An Evaluation of William A. Dembski's *The Design Inference*:

A Review Essay

William A. Dembski. *The Design Inference: Eliminating Chance Through Small Probabilities*. Cambridge University Press, 1998. xvii + 243 pp.

I. Introduction: The Aim of the Design Inference

William Dembski has done more than anyone else to attempt to lay the logical and epistemological foundations of the current formulation of the so-called Intelligent Design (ID) movement, a movement which claims to have attracted a significant number of scholars, and has certainly received a significant amount of publicity. Dembski has attempted to do this largely through two books, *The Design Inference: Eliminating Chance Through Small Probabilities*, published by Cambridge University Press, along with a more recent book on intelligent design.[1] It is the *Design Inference,* however, that provides the basis for Dembski's later work and where Dembski claims to have presented the formal underpinnings of how we detect design scientifically. Thus, in this review, I will focus on Dembski's first book, *The Design Inference*, and argue that there are several serious problems with his core methodology. I will then go on to offer a much better methodology for inferring to design for those who wish to do so.

In many respects, this review will parallel the critiques of Dembski presented by Branden Fitelson, Christopher Stephens, and Elliot Sober in their review of Dembski's book appearing in *Philosophy of Science,* though there are several aspects of their review that I disagree with.[2] Further, this review will be at a much less technical level.

Finally, since the whole ID movement has become quite controversial, I should briefly comment on the perspective from which I am writing this review. I am sympathetic to the basic thrust of ID, namely that considerations of design should not be excluded *a priori* from science, largely because such considerations could turn out to be explanatorily and predictively fruitful. On the other hand, I believe that because of its increasing importance in the Christian community, the central aspects of the current formulation of the ID program need to be carefully, critically, and fairly evaluated. Because of its highly technical nature, this is especially needed for *The Design Inference*. In this review, I will attempt to elaborate and evaluate the book in accessible terms while still being true to Dembski's more technical treatment.

II. Purpose of Book

As the subtitle suggests, the stated purpose of Dembski's book is to provide a method of eliminating chance as an explanation of an event. As Dembski stresses throughout his book, the "design inference" is *not* a method of determining when an intelligent agent caused an event: says Dembski, "The design inferred from the design inference does not logically entail an intelligent agent. The design that emerges from the design inference must not be conflated with intelligent agency" (p. 9).

At the core of Dembski's method of eliminating chance is the idea of the *Explanatory Filter* (Section 2.1). The Explanatory Filter essentially says that when explaining an event, one ought first to try to explain it in terms of known regularities (e.g., the laws of nature); if that fails, one ought to try to explain it by chance; if that fails, then one ought to infer to "design." Dembski then formally defines "design" as the "set-theoretic complement of the disjunction regularity-chance" (p. 36). That is, "to attribute an event to design is to say that it cannot reasonably be referred to either regularity or chance" (p. 36).

Dembski claims two advantages in defining design in this way. First, it makes his explanatory filter an unquestionably valid argument: if both regularity and chance are eliminated as an explanation of an event, then by *definition* it follows that it is "designed" in Dembski's sense. The other advantage is that "it avoids committing one to the doctrine of intelligent agency" (p. 36).

One disadvantage of this definition is that it offers no positive conception of the notion of "design," as Dembski admits: "The conception of design that emerges from the design inference is eliminative, asserting of an event what it is not, not what it is. To attribute an event to design is to say that chance and regularity have been ruled out" (p. 19). Another disadvantage is that it tends to mislead since the word "design" in normal usage refers to intelligent agency, not the mere elimination of chance. Indeed, in my experience, advocates of intelligent design, such as Michael Behe, often cite Dembski's book as providing a rigorous, scientific methodology for inferring to intelligent agency. *In the design inference, however, Dembski does not purport to provide a rigorous method for inferring to intelligent agency*. At most, within the book Dembski claims that his methodology provides the first step in inferring to design: as Dembski elaborates in Section 2.4, in most cases when we eliminate chance as an explanation of an event, we do as a matter of fact infer to an intelligent agency as the explanation.

III. Dembski's Methodology for Eliminating Chance

Dembski's method for eliminating chance can be expressed in two words: *specified improbability*. If an event is both specified (in a technical sense to be explained) and sufficiently improbable, Dembski claims, then we can eliminate chance as an explanation. Clearly, improbability is typically a necessary condition for eliminating chance: if an event is not very improbable--such as throwing double sixes--we normally have no problem attributing it to chance. But, improbability is clearly not enough. To see this, consider tossing a coin fifty times in a row: whatever sequence occurs, the probability of that particular sequence occurring is one in 2^{50}, which is approximately one in a million billion, clearly an enormously small probability. Yet, we would unproblematically attribute most such sequences of coin tosses to chance. Suppose, however, that the coin landed on heads fifty times in a row. Few people would attribute this to chance, even though it is no more improbable than any other sequence of fifty tosses. The difference, Dembski claims, is that the latter sequence falls into a pattern that is *specified*, whereas the patterns instantiated by most other sequences are not specified.

The core of Dembski's methodology, therefore, is to provide a precise formal account of when an event is specified, and then show that when a specified event is sufficiently improbable, chance can be eliminated as an explanation. This he attempts to do in chapters 5 and 6.

Dembski's Account of Specification

In presenting his account of specification, Dembski first divides patterns into two categories, *specifications* and *fabrications*: by definition, specifications are patterns that provide a basis for an inference to design, whereas fabrications are those that do not (p. 13). To understand the difference, consider the example Dembski gives of an archer who shoots an arrow at a large wall a long distance away. If every time the archer hits the wall, a small bull's-eye is drawn around the arrow, the fact that the archer hits the bull's-eye does not allow us to eliminate chance and attribute the occurrence to the skill of the archer. The reason, Dembski tells us, is that the bull's-eye, which is the pattern that *delimits* the event in this case, was constructed on the basis of where the arrow landed.[3] In contrast, if the bull's-eye was drawn prior to the arrow being shot, we would be tempted to attribute the arrow's landing in the bull's-eye to skill, not chance (p. 13).

Generalizing the above example, Dembski claims that *the feature that distinguishes patterns that are specifications from those that are fabrications is that the former patterns are in some sense independent of the event whereas the latter are not*: for example, in the specified case, the bull's-eye was drawn independently of where the arrow landed, whereas in the fabricated case it was not (p. 14).

Dembski refers to this relation of independence as *detachability*: thus, patterns that are detachable are specifications, and those that are not are fabrications. He then goes on to define detachability as follows: *a pattern that delimits an event is detachable, and hence specified, if it can be formulated independently of our knowledge of whether the event occurred* (p. 15). Put differently, Dembski claims that a pattern that delimits an event is *specified* if the pattern can be generated, using the available computational resources, independently of any knowledge that the particular event has occurred. Dembski calls the condition that one be able to generate the pattern using the available computational resources the <u>Tractability Condition</u> and the condition that one be able to generate the pattern *independently* of any knowledge of the event the <u>Conditional Independence Condition</u> (CINDE). Thus Dembski claims an event is detachable and hence specified if it meets both of these conditions (pp. 151-154).[4]

The major problem with Dembski's account is that, with sufficient computational resources at one's disposal for generating patterns, it ends up labeling as specifications patterns that clearly do not provide any basis for eliminating chance. To illustrate, consider some randomly selected sequence of 30 coin tosses, say H T H H T T T H T T H H T H H H T T H H H T H T T H T T T H. Before the advent of computers, one *might* plausibly be able to claim that such a pattern could not be generated without knowledge of the actual pattern of coin tosses, though this itself is highly questionable. With the advent of computers, however, it is obvious that such a pattern could be generated entirely independently of knowing the actual sequence of coin tosses. Indeed, a computer could generate every conceivable "30 coin toss" pattern and hence no matter what the sequence of coin tosses turned out to be, it would constitute a specification under Dembski's criteria. *But clearly, most patterns of coin tosses are not specifications since the vast majority do not provide any basis for eliminating chance*. Yet, by Dembski's own definition, the distinguishing feature of specifications, as opposed to fabrications, is that they are supposed to provide just such a basis.[5]

To see how serious this problem is, consider the example Dembski uses of Nicholas Caputo, a Democratic clerk from Essex County, New Jersey who was accused of assigning

Democrats the top ballot line in the county forty out of forty-one times. (Getting the top ballot line increases a candidate's chances of winning.) The New Jersey Supreme court eliminated chance as an explanation for these ballot selections because they said that the probability of them occurring by chance was less than one in fifty-billion.

Now, Dembski claims his methodology provides a rational reconstruction of the Court's reasoning (p. 162). For concreteness, Dembski supposes that the actual ballot outcome was as follows:

E_G: DDDDDDDDDDDDDDDDDDDDDRDDDDDDDDDDDDDDD

Dembski then claims that independently of knowing the actual ballot pattern, the New Jersey Supreme Court could have formulated various "cheating patterns" by which Caputo could have cheated, patterns such as "The Democrats got the top ballot line 41 times" (pattern D_{41}), "The Democrats got the top ballot line 40 times" (pattern D_{40}), etc. (p. 164).

Now, Dembski claims that pattern D_{40} clearly delimits event E_G since E_G is a case in which Democrats got the top ballot 40 times. Further, he claims, since D_{40} could be generated without knowing the actual cheating pattern, pattern D_{40} constitutes a specification. Thus, he concludes, since the occurrence of D_{40} is also very improbable (about one in fifty billion), it follows that we can eliminate chance as an explanation of the ballot sequence (pp. 165-167).

The problem with Dembski's account is that, with the help of a modern computer, every possible pattern of ballot selections (with a sequence length of 41) could be generated independently of knowledge of the actual pattern that occurred: the computer could simply generate all possible patterns using simple mathematical rules of combinatorics. Thus, given Dembski's criteria, every possible ballot pattern turns out to be a specification. This means that in this and many other cases his criteria not only fail to distinguish between specified and fabricated patterns as he defines these terms, but they end up falsely categorizing many patterns as specified that are clearly not specified in the sense of providing a basis for eliminating chance.

A further problem is that since the occurrence of any sequences of ballot selections is highly improbable (one in 2^{41}), it follows that if Dembski is correct, we should be able to infer to design no matter what sequence of Democrats and Republicans occurred! Surely this is an unacceptable consequence.

Now, the technical account Dembski presents in chapter 6 of his Law of Small Probabilities (LSP) could be used to provide an answer to this last objection, but I think at an unacceptable cost. According to LSP, one can only eliminate chance as an explanation of an event when it is improbable relative to the total number of *probabilistic resources* available. Specifically, the LSP claims that one can eliminate chance as an explanation of an event E if E is specified and the probability of E occurring is less than 1/[two times the total number of probabilistic resources available].

Now, Dembski defines the total number of probabilistic resources available as the product of the number of *replicational* resources available with the number of *specificational* resources available (pp. 181, 222). Further, he defines the number of replicational resources available as the number of trials in which an event could have occurred. For example, in the case of tossing two dies, it is the number of times the two dies are thrown. On the other hand, he defines the number of specificational resources available as simply the number of patterns that could be generated by one's computational device. Thus, in the modified Caputo case in which there is a computer available, the specificational resources are 2^{41} possible specifications. The upshot is that merely on the basis of considering the *specificational* resources, a necessary condition for eliminating chance as an explanation of an event E using Dembski's LSP is that the probability of E must be less than 1/[two times the number of specifications].

Thus, in my modified Caputo example, it follows that since a computer can generate 2^{41}

≈ 2 x 10^{12} = two thousand billion specifications, in order to eliminate chance, the improbability of the ballot sequence must be less than one in four thousand billion. When one factors in the replicational resources, the improbability must even be less than this! Since the probability of any given ballot pattern is greater than this, it follows that no ballot pattern, including Caputo's actual cheating pattern, D_{40}, is sufficiently improbable to eliminate chance as an explanation. Hence, it turns out that on Dembski's more technical account based on the LSP, the mere existence of a modern day computer in the courtroom would make it impossible for the Court to eliminate chance in the Caputo case (or many other cases) using his methodology. Yet, bringing a computer into the courtroom clearly would not change the Court's justification in eliminating chance. *I conclude, therefore, that as it stands, Dembski's methodology does not provide a rational reconstruction of the Court's reasoning in the Caputo case, nor in many other ordinary cases of inferring to design.*

Contrary to the primary claim of the book, therefore, his methodology does not provide an adequate procedure for inferring to design in everyday cases. Nonetheless, Dembski could respond that it provides an adequate procedure for inferring to design in biology, where he claims that the probability of intelligent life arising by chance plus natural selection is extraordinarily small. To elaborate, Dembski calculates that the maximum number of specifications in our universe could at most be 10^{150}. Thus, he claims, if we could show that the probability of intelligent life arising anywhere in the universe is less than $1/(2 \times 10^{150})$, then we could eliminate chance as an explanation. I believe that there are at least two serious problems with this response. First, even if Dembski were correct in claiming that his methodology does not run into the problems pointed out above in the case of biology, the fact still remains that his methodology does not account for ordinary cases in which we infer to design, something his book purports to do. Second, if it doesn't work in ordinary cases, why think it does in the special case of biology? [6]

An Alternative Account

So, how can one account for our everyday inferences to design, such as that of the Caputo case? One such account is given by a fundamental principle of confirmation theory, what I have elsewhere called the Prime Principle of Confirmation (PPC), and which Rudolph Carnap has called the "Increase in Firmness" principle, and others have simply called the Likelihood Principle.[7] According to the PPC, an event E *confirms* an hypothesis H_1 over an hypothesis H_2 if E is more probable or more to be expected to occur under H_1 than under H_2. Put technically, the PPC claims that if $P(E/H_1)/P(E/H_2) > 1$, then E provides evidence for H_1 over H_2, where $P(E/H_1)$ and $P(E/H_2)$ represent the conditional probability of E on H_1 and H_2, respectively. Moreover, the degree to which E provides evidence for H_1 over H_2 is proportional to the degree to which E is more probable under H_1 than H_2: that is, to the degree which $P(E/H_1)/P(E/H_2)$ is greater than 1.[8]

To illustrate this principle, consider the Caputo case. The actual ballot selection pattern was much more probable under the cheating hypothesis than under the hypothesis that it occurred by chance. Thus, the ballot pattern confirms that Caputo cheated. Indeed, it is so much more probable under the one hypothesis than under the other that the confirmation turns out to be extremely strong, so strong that virtually any court would conclude cheating was involved.

Similarly, the PPC makes sense of Dembski's archer case. When the bull's-eye is drawn before the arrow is shot, it would be reasonably likely for the archer to hit the bull's-eye if she aimed the arrow, but unlikely if she shot the arrow at random. That is, the probability of her hitting the bull's-eye under the hypothesis that she aimed the arrow is much greater than under the hypothesis that she did not aim it, and thus the dart's hitting the bull's-eye strongly confirms the aiming hypothesis over the non-aiming hypothesis. On the other hand, if the bull's-eye is drawn after the fact, the probability of the arrow's hitting the bull's eye is 100% whether or not she aimed it. Thus, no confirmation of the aiming hypothesis occurs.

One of Dembski’s main objections to this sort of reasoning, which he puts under the category of Bayes’s theorem, is that Bayes’s theorem is in the business of confirming hypotheses, whereas the design inference is in the business of eliminating hypotheses, not confirming them (p. 67). The first problem with Dembski’s objection is that, although not stated above, when an event E confirms an hypothesis H_1 over H_2, it also at the same time *disconfirms* H_2 with respect to H_1. Thus, in those cases in which one has two initially viable hypotheses, H_1 and H_2, and E is much, much more likely under H_1 than H_2, E will so strongly disconfirm H_2 that it will practically eliminate it as a viable hypothesis. In the Caputo case, for instance, the chance hypothesis is so strongly disconfirmed with respect to the cheating hypothesis that for all practical purposes it can be eliminated.

Secondly, most cases of inferring to design are not all or nothing affairs. Rather, the degree to which we are justified in inferring to design or any other hypothesis varies depending on the circumstances. If, for instance, the Democrats got the top ballot line 35 out of 41 times in the Caputo case, the court would have been more justified in claiming that Caputo cheated than if Democrats had been at the top only 26 times. Indeed, even in the actual case, the Court could not absolutely rule out chance--after all, highly improbable events do occasionally occur, even those that appear to be “specified.” The PPC captures this variation in justification, since the degree of justification tracks the degree to which the event is more probable under the one hypothesis, H_1, than the other, H_2. On the other hand, Dembski’s method does not. Even if Dembski's method worked, it would require a black and white cutoff point: for example, under his methodology, it could turn out that we were justified in eliminating chance if Democrats were on top 35 or more times, but not justified for any number less than 35.[9]

The other main objection Dembski presents to Baysian methodology is that it commits one to what are called *prior* probabilities, which Dembski complains cannot be objectively justified. Now, the prior probability of an hypothesis is our best judgement of the likelihood of the hypothesis when we neglect the confirmation or disconfirmation from the event in question. The prior probability of Caputo cheating, for example, would be our best judgement of how likely it is that he would have cheated based on everything we knew about him before finding out about the actual ballot selections. Since the PPC and Baysian methodology in general can only tell one the degree to which a body of evidence *increases* or *decreases* the likelihood of an hypothesis, it follows that the final probability of the hypothesis (called the *posterior* probability) ultimately will depend on the initial starting point--that is, the prior probability of the hypothesis. Thus, an evaluation of prior probabilities is essential when trying to determine the *final* likelihood of an hypothesis when using the PPC.

Now, it seems to me that the PPC and Baysian methodology are correct in assuming that the "elimination" of chance, or any other type of probabilistic inference, must rely on a partially subjective evaluation of prior probabilities. The "elimination" of chance, for instance, is crucially dependent on the prior probabilities of the alternative, non-chance, explanations; if these prior probabilities are low enough, chance cannot be eliminated. To illustrate, suppose that in the Caputo case the selection of ballots had been carefully monitored for fairness by several highly reliable and independent bi-partisan government agencies. In this situation, we might just begin to suspect that chance was the appropriate explanation for the actual ballot selections. Why? Because we would judge that, given the government oversight, the prior probability of the non-chance explanation--that is, that the ballots were rigged--is so low that it would offset the low probability of the event being due to chance.

Finally, let me say a few words about the advantages of using PPC. To begin with, it is practically uncontroversial. So, it is a principle that all sides can agree upon. Second, many philosophers think that this principle can be derived, via Bayes's theorem, from what is known as the *probability calculus*, the set of mathematical rules that are typically assumed to govern probability. Third, there does not appear to be any case of recognizably good reasoning that violates this principle. Fourth, as mentioned above, the principle allows one to assess the *degree* to which we are justified in inferring to design, instead of such an inference being an all or nothing affair, and it accounts for the need for a partially subjective determination of the initial plausibility of the non-chance hypotheses. These are both features of how chance is eliminated and design is inferred in ordinary life. Finally, the principle appears to have a wide range of applicability, undergirding much of our reasoning in science and everyday life, as the examples above illustrate. Indeed, some have even claimed that a slightly more general version of this principle undergirds all cases of confirmation in science. Because of this extraordinarily broad base of support for this principle, we can be very confident in it. In contrast, even if Dembski's method did not run into the above problems, it certainly does not have the sort of broad range of support that the PPC does. One way or another, given the very wide-acceptance of the PPC, Dembski needs to spend more than two pages in addressing why we should reject it as a method of inference.

IV. Conclusion

Above I have presented what I believe are several serious problems with Dembski's methodology, especially with his account of specification. Because of these problems, I must agree with Fitelson's, Sober's, and Stephens' conclusion in their review of Dembski's book, namely that Dembski's methodology does not provide an adequate procedure for either eliminating chance or inferring to design.[10] Further, I have argued that we already have an adequate methodology available that accurately reconstructs ordinary inferences to design, namely that given by the PPC. Although the issue is beyond the scope of this review essay, I think that the PPC can also provide an adequate basis for inferring to a transcendent designer from various features of the natural world, something advocates of Intelligent Design want to do. One way or another, I believe that those interested in inferring to a transcendent designer need to start with a methodology that adequately accounts for how we infer to design in everyday life, and then see if such a methodology can be extended to an inference to a transcendent designer.

Although I have argued that there are several serious flaws in the central methodology of *The Design Inference*, I would like to end this review on a more positive note by first suggesting a way in which Dembski *might* be able *partly* to rehabilitate the notion of specification using the PPC, though many other aspects of his account would remain seriously problematic. Roughly, he could define a specification as any type of pattern for which we have some reasons to expect an intelligent agent to produce it. (These reasons could be theoretical or based on past experiences regarding the sort of patterns we commonly observe intelligent agents producing, such as those exemplified by irreducibly complex systems.) By the PPC, specifications defined in this way would provide strong evidence for intelligent design if their existence is also highly improbable under the various competing non-intelligent-design hypotheses.

Secondly, it should be mentioned that although Dembski's program has typically been interpreted as primarily about laying the logical foundations of inference to an intelligent designer, and Dembski has said things to leave this impression, arguably the heart of his program lies elsewhere, namely in developing a quasi-naturalist category of "design" which in and of itself does not make reference to the action of an intelligent agent, but which in some strong way suggests design by such an agent. This can be seen by looking at Dembski's definitions of "design," none of which involve explicit reference to an intelligent agent. For example, besides defining design as that category into which an event falls when it cannot be explained by regularity or chance (p. 36), in several places Dembski also defines design as "patterned improbability" (p. xii) or as fundamentally signifying a "pattern or blueprint" (p. 227). Further, in his most recent book on intelligent design, Dembski spends all of chapter 6 arguing that intelligent design can be understood as a theory of information, thus suggesting that "information" is a synonym for "design."[11]

Although, as pointed out above, Dembski has not presented an adequate account of what specified complexity or the related notions of"design" or information are, I think this program of developing a quasi-naturalistic category of "design" has the promise of giving rise to a fruitful science. After all, those familiar with the history of science must remember that some of the most extraordinarily fruitful notions in science were vague and often seemingly contradictory at the time they were proposed. Further, at least many of them were proposed partly for theological or philosophical reasons. This is especially true of the idea of energy and its associated conservation law. Indeed, as physicist Freeman Dyson points out, even today energy is essentially a mysterious quantity, even though we have precise mathematical methods of dealing with it.[12] (An exception to this is general relativity, in which the gravitational energy is both non-local and cannot be mathematically defined except in special circumstances. [13]) Perhaps the idea of "information" or "specified complexity" or "design" as a fundamental feature of reality could be as fruitful for future science as the idea of energy has been for science during the last two centuries.[14]

1. *Intelligent Design: The Bridge Between Science and Theology* (Downers Grove, IL., InterVarsity Press, 1999).

2. "How Not to Detect Design–-Critical Notice: William A. Dembski, *The Design Inference*," *Philosophy of Science,* 66 (September, 1999). For a shorter and less technical review of Dembski's book, see Howard Van Till, "Does 'Intelligent Design' Have a Chance? An Essay Review," *Zygon*, vol. 34, no. 4, (December, 1999). See also Paul Nelson's response in the

same issue. Unlike the present review or the Fitelson, et al. review, Van Till does not examine the viability of Dembski's method as a method of eliminating chance, but mostly looks at whether his methodology can be used to infer to an intelligent designer of the universe.

3. A pattern is defined as *delimiting* an event if the event falls under the pattern.

4. Technically, Dembski explicates this idea in terms in what he calls "side information **I**," where **I** is conceived of as information that is fed into one's computational "device," such as a computer or a human mind. Dembski then calls the condition that, using information **I**, one be able to generate a pattern D that delimits an event E the *Tractability* condition, and the condition that **I** be epistemically independent of E the Conditional Independence Condition (CINDE). Expressed mathematically, Dembski defines CINDE as the condition that P(E/H & **J**) = P(E/H), for any information **J** generated by **I**, where E represents the event in question, H the chance hypothesis under consideration, and P(E/H& **J**) and P(E/H) represent the conditional (epistemic) probability of E on H&**J** and H, respectively. Basically, this mathematical condition says that given the chance hypothesis H, knowing information **I** or any information **J** generated by **I** should not affect our subjective degree of belief regarding whether or not E has occurred. (This is what Dembski means by **I** being epistemically independent of **E**.) *Dembski's key claim is that, for any event E, if one can find (i) a pattern D that both delimits E and meets the Tractability condition, and (ii) side information **I** that meets CINDE, then the event E is specified* (pp. 151-154).

To illustrate, consider the archer example above in which the chance hypothesis H is assumed to hold -- that is, in which the arrow is assumed to be shot aimlessly. Let side-information **I** be that the bull's-eye encompasses a region R. In the case in which we know that the bull's-eye was drawn after the fact, knowing **I** would increase our subjective degree of belief to 100% that the arrow had landed in R and hence condition CINDE would not be met. On the other hand, in the case in which the bull's-eye was drawn before the arrow was shot, knowing **I** would not affect our subjective belief that the arrow landed in R, and hence CINDE would be met. Thus, Dembski claims, in this latter case, but not in the former, we would be justified in inferring to design (pp. 151-154).

Apart from this technical apparatus, however, Dembski's criteria for an event being specified boil down to just what was stated in the main text above, namely that a pattern delimiting the event can be generated without knowledge that the event has actually occurred (p. 15). Thus, for the sake of the non-technical reader, we will use this simpler formulation of his criteria of specification. Nonetheless, the critique I will present can be easily translated into his more technical apparatus without loss of generality.

5. Dembski is aware of this problem in the limiting case of an infinitely powerful computational device. For example, he admits that since such a computational device would be capable of detaching all patterns, all patterns would become specifications (p. 18). But he seems unaware that the existence of finitely powerful computers also presents serious problems for his account.

6. In response to this question, Dembski could attempt to justify his methodology for the case of biology by appealing to his LSP combined with his calculation that the maximum number of specifications is 10^{150} (chapter 6, pp. 175-223). Each of these, however, has serious problems as I will now show.

Besides Dembski's justification for the LSP being flawed, as Fitelson, et al., note (op. cit., pp. 484-485), the LSP is subject to fatal counterexamples. Suppose, for instance, that the Pennsylvania Lottery was the only one in human history, thus making the number of replications equal to one. Further suppose: (i) that a million tickets were printed and sold, starting with 000000 and ending with 999999, thus making the total number of specifications--that is, the total number of possible winning patterns that are generated--equal to a million; (ii) that the Lottery was set up so that the probability of any given ticket being the winning number was one in three million; and (iii) that some particular number, say 101659, turned out to be the winning number. According to Dembski's LSP, we could not attribute 101659 being the winning number to chance. Why? Because the total probabilistic resources would be a million (that is, the number of replicational resources times the number of specificational resources). Thus, since the probability of 101659 being the winning number is less than 1/(two million), it follows by the LSP that it cannot be due to chance. Thus, since this same argument applies to whatever number turned out to be the winner, it follows from the LSP that we cannot attribute the lottery having a winner to chance. Clearly, however, this is the wrong conclusion to draw, especially if we had good reasons to believe that the lottery was not rigged. After all, if such a lottery were held, it would be no surprise that it had a winner, since the probability of some number winning is fairly large, namely 1/3.

Dembski's use of the LSP for eliminating chance (or chance plus natural selection) in biology further depends on his calculation that the maximal number specifications in the universe is 10^{150}: if we could show that the probability of some specified biological system arising by chance plus natural selection is less than $1/(2 \times 10^{150})$ anywhere in the universe, Dembski claims, then we could eliminate chance as an explanation.

Now, Dembski's calculation regarding the maximum number of specifications is based on the assumption that there are 10^{80} elementary particles in the universe with one specification per elementary particle state, along with a maximal rate--10^{45} changes per second--by which elementary particles can change their state (p. 209). There are several serious problems with this calculation, though I will only mention two. The first problem is that in quantum mechanics the actual state of an elementary particle is given by a state function ψ which takes on continuous values, and hence typically the number of states an elementary particle goes through in any period of time is actually infinite, making the number of specifications infinite. (Indeed, since the states of a quantum computer would be given by such a state function, it also would generate an infinite number of specifications). This means that in Dembski's scheme one could only absolutely eliminate chance for events of zero probability! Second, this probability bound assumes a non-inflationary cosmology. Inflationary universe cosmologies, which have been in vogue among cosmologists for the last fifteen years, would vastly, perhaps infinitely, increase what has been commonly assumed to be the size of the "universe" and hence the available replicational and specificational resources: for example, in an infinite universe one could only eliminate chance as an explanation using Dembski's methodology if the probability of intelligent life arising by chance were zero. In answer to this problem, Dembski simply dismisses inflationary cosmology claiming that the only evidence in its favor is "its ability to render chance plausible" (p. 215). This statement is far too quick. As can be found in any current text in cosmology (for example, John Peacock's *Cosmological Physics* [Cambridge: Cambridge University Press, 1999]), the main evidence offered for inflationary cosmology is that it solves certain purported problems with the standard big bang theory (such as the so-called horizon and flatness problem), not that it renders chance plausible.

7. See my "The Fine-Tuning Design Argument: A Scientific Argument for the Existence of God," in Michael Murray, editor, *Reason for the Hope Within* (Grand Rapids: Eerdmans, 1999) and Rudolph Carnap's *The Logical Foundations of Probability* (Chicago: University of Chicago Press, 1962). For a basic, but somewhat dated, introduction to confirmation theory, see Richard Swinburne, *An Introduction to Confirmation Theory* (London: Methuen and Co. Ltd, 1973). For literature specifically casting design arguments as likelihood comparisons see, for instance, A. W. F. Edwards, *Likelihood* (Baltimore : Johns Hopkins University Press, 1992) and Richard Royall, *Statistical Evidence : A Likelihood Paradigm* (New York : Chapman & Hall, 1997).

8. It should be noted that the type of probability used here is what is called *epistemic* probability. Epistemic probability is a widely-recognized type of probability that applies to claims, statements, and hypotheses--that is, what philosophers call *propositions*. Roughly, the

epistemic probability of a proposition can be thought of as the degree of confidence or belief we rationally should have in the proposition. For an in-depth discussion of epistemic probability, see Swinburne, op. cit., Ian Hacking, *The Emergence of Probability: A Philosophical Study of Early Ideas About Probability, Induction and Statistical Inference* (Cambridge: Cambridge University Press, 1975) , and Alvin Plantinga, *Warrant and Proper Function* (Oxford: Oxford University Press, 1993), chapters 8 and 9.

For those familiar with the probability calculus, a precise statement of the degree to which evidence counts in favor of one hypothesis over another can be given in terms of the odds form of Bayes's Theorem: that is, $P(H_1/E)/P(H_2/E) = [P(H_1)/P(H_2)] \times [P(E/H_1)P(E/H_2)]$. Although the PPC can be derived from Bayes's theorem by assuming that Bayes's theorem applies to *epistemic* probability, the validity of PPC does not require the applicability or truth of Bayes's theorem.

9. To see why the PPC captures this variation in justification, note that as the number of times the Democrats get the top ballot line increases, the more and more unlikely it becomes for such an event to occur by chance, and thus the larger the disparity in probabilities between the cheating hypothesis and the chance hypothesis, which in turn implies a higher degree of confirmation.

10. Op. cit., p. 487.

11. Op. cit.

12. Dyson, "Energy of the Universe, " *Scientific American* (September, 1971), pp. 51-59.

13. See, for instance, Charles Misner, Kip Thorne, and John Archibald Wheeler, *Gravitation* (New York: W. H. Freeman and Company,1973), pp. 457-59, 466-70.

14. The idea that "information" might prove to be a very fruitful, fundamental category in the biological sciences is not

unique to Dembski, but has been suggested by many others, such as University of Chicago biochemist James Shaperio ("A Third Way," *The Boston Review*, [bostonreview.mit.edu/br22.1/shapiro.html, Feb./Mar. 1997]) and Georgetown University theologian John Haught (*God after Darwin : A Theology of Evolution* [Boulder, Colo: Westview Press, 1999],Chapter 5).

I would like to thank Arthur Fine, Jeff Koperski, an anonymous reviewer, and especially Tim and Lydia McGrew for comments on an earlier version of this paper.