The Chance of the Gaps

William A. Dembski

Baylor University
P. O. Box 97130
Waco, Texas 76798

Discovery Institute
1402 Third Ave.
Seattle, WA 98101

7.11.01, appeared 2003 with Routledge in Neil Manson's *God and Design*

---

1. Probabilistic Resources

Statistical reasoning must be capable of eliminating chance when the probability of events gets too small. If not, chance can be invoked to explain anything. Scientists rightly resist invoking the supernatural in scientific explanations for fear of committing a god-of-the-gaps fallacy (the fallacy of using God as a stop-gap for ignorance). Yet without some restriction on the use of chance, scientists are in danger of committing a logically equivalent fallacy—one we may call the chance-of-the-gaps fallacy. Chance, like God, can become a stop-gap for ignorance. For instance, in the movie *This is Spinal Tap*, one of the lead characters remarks that a former drummer in his band died by spontaneously combusting. Any one of us could this instant spontaneously combust if all the fast-moving air molecules in our vicinity suddenly converged on us. Such an event, however, is highly improbable, and we do not give it a second thought.

Even so, high improbability by itself is not enough to preclude chance. After all, highly improbable events happen all the time. Flip a coin a thousand times, and you will participate in a highly improbable event. Indeed, just about anything that happens is highly improbable once we factor in all the ways what did happen could have happened. Mere improbability therefore fails to rule out chance. In addition, improbability needs to be conjoined with an independently given pattern. An arrow shot randomly at a large blank wall will be highly unlikely to land at any one place on the wall. Yet land it must, and so some highly improbable event will be realized. But now fix a target on that wall and shoot the arrow. If the arrow lands in the target and the target is sufficiently small, then chance is no longer a reasonable explanation of the arrow's trajectory.

Highly improbable, independently patterned events are said to exhibit specified complexity. The term specified complexity has been around since 1973 when Leslie Orgel introduced it in connection with origins-of-life research: "Living organisms are distinguished by their specified complexity. Crystals such as granite fail to qualify as living because they lack complexity; mixtures of random polymers fail to qualify because they lack specificity."[1] More recently, Paul Davies has also used the term in connection with the origin of life: "Living organisms are mysterious not for their complexity *per se*, but for their tightly specified complexity."[2] Events are specified if they exhibit an independently given pattern (cf. the target fixed on the wall). Events are complex to the degree that they are improbable. The identification of complexity with improbability here is straightforward. Imagine a combination lock. The more possibilities on the lock, the more complex the mechanism, and correspondingly the more improbable that it can be opened by chance. Note that the "complexity" in "specified complexity" has a particular probabilistic meaning and is not meant to exhaust the concept of complexity (Seth Lloyd, for instance, records dozens of types of complexity[3]).

The most controversial claim in my writings is that specified complexity is a reliable empirical marker of intelligent agency.[4] There are several places to criticize this claim. Elliott Sober criticizes it for failing to meet Bayesian standards of probabilistic coherence.[5] Robin Collins criticizes it for hinging on an ill-defined conception of specification.[6] Taner Edis criticizes it for admitting a crucial counterexample—the Darwinian mechanism of natural selection and random variation is supposed to provide a naturalistic mechanism for generating specified complexity.[7] None of these criticisms holds up under scrutiny.[8] Nevertheless, a persistent worry about small probability arguments remains: Given an independently given pattern, or specification, what level of improbability must be attained before chance can legitimately be precluded? A wall so large that it cannot be missed and a target so large that covers half the wall, for instance, are hardly sufficient to preclude chance (or "beginner's luck") as the reason for an archer's success in hitting the target. The target needs to be small to preclude hitting it by chance.

But how small is small enough? To answer this question we need the concept of a probabilistic resource. A probability is never small in isolation but only in relation to a set of probabilistic resources that describe the number of relevant ways an event might occur or be specified. There are thus two types of probabilistic resources, *replicational* and *specificational*. To see what is at stake, consider a wall so large that an archer cannot help but hit it. Next, let us say we learn that the archer hit some target fixed to the wall. We want to know whether the archer could reasonably have been expected to hit the target by chance. To determine this we need to know any other targets at which the archer might have been aiming. Also, we need to know how many arrows were in the archer's quiver and might have been shot at the wall. The targets on the wall constitute the archer's specificational resources. The arrows in the quiver constitute the archer's replicational resources.

Note that to determine the probability of hitting some target with some arrow by chance, specificational and replicational resources multiply: Suppose the probability of hitting any given target with any one arrow has probability no more than p. Suppose further there are N such targets and M arrows in the quiver. Then the probability of hitting any one of these N targets, taken collectively, with a single arrow by chance is bounded by Np, and the probability of hitting any of these N targets with at least one of the M arrows by chance is bounded by MNp. Thus to preclude chance for a probability p means precluding chance for a probability MNp once M replicational and N specificational resources have been factored in. In practice it is enough that $MNp < 1/2$ or $p < 1/(2MN)$. The rationale here is that since factoring in all relevant probabilistic resources leaves us with an event of probability less than 1/2, that event is less probable than not, and consequently we should favor the opposite event, which is more probable than not and precludes it.[9]

To recap, probabilistic resources comprise the relevant ways an event can occur (replicational resources) and be specified (specificational resources). The important question therefore is not What is the probability of the event in question? but rather What does its probability become after all the relevant probabilistic resources have been factored in? Probabilities can never be considered in isolation, but must always be referred to a relevant reference class of possible replications and specifications. A seemingly improbable event can become quite probable when placed within the appropriate reference class of probabilistic resources. On the other hand, it may remain improbable even after all the relevant probabilistic resources have been factored in. If it remains improbable (and therefore complex) and if the event is also specified, then it exhibits specified complexity.

2. Universal Probability Bounds

In the observable universe, probabilistic resources come in very limited supplies. Within the known physical universe there are estimated around 10^{80} elementary particles. Moreover, the properties of matter are such that transitions from one physical state to another cannot occur at a rate faster than 10^{45} times per second. This frequency corresponds to the Planck time, which constitutes the smallest physically meaningful unit of time.[10] Finally, the universe itself is about a billion times younger than 10^{25} seconds (assuming the universe is between ten and twenty billion years old). If we now assume that any specification of an event within the known physical universe requires at least one elementary particle to specify it and cannot be generated any faster than the Planck time, then these cosmological constraints imply that the total number of specified events throughout cosmic history cannot exceed

$$10^{80} \times 10^{45} \times 10^{25} = 10^{150}.$$

It follows that any specified event of probability less than 1 in 10^{150} will remain improbable even after all conceivable probabilistic resources from the observable universe have been factored in. A probability of 1 in 10^{150} is therefore a *universal probability bound*.[11] A universal probability bound is impervious to all available probabilistic resources that may be brought against it. Indeed, all the probabilistic resources in the known physical world cannot conspire to render remotely probable an event whose probability is less than this universal probability bound. The universal probability bound of 1 in 10^{150} is the most conservative in the literature. The French mathematician Emile Borel proposed 1 in 10^{50} as a universal probability bound below which chance could definitively be precluded (i.e., any specified event as improbable as this could never be attributed to chance).[12] Cryptographers assess the security of cryptosystems in terms of a brute force attack that employs as many probabilistic resources as are available in the universe to break a cryptosystem by chance. In its report on the role of cryptography in securing the information society, the National Research Council set 1 in 10^{94} as its universal probability bound for ensuring the security of cryptosystems against chance-based attacks.[13] Such levels of improbability are easily attained by real physical systems. It follows that if such systems are also specified and if specified complexity is a reliable empirical marker of intelligence, then these systems are designed.

Implicit in a universal probability bound such as 10^{-150} is that the universe is too small a place to generate specified complexity by sheer exhaustion of possibilities. Stuart Kauffman develops this theme at length in his book *Investigations*.[14] In one of his examples (and there are many like it throughout the book), he considers the number of possible proteins of length 200 (i.e., 20^{200} or approximately 10^{260}) and the maximum number of pairwise collisions of particles throughout the history of the universe (he estimates 10^{193} total collisions supposing the reaction rate for collisions can be measured in femtoseconds). Kauffman concludes: “The known universe has not had time since the big bang to create all possible proteins of length 200 [even] once.”[15] To emphasize this point, he notes: “It would take at least 10 to the 67th times the current lifetime of the universe for the universe to manage to make all possible proteins of length 200 at least once.”[16]

Kauffman even has a name for numbers that are so big that they are beyond the reach of operations performable by and within the universe—he refers to them as *transfinite*. For instance, in discussing a small discrete dynamical system whose dynamics are nonetheless so complicated that they cannot be computed, he writes: "There is a sense in which the computations are transfinite—not infinite, but so vastly large that they cannot be carried out by any computational system in the universe."[17] Kauffman justifies such proscriptive claims in exactly the same terms that I justified the universal probability bound a moment ago. Thus as justification he looks to the Planck time, the Planck length, the radius of the universe, the number of particles in the universe, and the rate at which particles can change states.[18] Kauffman's idea of transfinite numbers is insightful, but the actual term is infelicitous because it already has currency within mathematics, where transfinite numbers are by definition infinite (in fact, the transfinite numbers of transfinite arithmetic can assume any infinite cardinality whatsoever).[19] I therefore propose to call such numbers *hyperfinite numbers*.[20]

Kauffman often writes about the universe being unable to exhaust some set of possibilities. Yet at other times he puts an adjective in front of the word universe, claiming it is the *known* universe that is unable to exhaust some set of possibilities.[21] Is there a difference between the universe (no adjective in front) and the *known* or *observable* universe (adjective in front)? To be sure, there is no empirical difference. Our best scientific observations tell us that the world surrounding us appears quite limited. Indeed, the size, duration, and composition of the known universe are such that 10^{150} is a hyperfinite number. For instance, if the universe were a giant computer, it could perform no more than this number of operations (quantum computation, by exploiting superposition of quantum states, enriches the operations performable by an ordinary computer but cannot change their number); if the universe were devoted entirely to generating specifications, this number would set an upper bound; if cryptographers confine themselves to brute-force methods on ordinary computers to test cryptographic keys, the number of keys they can test will always be less than this number.

But what if the universe is in fact much bigger than the known universe? What if the known universe is but an infinitesimal speck within the actual universe? Alternatively, what if the known universe is but one of many possible universes, each of which is as real as the known universe but causally inaccessible to it? If so, are not the probabilistic resources needed to eliminate chance vastly increased and is not the validity of 10^{-150} as a universal probability bound thrown into question? This line of reasoning has gained widespread currency among scientists and philosophers in recent years. In this paper I will to argue that this line of reasoning is fatally flawed. Indeed, I will argue that it is illegitimate to rescue chance by invoking probabilistic resources from outside the known universe. To do so, artificially inflates one's probabilistic resources.

3. The Inflationary Fallacy

Only probabilistic resources from the known universe may legitimately be employed in testing chance hypotheses. In particular, probabilistic resources imported from outside the known universe are incapable of overturning the universal probability bound of 10^{-150}. My basic argument to support this claim is quite simple, though I need to tailor it to some of the specific proposals now current for inflating probabilistic resources. The basic argument is this: It is never enough to postulate probabilistic resources merely to prop an otherwise failing chance hypothesis. Rather, one needs independent evidence whether there really are enough probabilistic resources to render chance plausible.

Consider, for instance, two state lotteries, both of which have printed a million lottery tickets. Let us assume that each ticket has a one in a million probability of winning and that whether one ticket wins is probabilistically independent of whether another wins (multiple winners are therefore a possibility). Suppose now that one of these state lotteries sells the full one million tickets but that the other sells only two tickets. Ostensibly both lotteries have the same number of probabilistic resources—the same number of tickets were printed for each. Nevertheless, the probabilistic resources relevant for deciding whether the first lottery produced a winner by chance greatly exceed those of the second. Probabilistic resources are *opportunities* for an event to happen or be specified. To be relevant to an event, those opportunities need to be actual and not merely possible. Lottery tickets sitting on a shelf collecting dust might just as well never have been printed.

This much is uncontroversial. But let us now turn the situation around. Suppose we know nothing about the number of lottery tickets sold and are informed simply that the lottery had a winner. Suppose further that the probability of any lottery ticket producing a winner is extremely low. Now what can we conclude? Does it follow that many lottery tickets were sold? Hardly. We are entitled to this conclusion only if we have independent evidence that many lottery tickets were sold. Apart from such evidence we have no way of assessing how many tickets were sold, much less whether the lottery was conducted fairly and whether its outcome was due to chance. It is illegitimate to take an event, decide for whatever reason that it must be due to chance, and then propose numerous probabilistic resources because otherwise chance would be implausible. I call this the *inflationary fallacy*.[22]

Stated thus, the inflationary fallacy is readily rejected as a bogus form of argument. Nevertheless, it can be nuanced so that the problem inherent in it is mitigated (though not eliminated). The problem inherent in the inflationary fallacy is always that it multiplies probabilistic resources in the absence of independent evidence that such resources exist. Typically, however, when probabilistic resources get inflated, the rationale for inflating them is not simply to render chance plausible when otherwise it would be implausible. Hardly anyone is so crass as to admit, "I didn't like the alternatives to chance so I simply decided to invent some probabilistic resources." The rationale for inflating probabilistic resources is always more subtle, seeking confirmation in general coherence or consilience considerations even though independent evidence is lacking.

The inflationary fallacy therefore has a crass and a nuanced form. The crass form looks as follows:

Premise 1: Alternatives to chance are for whatever reason unacceptable for explaining some event—call that event X.

Premise 2: With the probabilistic resources available in the known universe, chance is not a reasonable explanation of X.

Premise 3: If probabilistic resources could be expanded, then chance would be a reasonable explanation of X.

Premise 4: Let there be more probabilistic resources.

Conclusion: Chance is now a reasonable explanation of X.

The problem with this argument is Premise 4 (the "fiat" premise), which creates probabilistic resources ex nihilo simply to ensure that chance becomes a reasonable explanation.

The more nuanced form of the inflationary fallacy is on the surface less objectionable. It looks as follows:

Premise 1: There is an important problem, call it Y, that admits a solution as soon as one is willing to posit some entity, process, or stuff outside the known universe. Call whatever this is that resides outside the known universe Z.

Premise 2: Though not confirmed by any independent evidence, Z is also not inconsistent with any empirical data.

Premise 3: With the probabilistic resources available in the known universe, chance is not a reasonable explanation of some event—call the event X.

Premise 4: But when Z is added to the known universe, probabilistic resources are vastly increased and now suffice to account for X by chance.

Conclusion: Chance is now a reasonable explanation of X.

This nuanced form of the inflationary fallacy appears in various guises and has gained widespread currency. It purports to solve some problem of general interest and importance by introducing some factor Z, which we will call an *inflaton*.[23] By definition, an inflaton will be some entity, process, or stuff outside the known universe that in addition to solving some problem also has associated with it numerous probabilistic resources as a by-product. These resources in turn help to shore up chance when otherwise chance would seem unreasonable in explaining some event.

4. Four Widely-Discussed Inflatons

I want therefore next to consider four inflatons that purport to resolve important problems and that have gained wide currency. The inflatons I will consider are these: the bubble universes of Alan Guth's inflationary cosmology, the many worlds of Hugh Everett's interpretation of quantum mechanics, the self-reproducing black holes of Lee Smolin's cosmological natural selection, and the possible worlds of David Lewis's extreme modal realist metaphysics.[24] My choice of proposals, though selective, is representative of the forms that the inflationary fallacy takes. While I readily admit that these inflatons propose solutions to important problems, I will argue that the costs of these solutions outweigh their benefits. In general, inflatons that inflate probabilistic resources, so that what was unattributable to chance within the known universe now becomes attributable to chance after all, are highly problematic and create more difficulties than they solve.

Let us start with Alan Guth's inflationary cosmology. Inflationary cosmology posits a very brief period of hyper-rapid expansion of space just after the Big Bang. Though consistent with general relativity, such expansion is not required. What's more, the expansion has now stopped (at least as far as we can tell within the known universe). Guth introduced inflation to solve such problems in cosmology as the flatness, horizon, and magnetic monopole problems. In standard Big Bang cosmology the first two of these problems seem to require considerable fine-tuning of the initial conditions of the universe whereas the third seems unresolvable if standard Big Bang cosmology is combined with grand unified theories. Inflationary cosmology offers to resolve these problems in one fell swoop. In so doing, however, the known universe becomes a bubble universe within a vast sea of other bubble universes, and the actual universe now constitutes the sea that contains these bubble universes.

Next let us consider Hugh Everett's interpretation of quantum mechanics. Everett's many worlds interpretation of quantum mechanics proposes a radical solution to what in quantum mechanics is known as the measurement problem. The state function of a quantum mechanical system corresponds to a probability distribution that upon measurement assumes a definite value. The problem is that any physical system whatsoever can be conceived as a quantum mechanical system described by a state function. Now what happens when the physical system in question is taken to be the entire universe? Most physical systems one considers are proper subsets of the universe and thus admit observers who are outside the system and who can therefore measure the system and, as it were, collapse the state function. But when the universe as a whole is taken as the physical system in question, where is the observer to collapse the state function?[25] Everett's solution is to suppose that the state function does not collapse but rather splits into all different possible values that the state function could assume (mathematically this is very appealing—especially to quantum cosmologists—because it eliminates any break in dynamics resulting from state-function collapse). In effect, all possible quantum histories get lived out. Suppose, for instance, someone offers me a million dollars to play Quantum Russian Roulette (i.e., a quantum mechanical device is set up with six possibilities, each having probability one-sixth, and such that a bullet fires into my brain and kills me when exactly one of these possibilities occurs but leaves me unharmed otherwise). If I choose to play this game, then for every one quantum world in which I get a bullet to the head there are five in which I live happily ever after as a millionaire.

Next let us consider Lee Smolin's cosmological natural selection of self-reproducing black holes. Smolin's self-reproducing black holes constitute perhaps the most ambitious of the inflatons we will consider. Smolin characterizes his project as explaining how the laws of physics have come to take the form they do, but in fact he is presenting a full-blown cosmogony in which Darwinian selection becomes the mechanism by which universes are generated and flourish. According to Smolin, quantum effects preclude singularities at which time stops.

Consequently, time does not stop in a black hole but rather “bounces” in a new direction, producing a region of space-time inaccessible to ours except at the moment of its origination. Moreover, Smolin contends that during a “bounce” the laws of nature change their parameters but not their general form. Consequently, the formation of black holes follows an evolutionary algorithm in which parameters get continually tightened to maximize the production of black holes. Within Smolin’s scheme the known universe is but one among innumerable black holes that have formed by this process and that in turn generate other black holes. Cosmological natural selection accounts not only for the generation of universes but also for their fine tuning and the possibility of such structures as life.

Finally, let us consider the possible worlds of David Lewis’s extreme modal realist metaphysics. Lewis, unlike Guth, Everett, and Smolin, is not a scientist but a philosopher and in particular a metaphysician. For Lewis any logically possible world is as real as our world, which he calls the actual world. It is logically possible for a world to consist entirely of a giant tangerine. It is logically possible that the laws of physics might have been different, not only in their parameters but also in their basic form. It is logically possible that instead of turning to mathematics I might have become a rock and roll singer. For each of these logical possibilities Lewis contends that there are worlds as real as ours in which those possibilities are actualized. The only difference between those worlds and ours is that we happen to inhabit our world—that is what makes our world the actual world. Lewis’s view is known as extreme modal realism. Modal realism asserts that logical possibilities are in some sense real (perhaps as abstractions in a mathematical space). *Extreme* modal realism emphasizes that logical possibilities are real in exactly the same way that the world we inhabit is real. Why does Lewis hold this view? According to him, possible worlds are indispensable for making sense of certain key philosophical problems, notably the analysis of counterfactual conditionals. What’s more, he finds that all attempts to confer on possible worlds a status different from the actual world are incoherent (he refers to these disparagingly as *ersatz* possible worlds and finds them poor substitutes for his full-blown possible worlds).

I have provided only the briefest summary of the views of Alan Guth, Hugh Everett, Lee Smolin, and David Lewis. The problems these thinkers raise are important, and the solutions they propose need to be taken seriously. Moreover, except for David Lewis's possible worlds, which are purely metaphysical, the other three inflatons considered make contact with empirical data. Lee Smolin even contends that his theory of cosmological natural selection has testable consequences—he even runs through several possible tests. The unifying theme in Smolin's tests is that varying the parameters for the laws of physics should tend to decrease the rate at which black holes are formed in the known universe. It is a consequence of Smolin's theory that for most universes generated by black holes, the parameters of the laws of physics should be optimally set to facilitate the formation of black holes. We ourselves are therefore highly likely to be in a universe where black hole formation is optimal. My own view is that our understanding of physics needs to proceed considerably further before we can establish convincingly that ours is a universe that optimally facilitates the formation of black holes. But even if this could be established now, it would not constitute independent evidence that a black hole is capable of generating a new universe. Smolin's theory, in positing that black holes generate universes, would explain why we are in a universe that optimally facilitates the formation of black holes. But it is not as though we would ever have independent evidence for Smolin's theory, say by looking inside a black hole and seeing whether there is a universe in it. Of all the objects in space (stars, planets, comets, etc.) black holes divulge the least amount of information about themselves.

5. Explanatory Power and Independent Evidence

Each of the four inflatons considered here possesses explanatory power in the sense that each explains certain relevant data and thereby solves some problem of general interest and importance. These data are said to confirm or provide epistemic support for an inflaton insofar as it adequately explains the relevant data and does not conflict with other recognized data. What's more, insofar as an inflaton does not adequately explain the relevant data, it lacks explanatory power and is disconfirmed. In general, therefore, explanatory power entails testability in the weak sense that if a claim fails adequately to explain certain relevant data, it is to be rejected (thus failing the test).

Nevertheless, even though the four inflatons considered here each possesses explanatory power, none of them possesses independent evidence for its existence. Independent evidence is by definition evidence that helps establish a claim apart from any appeal to the claim's explanatory power. The demand for independent evidence is neither frivolous nor tendentious. Instead, it is a necessary constraint on theory construction so that theory construction does not degenerate into total free-play of the mind.[26] Consider for instance the "gnome theory of friction." Suppose a physicist claims that the reason objects do not slide endlessly across surfaces is because tiny invisible gnomes inhabit all surfaces and push back on any objects pushed along the surfaces. What's more, the rougher a surface, the more gnomes inhabit it, and consequently the greater the resistance to an object moving across the surface. Suitably formulated, the gnome theory of friction can explain how objects move across surfaces just as accurately as current physical theory. So why do we not take the gnome theory of friction seriously? One reason (though not the only reason—the gnome theory has many more problems than described here) is the absence of independent evidence for gnomes.

Independent evidence and explanatory power need to work in tandem, and for one to outpace the other typically leads to difficulties. In spinning out their theories, conspiracy theorists place all their emphasis on explanatory power but ignore the demand for independent evidence. In enumerating countless low-level facts, crude inductivists place all their emphasis on independent evidence and thus miss the bold hypotheses and intuitive leaps that make for explanatory power and thus are capable of tying together their disparate facts. Independent evidence is the strict disciplinarian to explanatory power's carefree genius. Each is needed to balance the other. My favorite story illustrating the interplay between the two is due to John Leslie.[27] Suppose an arrow is fired at random into a forest and hits Mr. Brown. To explain such a chance occurrence it would suffice for the forest to be full of people. The forest being full of people therefore possesses explanatory power. Even so, this explanation remains but a speculative possibility until it is supported by independent evidence of people other than Mr. Brown in the forest.

The problem with the four inflatons considered above is that none of them admits independent evidence. The only thing that confirms them is their ability to explain certain data or resolve certain problems. With regard to inflationary cosmology, we have no direct experience of hyper-rapid inflation nor have we observed any process that could reasonably be extrapolated to hyper-rapid inflation. With regard to the many-worlds interpretation of quantum mechanics, we always experience exactly one world and have no direct access to alternate parallel worlds. If there is any access at all to these worlds, it is indirect and circumstantial. Indeed, to claim that quantum interference signals the influence of parallel worlds is to impose a highly speculative interpretation on the data of quantum mechanics that is far from compelling.[28] With regard to black hole formation, there is no way for anybody on the outside to get inside a black hole, determine that there actually is a universe inside there, and then emerge intact to report as much. With regard to possible worlds, they are completely causally separate from each other—other possible worlds never were and never can be accessible to us, either directly or indirectly.

The absence of independent evidence for these inflatons makes the problem of underdetermination especially acute for them. In general, when a hypothesis explains certain data, there are other hypotheses that also explain the data. In this way, data are said to underdetermine hypotheses. Nonetheless, it may be that one hypothesis explains the data better than the others so that it is possible to adjudicate among hypotheses simply on the basis of explanatory power. On the other hand, it may be that competing hypotheses exhibit identical explanatory power or that advocates of competing hypotheses claim that their preferred hypotheses exhibit the greater explanatory power. In either case, independent evidence will be required to adjudicate among the hypotheses. With the four inflatons here considered, no such independent evidence is forthcoming.

I want therefore next to examine these four inflatons in relation to design to see whether design might be amenable to independent evidence in a way that the four inflatons are not. As I defined it, an inflaton is some entity, process, or stuff outside the known universe that helps explain certain data and thereby resolve some problem. Notably absent from the inflatons described by Guth, Everett, Smolin, and Lewis is a designer. Their inflatons are fully compatible with naturalism and thoroughly nonteleological. Now the interesting thing is that a designer, especially when fleshed out into a full-blown theistic deity, can be employed to resolve the very problems that the four inflatons considered here were meant to resolve. The fine-tuning of the universe and the form of the laws of physics that are central to Guth's and Smolin's concerns can be attributed to a divine act of creation. Moreover, such a deity could collapse the state function of the universe and thereby resolve the measurement problem of quantum mechanics when this problem is applied to the universe taken as a whole. And finally, such a deity, by being suitably omniscient and thus possessing what philosophers of religion call "middle knowledge," could provide a semantics for counterfactual conditionals and resolve many of the other problems for which David Lewis thinks he requires possible worlds.[29]

Now I want to stress that I am not advocating these theistic alternatives to the four inflatons considered above (I personally think there is something to the theistic fine-tuning arguments, but I am no fan of middle knowledge and have serious doubts about God's role as a state-function collapser). My point, rather, is this: Given that there are design-theoretic alternatives to the inflatons considered here and given that such alternatives immediately raise the problem of underdetermination, the only way to resolve this problem is via independent evidence. So let me pose the question: Is there independent evidence that would allow us to distinguish the four inflatons considered above from a design-theoretic alternative? We have already seen that there is no independent evidence that supports these four inflatons. But could there be independent evidence that supports a design-theoretic alternative and in so doing also disconfirms these four inflatons? I am going to argue that there is.

6. Arthur Rubinstein—Consummate Pianist or Lucky Poseur?

The four inflatons considered here allow for unlimited probabilistic resources. Now the problem with unlimited probabilistic resources is that they allow us to explain absolutely everything by reference to chance—not just natural objects that actually did result by chance and not just natural objects that look designed, but also all artificial objects that are in fact designed. In effect, unlimited probabilistic resources collapse the distinction between apparent design and actual design and make it impossible to attribute anything with confidence to actual design. Was Arthur Rubinstein a great pianist or was it just that whenever he sat at the piano, he happened by chance to put his fingers on the right keys to produce beautiful music? It could happen by chance, and there is some possible world where everything is exactly as it is in this world except that the counterpart to Arthur Rubinstein cannot read music and happens to be incredibly lucky whenever he sits at the piano. Examples like this can be multiplied. There are possible worlds in which I cannot do arithmetic and yet sit down at my Macintosh computer and write probabilistic tracts about intelligent design. Perhaps Shakespeare was a genius. Perhaps Shakespeare was an imbecile who just by chance happened to string together a long sequence of apt phrases. Unlimited probabilistic resources ensure not only that we will never know, but also that we have no rational basis for preferring one to the other.

Given unlimited probabilistic resources, there is only one way to rebut this anti-inductive skepticism, and that is to admit that while unlimited probabilistic resources allow bizarre possibilities like this, these possibilities are nonetheless highly improbable in the little patch of reality that we inhabit. Unlimited probabilistic resources make bizarre possibilities unavoidable on a grand scale. The problem is how to mitigate the craziness entailed by them, and the only way to do this once such bizarre possibilities are conceded is to render them improbable on a local scale. Thus in the case of Arthur Rubinstein, there are worlds where someone named Arthur Rubinstein is a world famous pianist and does not know the first thing about music. But it is vastly more probable that in worlds where someone named Arthur Rubinstein is a world famous pianist, that person is a consummate musician. What's more, induction tells us that ours is such a world.

But can induction really tell us that? How do we know that we are not in one of those bizarre worlds where things happen by chance that we ordinarily attribute to design? Consider further the case of Arthur Rubinstein. Imagine it is January 1971 and you are at Orchestra Hall in Chicago listening to Arthur Rubinstein perform. As you listen to him perform Liszt's "Hungarian Rhapsody," you think to yourself, "I know the man I'm listening to right now is a wonderful musician. But there's an outside possibility that he doesn't know the first thing about music and is just banging away at the piano haphazardly. The fact that Liszt's 'Hungarian Rhapsody' is pouring forth would thus merely be a happy accident. Now if I take seriously the existence of other worlds, then there is some counterpart to me pondering these very same thoughts, only this time listening to the performance of someone named Arthur Rubinstein who is a complete musical ignoramus. How, then, do I know that I'm not that counterpart?"[30]

Indeed, how do you know that you are not that counterpart? First off, let us be clear that the Turing Test is not going to come to the rescue here by operationalizing the two Rubinsteins and rendering them operationally indistinguishable. According to the Turing Test, if a computer can simulate human responses so that fellow humans cannot distinguish the computer's responses from an individual human's responses, then the computer passes the Turing Test and is adjudged intelligent.[31] This operationalizing of intelligence has its own problems, but even if we let them pass, success at passing the Turing Test is clearly not what is at stake in the Rubinstein example. The computer that passes the Turing Test presumably "knows" what it is doing (having been suitably programmed) whereas the Rubinstein who plays successful concerts by randomly positioning fingers on the keyboard does not have a clue. Think of it this way: Imagine a calculating machine whose construction guarantees that it performs arithmetic correctly and imagine another machine that operates purely by random processes. Suppose we pose the same arithmetic problems to both machines and out come identical answers. It would be inappropriate to assign arithmetic prowess to the random device, even though it is providing the right answers, because that is not its proper function—it is simply by chance happening upon the right answers. On the other hand, it is entirely appropriate to attribute arithmetic prowess to the other machine because it is constructed to perform arithmetic calculations accurately—that is its proper function. Likewise, with the real Arthur Rubinstein and his chance-performing counterpart, the real Arthur Rubinstein's proper function is, if you will, to perform music with skill and expression whereas the counterpart is just a lucky poseur. When Turing operationalized intelligence, he clearly meant intelligence to be a proper function of a suitably programmed computer and not merely a happy accident.[32]

How, then, do you know that you are listening to Arthur Rubinstein the musical genius and not Arthur Rubinstein the lucky poseur? To answer this question, let us ask a prior question: How did you recognize in the first place that the man called Rubinstein performing in Orchestra Hall was a consummate musician? Reputation, formal attire, and famous concert hall are certainly giveaways, but they are neither necessary nor sufficient. Even so, a necessary condition for recognizing Rubinstein's musical skill (design) is that he was following a prespecified concert program, and in this instance that he was playing Liszt's "Hungarian Rhapsody" note for note (or largely so—Rubinstein was not immune to mistakes). In other words, you recognized that Rubinstein's performance exhibited specified complexity. Moreover, the degree of specified complexity exhibited enabled you to assess just how improbable it was that someone named Rubinstein was playing the "Hungarian Rhapsody" with éclat but did not have a clue about music. Granted, you may have lacked the technical background to describe the performance in these terms, but the recognition of specified complexity was there nonetheless, and without that recognition there would have been no way to attribute Rubinstein's playing to design rather than chance.

7. Independent Evidence for a Designer

Specified complexity is how we eliminate bizarre possibilities in which chance is made to account for things that we would ordinarily attribute to design. What's more, specified complexity is how we assess the improbability of those bizarre possibilities and therewith justify eliminating their chance occurrence. That being the case (and it certainly is the case for human artifacts), on what basis could we attribute chance to natural phenomena that exhibit specified complexity? Let us be clear that inflating probabilistic resources does not just diminish a universal probability bound and make it harder to attribute design—inflating probabilistic resources is not a matter of replacing one universal probability bound by another that is more stringent. Inflating probabilistic resources eliminates universal probability bounds entirely—the moment one posits unlimited probabilistic resources, anything of nonzero probability becomes certain (probabilistically this follows from the Strong Law of Large Numbers[33]). It seems, however, that in practical life we do allow for probability bounds to assess improbability and therewith specified complexity. A sentence or two verbatim repeated by another author can be enough to elicit the charge of plagiarism. It could happen by chance and given unlimited probabilistic resources there are patches of reality where it did happen by chance. But we do not buy it—at least not for our patch of reality. In practical life we tend not to be very conservative in setting probability bounds. They tend to be quite large, and certainly much larger than the universal probability bound of 10^{-150} that I have been advocating.

The difficulty confronting unlimited probabilistic resources can now be put quite simply: There is no principled way to discriminate between using unlimited probabilistic resources to retain chance and using specified complexity to eliminate chance. You can have one or the other, but you cannot have both. And the fact is, we already use specified complexity to eliminate chance. Let me stress that there is no *principled* way to make the discrimination. It is, for instance, possible to invoke naturalism as a philosophical presupposition and use it to discriminate between using probabilistic resources to retain chance when designers unacceptable to naturalism are implicated (e.g., God) and using specified complexity to eliminate chance when designers acceptable to naturalism are implicated (e.g., Francis Crick's space aliens who seed the universe with life[34]). Thus for artifactual objects exhibiting specified complexity and for which an embodied intelligence could plausibly have been involved, we would attribute design; but for natural objects exhibiting specified complexity and for which no embodied intelligence could plausibly have been involved, we would invoke unlimited probabilistic resources and thus attribute chance (or perhaps simply plead ignorance). But this is entirely arbitrary. Indeed, the problem of unlimited probabilistic resources throws naturalism itself into question, and it does no good to invoke naturalism to resolve the problem.

It is important to understand that I am not arguing that the inflation of probabilistic resources entails anti-inductive skepticism. Indeed, my argument here is not anti-inductive but pro-specified complexity. I did offer anti-inductive argument in chapter 6 of *The Design Inference*. My focus there was on the set of all logically possible worlds, and thus on worlds that instantiate every possible set of natural laws. In that case, inflating probabilistic resources entails inductive skepticism since there are far more worlds that agree with our world up to the present and go haywire afterward than there are worlds that continue to obey the regularities observed thus far. My argument here, however, allows that the worlds that inflate probabilistic resources obey laws of the same form as the laws of our universe. In that case, the vast majority of worlds in which Rubinstein delivers an exquisite performance are worlds in which Rubinstein is a skilled musician rather than a lucky poseur. But to convince ourselves for such worlds that Rubinstein is indeed a skilled musician rather than a lucky poseur requires specified complexity. Even with unlimited probabilistic resources, we need to distinguish design from nondesign, and specified complexity is how we do it. Consequently, there is no principled way to discriminate between using unlimited probabilistic resources to retain chance and using specified complexity to eliminate chance. And since we already use specified complexity to eliminate chance, invoking unlimited probabilistic resources to retain chance is not a defensible option. I am not arguing that inflating probabilistic resources destroys induction. I am arguing that inflating probabilistic resources does not destroy specified complexity. In particular, probabilistic resources from outside the known universe are irrelevant to assessing specified complexity.[35]

We are now in a position to see why a designer outside the known universe could in principle be supported by independent evidence whereas the inflatons introduced by Guth, Everett, Smolin, and Lewis cannot. We already have experience of human and animal intelligences generating specified complexity. If we should ever discover evidence of extraterrestrial intelligence, a necessary feature of that evidence would be specified complexity. Thus, when we find evidence of specified complexity in nature for which no embodied, reified, or evolved intelligence could plausibly have been involved, it is a straightforward extrapolation to conclude that some unembodied intelligence must have been involved. Granted, this raises the question of how such an intelligence could coherently interact with the physical world.[36] But to deny this extrapolation merely because of a prior commitment to naturalism is not defensible. There is no principled way to distinguish between using specified complexity to eliminate chance in one instance and then in another invoking unlimited probabilistic resources to render chance plausible.

Design allows for the possibility of independent evidence whereas the inflatons of Guth, Everett, Smolin, and Lewis do not. Specified complexity can be a point of contact between the known universe and an intelligence outside it—designers within the universe already generate specified complexity and a designer outside could potentially do the same. That is what allows for independent evidence to support unembodied designers. Provided nature supplies us with instances of specified complexity that cannot reasonably be attributed to any embodied intelligence,[37] the inference to an unembodied intelligence becomes compelling and any instances of specified complexity used to support that inference can rightly be regarded as independent evidence. By contrast, the inflatons of Guth, Everett, Smolin, and Lewis provide no such palpable connection with the known universe. Indeed, what in our actual experience can straightforwardly be extrapolated to hyper-rapid expansion of space, quantum many worlds, cosmological natural selection, and causally inaccessible possible worlds? Is it, for instance, a straightforward extrapolation that takes us from biological natural selection of carbon-based life to cosmological natural selection of black holes? To be sure, there is an extrapolation here, but one where all meaningful analogies with actual experience break down.

Three crucial questions now face design: (1) Is specified complexity exhibited in any natural systems where no embodied intelligence could plausibly have been involved? (2) If so, does the design apparent in such systems match up meaningfully with known designs due to known embodied designers? (3) Does a theory of design that treats specified complexity as a reliable marker of intelligence possess sufficient explanatory power to render it interesting and fruitful for science? In *No Free Lunch* I argue for an affirmative answer to each of these three questions.[38]

8. Closing off Quantum Loopholes

In concluding this paper, I want to address one possible worry that might remain. I have argued that it does no good to look outside the known universe to increase one's probabilistic resources. But what about looking inside the known universe for additional probabilistic resources? Take, for instance, quantum computation. Peter Shor has described an algorithm for quantum computers that is capable of factoring numbers vastly larger than can be factored with conventional computers (thus threatening cryptographic schemes that depend on factorization constituting a hard computational problem).[39] David Deutsch therefore asks,

> When Shor's algorithm has factorized a number, using 10^{500} or so times the computational resources that can be seen to be present, where was the number factorized? There are only about 10^{80} atoms in the entire visible universe, an utterly minuscule number compared with 10^{500}. So if the visible universe were the extent of physical reality, physical reality would not even remotely contain the resources required to factorize such a large number. Who did factorize it, then? How, and where, was the computation performed?[40]

In raising these questions, Deutsch is advocating a many-worlds interpretation of quantum mechanics. This interpretation is not mandated. Indeed, interpretations of quantum mechanics abound and all of them, insofar as they are coherent and empirically adequate, are empirically indistinguishable. As Anthony Sudbery remarks, "An interpretation of quantum mechanics is essentially an answer to the question 'What is the state vector?' Different interpretations cannot be distinguished on scientific grounds—they do not have different experimental consequences; if they did they would constitute different *theories*."[41] Yet if we resist the many-worlds interpretation of quantum mechanics and the unlimited probabilistic resources this interpretation provides, does not quantum mechanics, and quantum computation in particular, invite a huge number of probabilistic resources into our own known universe? I submit that it does not. True, quantum computation may alter the computational resources relevant to assessing the security of cryptosystems against brute force attacks that enlist the entire universe as a giant quantum computer. As a result, universal computation bounds will diverge from universal probability bounds—in the past they were largely identical because they were based on conventional computing whereas now they would diverge because of the increased computational resources due to quantum computing.

Even so, quantum computation provides no justification for altering the universal probability bound of 10^{-150}. To see this, let us pose a related but different question from the one raised by Shor. Shor asked how large a number could be factored with quantum computers as opposed to conventional computers. He found that quantum computers vastly increased the size of the numbers that could be factored. But now let us ask how many numbers could be factored with quantum computers as opposed to conventional computers. To factor a given number on either a conventional or a quantum computer means entering it respectively as a specific sequence of bits or qubits, performing the relevant computation, and then identifying a specific output sequence as the answer. If we now ignore computation times, it follows that in terms of the sheer quantity of numbers that can be factored, quantum computation offers no advantage over conventional computation—specific numbers still have to be inputted and outputted. Input and output themselves take time, space, and material, and there are no more than 10^{150} specific numbers that computers, whether conventional or quantum, can ever input and output.

The lesson here is that specified complexity, precisely because it requires items of information to be specifically identified, provides no opening for quantum computation to exploit quantum parallelism or superposition and thereby generate specifications. We can imagine a quantum memory register of 1,000 qubits in a superposition of states representing every possible sequence of 0s and 1s of length 1,000. Nevertheless, this memory register is incapable of specifying even a single conventional bit string of length 1,000 until a measurement is taken and the superposition of states is projected onto an eigenstate.

Though quantum computation offers to dramatically boost computational power by allowing massively parallel computations, it does so by keeping computational states indeterminate until the very end of a computation. This indeterminateness of computational states takes the form of quantum superpositions, which are deliberately exploited in quantum computation to facilitate parallel computation. The problem with quantum superpositions, however, is that they are incapable of concretely realizing specifications. A quantum superposition is an indeterminate state. A specification is a determinate state. Measurement renders a quantum superposition determinate by producing an eigenstate, but once it does, we are no longer dealing with a quantum superposition. Because quantum computation thrives precisely where it exploits superpositions and avoids specificity, it offers no means for boosting the number of specifications that can be concretely realized in the known universe.[42]

Is there any place else to look for additional probabilistic resources inside the known universe? According to Robin Collins, quantum mechanics offers still one other loophole for inflating probabilistic resources and thereby undercutting specified complexity as a reliable indicator of design. Collins notes that the state function of a quantum mechanical system can take continuous values and thus assume infinitely many possible states. From this he draws the following conclusion: "This means that in Dembski's scheme one could only absolutely eliminate chance for events of zero probability!"[43] Presumably he thinks that because quantum systems can produce infinitely many possible events, this means that quantum systems also induce infinitely many probabilistic resources. And since infinitely many probabilistic resources coincide with a probability threshold of zero, my scheme could therefore only eliminate chance for events of probability zero. The problem here is that Collins fails to distinguish between the *range* of possible events that might occur and the *opportunities* for a given event to occur or be specified. A reference class of possibilities may well be infinite (as in the case of certain quantum mechanical systems). But the opportunities for sampling from such a reference class and thereby inducing information are always finite and extremely limited. Probabilistic resources always refer to the opportunities for sampling from a range of possible events. The range of possible events itself might well be infinite. But this has no bearing on the probabilistic resources associated with a given event in that range.

It appears, then, that we are back to our own known little universe, with its very limited number of probabilistic resources but therewith also its increased possibilities for detecting design. This is one instance where less is more, where having fewer probabilistic resources opens possibilities for knowledge and discovery that would otherwise be closed. Limited probabilistic resources enrich our knowledge of the world by enabling us to detect design where otherwise it would elude us. At the same time, limited probabilistic resources protect us from the unwarranted confidence in natural causes that unlimited probabilistic resources invariably seem to engender. In short, limited probabilistic resources eliminate the chance of the gaps.

Notes

[1]Leslie Orgel, *The Origins of Life* (New York: Wiley, 1973), 189.
[2]Paul Davies, *The Fifth Miracle* (New York: Simon & Schuster, 1999), 112.
[3]See John Horgan, *The End of Science* (New York: Broadway Books, 1996), 303, n. 11.
[4]See William A. Dembski, *The Design Inference* (Cambridge: Cambridge University Press, 1998).
[5]See Elliott Sober, "Testability," *Proceedings and Addresses of the American Philosophical Association* 73(2) (1999): 47–76; and Branden Fitelson, Christopher Stephens, and Elliott Sober, "How Not to Detect Design—Critical Notice: William A. Dembski, *The Design Inference*," *Philosophy of Science* 66 (1999): 472–488.
[6]Robin Collins, "An Evaluation of William A. Dembski's *The Design Inference*: A Review Essay," *Christian Scholar's Review* 30(3) (2001): 329–341.
[7]Taner Edis, "Darwin in Mind: 'Intelligent Design' Meets Artificial Intelligence," *Skeptical Inquirer* 25(2) (March/April 2001): 35–39.
[8]See William A. Dembski, *No Free Lunch: Why Specified Complexity Cannot Be Purchased without Intelligence* (Lanham, Md.: Rowman & Littlefield, 2001), forthcoming.
[9]Full details for this rationale are given in chapter 6 of *The Design Inference*, and specifically in section 6.3 titled "The Magic Number 1/2."
[10]See David Halliday and Robert Resnick, *Fundamentals of Physics*, 3rd ed. extended (New York: Wiley, 1988), 544. Note that universal time bounds for electronic computers have clock speeds between ten and twenty magnitudes slower than the Planck time—see Ingo Wegener, *The Complexity of Boolean Functions* (Stuttgart: Wiley-Teubner, 1987), 2.
[11]For the details justifying this universal probability bound, see William A. Dembski, *Design Inference: Eliminating Chance through Small Probabilities* (Cambridge: Cambridge University Press, 1998), sec. 6.5.
[12]Emile Borel, *Probabilities and Life*, trans. M. Baudin (New York: Dover, 1962), 28. See also Eberhard Knobloch, "Emile Borel as a Probabilist," in *The Probabilistic Revolution*, vol. 1, eds. L. Krüger, L. J. Daston, and M. Heidelberger (Cambridge, Mass.: MIT Press, 1987), 228.
[13]Kenneth W. Dam and Herbert S. Lin, eds., *Cryptography's Role in Securing the Information Society* (Washington, D.C.: National Academy Press, 1996), 380, n. 17. See also Singh, *The Code Book*, which is filled with arguments that tacitly appeal to universal probability bounds. For instance, Singh quotes William Crowell, Deputy Director of the National Security Agency: "If all the personal computers in the world—approximately 260 million computers—were to be put to work on a single PGP encrypted message, it would take on average an estimated 12 million times the age of the universe to break a single message" (317).
[14]Stuart Kauffman, *Investigations* (New York: Oxford University Press, 2000). Although Kauffman does not explicitly mention the phrase "specified complexity," his emphasis throughout this book is on the complexity of biological systems, and the type of complexity he is concerned to explain is in fact specified complexity.
[15]Ibid., 144.
[16]Ibid.
[17]Ibid., 138.
[18]Ibid., 137–138, 144, 162, 167.
[19]See Michael Hallett, *Cantorian Set Theory and Limitation of Size* (Oxford: Oxford University Press, 1984), 55–56.
[20]Peter Rüst refers to such numbers as "transastronomical." See Peter Rüst, "How Has Life and Its Diversity Been Produced?" *Perspectives on Science and Christian Faith* 44(2) (1992): 80. Emile Borel referred to the reciprocal of such numbers as "probabilities which are negligible on the supercosmic scale." See Emile Borel, *Probabilities and Life*, trans. M. Baudin (New York: Dover, 1962), 28–30.
[21]See Kauffman, *Investigations*, 144, where he switches indiscriminately between referring "the known universe" and simply "the universe."
[22]Dembski, *The Design Inference*, sec. 6.6.
[23]Within inflationary cosmology, inflatons are fields that drive inflation. I am using the term in a more general sense.
[24]See respectively Alan Guth, *The Inflationary Universe: The Quest for a New Theory of Cosmic Origins* (Reading, Mass.: Addison-Wesley, 1997); Hugh Everett III, "'Relative State' Formulation of Quantum Mechanics," *Reviews of Modern Physics* 29 (1957): 454–462; Lee Smolin, *The Life of the Cosmos* (Oxford: Oxford University Press, 1997); and David Lewis, *On the Plurality of Worlds* (Oxford: Basil Blackwell, 1986).
[25]Strictly speaking an observer is not necessary. All that is necessary for quantum measurement is that to each eigenstate for a subsystem there correspond a unique relative state for the remainder of the whole system. If the subsystem is the whole universe, however, then there is no remainder and nothing (apparently) to do the measuring.

Everett's solution is to deny that state functions collapse to eigenstates and assert instead that all possible eigenstates are realized. Simon Saunders thinks that sense can be made of Everett's solution without postulating many worlds. See Simon Saunders, "Decoherence, Relative States, and Evolutionary Adaptation," *Foundations of Physics* 23 (1993): 1553–1595.

[26]The need for independent evidence to confirm a scientific theory has frequently been noted in connection with intelligent design. Philip Kitcher, for instance, citing Leibniz, describes the need for "independent criteria of design" before design can be taken seriously in science (*Abusing Science: The Case against Creationism* [Cambridge, Mass.: MIT Press, 1982], 138). In *No Free Lunch* I attempt to answer Kitcher's challenge for the case of intelligent design. Nevertheless, it is a challenge that all scientific theories must at some point face, the inflatons considered here being a case in point.

[27]John Leslie, *Universes* (London: Routledge, 1989), 10, 12.

[28]David Deutsch would reject my claim that the many-worlds interpretation lacks independent evidence. Describing the double-slit experiment in *The Fabric of Reality: The Science of Parallel Universes—and Its Implications* (New York: Penguin, 1997), Deutsch writes, "A real, tangible photon behaves differently according to what paths are open, elsewhere in the apparatus, for something to travel along and eventually intercept the tangible photon. Something does travel along those paths, and to refuse to call it 'real' is merely to play with words. 'The possible' cannot interact with the real: non-existent entities cannot deflect real ones from their paths. If a photon is deflected, it must have been deflected by something, and I have called that thing a 'shadow photon'" (49).

For Deutsch shadow photons reside in universes different from our own and yet causally interact with our universe by, for instance, deflecting photons. In fact, to read Deutsch one would think that the many-worlds, or as he calls it the "multiverse," interpretation of quantum mechanics is the only one that is coherent and experimentally supported. As he writes, "I have merely described some physical phenomena and drawn inescapable conclusions.... Quantum theory describes a multiverse" (50). Or, "The quantum theory of parallel universes is not the problem, it is the solution. It is not some troublesome, optional interpretation emerging from arcane theoretical considerations. It is the explanation—the only one that is tenable—of a remarkable and counter-intuitive reality" (51).

But in fact, one can interpret the double-slit experiment and other quantum mechanical results without multiple worlds and do so coherently—i.e., without internal contradiction and without contradicting any empirical data. And there are plenty such interpretations. The uniting feature of these different interpretations is that they are empirically equivalent—if not, there would be multiple quantum theories. As it is, there is only one quantum theory and many interpretations. See Anthony Sudbery, *Quantum Mechanics and the Particles of Nature* (Cambridge: Cambridge University Press, 1984), 212–225.

Deutsch sees the deflection of photons in a double-slit experiment as sure evidence of parallel universes interacting with our own. Deutsch's very reference to "deflected photons" is a throwback to metaphors of classical physics that have no proper place in quantum mechanics. To invoke them as independent evidence of the many-worlds interpretation of quantum mechanics is to confuse what needs to explained with what adjudicates among competing explanations or interpretations. The behavior of photons passing through two slits and exhibiting an interference pattern on a screen needs to be explained, but that behavior does not single out the many-worlds interpretation as, to quote Deutsch, "the only one that is tenable." Deutsch's uncompromising advocacy of the many-worlds interpretation of quantum mechanics is as dogmatic as it is unfounded.

[29]For a sampling of theistic solutions to such problems consult the essays in William Lane Craig and J. P. Moreland, eds., *Naturalism: A Critical Analysis* (London: Routledge, 2000) and Michael J. Murray, ed., *Reason for the Hope Within* (Grand Rapids, Mich.: Eerdmans, 1999).

[30]Note that I am not wedded to any particular metaphysical position about counterparts. My argument here treats counterparts as separate individuals and thus not as a single transworld individual. But for my argument to work it is enough that separate persons with similar cognitive faculties and background beliefs exist in separate worlds and be listening to separate Rubinsteins, the one real and the other fake. Transworld identity is therefore not required nor is a theory of counterparts. For David Lewis's theory of counterpart relations and his critique of transworld identity in modal metaphysics see Lewis, *On the Plurality of Worlds*, 9–13 and 210–220 respectively. For Alvin Plantinga's indexical account of transworld identity and his critique of Lewis's counterpart theory see Alvin Plantinga, *The Nature of Necessity* (Oxford: Clarendon Press, 1974), 88–101 and 102–120 respectively.

[31]Alan Turing, "Computing Machinery and Intelligence," *Mind* 59 (1950): 434–460.

[32]For more on proper function see Alvin Plantinga, *Warrant and Proper Function* (Oxford: Oxford University Press, 1993).

[33]For the Strong Law of Large Numbers see Heinz Bauer, *Probability Theory and Elements of Measure Theory*, trans. R. B. Burckel, 2nd English ed. (New York: Academic Press, 1981), 172.

[34]See Francis Crick and Leslie E. Orgel, "Directed Panspermia," *Icarus* 19 (1973): 341–346.

[35]I am grateful to Rob Koons for pressing me to clarify this point.

[36]See William A. Dembski, *No Free Lunch*, sec. 6.5.
[37]Ibid., ch. 5.
[38]Ibid.
[39]Peter Shor, "Algorithms for Quantum Computation: Discrete Logarithms and Factoring," *Proceedings of the 35th Annual Symposium on Foundations of Computer Science* (1994): 124–134.
[40]Deutsch, *Fabric of Reality*, 217.
[41]Sudbery, *Quantum Mechanics and the Particles of Nature*, 212.
[42]For an overview of quantum computation see Colin P. Williams and Scott H. Clearwater, *Explorations in Quantum Computing* (New York: Springer-Verlag, 1998). See also Anthony J. G. Hey, ed., *Feynman and Computation: Exploring the Limits of Computers* (Reading, Mass.: Perseus, 1999).
[43]Collins, "An Evaluation of William A. Dembski's *The Design Inference*," 336, n. 7.