic single-universe hypothesis *of itself* should lead us to expect parameters of physics to be life-permitting. This means that in assessing the conditional epistemic probability in this and other similar cases, one must exclude contributions to our expectations arising from other information we have, such as that we are alive. In the case at hand, one way of doing this is by means of the following sort of thought experiment. Imagine a disembodied being with mental capacities and a knowledge of physics comparable to that of the most intelligent physicists alive today, except that the being does not know whether the parameters of physics are within the life-permitting range. Further, suppose that this disembodied being believed in the atheistic single-universe hypothesis. Then, the degree that being should rationally expect the parameters of physics to be life-permitting will be equal to our conditional epistemic probability, since its expectation is solely a result of its belief in the atheistic single-universe hypothesis, not other factors such as its awareness of its own existence.