Are Probabilities Indispensable to the Design Inference?

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Abstract

After sketching the various probabilistic accounts of the design inference, including the Bayesian, classical, and Dembskian models, I make a stab at developing, in an admittedly crude form, a non-probabilistic model, based on a measure of *ontological complexity*, which, I conjecture, may more faithfully represent the design inference as found in such classical texts as Aquinas, Reid and Paley. I discuss the various pluses and minuses of probabilistic and non-probabilistic models, with reference to one important test case: inferring design from anthropic coincidences in the fundamental constants of physics.

1 Introduction

Inferences to design form a large part of the natural workings of the human mind. Archeology, criminology, cryptography and natural theology, to name but a few domains, are saturated with such inferences. In fact, in every case in which we detect intelligent purpose in the actions or effects of other human beings, we are engaging in an inference to design. The job of a philosophical logician is to cull from such established practices the lineaments of the norms by which such inference are governed. As in other branches of theoretical science, the task of philosophical logic can be defined as the search for a simple and elegant model that saves the phenomena: one that gives correct answers where our pre-theoretic intuitions are certain, plausible answers where our intuitions are uncertain, and, in at least some cases, answers where our intuitions are silent.

Probability theory provides a simple model of inferences in the face of uncertainty. More specifically, both Bayesian theory and the classical statistical approach of Sir Ronald Fisher provide accounts that are arguably indispensable in cases in which the hypotheses that are being tested are themselves statistical in nature: e.g., hypotheses about what percentage of the population supports the President's tax cut proposal, about whether smoking is positively correlated with strokes, and if so, to what degree, or about the probability of a uranium atom's decaying in the next twenty years.

However, there are many other cases in which inferences are drawn which seem to have no essential connection with statistics, and, in these cases, it is not so obvious that probabilities can provide a useful model. For example, we might infer that the proper interpretation of *Hamlet* includes the insight that Shakespeare fails to provide an objective correlate adequate to the emotions that Hamlet experiences, or that the pyramids of Giza were built as elaborate tombs for Egyptian pharaohs. Many inferences to design would appear to fall into this category: discussions of design in Plato, Aquinas, Thomas Reid or William Paley make no explicit reference to frequencies or odds.

The imperial probabilist faces two challenges – two lacunae or gaps that must be filled. First, there is a gap between the qualitative nature of our initial judgments and the quantitative propositions of the probability calculus. There is an almost certainly false precision and exactitude being introduced in the transition from such qualitative judgments as *this almost certainly couldn't have been the result of mere chance* to *the probability that this was produced by mere chance is less than one in* 10^{150}. Second, after the probability calculus has finished its work, there is a complementary gap between the quantitative conclusions of the calculus, such as *the probability of design in this case is greater than* 50%, and such qualitative judgments as *we are warranted in inferring design*. Does the detour through probabilities represent a mere *unnecessary shuffle*, as Wittgenstein said of G. E. Moore's appeal to intuition as a special faculty? [**?**, section 213]

The non-probabilistic model that I will develop could be thought of as a special case of Gilbert Harman's *inference to the best explanation*[**?**][**?**]. More precisely, it is an instance of *inference to the best causal explanation*. In fact, if my minimalist account of intelligent agency is correct, according to which the essence of intelligent agency is its causation of complex intermediaries as means to a relatively simple end, then the design inference could aptly be described as *inference to the only possible causal explanation*.

2 Varieties of the Design Inference

Our knowledge of teleological connections can be either direct or indirect. If a particular instance of functionality is mediated by natural selection or by a designer's intentions, then we can discover the functionality by discovering the mediation. If I can demonstrate that a particular organism would not long survive if a molecule did not have a particular effect, then I can reasonably infer that the molecule has that effect as one of its functions. Similarly, if I learn that a competent designer intended the artifact to crush olives, and it does in fact crush them, and in the way envisaged, then I have learned that crushing olives is one of its functions.

Indirect knowledge of teleological purpose involves an abductive inference: inferring the nature of the cause of token t from its internal structure and its context. We can think of abduction as a kind of inductive inference to the best explanation: the preferred abductive hypothesis is one which best explains the observed characteristics of t. Such an abduction is simply a matter of inferring a simple causal hypothesis from a large and variegated sample of observable features. Suppose that we find a situation token t whose internal structure exhibits a large number of factors, $A_1, A_2, \ldots, A_n$, each of which, independently of the others, promotes some effect B. In such a case, it is reasonable to infer that the presence of each factor A_i was caused by the causal connection between A_i and B, that is, that each of the A_i's has a function that is somehow correlated with B. Unlike the case of direct inference, it is difficult to identify precisely what the purpose of the A_i's is: their purpose might be B, or it might be some situation-type C that is regularly produced by B, or of which B is a regular by-product, or which has some other, more complex relationship to B.

It is important to recognize that, despite what Daniel Dennett has said about the "intentional stance," it is not necessary to discover states that *optimally* realize some end. Imperfect functions can be discovered with as much objectivity and certainty as can optimally designed functions. It is not required that the various factors that promote some end B do so optimally: all is required is that there exist a number of separate factors whose existence can be economically explained by reference to their common effect.

The crucial question is this: when do we know that the observed features $A_1, A_2, \ldots, A_n$ are numerous and varied enough to license the inference to teleological purpose (and, hence, to intelligent agency)? This question very quickly brings us into the domain of the epistemology of induction, a complex and highly disputed field. At present, there are several competing theories of induction, each of which can be applied to the problem of the inference of design. Many modern epistemologies of induction are probabilistic in nature. I will discuss three such probabilistic theories: Bayesianism, the likelihood-ratios theory, and William Dembski's adaptation of classical Fisherian statistics. In addition, I would urge that we should take seriously the possibility that a non-probabilistic account can best account for our epistemological preferences and practices. I will sketch a non-probabilistic version of design inference that I call an "Aristotelian" account.

2.1 The Bayesian Account

The Bayesian approach to the design inference has been championed by Richard Swinburne and, more recently, by Robin Collins. The Bayesian treats the observed features $A_1, A_2, \ldots, A_n$, which share the property of promoting the effect B, as evidence that confirms the hypothesis that token t was caused by a process that somehow involved the causal connection between the A_i's and B. This design hypothesis, H, must be assigned a prior probability, $P(H)$. In addition, the Bayesian needs two additional probability values: the probability $P(E/H)$, the probability of the observed evidence conditional on H, and $P(E/\neg H)$, the probability of the evidence conditional on the denial of H, $\neg H$. These three probabilities can be used, via Bayes's theorem, to compute the posterior probability of the design hypothesis.

Bayesians take a variety of positions on the question of whether there are any rational constraints on one's *prior* probability function. So-called "subjective" Bayesians (one might also call them "minimalist Bayesians") hold that there are no such constraints on the prior. The only requirement of reason is that one update one's prior with new evidence by means of Bayes's theorem. One's starting point is entirely underdetermined. A subjective Bayesian could never assert that the evidence had made the design hypothesis probable absolutely, for everyone, but only that the evidence has made that hypothesis somewhat more likely than it was before. Whether its probability ever exceeds one-half may depend on how low its prior probability was in the first place.

Other Bayesians accept a variety of rational constraints on the prior probability function. One extreme version of this would be the *logical* theory of probability proposed by Rudolf Carnap in his early work. Carnap conjectured that purely logical considerations could be used to define the uniquely rational prior probability assignment. Few Bayesians would go that far today. Many, however, would follow Alvin Plantinga in thinking that considerations about the *proper functioning* of the human mind can be used to define, roughly and with a certain degree of vagueness, a class of rational priors, or a rough ordering of priors as more or less rational. Typically, priors that exhibit a greater degree of symmetry and smoothness are considered more rational than those that distribute prior probabilities in a herky-jerky series of peaks and valleys. A rational prior attempts to implement some sort of *principle of indifference*, assigning roughly equal probabilities to similar possibilities.

As applied to the problem of assessing the intelligence involved in the development of life, the Bayesian model requires the consideration of a range of hypothetical agents, each with its own purposes and its own powers of foresight and planning. For an non-Darwinian design hypothesis to be successful, at least one of these hypothetical agents must have both a non-negligible prior probability and a significant propensity for producing the kind of adaptations we observe. The prospects for such a successful design inference are much improved if there are objective values (of beauty, order and variety) that can be presumed to guide a hypothetical rational agent.

2.2 The Likelihood Ratio Model

An attempt to avoid the problem of the priors. We can use ratio of likelihoods to compare one hypothesis to another. Does the evidence give us sufficient grounds for choosing the first hypothesis over the second? The Neyman-Pearson test

Problem: it can still be hard to tell what the likelihoods are, if the designer is unknown. In addition, in the case of the anthropic coincidences, what does it mean to assign probability to a range of values of the fundamental constants?

2.3 The Classical Approach

Classical statistics, as developed by Sir Ronald Fisher and adapted by William Dembski, is modeled on the falsification procedure proposed by Sir Karl Popper. A rule is proposed for when we should treat a hypothesis as to be *rejected* on the basis of the observed evidence. This is a generalization of deductive falsification: rejecting a hypothesis when one of its deductive consequences has been shown to be false. A deductively falsified theory cannot be true (assuming that the observed contrary result is veridical). Analogously, the defender of the classical statistical model argues that we should reject a theory when some event is observed that is, according to that same theory, highly improbable. How improbable should the event be before we can legitimately reject the theory? Dembski has proposed that the event should be so unlikely (assuming the theory to be true) that the probability that such an event should occur even once in the entire history of the physical universe is below one-half. This standard corresponds to something greater than one chance in ten to the 150th power (since no event, even a subatomic one, could recur more often than ten to the 150th power times).

In the case of the design inference, the hypothesis whose rejection we are considering is the negation of the design hypothesis. That is, we are considering whether we should reject the hypothesis that the observed situation token t was caused by some process that did *not* involve any causal connection between the A_i's and any common effect.

Thus, both the Bayesians and the classical statisticians agree that the probability $P(E/\neg H)$ (where H is the design hypothesis) must be computable and must be very low. The two differ in that the classicist does not think that the other two probabilities, the prior probability of the design hypothesis, and the predictability of the observed data from the design hypothesis, are at all relevant. This means that it is in general easier for the classicist to tell whether, by his lights, a particular design inference is warranted.

The principal advantage of the Bayesian approach is that it rests on an uncontroversial result of probability theory, Bayes's theorem. There are a number of arguments that support reasoning in accordance with the standard probability calculus, on pain of a kind of inconsistency analogous to logical inconsistency. However, the application of Bayesian reasoning to real scientific problems is not without its own problems. In particular, the problem of old evidence (using data that has already been collected to support a new conjecture) has never been given a fully satisfactory solution in purely Bayesian terms (see for example, John Earman's discussion of this problem [**?**]).

In addition, the claim that Bayesian inferences rest directly on a formal result of the probability calculus is somewhat overstated. It is a result of the probability calculus that $Pr(H/E)$ should be calculated according to Bayes's Theorem; however, this does not imply that the *posterior* probability of H, after observing E, should be equivalent to the prior conditional probability $Pr(H/E)$. Bayesians implicitly assume that diachronic consistency (consistency through time) is all-important, yet surely Emerson was right when he described such rigid diachronic consistency as the "hobgoblin of small minds". A certain degree of diachronic consistency is certainly a virtue (its absence being the vice of flightiness), but a willingness to undergo quite radical changes of mind is also a virtue. The Bayesian stands willing to alter his degrees of belief, but only by, in effect, conditionalizing on a new set of available total evidence; he is never willing to consider that his initial estimates of conditional likelihoods might have been in error. But there are clearly situations in which it would be reasonable, upon observing some E to which one had given a vanishingly small prior probability, to revise that estimate of E's likelihood, rather than to rigidly insist on conditionalizing on E, no matter how drastic the consequences of doing so.

The classical statistical approach comes in a variety of versions, depending on how rigorously empirical a view one takes of the probability judgment involved. A "rationalist" version of the classical model would allow the judgment of the improbability the no-design hypothesis to be based on non-empirical, aprioristic grounds. For instance, in the case of the anthropic coincidences, a rationalist might argue that it is reasonable to assign a very low probability to a narrow, anthropic range of values of some constant, on the grounds that the appropriate probability assignment to use should be smooth and symmetrical. In contrast, an "empiricist" version of the classical model would insist that any judgment of probability or improbability be based upon observed frequencies. Since we cannot observe a multitude of alternative configurations of the fundamental constants of physics, we have no basis for assigning any probability to any range of values.

The rationalist might respond that even the Humean empiricist must make use of some aprioristic assumptions based on considerations of symmetry and smoothness. The empiricist must license extrapolations from observed frequencies in order to reach the hypothesis rejection region. These extrapolations depend on strong independence assumptions that cannot themselves be verified empirically but must instead be justified on a priori grounds. Consider, for example, the empiricist argument against the undirected origin of life. Sure enough, we have empirical data about the likelihood of various chemical reactions occurring naturally — the spontaneous formation of chains of peptides and of amino acids, for example. But how do we get from those observed frequencies to an estimate of the probability of biogenesis? To perform the extrapolation and get the requisite extraordinarily small likelihoods, we have to make some very strong independence assumptions. A defender of spontaneous biogenesis might reply that since we know that biogenesis happened at least once in the history of earth, we have sufficient reason to disbelieve those independence assumptions. Any counter-argument to this claim will depend on an appeal to a priori considerations.

Dembski's model of the design inference includes one element in addition to Fisher's classical model: the requirement of *specification*. Dembski defines the specification of an event in terms of the computational resources needed to characterize the event. An event warrants the inferring of design when it meets the dual condition of *specified complexity*: its probability must be sufficiently low (complexity), and the computational resources needed to define the event must fall below a certain level (λ).

Dembski proposed the use of algorithmic complexity theory, or Kolmogorov complexity theory, in conjunction with probability theory. An event triggers a design inference when its both its algorithmic complexity and its prior probability fall below appropriate thresholds. The computational threshold λ can be taken as given by the shortest length of a Turing machine program able to generate the description of the observed event,

Although Dembski provides a principled answer to the question of where to set the improbability threshold (viz., so low that such an event has a less than one-half chance of occurring even once in the history of the world), he provides no such principled basis for selecting the computational threshold λ. However, I think he does provide a way of avoiding this problem: the consideration of the *specificational completion* of an event E.

Suppose that an event E can be specified by computational resources of measure λ but cannot be specified with resources of any lower measure. Suppose that the probability of the occurrence of E even once in the history of the world is r. We can then define the specificational completion of E, E^{Ω}, as the sum (or disjunction) of all events E' meeting two conditions: (i) the probability of E' is less than or equal to r (that is, less than or equal to the probability of E), and (ii) E' can be specified by resources of measure λ or less. The probability of E^{Ω} will be greater than that of E, but still quite small, if both the probability and the measure of specificational resources associated with E are quite small. If the probability of E^{Ω} is itself so low that there is less than a one-half chance that such an event should occur even once in the history of the world, then a design inference is triggered. Note that this version of Dembski's filter makes no reference to any fixed measure of computational resources.

By way of illustration, consider two poker hands: a royal flush (in spades), and a hand consisting of a four and Jack of diamonds, a seven of clubs, a Queen of hearts, and a ten of spades. The two hands are equally unlikely, but, given the rules of poker, the second hand requires far more specificational resources. There are only a handful of hands that can be specified as economically as a royal flush; hence, the specificational completion of the royal flush is still extremely unlikely. In contrast, almost any possible hand (each as unlikely as these two) can be specified using the resources needed to specify the second hand. Hence, the specificational completion of the second hand has a probability of nearly one. Thus, by applying the improbability test to the specificational completion of an event yields an intuitively successful criterion for inferring design.

Granting, for the sake of argument, that Dembski's model provides a good fit to our intuitive judgments about the conditions of warranted design inference, can we provide any explanation for its success? Is there any connection between specified complexity (the improbability of an event's specificational completion) and teleology? I conjecture that there is. An event can be specified in many ways, but three are especially prominent: by means of its causes, by means of its intrinsic structure, and by means of its effects. In most cases, if an event can be specified with few resources in terms of either its causes or its internal structure, it will not be an extremely unlikely event. An event with simple causes or with simple internal constitution is an event that has a fairly high prior probability, given the essential connection between simplicity and prior probability. Thus, in general, an event will have specified complexity only when it is specified in terms of its *effects*.

An event with a simple effect but with quite complex causes and internal structure can be improbable to any possible degree. Since agency is (by definition) that which orders complex events to a fixed effect, it is quite possible to have a simple effect combined with a complex cause, and for the complex cause to be highly improbable in the absence of a teleological explanation (since teleology is the only alternative to sheer coincidence in such a case).

The examples Dembski discusses can all be made to fit this conjecture of the necessity of teleological specification. Caputo's series of ballot constructions is specified because in nearly every case, the order of names he chose promoted a single effect: the victory of the Democratic candidate. A royal flush is distinguished within poker by virtue of its characteristic effect: a win by whoever holds the hand. Even a case like the signal detected in the movie and novel *Contact*, namely, a series of blips counting out the first one hundred prime numbers in order, can be thought of as characterized in terms of its effect: the triggering of a recognition event in the mind of a mathematically literate observer.

2.4 An Ontological Approach: The Aristotelian Diamond

The task of constructing a model of the inference to design is, as I have argued, an essentially inductive, a posteriori one. A successful model is one that agrees with our epistemological intuitions in clear cases of warranted and unwarranted inferences to design. It is unreasonable to demand of any model of design inference that it be able to provide an a priori proof of its own reliability, of a kind that would satisfy, for example, a Cartesian or Humean skeptic. I will assume that the refutation of inductive (or, more broadly, inferential) skepticism is not among our aspirations. We should be content with the more modest achievement of discovering a plausible and useful generalization underlying our ordinary epistemological judgments.

If our goal is to formulate the criteria for reasonable or warranted inference to design, there is no good reason to assume that probability must enter into our account at all. If introducing probability is useful, well and good, but if it merely introduces a "useless shuffle" (as Wittgenstein once described appeals to "intuition"), then we would do well to consider non-probabilistic accounts seriously. Certainly, human beings have made warranted inferences to design long before the mathematical laws of probability were formulated with any precision or accuracy. Classic examples of design inference, such as those of Aristotle, Aquinas, Reid or Paley, involved no explicit appeals to probability.

In light of the discussion above about the connection between teleology and specified complexity, a simplification of Dembski's filter suggests itself. Instead of talking about the improbability of the specificational completion of an observed event, we could instead focus merely on the intrinsic or ontological complexity of a cause in contrast to the relative simplicity of its effect. In many cases, our only grounds for attributing a low probability to an event is its high degree of organizational complexity. We derive a low probability value by multiplying together some presumed probability of the occurrence of each part of the complex structure, implicitly assuming that the relevant probabilities are mutually independent. As I mentioned above, it is typically very difficult to verify such independence assumptions empirically. Hence, the introduction of probabilities involves a kind of unnecessary detour through the a priori. Rather than speculatively introducing an unverifiable probability judgment, we could ground a warranted design inference directly in the underlying facts about the ontological complexity of the cause.

A non-probabilistic model of the design inference could be diagrammed by means of a diamond. We observe the top half of the diamond: a simple effect (the top apex of the diamond) causally explained by a complex cause (the span of the diamond at its greatest width). In order to explain the correlation of the parts of the complex cause needed to produce the simple effect, we postulate a prior simple cause, the action of an intelligent agent (represented by the bottom half of the diamond).

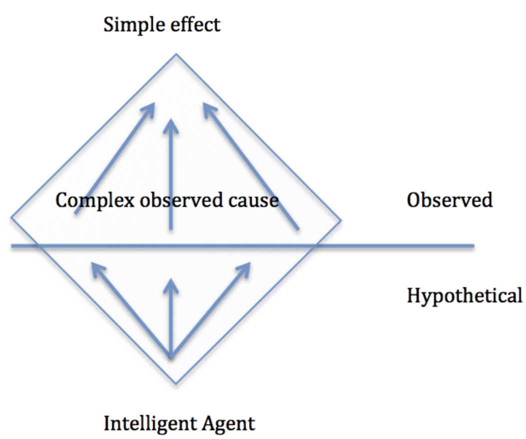

Figure 1: Aristotelian diamond

This design inference is strongly analogous to the rule of causal inference proposed by the positivistic philosopher Hans Reichenbach. Reichenbach argued that whenever we observe a projectible correlation between distinct events, we should always attribute the correlation to the action of a common cause. In the case of a design inference, we are seeking the cause of a single, particular configuration of fact (a situation-token), rather than a repeatable statistical correlation (as was Reichenbach). However, when the observed situation-token exhibits a sufficient number of features that are ordered to a single, simple effect, we have something essentially equivalent to a projectible correlation, and the principle behind Reichenbach's rule applies.

To make this Aristotelian model precise, two things are needed: first, a mathematically rigorous account of the relevant causal relation, and second, a useful measure of ontological complexity. The model of causal explanation that I developed in *Realism Regained* can serve the first purpose. The causal relation we need in this application is a version of what I called *causal explanation*. Causal explanation is a relation between two facts, In *Realism Regained*, I defined the relation of causal explanation $\rhd$ in terms of a set of modal or stochastic relations (such as necessitation or conditional objective chance). [**?**]

All that is required to complete the model is an account of the measure of ontological complexity. This should be a measure that applies to fact-types, the internal structures of individual facts or situations. A simple type should always be given a non-zero measure, and the measure of the conjunction of two metaphysically independent types should be the sum of the measures of the conjuncts. In Appendix A, I propose a few additional axioms for the theory of this measure.

If such a measure μ can be sufficiently characterized, we can define the Aristotelian conception of warranted inference to design as follows:

A fact s warrants an inference to design just in case there exists a fact t meeting these two conditions:

1. $(s \rhd t)$, and there exists no token $s\prime$ that is a part of s of such a kind that: both (i) $\mu(s\prime) < \mu(s)$ and (ii) $(s\prime \rhd t)$;
2. $\mu(s) - \mu(t) > b$;

where b is some critical value, determined inductively by surveying clearly warranted and clearly unwarranted design inferences.

If a design inference is warranted, the Aristotelian model also provides a measure of the degree of intelligence displayed in the design. (This isn't the same thing as the degree of foresight involved, which instead concerns the possible paths by which the agent could have arrived at the present instance of design.) If the difference between $\mu(s)$ and $\mu(t)$ exceeds the critical value b, then we can take the former, the complexity of the cause, s, to measure the degree of intelligence displayed.

As I argued above, I think it is plausible to suppose that any case that survives Dembski's filter will also trigger a design inference using the Aristotelian diamond. However, is the converse true? Is there a danger that the Aristotelian diamond is too permissive, countenancing design inferences that are clear cases of false positives? Couldn't we imagine cases of simple effect with complex causes, where we would have no suspicions that design is involved?

For example, consider the case of a brown leaf that is blown off a tree by an autumnal breeze. The effect is clearly a simple one – the detachment of a leaf from its stem – and the cause is arguably quite complex, since the breeze consists of the individual movements of millions of air molecules.

The Aristotelian diamond requires that, once we have identified a concrete situation-token s that causes an effect t we find the ontologically simplest part s_0 of s that is sufficient to count as a causal explanation of t. The ontological complexity of the critical fact s_0 is doubly constrained: first, by the requirement that it be casually sufficient for the effect t, and second, by the requirement that it be the ontologically simplest causally sufficient part of s. In the case of the breeze and the falling leaf, the ontologically simplest part of the breeze causally responsible for the leaf's detachment will presumably involve the breeze's transmission of some quantum of momentum to the leaf. This property is not especially complex. In order to explain the detachment of the leaf, we do not have to give an extraordinarily fine-grained characterization of the breeze: in particular, we do not have to give an accounting of the individual trajectories of each and every molecule. If such a detailed accounting really were necessary, as, for example, in a hypothetical case in which the breeze causes just those movements of the tumblers of a lock that are needed to open it, then we would have a case calling for some kind of intelligent agency.

Suppose that we find a case in which a single effect is overdetermined by a large number of separate, simultaneous causes, as, for instance, the death of the prisoner is overdetermined by a volley of bullets from the squad of executioners. When we have several facts $s_1, \ldots s_n$ that are pairwise disjoint (no two tokens share a common part) and unordered causally (no token is causally prior or posterior to another), if each situation-token is sufficient to explain causally some simple effect t, then we can, when assessing the situation as warrant for a design inference, compare the difference between the *sum* of the complexities of the causes, $\Sigma_1^n \mu(s_i)$, and the complexity of the effect, $\mu(t)$, with the critical value b.

3 Case Study: The Anthropic Coincidences

The anthropic coincidences in the fundamental constants, coincidences, sometimes involving apparent fine-tuning of these values, necessary for the formation of stars, heavy elements, organic compounds, and, presumably, life itself, provides a case in which an inference to design seems compelling to many physicists and philosophers. I will examine the application to this problem of two of the models described above: the Dembski/Fisher model, and the Aristotelian, ontological model. The Bayesian approach has already been applied to the anthropic coincidences by Swinburne and Collins, among others. In any case, the central issue that I will address in applying the Dembski/Fisher model would be equally relevant to a discussion of the Bayesian model, since both depend on the assignment of extremely low probability to the observed, anthropic values, in the absence of their intentional design.

3.1 Applying the Probabilistic Models

To apply the probabilistic model to the phenomena of anthropic coincidences two things are needed: a space of possible universes, each point in the space representing a unique assignment of values to the fundamental constants, and a probability function (or set of such functions), defined over regions of this space. A subjectivist could use as the relevant probability function one that represents his own subjective degrees of belief. At the opposite extreme, a believer in logical probability can also make do with a single probability function, the function representing the uniquely rational assignment of prior probabilities. For probabilists between these two extremes, a more or less vaguely defined set of rational probability functions would be required.

Where a set of prior functions is involved, the design function would be triggered whenever the anthropic values of the constant are, conditional on the non-existence of a designer, sufficiently improbable on *all* of the permissible probability functions. For simplicity's sake, I will assume that we can choose a single probability function as sufficiently typical.

In the simplest version of the anthropic argument, we consider the region B of the space of possible configurations of the fundamental constants that permit the existence of some kind of life. If the value of $Pr(B)$ falls below the critical value, say one in ten to the 150th power, then the design inference is triggered. This version of the argument is vulnerable to the *exotic universe* objection. It is arguable that we tend to seriously underestimate the extent of the region B by failing to imagine universes in which the fundamental constants take values quite different from those in our universe but still capable of supporting life, even life as we know it. The simulations that currently support the claim of fine-tuning all involve making small changes in the value of one constant, while leaving the values of the other constants unchanged. This means that we are in effect searching only a small neighborhood of the actual world.

The *exotic world* problem can be met by what John Leslie [**?**] has called the *Fly on the Wall* response. Leslie imagines a wall which is nearly covered by flies, so the probability of a bullet's hitting a fly, when shot at the wall, is quite how. However, in reality, a bullet is fired and hits a single fly that is entirely isolated, the only fly in a relatively large fly-free region of the otherwise-fly-infested wall. Leslie suggests, plausibly, that this event is one suggestive of design. Although the probability of hitting a fly is not low, the probability of hitting a fly in the almost fly-free region in which the fly was hit is extremely low. Let N be a natural neighborhood of the actual world, a region of the possibility space that includes the actual world and which is not defined in a highly gerrymandered or adventitious matter. If the conditional probability $Pr(B/N)$ is extremely low, the this second version of the anthropic argument is triggered.

This second version is, in turn, vulnerable to the *exotic life* problem. The skeptic can argue that we seriously underestimate the extent of B due to our lack of imagination, our inability to imagine all of the forms of life radically different from the forms of life familiar to us in the actual world. For example, there could be, for all we know, possible life forms consisting entirely of neutrinos, dark matter, patterns of energy with neutron stars, or any of an indefinite number of physical environments that are little understood. These exotic forms of life might well exist in possible worlds in which the values of the fundamental constants make our familiar, carbon-and-water-based life untenable.

The obvious response to the *exotic life* problem leads us to the third version of the anthropic argument. Instead of looking at B, we can instead consider the region C, the region of the possibility space that makes possible, not just life in any form, but specifically the kind of life with which we are familiar: carbon-based, aqueous life occurring on a planet. We can ignore the possibility of exotic life and confidently evaluate the probability of $Pr(C/N)$. This version of the argument has the advantage of being entirely local in character: we have to consider only universes similar to the actual universe, and only forms of life similar to actual life.

However, although it may be clear that $Pr(C/N)$ is extremely low, we must still consider what Dembski labels the *specification problem.* Is C specified? Clearly, more computational resources are needed to define C than are needed in defining B, since more is needed to specify carbon-based, planetary life than is needed to specify mere life itself.

As I suggested above, the most perspicuous way of solving the specification problem is to consider the specification completion of C, C^{Ω}. If the probability $Pr(C^{\Omega}/N)$ is extremely low, a design inference is warranted. Although this solves the specification problem, it resurrects the exotic life problem, since in estimating the extent of the region C^{Ω}, we must consider all forms of life that meet two conditions: they can be specified with resources no greater than those needed to specify C, and the conditional probability of the subregion of N permitting these forms of life is no greater than $Pr(C/N)$.

In order to solve both the exotic life problem and the specification problem simultaneously, we must find another way of estimating $Pr(C^{\Omega}/N)$. To perform such an estimation, we need some kind of measure of the degree of specification involved in defining C — the greater the resources involved in the specification, the greater the estimated probability of the specificational completion C^{Ω}. Let $\rho(E/A)$ be a function indicating the number of atomic resources needed to specify event E, given the resources needed to specify event A. (The function ρ will be an example of what Dembski called a *complexity measure* in Chapter 4 of *The Design Inference.*) Thus, $\rho(C/N)$ gives us a measure of the algorithmic resources needed to specify C.

In order to estimate the probability of C^{Ω} given N, we must first estimate the maximum number of events that can be specified (relative to N) by means of resources not exceeding $\rho(C/N)$. If we assume that each element in $\rho(C/N)$ consists in a choice of one or the other of a pair of alternatives (i.e., essentially a bit of information), then we can estimate the number of possible resource-bounded specifications as $2^{\rho(C/N)}$. Next, we must consider the maximum possible probability value of each alternative specification. Any specification whose probability is greater than $Pr(C/N)$ is automatically excluded from C^{Ω}, so this is the greatest relevant value. The probability of C^{Ω} is greatest if all of the alternative specifications are mutually exclusive, in which case its probability is simply the sum of the probabilities of the individual specifications. Thus, we can set the following as a firm upper bound on the probability $Pr(C^{\Omega}/N)$:

$$Pr(C^{\Omega}/N) \leq Pr(C/N) \cdot 2^{\rho(C/N)}$$

If this value is less than the critical probability of one-half,[1] then the inference to design is warranted. Thus, all three problems, the exotic universe problem, the exotic life problem, and the specification problem can be solved simultaneously.

However, one critical problem remains: the *subjectivity problem*. Are there sufficient constraints on a rational prior to guarantee that the probability of the set of anthropic values is sufficiently low? Since we cannot observe a sample of universes that would result in the absence of design, we cannot use any empirical data to help calibrate these probabilities. Are aesthetic considerations, such as symmetry and smoothness, powerful enough to yield a determinate answer?[2]

In many cases, the anthropic coincidences involve a ratio between the strength of two forces, such as the electromagnetic and the strong nuclear forces. In such cases, it would seem that the ratio could have, in principle, taken any value, from $-\infty$ to ∞. The smoothest and most symmetrical possible prior probability function would assign an infinitesimal value to any finite range of values for this ratio. (Such infinitesimal values can be modeled by means of non-standard analysis, building on the work of Abraham Robinson in the 1960's.) However, such a prior, although intuitively attractive, poses a major problem. A non-standard, infinitesimal-valued prior makes it too easy for the design inference to be warranted: whenever the anthropic values lie within a finite range, no matter how large, the probability of the anthropic range will be infinitesimal and the design inference will be maximally warranted. This kind of non-standard prior makes the impressive *fine-tuning* of many of the values totally irrelevant. That would seem to be a counter-intuitive result.[3]

If, instead, we limit ourselves to probability functions with standard, finite real numbers as values, we face another embarrassment of riches: a bewildering variety of possible probability functions, some of which underwrite a design inference, and some of which do not. The probabilist is not without recourse, however: he can quite plausibly claim that in many cases the anthropic values are so narrowly constrained that any *reasonable* prior will assign them astronomically low probabilities. Still, it would be nice to be able to say more than *I know them when I see them* in response to the question *Which possible priors are reasonable?*

[1] In the case of the anthropic coincidences, the *replicational resources* consist of only one universe, the actual one. Hence, the critical value of 10^{150} that Dembski mentions in *The Design Inference* is not the appropriate one, since that value represents the upper bound on the number of possible physical events *within* the universe. Since the replicational resources are in the case of the anthropic coincidences are minimal, the critical value is one-half. (Thanks to Lydia McGrew for pointing this out to me.)

[2] My awareness of the gravity of this problem is due to work by Timothy and Lydia McGrew and Eric Vestrup. See their article in Mind. [**?**]

[3] This objection was also posed to me by Vestrup and the McGrews.

If there is an way to provide a principled basis for the construction of such priors, it must have to do with the inherent structure of the fundamental constants involved. This means that we must analyze the ontological complexity of the coincidences and use this complexity as the ground for prior probability judgment. This raises the question of whether a non-probabilistic model might capture the right conditions for warranted design inference without the detour through probability theory.

Pruss's point: we can't apply the principle of indifference unless we know what determinable quantity to use. Take any apparently fine-tuned quantity. We can find mathematical functions of that quantity relative to which nearly all of the state space is compatible with life. We need to use natural quantities – in the sense discussed by David Lewis in 1983 [**?**]

3.2 The Metaphysics of Laws of Nature and of Physical Quantities

Three theories: the anthropocentric neo-Humean model, the Dretske-Armstrong-Tooley model, and the powerism model.

Good reasons to reject the first. The second and third presuppose natural quantities as constituents of laws or of particular, law-governed interactions.

Mention the atomistic and holistic models here? There is a third option. A natural unit (like the real number 1), with each determinate quantity fixed by a combination of addition of units and acts of division. Perhaps the ontological complexity of a rational number r is the least number m such that there exist positive integers x and y such that $m = x + y$, and $r = x/y$. What about irrational reals? They might have infinite ontological complexity. But surely some, like π or the square root of 2, are not so complex. For our purposes, we don't need to worry about them.

3.3 Applying the Ontological Model

Using the upper bound we found for the probability of the specificational completion of C, the anthropic coincidences needed for carbon-based life, that we discovered in the previous section, consider again the critical inequality:

$$Pr(C/N) \cdot 2^{\rho(C/N)} < \frac{1}{2}$$

If we apply the function $-\log_2$ to both sides, the result is this:

$$-\log_2(Pr(C/N)) - \rho(C/N) > 1$$

If we take $-\log_2(Pr(C/N))$ as an estimate of the ontological complexity of the anthropic coincidences, and $\rho(C/N)$ as a measure of the ontological complexity of the effect of these coincidences, viz., the existence of carbon-based, aqueous life, then we have an instance of an Aristotelian diamond. The design inference is warranted whenever there is a gap between the complexity of the cause and the complexity of the effect.

This suggests that we look for a more direct measure of the ontological complexity of the anthropic coincidences than $-\log_2(Pr(C/N))$, which makes the inference vulnerable to the subjectivity problem discussed in the last section. One might think, however, that the anthropic coincidences do not offer much a prospect for such an ontological complexity. In evaluating the ontological complexity of a flagellum or a blood clotting mechanism, we would seem to have some obvious starting points: parts that need to have certain intrinsic features and certain kinds of relationships one to another. In what does the ontological complexity of, say, the ratio between the electromagnetic force and the strong nuclear force consist?

I

There are at least two ways of thinking about wholes and parts, and these two ways can be applied to the case of tropes. The first way is the atomistic one: the world consists of atomic parts that cannot (in any sense whatsoever) be further subdivided. An atomic theory of the parts of universal physical quantities would posit the existence of atomic micro-units. Any given determinate quantity — say, the particular intensity of electrical charge in a typical electron — would consist of a determinate number of these atomic micro-units. The anthropic balance between the strengths of the electromagnetic force and the strong nuclear force, for example, would consist in the appropriate number of atomic force-tropes being present in each case.

The second approach to parts and wholes is that of Platonic constructionism.

Is it possible to estimate, in any particular case, how many atomic tropes or how many acts of limitation are involved? There are, I think, a number of promising strategies. One approach is to use the anthropic coincidences themselves to put upper bounds on the size of the atoms, or lower bounds on the size of the Unlimited. Suppose that the ratio between two forces, F and G, is constrained anthropically to lie within the range $r \pm \frac{r}{q}$ (typically with $r \geq 1$ and $q > 1$). In the case of the atomic theory, we can be confident that the atomic units are no larger than the lesser of the two forces, F. This entails that the complexity of the greater force, G, is at least $r - \frac{r}{q}$ and that of F is at least one. In addition, in order for the fine-tuning to be possible, the atomic tropes can be no larger than $\frac{2\mu(G)}{q}$, which puts the complexity of the greater force G at a minimum of $\frac{q}{2} - 1$ and that of F at a minimum of $\frac{q\mu(F)}{2\mu(G)} - 1$. Thus, the complexity of the coincidence increases as either r (the absolute value of the ratio) or q (the degree of fine-tuning involved) increases.

When we turn to the constructionist model, we can take the magnitude of the larger force, G, to put a lower bound on the magnitude of the maximum possible force intensity. The indeterminacy of the range $\langle 0, \mu(G) \rangle$ of values of F must be narrowed to a range whose width is $\frac{r(q^2-1)}{2q} \cdot \mu(G)$. Each delimitation will, on average, halve the width of the permitted range. Hence, the complexity of the smaller force, F, must be at least $\log_2(\frac{r(q^2-1)}{q}) - 1$, which, for large values of q, is approximately equal to $\log_2(rq)$. Again, the complexity of the coincidence increases as both r and q increase.

Alternatively, we can estimate the ontological complexity of these force magnitudes by using what we know of physics to suggest the magnitude of atomic tropes (on the atomic account) or the magnitude of the maximum possible force (on the infinite-divisibility account). For example, if we use the three fundamental constants c, the velocity of light in a vacuum, h, Planck's constant, and G, Newton's gravitational constant, we can define *natural* units of time, length, energy and force. The natural unit of length, 10^{-35} meters, is approximately the diameter of fundamental particles, like quarks or electrons. The fundamental unit of time, 10^{-44} seconds is also extremely small. However, the natural unit of energy or mass, Planck's mass, is quite large, approximately 10^{18} times larger than the mass of a neutron. The natural unit of force is also quite large, $10^{48}\,\frac{\text{gm}}{\text{sec}^2}$. Thus, an atomic theory of space, time and fundamental particles seems attractive, while the infinite-divisibility account would seem more plausible in the case of mass-energy or force.

In some cases, the anthropic coincidences take a somewhat simpler form. Let's call the form discussed above *alpha fine tuning*: fine-tuning in which some dimensionless ratio between two fundamental constants is constrained to lie within the interval $r \pm \frac{r}{q}$, with both q and $(r - \frac{r}{q})$ greater than *one*. In other cases, which I will call *beta fine-tuning*, a dimensionless ratio of this kind is constrained to be greater than some lower bound r_b. Thus, the ratio is bounded from below, but not from above. For beta fine-tuning to yield a significant degree of ontological complexity, the lower bound r_b must be quite large.

There is a third kind of fine-tuning, *gamma fine-tuning*. This is a higher-order kind of fine-tuning, in which there are two dimensionless ratios r and r', each representing a ration between two fundamental constants. In gamma fine-tuning, the two ratios are both quite large and yet each is constrained to lie within a few orders of magnitude of the other. This relationship could be represented by means of logarithms:

$$|\log(r) - \log(r')| < b$$

with b much smaller than either $\log(r)$ or $\log(r')$. A case such as this is discussed by Paul Davies in *The Accidental Universe* [**?**, pp. 69-70], based on some work by Brandon Carter. (See also Barrow and Tipler [**?**, pp. 339-340].) Davies reports that the ratio between the gravitational coupling constant and the twelfth power of the electromagnetic coupling constant must lie within a few orders of magnitude of the fourth power of the ratio between the mass of the electron and the mass of the proton:

$$\frac{\alpha_G}{\alpha^{12}} \approx (\frac{m_e}{m_p})^4$$

Each ratio is in the neighborhood of 2.5×10^{13}, and these two large numbers must vary from one another by no more than a single power of ten if stars are to form. This gamma fine-tuning raises some challenging, and heretofore unasked, questions about the degree of ontological complexity needed to satisfy such a relationship. For this reason, I am postponing consideration of such gamma fine-tuning to future work and will focus in this paper exclusively on alpha and beta fine-tuning.

The example of the fine-tuning of the gravitational and electromagnetic constants raises another complication, whose unraveling will have to wait: namely, anthropic ratios in which, not the constants themselves, but constants raised to various powers are compared. In the example above, it is the ratio between the gravitational constant and the *twelfth power* of the electromagnetic coupling constant that was relevant.

Once we have an estimate of the complexity of each anthropic coincidence, we can, assuming that the coincidences are mutually independent, simply add the complexities together to obtain a measure of the complexity of the cause of the existence of carbon and planetary systems. All that remains is to work out an estimate of the complexity of both carbon and star-planet systems. One could also estimate the complexity of life, that is, the complexity of the generic form of life (something like the *capacity for self-realization*), not the complexity of the actual realizations of life in specific living organisms. However, from the perspective of the Aristotelian diamond, unlike that of the Bayesian perspective, there is no need to include in the effect some value that an agent might be expected to prefer. Thus, we can focus instead on the existence of carbon and planetary systems alone. We are not imagining that it is the existence of carbon or of planets that constitutes an (or even the) ultimate purpose of the hypothesized intelligent agent. The Aristotelian diamond detects the presence of telic, goal-directed activity: it does not, by itself, identify the goal (in this respect, it resembles Dembski's filter, rather than a Bayesian inference). Presumably, the existence of carbon and of planetary systems are either constituents or proximate by-products of that ultimate purpose, or proximate means toward the realization of that goal. It seems a reasonable conjecture that the ultimate purpose of the existence of carbon and planetary systems is the production of life of the sort found on the Earth. However, it is not necessary that we estimate the complexity of that ultimate end (even in its broad, generic outlines): it is sufficient for us to measure the complexity of the proximate means. The ontological constitution of both carbon and that of star-planet systems are arguably quite simple. It would be reasonable to suppose that the gap in complexity between the anthropic coincidences and the constitution of these effects is great enough to license an inference to design.

To make this discussion more concrete, let's turn to some of the specific anthropic coincidences as found in the works of Barrow and Tipler [**?**], Paul Davies [**?**][**?**], Hugh Ross [**?**], and John Leslie [**?**].

The atomistic approach consistently yields a higher estimate of the ontological complexity of the coincidences, ranging from a low of three (in the case of the three spatial dimensions) to a maximum of 10^{120}, in the case of the cosmological constant. However, although the infinite-divisibility model is quite a bit more conservative, we still end up with a total complexity (from just this list of eleven coincidences) of over eight hundred. We must compare these numbers with the complexity of the effect of the coincidences: the existence of carbon

Anthropic Coincidence	$r \pm \frac{r}{q}$, or r_b	$r - \frac{r}{q} + 1$	$\frac{q}{2} + \frac{q}{2r}$	Max
Cosmic density [**?**, pp. 410–411]	1 ± 10^{-56}	$1 - 10^{-56}$	10^{56}	10^{56}
Cosmological constant [**?**, p. 413]	10^{120}	10^{120}	NA	10^{120}
Electromagnetic/ gravitational forces [**?**, p. 39]	10^{35}	NA	NA	10^{35}
Strong/ electromagnetic forces [**?**, p. 35]	$10^5 \pm \frac{10^5}{50}$	9.8×10^4	25	9.8×10^4
Proton/electron mass [**?**, p. 336]	1403	1403	NA	1403
Proton/electron charge [**?**, p. 62]	1 ± 10^{-10}	$1 - 10^{-10}$	10^{10}	10^{10}
Dimensions of space [**?**, pp. 94-98]	3	3		3
Metric signature	$+++-$	4		4
Ground state of ^{14}C/(sum of ^{8}Be and ^{4}He) [**?**, pp. 126–127]	$1 \pm \frac{1}{25}$	0.96	25	25
Number of protons/electrons [**?**, p. 123]	1 ± 10^{-37}	$1 - 10^{-37}$	10^{37}	10^{37}
Sum				$10^{10} \sim 10^{120}$

Table 1: Complexity of Anthropic Coincidences: Atomistic Model

Anthropic Coincidence	$r \pm \frac{r}{q}$, or r_b	$\log_2(rq)$, or $log_2(r_b)$
Cosmic density	1 ± 10^{-56}	187
Cosmological constant	10^{-120}	399
Electromagnetic/ gravitational forces	10^{35}	117
Weak/strong nuclear forces	$10^{17} \pm \frac{10^{17}}{10}$	34
Strong/electromagnetic forces	$10^5 \pm \frac{10^5}{50}$	19
Proton/electron mass	1403	11
Proton/electron charge	1 ± 10^{-10}	34
Dimensions of space	3	2
Metric signature	$+++-$	4
Ground state of ^{14}C/(sum of ^{8}Be and ^{4}He	$1 \pm \frac{1}{25}$	3
Number of protons/electrons	1 ± 10^{-37}	123
Sum		933

Table 2: Complexity of Anthropic Coincidences: Infinite Divisibility Model

Attribute	Atomistic Model	Infinite-divisibility Model
Carbon	12-42	8
Planetary system	339,400	19
Sum	340,000	27

Table 3: Complexity of the Generic Form of Life

and planetary systems.

On the atomistic model, the constituents of carbon would lie in the range of twelve (the number of protons and neutrons in a typical carbon atom) to forty-two (the number of quarks and electrons). For each constituent, two or three facts should be sufficient (identifying the type of particle and its location, either in the nucleus or in the surrounding orbits), yielding a total complexity of between twenty-four and 126. The complexity of a simple planetary system could be measured by the number of earth-masses needed to compose the mass of the sun, plus the number of earth-diameters of distance between the earth and the sun, for a total of about 340,000. We don't need to measure the actual number of atomic tropes present in the construction of a planetary system: we can treat the complexity of the earth-like planet as a given and measure the complexity of the whole system using planetary dimensions of mass and distance as the relevant units, just as, in measuring the complexity of an instance of fine-tuning, we could use the intensity of the weaker force as the relevant unit in measuring the complexity of the stronger one.

To determine the complexity of carbon on the infinite-divisibility model, we would have to consider how many possible elements we must start with. I will assume that any elements larger than number 256 will be too unstable to constitute a significant part of any possible universe. Whittling 256 down to one (namely, carbon) requires eight binary divisions. Secondly, the specification of a planetary system would require at least $log_2(340,000)$, or nineteen, divisions.

Even in the case of the conservative model, we still have a gap of over nine hundred between the complexity of the cause and that of the effect. This is surely great enough to warrant an inference to design.

4 Conclusion

The ontological-complexity account of the design inference holds one very important advantage over either of the probabilistic accounts: it is immune to the *unknown law of nature* gambit, that is much favored by naturalistic opponents to design. Both of the probabilistic versions require us to start with the judgment that the relevant phenomena are of such a kind to have a very low probability, in the absence of an intelligent designer. This involves using our present knowledge of the laws of nature (and of other relevant necessities and possibilities, such as those of logic and mathematics) to estimate the improbability of some observed phenomenon. The opponent to design can always respond by insisting that we posit some new law of nature with the effect of raising the probability of the phenomenon. Indeed, they can do so quite reasonably, since this is what is done in science all the time. If existing laws assign a vanishingly low probability to an observed phenomenon, it makes sense to supplement or revise our set of deterministic and stochastic laws to accommodate the new phenomenon.

From the point of view of the ontological-complexity account, such attempts to posit new laws or mechanisms in nature that raise the probability of the apparently telic phenomenon are to be encouraged, and, even if thoroughly successful, they will in no way diminish our warrant to infer design. Such investigations in the order of efficient causality merely represent an attempt to fill out our knowledge of the lower half of the Aristotelian diamond. They do nothing to alter the geometrical structure of the diamond, since they do not force any revision of our estimate of the complexity either of the apex or of the transversal.

For example, if we discover that all of the anthropic coincidences in the fundamental constants and initial conditions of the universe were explainable in terms of some simple and elegant unified theory, this would raise the probability of the observed coincidences, but it would in no way diminish our warrant in inferring that the coincidences were the product of design, since it would not lower our estimate of the internal ontological complexity of the coincidences by even the smallest amount. We should conclude, instead, that either the structure of the world described by the new unified theory is itself intelligent, or that it is an instrument purposely constructed by some other, still more intelligent agent.

Are probabilities then entirely irrelevant to the issue of when the design inference is warranted? They are not *directly* relevant, but they may be *indirectly* so: they are relevant, not to the design inference itself, but to possible rebuttals or (as contemporary epistemologists put it) *defeaters* of the design inference. The Aristotelian diamond provides us with only a presumption in favor of design. (When the ontological gap is wide, it can provide us with a very strong presumption.) However, this presumption is defeasible or rebuttable. If the opponent of design can give us good reason to believe that a *false appearance* of design is, in a particular case, especially likely, then the inference to design can be blocked successfully.

For example, suppose that we applied the Aristotelian diamond model to the earth, the sun, and the rest of the solar system and found that the system was apparently designed to make possible the existence of abundant oxygen, nitrogen and liquid water on the earth's surface. This would give us good prima facie reason for believing that the earth's system was designed by an intelligent agent whose purposes were somehow associated with these conditions on the earth's surface. However, such an inference could, in principle, be vulnerable to a version of the so-called *Weak Anthropic Principle*, or, as I prefer, to an appeal to *observer selection*. One might argue that scientific observers are likely to exist only in earth-like conditions, and that there are so many stars in the universe that it is not unlikely that an earth-like environment might come into being somewhere in the cosmos. Since we can only observe conditions compatible with the existence of observers, we could explain away the apparent design of our local conditions in this way.

Of course, this rebuttal is itself only presumptive. It can itself be successfully rebutted or defeated. If it turns out that earth-like systems are so special that it is unlikely that even one such system would come about by chance in the entire known universe, then the appeal to observer selection would be defeated.

The crucial thing to grasp is that it is the critic of design who must make use of estimates of probability. The burden is on the skeptic to provide good rational or empirical grounds for believing that the false appearance of design is not unlikely under actual conditions. Design skeptics, in common with other skeptics from antiquity to the modern day, attempt an illegitimate shift in the burden of proof. The skeptic attempts to rebut a successful design inference by merely *raising the possibility* that the appearance of design may be illusory, challenging the defender of the inference to prove a negative — to prove that the skeptical scenarios could *not* have happened. The appropriate response to such skeptical challenges is to place the burden of proof where it belongs: the skeptic must provide substantial and specific grounds for doubting the soundness of the design inference in the particular case in question. As Wittgenstein pointed out, doubt requires good grounds, just as belief itself does.

There is another, closely related advantage to the ontological-complexity account of the design inference. The probabilistic accounts require that, before we proceed to even considering an inference to design, we must first establish that the observed phenomenon is contingent, not a matter of necessity. This is explicitly a node in Dembski's filter, and it is implicit in any probabilistic account, since what is believed to be true of necessity must be assigned a probability of *one*. However, it is quite easy to imagine scenarios in which evidence for design can be, in and of itself, compelling evidence for the contingency of what had, heretofore, been believed to have been necessary. For example, in the postscript of Carl Sagan's novel *Contact*, Sagan imagines a scenario in which the decimal expansion (to be more precise, the expansion in base eleven) of the number π is discovered to contain an encrypted graphics file, containing voluminous information about the structure and evolution of the cosmos. If we were to discover such a thing, we would have compelling reason to conclude that the number π, which we have always assumed to take the value it does as a matter of necessity, is in fact an artifact that has been constructed for a communicative purpose, and artifacts are contingent, not necessary. Similarly, the anthropic coincidences are, in and of themselves, compelling evidence that the fundamental physical constants and initial conditions of the universe are artifacts, and hence contingent.

To end on an irenic note, I would like to point out that, even if one utterly rejects my claim that probabilities are dispensable in this context, the kind of ontological-complexity analysis that I sketch above might still be useful. In particular, such analysis might play an essential role in the principled construction of the probability assignments required by both the Bayesian and the classical-statistical models. The a priori probability of a situation of a given type ought to be an exponentially decreasing function of the type's ontological complexity. Where the observed phenomenon is quite complex, we have good grounds for assigning it a low probability (in the absence of a designer), as both the

Bayesian and classical-statistical approaches require. If the apparent purpose of the phenomenon is quite simple, this provides grounds for assigning a relatively high probability to this purpose's actually being the purpose of a hypothesized designer (that is, for assigning the result a high likelihood, conditional on the hypothesis of a designer, as the Bayesian approach requires).