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Messages from Heaven

Nature is what the world would be if there were no God.

–William Dembski, 1999

Intelligent Design

The argument from design stands or falls on whether it can be demonstrated that some aspect of the universe such as its origin or biological life could *not* have come about naturally. The burden of proof is not on the naturalist or evolutionist to rule out supernatural causes. Rather, it is on the supernaturalist to demonstrate that something from outside *nature* must be introduced to explain the data.

This realization finally seems to be hitting home in the community of knowledgeable believers. Although many preachers, lawyers, and politicians still think they can win debating points for religion by poking holes in evolution or otherwise castigating the "dogmatic naturalism" of science, more sophisticated theologians understand that this strategy only works when the debate is held in front of a congregation of faithful parishioners. Similarly, awe-inspiring photographs of galaxies and stars, or detailed maps of the structure of the cosmic microwave background radiation do not signal the existence of a creator—unless those photographs and maps contain some undeniable "message from heaven."

Mathematician and theologian William Dembski says that he has seen just such a message from heaven, written in the patterns of nature. This has made him a hero and a martyr to some, while a fool and a pariah to others.

Dembski is a major spokesperson in the new creationist movement that goes by the designation *intelligent design,* which was briefly introduced in chapter 2. He claims to have *proven* that the order and complexity of the physical world are incapable of being brought about naturally. Thus he directly disputes Hume's case against the argument from design.[1]

Dembski makes his opposition to theists who support evolution very clear:

> *Design theorists are no friends of theistic evolution.* As far as design theorists are concerned, theistic evolution is American evangelicalism's ill-conceived accommodation to Darwinism.[2]

In 1999, after he had gained considerable notoriety from his speeches and writings, Dembski was invited by President Robert Sloan of Baylor University, a moderate Baptist institution in Waco, Texas, to become director of a new institute for intelligent design studies on campus. The center was to be named after chemist Michael Polanyi, who questioned that the world could be explained by natural laws alone.

The Polanyi Center was established by executive order, without the normal faculty consultation, and when the Baylor faculty heard about it, many were unhappy. Charles Weaver, a professor of psychology and neuroscience at Baylor, typified the concern of professors about the reputation of the institution: “When you say Baylor now, people are going to go, 'Oh, yeah, they have that creationist center.'" Waco also happens to be the unfortunate location of the Branch Davidian compound that was destroyed with great loss of life during a federal assault in 1993. This added to the concern of the faculty that Baylor, really a very fine university, might become associated with kooks.[3]

The Baylor faculty senate voted twenty-seven-to-two to dismantle the new center, but President Sloan refused to comply. Instead, he invited an outside committee of scholars to consider the legitimacy of the center and evaluate intelligent design as an academic discipline. Despite Dembski's vigorous objections that the committee was not qualified to provide peer review of his work, it recommended that this work be allowed to continue. The committee report was conciliatory. It said that it considers “research on the logical structure of mathematical arguments for intelligent design to have a legitimate claim to a place in the current discussions of the relations of religion and science.” They recommended that the Polanyi name be removed and that an advisory committee oversee the work of the center. Perhaps most significantly, the committee specified that the center was more naturally at home within the Baylor Institute of Faith and Learning and that it would be too restrictive for it to focus attention "on a single theme only, such as the design inference."[4]

Dembski nevertheless saw the decision as a great victory in the battle of good against evil. In a press release, he exulted, “Dogmatic opponents of design who demanded the Center be shut down have met their Waterloo. Baylor University is to be commended for remaining strong in the face of intolerant assaults on freedom of thought and expression.” After refusing to retract this incautious statement, Dembski was removed as center director by the Baylor administration..[5]

Dembski was replaced as director of the center, now called the Baylor Project on Religion and Science, by Bruce Gordon. Gordon has written that one of the principle reasons for the academic resistance to design-theoretic research is that it has been "hijacked as part of a larger cultural and political movement." He adds, "Inclusion of design theory as part of the standard discourse of the scientific community, if it ever happens, will be the result of a long and difficult process of quality research and publication. It also will be the result of overcoming the stigma that has become attached to design research because of the antievolutionary diatribes of some of its proponents on the one hand and its appropriation for the purpose of Christian apologetics on the other."[6]

As these events once again illustrate, the dispute between creationists and scientists is more political than academic, and the battle metaphor used by Dembski was not inappropriate even if it was ill-advised. We saw in chapter 2 how law professor Phillip Johnson is leading a political war against what he perceives as a dogmatic bias toward naturalism in mainstream science. Dembski's "battle of Waterloo" has by no means been fought to completion, and it is far from clear which side will emerge victorious.

While numerous expert critiques of Dembski's ideas exist in the literature,[7] I I wish to focus on some glaring errors that cast grave doubt on his whole program.

Information Theory

In his book *Intelligent Design,* Dembski makes the assertion that "intelligent causes are necessary to explain the complex, information-rich structure of biology and that these causes are empirically detectable."[8] This is a scientific statement and so should be evaluated scientifically, outside the political arena.

Dembski has become prominent for his claim to have brought modern information theory to bear on the issue of design. However, his writing on the subject is ambiguous, and considerable debate exists on what he has exactly done. What is clear is that he has not applied information theory as it is conventionally practiced in the field. In order to be as precise as possible in justifying this statement, I must get technical at this point. Those readers who have some knowledge of mathematics should be able to follow the arguments. For those who do not, I will also summarize my conclusions in the less-precise medium of words.

Dembski defines the "measure of information in an event of probability *p*" as

$$I_D = -log_2 p \tag{1}$$

where the base-2 logarithm is used.[9] He cites as a reference *The Mathematical Theory of Communication* by Claude Shannon and Warren Weaver.[10]

Shannon is regarded as the father of information theory. Working for Bell Labs, a major private research company in the phone industry (now reorganized), Shannon was concerned with the efficient communication of electronic signals. Let me give a short summary of his theory, which is now widely applied in communications and computer engineering.

Suppose we want to transmit a message containing a single symbol, such as a letter or number, from a set of *n* symbols. Shannon defined a quantity

$$H = -\sum_i p_i \log_2 p_i = -\langle \log_2 p_i \rangle \tag{2}$$

that he called "the entropy of the set of probabilities $p_1 \ldots . p_n$" for the symbols in the message. That is, p_i is the probability for the *i*'th symbol in the list. The sum over *i* goes from 1 to *n*. Because of the base-2 logarithm, the units of *H* are *bits*.

The angle brackets in (2) refer to the average of the enclosed quantity, and the fact that *H* is an average over an ensemble of symbols is important to keep in mind in the ensuing discussion.

In today's literature on information theory, *H* is called the *Shannon uncertainty*.

The information, R, carried by a message is defined as the decrease in Shannon uncertainty when the message is transmitted. That is,

$$R = H(\text{before}) - H(\text{after}) \tag{3}$$

If we consider the special case when all the probabilities p_i are equal, we get the simpler form

$$H = -\log_2 p_i \tag{4}$$

Let me illustrate the idea of information with a simple example of a single-character message that can be one of the eight letters *S, T, U, V, W , X, Y,* or *Z* with equal probability. Before the message is transmitted, $n = 8$, $p_i = 1/8$, and $H(\text{before}) = -\log_2(1/8) = \log_2(8) = 3$. After the message is successfully transmitted, we know what the character is, so $p_i = 1$ and $H(\text{after}) = -\log_2(1) = 0$. Thus $R = 3$ bits of information are received as the uncertainty is reduced by 3 bits.

Now suppose that the message is a little garbled so that we know the symbol transmitted is either a *U* or a *V*, but we cannot tell which, and they have equal probability. Then, after the message is received, $p_i = 1/2$ and $H(\text{after}) = -\log_2(1/2) = 1$. In that case, $R = 3 - 1 = 2$ bits of information are received.

Dembski's definition of information, $I_D = -\log_2 p$, is of the same form as the Shannon uncertainty in the special case of equal probabilities, as given in (4). However, we can immediately see that this definition is not conventional and will equal *R*, as given in (3), only for equal probabilities and when the transmission is perfect so that $H(\text{after}) = 0$. While Dembski refers to Shannon, he does not mathematically derive the expression for information he uses from Shannon's expression, nor justify it by any other method. His examples, however, indicate that he does not limit himself to equal probabilities within an ensemble of symbols or "events. Neither does he average over the ensemble. In fact, his so-called information" is really just another way of writing the probability, *p,* of an event in logarithmic form. This quantity is called *surprisal* in the

literature, although too trivial to warrant a separate term.[11]

Before continuing with Dembski's theory, let us take a closer look at the interpretation of the Shannon uncertainty *H*. Shannon notes that "the form of *H* will be recognized as that of entropy as defined in certain formulations of statistical mechanics," referring to the classic monograph *The Principles of Statistical Mechanics* by Richard Tolman,[12] which has been on my bookshelf since my graduate student days. Shannon explicitly states that "*H* is then, for example, the *H* in Boltzmann's *H*-theorem." Actually, in statistical mechanics the quantity I will call H_{SM} is defined without the minus sign and using the natural logarithm:

$$H_{SM} = \sum_i p_i \log_e p_i \tag{5}$$

However, Shannon notes that any constant multiplying factor, positive or negative, could have suited his purposes, since it just sets the units. As we saw above, the choice he made in (1) gives units in bits.

Boltzmann's *H*-theorem is one of the most famous in physics. In the 1890s, Ludwig Boltzmann showed that no matter what the initial distribution of velocities of the molecules of a gas, the effect of collisions led to a decrease in H_{SM} with time until a minimum is reached, at which point the gas is in equilibrium.[13]

Boltzmann and Josiah Willard Gibbs found that the laws of classical thermodynamics could be derived from statistical mechanics on the assumption that matter was composed of atoms, whose existence had not yet been fully confirmed by experiment at that time. In particular, the quantity H_{SM} was seen to be simply related to the thermodynamic entropy *S* by $S = -kH_{SM}$, where *k* is Boltzmann's constant. The *H*-theorem then implied that the entropy approaches maximum at equilibrium, as was well known from thermodynamics. This gave a statistical explanation for the second law of thermodynamics, which says that the entropy of an isolated system will increase with time or stay constant, that constant being achieved when equilibrium is reached.

The relationship between the entropy, *S*, of statistical mechanics and Shannon's uncertainty *H* then is,

$$S = k \log_e(2) H \quad (6)$$

That is, they are equal within a constant and have the same sign. So Shannon was justified in calling *H* the "entropy."

Summarizing the conclusions of this section: (1) Dembski's definition of information is not that used in the discipline of information theory, (2) information is conventionally defined as the change of a quantity called the Shannon uncertainty, and (3) entropy and Shannon uncertainty are equal within a constant.

Conservation of Information

In his book *Intelligent Design* and other writings, Dembski claims to prove a principle he calls, borrowing the term from 1960 Nobel laureate in medicine, Peter Medawar, the *law of conservation of information.* According to Dembski's—but not Medawar's—version of this principle, the number of bits of information cannot change in any natural process such as chance or the operation of some physical law. As Dembski states it, "Chance and law working in tandem cannot generate information."[14] I will try to show that this is incorrect, when interpreted as some universal principle applying under all circumstances, which Dembski seems to do.

The basic idea of conservation of information is simple, and is illustrated in figure 4.1. Suppose we start out with a certain number of bits of information about a system. Let the system be composed of five coins. Any configuration of heads (H) or tails (T) is information that can be represented by five bits. For example, HTTHT = 10010. According to Dembski, two possible natural processes can act on that information. One is some well-defined operation that can be likened to the action of a physical law or computer algorithm. For example, the operation might be: every time a flipped coin lands on the table, turn it over. Thus we have HTTHT → THHTH, or 10010 → 01101. Clearly, the number of bits has not changed and so, while the message may be different in content, it contains no more or less information than previously. In this process, at least, information is conserved.

In his book *The Limits of Science*, Medawar described the impossibility of creating

new information from closed logical systems: "No process of logical reasoning—no mere act of mind or computer-programmable operation—can enlarge the information content of the axioms and premises or observation statements from which it proceeds."[15] However, unlike Dembski, Medawar did not claim this as a universal principle but instead claimed that it applied only to *closed* systems. Medawar also made no claim that the same rule applied to chance processes, which Dembski includes in his version of the principle.

Let us look at what happens to our original information representing five coin tosses under the operation of random chance. Regardless of the original bit sequence, the process will produce a new one in which H and T are equally likely. Thus HTTHT → TTHTT or HHTTH (10010 → 00100 or 11001) or any other possible permutation. Again, the number of bits does not change, so no information is generated or lost. Notice that Dembski has, as he did above, again assumed a closed process in which no bits can flow in or out. This is not the most general situation.

Thus, Dembski claims, the very existence of information in the universe is irrefutable evidence for the existence of design. This conclusion has left many people impressed. For example, Rob Koons, an associate professor of philosophy at the University of Texas, calls Dembski the “Isaac Newton of information theory.”[16]

Hardly. First, as I have already noted, Dembski's definition of information does not correspond to that used in the field, except as a special case to which he does not limit himself. We have seen that conventional information is defined as the decrease in Shannon uncertainty during the transmission of a message. Furthermore, we have seen that Shannon uncertainty is equal, within a constant, to the entropy used in statistical mechanics.

As has been well known in physics for more than a century, entropy is *not* conserved. In fact, the second law of thermodynamics says that the total entropy of an isolated system of many bodies must remain constant *or increase,* as implied by Boltzmann's *H*-theorem, discussed above. Entropy can even decrease for nonisolated systems, which happens when they are organized from the outside, or in any system with small numbers of particles. In fact, in the example I gave of the transmission of a message, the entropy / uncertainty is seen to decrease. This is an illustration of a

nonisolated system, the transmitter, sending information to another nonisolated system, the receiver.

Indeed, every time you rub your hands together, you are making entropy. From an information standpoint, uncertainty is increasing (the molecular motions in your hands are becoming more irregular) and so information is being lost. It is possible to come up with many examples in which information is not conserved. Thus, Dembski's "proof" fails because it violates the second law of thermodynamics. Actually, Dembski is aware that information can degrade,[17] but this only demonstrates his inconsistency. His "law" of conservation of information does not permit this.

Let us move from individual systems to the universe as a whole. Under the naturalistic assumption that no forces act on it from the outside, the universe is an isolated system. Thus, it would appear that no gain of conventional information (negative entropy) with time is possible in the universe as a whole. However, the universe could have begun in complete disorder without violating the second law, and local pockets of order can still form as time progresses. This is made possible by the expansion of the universe, which continually opens up more room for order to form (see chapter 6 for further discussion of this point).

Now, perhaps Dembski might argue that it was not his intent to define information in terms of the Shannon uncertainty, although he uses Shannon as a reference and mentions no other source. In any case, we can show that we can still imagine natural processes adding bits of Dembski information to a system. A computer simulation can be used to illustrate this, but the creationist can then say that it is still "designed." Let us consider an example that involves only chance, with no designer intervention.

Suppose we have two bar magnets, one sitting on top of the other, as shown in figure 4.2(a). Because of their mutual attraction, only the two configurations shown, with either both north poles up or both south poles up, will be stable. This can be specified by one bit of information, say $H = 1$ for north poles up and $H = 0$ for both north poles down. Note that $H = I_D$ in this case.

We open the window and a random breeze comes through and knocks the magnets apart. Assume they are constrained so they cannot fall on their sides but must

always land vertically. Now, because the poles are no longer in contact, the four configurations shown in (b) are possible. We then need two bits to describe the situation: H = 11 for both north poles up, H = 10 for the first north up and the second down, H = 01 for the second north up and the first down, and H = 00 for both north poles down. Thus, the information in the system has increased by one bit as the result of a chance process. (We would need even more bits to describe the possible orientations for the magnets on their sides.) Thus information is generated by chance, in violation of Dembski's law of conservation of information. Such a law cannot be found in the standard usages and practices within the field of information theory.

Panning for Design

The law of conservation of information is not the only unloaded weapon to be found in the arsenal of intelligent design. In tune with the arguments of Ross presented in chapter 3, Dembski attempts to show that design is evident by virtue of what, in his personal estimation, are probabilities that are too low for the natural production of order.

In this approach, Dembski seems to be utilizing his own definition of information, which we saw in the previous section is not the conventional one. In fact, he is simply doing a trivial mathematical transformation on the probability of an event, converting it to bits by taking the negative of its base-2 logarithm. In Dembski's usage, the lower the probability of an event, the greater the information contained in that event.

Dembski introduces a series of "filters," which he applies to observed phenomena in order to determine whether or not they are designed. He tests these filters by also applying them to examples of human design, on the assumption that supernatural design must follow the same rules. His filters pass only information that is both *complex* and *specified*. The resulting *complex specified information* is then interpreted as the consequence of intelligent design.

Let me illustrate these criteria in terms of the example of five consecutive coin tosses used earlier. We saw that this system has five bits of information. Suppose that, before the first toss, we *specify* a particular sequence, say all heads, HHHHH. Or it could

be all tails or any other sequence, such as HTTHT, as long as it is specified in advance.

Now, five heads in a row, or any other sequence of five coins, will happen frequently by chance. On average, about one in every thirty-two tosses of 5 coins will land with all 5 heads up. However, suppose we do the experiment with 500 coins instead of 5 and specify in advance that all fall heads up. It would require $2^{500} = 10^{150}$ tosses of 500 coins each, again on average, to obtain 500 heads specified in advance in an event of 500 consecutive coin tosses by chance. That is, the probability for this outcome is 10^{-150}, and the Dembski information contained in the event is 500 bits.

Dembski says this is impossible, for all practical purposes, and defines as "complex" any event containing at least 500 bits of information.[18] This, he notes, is a far more stringent bound than the 166 bits implied by the "universal probability bound" of $10^{-50} = 2^{-166}$ proposed by mathematician Emile Borel.[19]

However, while some *prespecified* sequence of 500 bits, such as all heads or any other specific pattern of heads and tails selected before the fact, has this very low probability of being chance, the probability for *any* sequence of heads and tails in 500 or any number of tosses is 100 percent! So, if after the coins are tossed we look at the sequence that is produced, we cannot very well say that particular sequence is impossible when there it is, staring us in the face.

Unfortunately, Dembski does not define specificity as precisely as he does his albeit idiosyncratic definition of complexity. In the coin example I have used, the sequence is specified in advance. This is fine. However, Dembski cannot leave it at that because, then, his whole program to detect design *after the fact* would be defeated. So, as a dubious and dangerous tactic, he allows specificity to be postdetermined. This approach is presumed to capture"design information" that would otherwise be written off to chance, perhaps rightly so.

Although specificity is difficult to define, like pornography you are supposed to know it when you see it. Dembski uses an example from the film *Contact*, based on Carl Sagan's novel, in which the character played by actress Jodie Foster detects a signal from outer space containing the sequence of prime numbers up to 101. She concludes that it comes from an intelligent source. Indeed, if such a message were to come from the skies, then we would all become believers that something out there knows

mathematics. However, the message that Dembski claims to detect when he applies his filters to physical systems like biological organisms is not comparable to the sequence of prime numbers up to 101.

For example, he claims that "the CSI of a flagellum far exceeds 500 bits".[20] What he is really saying is that the probability of a flagellum being produced by natural processes is less than 10^{-150}. He does not know that. He simply asserts it as a fact. As Dawkins and others have shown, natural selection is fully capable of generating large amounts of information. Furthermore, the huge amount of apparently random and useless DNA sequences in the functioning genomes of organisms indicates that a strong element of chance was involved in their development. Living structures do not at all resemble Paley's watch or a Boeing 747 aircraft. In fact, the genetic blueprints of living structures show far more evidence of random processes than they show evidence of effective adaptation by the blind processes of "design" by natural selection, and none for intelligent design.

Physicist, and theist, Howard Van Till points out that Dembski's definition of complexity is highly unorthodox when you look at how it is applied.[21] For example, as I have noted, Dembski argues that any biotic system is complex if the probability for it being assembled by natural processes is less than 10^{-150}. This makes complexity not a property of the system but the means by which it is actualized.

Furthermore, when Dembski actually calculates the probability for a specific system, like the flagella in E. Coli bacteria, he does so by assuming that the system was assembled by chance processes alone. Van Till comments: "We reject that argument as a totally unrealistic caricature of how the flagellum is actualized and an approach that totally ignores the role of the bacterial genome in coding for all of the structures and functions that contribute to the nature of E. Coli."[22] While the chance probability might be less than the probability bound, the probability for chance plus other natural processes, such as natural selection, will always be greater.

No Free Lunch

Dembski's latest effort to demonstrate the inability of natural processes to solely account for the evolution of life involves computer programs that attempt to solve

optimization problems.[23] As a simple example of an optimization problem, suppose you are hiking in the Rocky mountains and wish to find the best path to take to reach the bottom of a certain valley, where the best path may not be the shortest one but that requiring the least expenditure of energy. In this case, the energy is an example of a *cost function* or *fitness function.* The search algorithm would try to find the path that has minimum total expended energy. A contour map of the Rockies would constitute an example of what is referred to as a *fitness landscape,* with mountain peaks requiring high cost to scale and valleys requiring low cost.

The simplest optimization method is to generate a large number of random paths and chose the best from the set. For any given problem, this can be generally improved upon by a number of techniques, such as examining the cost function around the current position and moving in direction where it is lowest. In my example, you would walk downhill from where you are to a new position, look around again, and continue downhill. This may get you down to the desired valley quickly with minimum expenditure of energy. But it may also bring you down into a different valley than the one you are seeking and confront you with mountains to climb or force you to take a long path around to seek out a pass that will get you through them. The pioneers of the American West were faced with such problems, and had no computers to guide them.

In a certain subclass of optimization programs, the programmer does not specify the algorithms in detail but uses methods analogous to those of natural selection where different solutions are tried and those aspects which work better than others are retained while the less efficient aspects are discarded. These are called *evolutionary algorithms*. For example, the program might find that going down hill all the time is bad, while occasionally moving in a random direction instead is better. So, without guidance from the programmer, it may settle on a solution that combines the two techniques in some ratio.

It turns out that for the general class of search algorithms, not just evolutionary ones, no universal algorithm exists that will work for all problems. Certain "No Free Lunch" theorems have been proven which show that the performance of an algorithm when averaged over all cost functions performs no better and no worse than any other algorithm, including blind search.[24] What works best for the Rockies may not work for

Nebraska and when all landscapes are considered, nothing works better than chance.

Dembski uses this result to assert that Darwinian mechanisms are therefore no better than chance. Since, he claims, chance alone cannot produce the complexity of life, it follows that natural selection cannot be the sole mechanism for biological evolution.

An exhaustive review of *No Free Lunch* and Dembski's earlier work has been provided by Richard Wein.[25] He points out that the type of search algorithms addressed by the No Free Lunch theorems, including evolutionary algorithms, do not apply to biological evolution. While evolutionary algorithms use natural selection, they do not and are not meant to simulate biological evolution. Biological organisms do not have a fixed cost functions but ones that change over time in response to changes in the population.

H. Alan Orr has seen similar flaws in Dembski's reasoning.[26] Biological evolution has no pre-set target, no specific fitness landscape like the Rocky mountains. As Orr puts it: "Darwinism, I regret to report, is sheer cold demographics. Darwinism says that my sequence has more kids than your sequence and so my sequence gets common and yours gets rare. If there's another sequence out there that has more kids than mine, it'll displace me. But there's no pre-set target in this game. (Why would evolution care about a pre-set place? Are we to believe that evolution is just inordinately fond of ATGGCAGGCAGT…?)."

In another review, Jason Rodenhouse agrees that fitness landscapes evolve along with organisms, calling this "a bedrock principle of modern ecology."[27]

Jeffrey Shallit points out that Dembski has avoided discussing the types of computer programs that deal with *artificial life* which more closely relate to biological evolution: "The field of artificial life evidently poses a significant challenge to Dembski's claims about the failure of evolutionary algorithms to generate complexity. Indeed, artificial life researchers regularly find their simulations of evolution producing the sorts of novelties and increased complexity that Dembski claims are impossible." [28]

Irreducible Complexity

In assigning a low probability for natural selection, Dembski relies partially on the work of his close colleague, biochemist Michael Behe. The publication of *Darwin's Black Box:*

The Biochemical Challenge to Evolution quickly launched Behe into the constellation of intelligent design stars, right alongside Dembski. In this book, Behe introduces the notion of *irreducible complexity*. A system is irreducibly complex when it is "composed of several well-matched, interacting parts that contribute to the basic function, wherein the removal of any one of the parts causes the system to effectively cease functioning."

Behe applies this to various biological systems such as blood-clotting and cellular flagella, but the idea is most simply explained with the prosaic example of a mousetrap.[29] Remove any single element, say the hammer or spring, and the mousetrap ceases to function. Like Paley's watch, the mousetrap is thus an example of an artifact that cannot have arisen by natural selection. As Behe explains it, "In order to be a candidate for natural selection, a system must have *minimal function:* the ability to accomplish a task in physically realistic circumstances."[30]

Behe insists that biology contains many such minimal systems which could not have evolved by natural selection. "An irreducibly complex system," he says, "cannot be produced directly (that is, by continuously improving the initial function, which continues to work by the same mechanism) by slight, successive modifications of a precursor system, because any precursor to an irreducibly complex system that is missing a part is by definition nonfunctional."[31]

When he wrote his book, Behe apparently was unaware that six decades earlier, Nobel prize-winner H. J. Muller had already considered irreducibly complex systems, although he did not use the term, and had shown in some detail how they could have evolved naturally.[32]

Behe's assertions have been widely refuted.[33] Critics point to at least one fundamental mistake: Behe assumes that each part of a biological system always had the function it now performs. In fact, countless examples of changing function exist. Thus, a part evolves by natural selection by virtue of one function, and then is gradually adapted to another function as the larger system evolves. Even Behe's mousetrap parts were not invented solely for a mousetrap. Springs and hammers had other functions long before being utilized in rodent extermination.

Like Dembski and other creationists who fail to do their homework, Behe only damages his own credibility with assertions that are provably incorrect. For example,

he claims that

> There is no publication in the scientific literature—in prestigious journals, specialty journals, or books—that describes how molecular evolution of any real, complex biochemical system either did occur or even might have occurred.[34]

Not really. Biologist Kenneth Miller is one of the new breed of theistic scientists who think they can find a place for God within the framework of evolution. He has checked Behe's claim for himself. Taking what he describes as a "quick look" at the literature, Miller easily found "four glittering examples of what Behe claimed would never be found."[35]

Chemist Behe does not make a sufficiently strong case for intelligent design in biological systems for Dembski to be justified in his assigning a low probability for natural selection in his design filter. Far from "proving" the need for intelligent design, Dembski's design filter amounts to nothing more than inventing probability estimates after the fact so that the answer comes out favorable to his thesis of intelligent design.

Furthermore, even if one computes a low probability for an event arising from natural processes, this does not prove it cannot have happened that way. Low-probability events occur naturally every day. People win lotteries, are struck by lightning, and run into long-lost relatives. One can infer design as the more likely alternative than random chance only by also computing the probability for design as well as chance and then comparing the probabilities for the two alternatives.

The argument from design, in both its historical and contemporary manifestations, is based on observations and so I have treated it as a scientific matter. However, we have seen that whether the data come from cosmology, biology, or everyday human experience, their interpretation, in terms of the origins of the design seen in them, is in the eye of the beholder. All the reasons to believe based on design reduce to a single reason—a human propensity to see deep and meaningful patterns in the world around them, even when those patterns are not present.

In the United States the new creationist movement has convinced many people

and their political servants that scientists are being unfair in not supporting the teaching of alternatives to evolution in science classes. They say it is censorship to exclude intelligent design from those classes. The usual argument raised against teaching intelligent design is that it unconstitutionally promotes religion. Design promoters, however, insist that they have no particular designer in mind. No one believes them, but skilled lawyers arguing for the cause of impartiality on their behalf could probably prevail in court. In any case, a better argument exists: Intelligent design theory, as currently formulated by its leading proponents, should not be taught in science classes because it is provably wrong.

The Role of Randomness in Generating Complexity

Although the specific arguments that Dembski, Behe, and other design theorists have presented so far are fatally flawed, they still represent the deep intuition of most people that the complex structures we see around us cannot have come about naturally. And no structure seems more complex and more difficult to understand than the human brain. It seems clear to many that the human brain itself is evidence for design. Surely, they suppose, the properties we label as mind—thinking, feeling, creating—are more than the action of a collection of atoms.

In *The Emperor's New Mind*, *Shadows of the Mind*, and other writings, mathematician Roger Penrose claimed to show that the brain was not simply a computer, at least, as we understand a computer to be.[36] On the basis of certain, sophisticated incompleteness theorems, which have been derived in mathematics and computer science, Penrose argued that humanlike "artificial intelligence" was impossible for any physical system operating according to computable algorithms based on known physics. Of course, the architecture of the brain is quite different from today's commercial computers. However, Penrose insists that his conclusions also apply to neural networks such as the brain. He says that something more than computation is happening in the brain.

Penrose admits that he is a Platonist who regards proven mathematical truths as more real than the concrete objects of our experience. He argues that some mathematical truths cannot be established by the execution of a computer algorithm

and so something more than computation is going on in a mathematician's brain. Penrose does not think that this something is supernatural. Rather, he seeks a physical mechanism not present in computers and suggests that it might be found in quantum gravity.

I have argued elsewhere that quantum effects of any sort, much less quantum gravity, are unlikely to play a major, direct role in human thinking.[37] Of course, quantum effects predominate within the atoms and molecules of the brain, but the basic physics and chemistry of biological systems are not uniquely different from those of inanimate systems like rocks. A carbon atom in a rock has the same energy levels as a carbon atom in a brain cell. The issue is whether additional, larger-scale quantum effects are present in the brain.

While biological structures, in the brain or elsewhere, are "microscopic" in the sense that they are not visible to the unaided human eye, they are large on the quantum scale and are still well described by classical mechanics. In a concrete example, the mass, m, of the vesicle that carries transmitter chemicals across a synaptic gap is typically 10^{-22} kilogram, a hundred thousand times more massive than a hydrogen atom. The speed of the vesicle, v, is on the order of 10 meters per second and so its momentum, $p = mv$, will be on the order of 10^{-21} kilogram-meters per second. The synaptic gap distance, d, is about 10^{-9} meters, ten times the diameter of an atom. This is to be compared with the de Broglie wavelength of the vesicle, $\lambda = h/p$, where h is Planck's constant, which is on the order of 10^{-12} meter. Quantum interference effects would occur if the vesicle's de Broglie wavelength were comparable to or larger than the gap distance. In fact, it is three orders of magnitude smaller. This difference in size scale places even the tiniest of functional cellular structures well within the scope of classical mechanical description.

Of course, quantum effects such as superconductivity can occur at even macroscopic distances, especially for low-mass particles such as electrons cooled to very low temperatures where their momenta are very low and their de Broglie wavelengths correspondingly high. But, so far, no analogous processes have been discovered in the brain.[38]

Nevertheless, a simple mechanism exists, which is well known to complexity

theorists, that can enable the brain or an electronic circuit to act in a noncomputable way and perform creative acts. This process involves random fluctuations. Fluctuations in brain currents can be expected to be induced by external sources in the environment such as cosmic rays, internal sources such as radioactive potassium in blood, or just thermal motion. Like the fluctuations that provide for mutations in the evolutionary process, these might serve to trigger what complexity theorists call a *bifurcation*, when a system moves from one quasi-stable state to another.

Suppose, for example, you have a computer program that is searching for the solution to a problem. You would like to avoid the situation in which the search continues over and over again using the same rules. By nudging the system to another state, it might find the solution by applying a slightly different set of rules. Thus it becomes less rigid, more "creative." Game theorists have long known that intentionally introducing random shifts can be a good gaming strategy.

While Penrose argues that such a process would still be computable,[39] a simple example demonstrates how randomness can break open the bottleneck that can occur in a strictly computable process.[40] In this example, a cop is chasing a robber who can move freely between two houses. The two start off in different houses and have the choice of changing houses or staying put. The robber is caught if he ends up in the same house as the cop. If the cop conducts her search following instructions in the police manual, "by the book," and the robber has a copy of that manual, then the robber will never get caught. He knows the algorithm, so he can move into the other house every time the cop decides to switch. However, if the cop breaks the rules and makes a completely random choice on whether to move into the other house or not, the robber can only guess and will eventually be caught.[41] This illustrates what so many people find so deeply counterintuitive—that chance can in fact produce a desired, creative outcome which may be impossible by any other means.

Regardless of the true extent to which randomness plays a role in the brain, what Penrose, Dembski, and others have failed to acknowledge is that it can provide just the push a complex system needs to generate a higher level of complexity. This is precisely the role chance plays in evolution, and, because it is unplanned and undesigned, it is an anathema to those who desperately need to see cosmic purpose in their lives.

Philosopher David Roche has pointed out that Dembski confuses two concepts in his theory of intelligent design: *information* and *complexity*.[42] As I have indicated above, information is degraded by natural processes, in violation of Dembski's law of conservation of information but demanded by the (well-confirmed) second law of thermodynamics. Complexity, however, can increase by a combination of randomness and selection.

As physicist Taner Edis explains it: "A random function, because it is patternless, can be used to break out of any pre-defined framework. It serves as a novelty generator."[43]

Roche adds:

> The great achievement of Darwinism is not that it explains the origins of information (in the Shannon sense), but that it explains the origin of complexity. And, it does so in terms of a completely material process: *random* mutation followed by *non-random* selection. Via such a process, the simple can give rise to the complex; "from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved."[44]

Recently Dembski has seemed to tire of attempting to answer his many scientific critics, a huge task by any measure. At his request, I provided him with a copy of this chapter and chapter 2, inviting comments and corrections, but he never responded. Invited to speak at a conference of skeptics in California in June, 2002, Dembski almost completely ignored the important areas of dispute and wished his audience "good luck" in convincing the mass of people of the validity of evolution. He referred to polls showing that the majority of American believe in creationism and argued that Intelligent Design will win, not because it is true but because most people believe it to be true.[45]

The God of the Gaps

People have always looked to magic to explain what they do not understand. In their

early days, humans knew little and so magic was everywhere. As science developed, providing "natural" explanations for many phenomena, the need for magic diminished. By the seventeenth century and the rise of Newtonian physics, it seemed that very little room was left for magic.

However, as we saw earlier, Newton himself conceded that his laws of mechanics and gravity did not account for everything. For example, while the elliptical orbits of planets followed from his laws of mechanics and gravity, those laws did not determine the particular orientations of planetary orbits. This left an opening for a little magic in the arrangement of the planets.

Thus originated the modern version of the doctrine of the *God of the gaps* in which the creator leaves holes in his own laws to allow for human free will and where he pokes his finger occasionally to make sure that events still follow along according to his divine plan. This implies that God can be seen in the unexplained features of natural law, where his miraculous intervention should be evident.

As time progressed, however, the gaps in Newtonian physics gradually narrowed, nonmiraculously, leaving smaller and smaller holes where God could poke his finger. Pierre Simon Laplace (d. 1827), who generalized mechanics and placed it on an elegant mathematical footing, believed all the gaps were filled by the *Newtonian world machine.*

Still, the God-of-the-gaps doctrine has resurfaced often over the centuries, especially in regard to those sciences not as highly developed as Newtonian physics. This doctrine is experiencing another revival today. Breaches in physics, cosmology, and biology, real and imagined, are being proposed as places for God's purposeful action.

By itself, the existence of gaps in science is not unusual. Unexplained features often appear during the development of scientific theories, but are usually repaired by further developments. This has been the normal course of science. However, in recent times assertions are being made that certain cracks in the traditional, purely material, edifice of science cannot be repaired by the application of additional, conventional cement. Rather, a concoction of ephemeral spirits must be added into the mix.

Back in the early nineteenth century, geologists uncovered stratification and

other features that indicated great upheavals in Earth's crust in the past. The causes of these gigantic movements were not immediately evident. In 1819 Oxford geologist William Buckland announced that these observations confirmed scripture and were the consequence of God's actions. He asserted that science can only collect data, that revelation was needed to understand the ultimately divine causes of phenomena.

The eminent Victorian geologist Charles Lyell undermined Buckland's claim by providing plausible natural explanations for geological changes. Still, Lyell saw God's intervention as necessary to explain the existence of life on Earth. Closing Buckland's gap, Lyell left another open. However, Charles Darwin, who took Lyell's *Principles of Geology* with him on the voyage of the *Beagle*, closed that gap with his theory of evolution by natural selection.

Except for scriptural literalists, like the young-Earth creationists we learned about in chapter 2, most theologians today admit at least some limited role for natural selection as an agent for biological change over time. What many, but not all, find impossible to accept is the notion that humanity is the product solely of chance and impersonal natural processes. As we saw earlier, a new class of creationists has accepted as valid both the modern cosmological estimates of the age of the universe and much of the evolutionary theory of biology. However, they still insist that the theory of evolution contains gaps which cannot, even in principle, be closed without including outside intervention that they term intelligent design. While these new creationists insist that they are not promoting religion, no objective observer can doubt that explicit vindication of the belief in the traditional, supernatural Judeo-Christian-Islamic creator is their ultimate objective.

Parallel campaigns to incorporate religious concepts into science are now underway on the fringes of physics and cosmology. As we found in the case of Hugh Ross, some contemporary science-theists are familiar with modern physical theories and view them as supportive of their belief in a purposeful creation. They still seek the God of the gaps in places where the theories show possible flaws or where natural explanations are still lacking. As in the case of biology, these science-theists think they may have even found fundamental openings in physics and cosmology that cannot, in principle, be closed by impersonal, material forces alone no matter how much further

science progresses.

Those who do not have a good understanding of the scientific method often fail to appreciate that serious theories, even well-established ones, are always growing—evolving—as better data come in. Early calculations meant to describe initial, crude data usually make simplifying assumptions. These then get modified as the new data enable greater detail to be explored. Truly fundamental theories, such as Newton's laws, contain room for these modifications. Indeed, they imply them. The successful modification of a theory enhances its credibility by providing testimony that it has some connection with reality. Many critics of science cannot comprehend this because they have not themselves participated the process of science and seen how it works. "Look at how science keeps changing," they say, as if this were a strike against it.

This illustrates one of the grave problems we all have with scientific understanding today. None of us can follow the details of every theory to the point where we can say we understand it thoroughly. For example, many physicists, myself included, are hopelessly overwhelmed by the mathematics of *m*-theory. We have no choice but to rely on authority. This is an ironic twist of history when we consider that the modern scientific revolution began four hundred years ago with the rejection of Church authority by Copernicus and Galileo.

Nevertheless, greater understanding can still be obtained, with sufficient effort, when the number of theories we strive to grasp is not so great as to overwhelm and when trusted authorities employing time-tested methods can provide support where we require it. This is the situation at the science-religion interface, where only a few scientific disciplines like physics, cosmology, and biology enter in an important way. A theist looking for gaps in cosmology in which to seek God can and should learn a significant amount of cosmology. Many have done just that, and their claims thereby become more credible and attract a wider, more knowledgeable audience.

Scientifically competent theists understand that the arguments for the existence of God from classical theology rely less on observed fact and more on scholarly rhetoric. The questions they raise about the source of order in the universe, as exemplified by natural laws, and how something can come from nothing, are more philosophical than scientific. Many scientists stay out of the dispute because they feel

that it is insufficiently empirical and only the empirical is to be trusted. However, I am not one of those who think that science has nothing to say about ultimate origins, just because no one was there to make measurements. I will try to show that science has a lot to say, even if it is not always directly subject to the empirical testing that most scientists would prefer.

Current theories in physics and cosmology are already well established by their success in meeting the challenge of severe testing against existing data. We have every right to logically extrapolate those theories into the gaps where empirical data are currently not available, and may indeed never be. Those extrapolations can turn out to be misdirected, so they should not be treated as scientifically established facts. At the very least, however, they can serve to develop possible scenarios by which the gaps in current knowledge might plausibly be filled by natural explanations, thus refuting any assertions that a supernatural explanation is required by the data.

Notes

1. William A. Dembski, *The Design Inference* (Cambridge: Cambridge University Press, 1998); William A, Dembski, *Intelligent Design: The Bridge between Science and Theology* (Downer's Grove, Ill.: Intervarsity Press, 1999).

2. Dembski, *Intelligent Design*, p. 3 (emphasis in original).

3. Lauren Kern, "In God's Country: William Dembski thought Baylor University would be the perfect place to investigate a scientific alternative to Darwinism. Little did he realize he would be crucified for his cause," *Houston Pres*s, December 14, 2000.

4. The External Review Committee Report Baylor University [online], pr.baylor.edu/pdf/001017polanyi.pdf.

5. Kern, "In God's Country"; Eugenie C. Scott, "Baylor's Polanyi Center in Turmoil,"

Reviews of the National Center for Science Education 20, no. 4 (2000): 9-11.

6. Bruce Gordon, "Intelligent Design Movement Struggles with Identity Crisis," *Research News & Opportunities in Science and Theology* 2, no. 1 (2001): 9.

7. Brandon Fitelson, Christopher Stephens, and Elliott Sober, "How Not to Detect Design—Critical Notice: William A. Dembski, The Design Inference," *Philosophy of Science* 66, no. 3 (1999): 472-88; Taner Edis, "Darwin in Mind: 'Intelligent Design' Meets Artificial Intelligence." *Skeptical Inquirer* 25, no. 2 (2001): 35-39; David Roche, "A Bit Confused: Creationism and Information Theory," *Skeptical Inquirer* 25, no. 2 (2001): 40-2; Mark Perakh, "A Consistent Inconsistency, " [online], http://www.talkreason.org/articles/dembski.cfm#info, November, 2001; A complete set of links to articles and books on both sides of the issue can be found at the website *Critical Thought and Religious Liberty,* [online], http://www.freethought-web.org/ctrl/intelligent-design.html.

8. Dembski, *Intelligent Design*, p. 106.

9. Ibid., p. 156; If $x = \log_2 y$, then $y = 2^x$. The more familiar logarithms have base 10, although the natural logarithm that arises from the exponential function $y = e^x$, where $x = \log_e y$ and e is the irrational number 2.7182818. . . is more common in mathematics and physics..

10. Claude Shannon and Warren Weaver, *The Mathematical Theory of Communication* (Urbana: University of Illinois Press, 1949).

11. I am grateful to Richard Wein for clarifying for me what Dembski has done.

12. Richard C. Tolman, *The Principles of Statistical Mechanics* (London: Lowe & Brydone, 1938). Later printings available from Oxford University Press.

13. The derivation of the *H*-theorem, for both classical and quantum systems, can be found in Tolman, *The Principles of Statistical Mechanic*s. For an interesting philosophical discussion of the *H*-theorem as it relates to the arrow of time, see Huw Price, *Time's Arrow and Archimedes Point: New Directions for the Physics of Time* (Oxford: Oxford University Press, 1996). I also discuss this connection in Victor J. Stenger, *Timeless Reality: Symmetry, Simplicity, and Multiple Universes,* (Amherst, N.Y.: Prometheus Books, 2000).

14. Dembski, *Intelligent Design*, p. 168.

15. Peter B. Medawar, *The Limits of Science* (New York: Harper & Row, 1984), p. 79.

16. Kern, "In God's Country."

17. Dembski, *Intelligent Design*, p. 170.

18. Ibid., p. 166.

19. Emile Borel, *Probabilities and Life*, trans. M. Baudin (New York: Dover, 1962), p. 28.

20. Dembski, *Intelligent Design*, p. 178.

21. Howard J. Van Till, "E. Coli at the *No Free Lunchroom,"* [online], http://www.aaas.org/spp/dser/evolution/perspectives/vantillecoli.pdf.

22. Ibid.

23. William A. Dembski. *No Free Lunch: Why Specified Complexity Cannot Be Purchased without Intelligence*. Rowman & Littlefield (2002).

24. David H. Wolpert and William G. Macready, "No Free Lunch Theorems for Optimization," IEEE Transactions on Evolutionary Computation 1 (1997): 67–82. Joseph Culberson, "On the Futility of Blind Search: An Algorithmic View of 'No Free Lunch,'" Evolutionary Computation 6 (1998): 109–27.

25. Richard Wein, "Not a Free Lunch But a Box of Chocolates," [online], http://www.talkorigins.org/design/faqs/nfl/#summary.

26. H. Allen Orr, *Boston Review*, Summer 2002.

27. Jason Rodenhouse, "Probability, Optimization Theory and Evolution," *Evolution* 56(8): 1721-2, 2002; [online], http://www.math.ksu.edu/~jasonr/dembski.htm.

28. Jeffrey Shallit, Review of No Free Lunch, *BioSystems* 66 (1-2) (2002), 93-9; [online]; http://www.math.uwaterloo.ca/~shallit/bookrev.html.

29. Michael J. Behe, *Darwin's Black Box: The Biochemical Challenge to Evolution* (New York: Free Press, 1996), p. 42.

30. Ibid., p. 45.

31. Ibid., p. 39.

32. H. J. Muller, "Reversibility in Evolution Considered from the Standpoint of Genetics," *Biological Reviews* 14 (1939): 261-80.

33. Robert Dorit, review of *Darwin's Black Box*, by Michael Behe, *American Scientist* (September-October, 1997); H. Allen Orr, "Darwin v. Intelligent Design (Again): The latest attack on evolution is cleverly argued, biologically informed--and wrong," *Boston Review* (1998); Niall Shanks and Karl H. Joplin, "Redundant Complexity: A Critical Analysis of Intelligent Design in Biochemistry," *Philosophy*

of Science 66 (1999): 268-98; Kenneth R. Miller, *Finding Darwin's God: A Scientist's Search for a Common Ground Between God and Evolution* (New York: HarperCollins, 1999).

34. Behe, *Darwin's Black Box*, p. 185.

35. Miller, *Finding Darwin's God*, p. 143.

36. Roger Penrose, *The Emperor's New Mind: Concerning Computers, Minds, and the Laws of Physics* (Oxford: Oxford University Press, 1989); Roger Penrose, *Shadows of the Mind: A Search for the Missing Science of Consciousness* (Oxford: Oxford University Press, 1994).

37. Victor J. Stenger, *The Unconscious Quantum: Metaphysics in Modern Physics and Cosmology* (Amherst, N.Y.: Prometheus Books, 1995), chap. 10.

38. See Stuart R. Hameroff, *Ultimate Computing: Biomolecular Consciousness and Nano-Technology*. (Amsterdam: North-Holland, 1987). Hameroff proposes that large-scale quantum effects might occur in the microtubules attached to cells. These have an inner diameter of typically 14×10^{-9} meter, even larger than the synaptic gap. Penrose in *Shadows of the Mind* has enthusiastically backed this notion, however it has not yet received convincing empirical support. They do not explain why the microtubules attached to brains cells are any different from those of the bladder or big toe.

39. Penrose, *Shadows of the Mind*, p. 169.

40. Taner Edis, "How Gödel's Theorem Supports the Possibility of Machine Intelligence," *Minds and Machines* 8 (1998): 251.

41. By totally random I mean not pseudorandom. A pseudorandom number is

generated by an algorithm, and so the robber can, in principle, predict its value if he knows the algorithm. However, assuming, as is conventional, that quantum mechanical fluctuations are unpredictable, a quantum source can be used as the random number generator.

42. Roche, "A Bit Confused."

43. Edis, "Darwin in Mind."

44. Roche, "A Bit Confused," quoting Darwin, *The Origin of Species.*

45. Mark Perakh, "A Presentation Without Arguments: Dembski Disappoints," *Skeptical Inquirer* 26(6), 31-4 (2002).