A Scientific History – and Philosophical Defense – of the Theory of Intelligent Design

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The Current Landscape

In December of 2004, the renowned British philosopher Antony Flew made worldwide news when he repudiated a lifelong commitment to atheism, citing, among other factors, evidence of intelligent design in the DNA molecule. In that same month, the American Civil Liberties Union filed suit to prevent a Dover, Pennsylvania school district from informing its students that they could learn about the theory of intelligent design from a supplementary science textbook in their school library. The following February, *The Wall Street Journal* (*Klinghoffer* 2005) reported that an evolutionary biologist at the Smithsonian Institution with two doctorates had been punished for publishing a peer-reviewed scientific article making a case for intelligent design.

Since 2005, the theory of intelligent design has been the focus of a frenzy of international media coverage, with prominent stories appearing in *The New York Times*, *Nature*, *The London Times*, *The Independent* (London), *Sekai Nippo* (Tokyo), *The Times* of India, *Der Spiegel*, *The Jerusalem Post* and *Time* magazine, to name just a few. And recently, a major conference about intelligent design was held in Prague (attended by some 700 scientists, students and scholars from Europe, Africa and the United States), further signaling that the theory of intelligent design has generated worldwide interest.

But what is this theory of intelligent design, and where did it come from? And why does it arouse such passion and inspire such apparently determined efforts to suppress it?

According to a spate of recent media reports, intelligent design is a new “faith-based” alternative to evolution – one based on religion rather than scientific evidence. As the story goes, intelligent design is just biblical creationism repackaged by religious fundamentalists in order to circumvent a 1987 United States Supreme Court prohibition against teaching creationism in the U.S. public schools. Over the past two years, major newspapers, magazines and broadcast outlets in the United States and around the world have repeated this trope.

But is it accurate? As one of the architects of the theory of intelligent design and the director of a research center that supports the work of scientists developing the theory, I know that it isn't.

The modern theory of intelligent design was not developed in response to a legal setback for creationists in 1987. Instead, it was first proposed in the late 1970s and early 1980s by a group of scientists – Charles Thaxton, Walter Bradley and Roger Olson – who were trying to account for an enduring mystery of modern biology: the origin of the digital information encoded along the spine of the DNA molecule. Thaxton and his colleagues came to the conclusion that the information-bearing properties of DNA provided strong evidence of a prior but unspecified designing intelligence. They wrote a book proposing this idea in 1984, three years before the U.S. Supreme Court decision (in *Edwards v. Aguillard*) that outlawed the teaching of creationism.

Earlier in the 1960s and 1970s, physicists had already begun to reconsider the design hypothesis. Many were impressed by the discovery that the laws and constants of physics are improbably "finely-tuned" to make life possible. As British astrophysicist Fred Hoyle put it, the fine-tuning of the laws and constants of physics suggested that a designing intelligence "had monkeyed with physics" for our benefit.

Contemporary scientific interest in the design hypothesis not only predates the U.S. Supreme Court ruling against creationism, but the formal theory of intelligent design is clearly different than creationism in both its method and content. The theory of intelligent design, unlike creationism, is not based upon the Bible. Instead, it is based on observations of nature which the theory attempts to explain based on what we know about the cause and effect structure of the world and the patterns that generally indicate intelligent causes. Intelligent design is an inference from empirical evidence, not a deduction from religious authority.

The propositional content of the theory of intelligent design also differs from that of creationism. Creationism or Creation Science, as defined by the U.S. Supreme Court, defends a particular reading of the book of Genesis in the Bible, typically one that asserts that the God of the Bible created the earth in six literal twenty-four hour periods a few thousand years ago. The theory of intelligent design does not offer an interpretation of the book of Genesis, nor does it posit a theory about the length of the Biblical days of creation or even the age of the earth. Instead, it posits a causal explanation for the observed complexity of life.

But if the theory of intelligent design is not creationism, what is it? Intelligent design is an evidence-based scientific theory about life's origins that challenges strictly materialistic views of evolution. According to Darwinian biologists such as Oxford's *Richard Dawkins* (1986: 1), livings systems "give the appearance of having been designed for a purpose." But, for modern Darwinists, that appearance of design is entirely illusory. Why? According to neo-Darwinism, wholly undirected processes such as natural selection and random mutations are fully capable of producing the intricate designed-like structures in living systems. In their view, natural selection can mimic the powers of a designing intelligence without itself being directed by an intelligence of any kind.

In contrast, the theory of intelligent design holds that there are tell-tale features of living systems and the universe – for example, the information-bearing properties of DNA, the miniature circuits and machines in cells and the fine tuning of the laws and constants of physics – that are best explained by an intelligent cause rather than an undirected material process. The theory does not challenge the idea of "evolution" defined as either change over time or common ancestry, but it does dispute Darwin's idea that the cause of biological change is wholly blind and undirected. Either life arose as the result of purely undirected material processes or a guiding intelligence played a role. Design theorists affirm the latter option and argue that living organisms look designed because they really were designed.

A Brief History of the Design Argument

By making a case for design based on observations of natural phenomena, advocates of the contemporary theory of intelligent design have resuscitated the classical design argument. Prior to the publication of *The Origin of Species* by Charles Darwin in 1859, many Western thinkers, for over two thousand years, had answered the question "how did life arise?" by invoking the activity of a purposeful designer. Design arguments based on observations of the natural world were made by Greek and Roman philosophers such as *Plato* (1960: 279) and

Cicero (1933: 217), by Jewish philosophers such as Maimonides and by Christian thinkers such as Thomas Aquinas[1] (see *Hick* 1970: 1).

The idea of design also figured centrally in the modern scientific revolution (1500-1700). As historians of science (see *Gillespie* 1987: 1-49) have often pointed out, many of the founders of early modern science assumed that the natural world was intelligible precisely because they also assumed that it had been designed by a rational mind. In addition, many individual scientists – Johannes Kepler in astronomy (see *Kepler* 1981: 93-103; *Kepler* 1995: 170, 240),[2] John Ray in biology (see *Ray* 1701) and Robert Boyle in chemistry (see *Boyle* 1979: 172) – made specific design arguments based upon empirical discoveries in their respective fields. This tradition attained an almost majestic rhetorical quality in the writing of Sir Isaac Newton, who made both elegant and sophisticated design arguments based upon biological, physical and astronomical discoveries. Writing in the General Scholium to the *Principia*, *Newton* (1934: 543-44) suggested that the stability of the planetary system depended not only upon the regular action of universal gravitation, but also upon the very precise initial positioning of the planets and comets in relation to the sun. As he explained:

> [T]hough these bodies may, indeed, continue in their orbits by the mere laws of gravity, yet they could by no means have at first derived the regular position of the orbits themselves from those laws [...] [Thus] [t]his most beautiful system of the sun, planets and comets, could only proceed from the counsel and dominion of an intelligent and powerful Being.

Or as he wrote in the *Opticks*:

> How came the Bodies of Animals to be contrived with so much Art, and for what ends were their several parts? Was the Eye contrived without Skill in Opticks, and the Ear without Knowledge of Sounds? [...] And these things being rightly dispatch'd, does it not appear from Phænomena that there is a Being incorporeal, living, intelligent, omnipresent [...]. (*Newton* 1952: 369-70.)

Scientists continued to make such design arguments well into the early nineteenth century, especially in biology. By the later part of the 18th century, however, some enlightenment philosophers began to express skepticism about the design argument. In particular, David Hume, in his *Dialogues Concerning Natural Religion* (1779), argued that the design argument depended upon a flawed analogy with human artifacts. He admitted that artifacts derive from intelligent artificers, and that biological organisms have certain similarities to complex human artifacts. Eyes and pocket watches both depend upon the functional integration of many separate and specifically configured parts. Nevertheless, he argued, biological organisms also differ from human artifacts – they reproduce themselves, for example – and the advocates of the design argument fail to take these dissimilarities into account. Since experience teaches that organisms always come from other organisms, Hume argued that analogical argument really ought to suggest that organisms ultimately come from some primeval organism (perhaps a giant spider or vegetable), not a transcendent mind or spirit.

Despite this and other objections, Hume's categorical rejection of the design argument did not prove entirely decisive with either theistic or secular philosophers. Thinkers as diverse as the Scottish Presbyterian *Thomas Reid* (1981: 59), the Enlightenment deist *Thomas Paine* (1925: 6) and the rationalist philosopher Immanuel Kant, continued to affirm[3] various versions

[1] Aquinas used the argument from design as one of his proofs for the existence of God.

[2] Kepler's belief that the work of God is evident in nature is illustrated by his statement in the *Harmonies of the World* that God "the light of nature promote[s] in us the desire for the light of grace, that by its means [God] ma[y] transport us into the light of glory" (*Kepler* 1995: 240. See also *Kline* 1980: 39).

[3] Kant sought to limit the scope of the design argument, but did not reject it wholesale. Though he rejected the argument as a proof of the transcendent and omnipotent God of Judeo-Christian theology, he still accepted that it could establish the reality of a powerful and intelligent author of the world. In his words, "physical-theological argument can indeed lead us to the point of admiring the greatness, wis-

of the design argument after the publication of Hume's *Dialogues*. Moreover, with the publication of William Paley's *Natural Theology*, science-based design arguments would achieve new popularity, both in Britain and on the continent. *Paley* (1852: 8-9) catalogued a host of biological systems that suggested the work of a superintending intelligence. Paley argued that the astonishing complexity and superb adaptation of means to ends in such systems could not originate strictly through the blind forces of nature, any more than could a complex machine such as a pocket watch. Paley also responded directly to Hume's claim that the design inference rested upon a faulty analogy. A watch that could reproduce itself, he argued, would constitute an even more marvelous effect than one that could not. Thus, for Paley, the differences between artifacts and organisms only seemed to strengthen the conclusion of design. And indeed, despite the widespread currency of Hume's objections, many scientists continued to find Paley's watch-to-watchmaker reasoning compelling well into 19th century.

Darwin and the Eclipse of Design

Acceptance of the design argument began to abate during the late 19th century with the emergence of increasingly powerful materialistic explanations of apparent design in biology, particularly Charles Darwin's theory of evolution by natural selection. Darwin argued in 1859 that living organisms only *appeared* to be designed. To make this case, he proposed a concrete mechanism, natural selection acting on random variations, that could explain the adaptation of organisms to their environment (and other evidences of apparent design) without actually invoking an intelligent or directing agency. Darwin saw that natural forces would accomplish the work of a human breeder and thus that blind nature could come to mimic, over time, the action of a selecting intelligence – a designer. If the origin of biological organisms could be explained naturalistically,[4] as *Darwin* (1964: 481-82) argued, then explanations invoking an intelligent designer were unnecessary and even vacuous.

Thus, it was not ultimately the arguments of the philosophers that destroyed the popularity of the design argument, but a scientific theory of biological origins. This trend was reinforced by the emergence of other fully naturalistic origins scenarios in astronomy, cosmology and geology. It was also reinforced (and enabled) by an emerging positivistic tradition in science that increasingly sought to exclude appeals to supernatural or intelligent causes from science *by definition* (see *Gillespie* 1979: 41-66, 82-108 for a discussion of this methodological shift). Natural theologians such as Robert Chambers, Richard Owen and Asa Gray, writing just prior to Darwin, tended to oblige this convention by locating design in the workings of natural law rather than in the complex structure or function of particular objects. While this move certainly made the natural theological tradition more acceptable to shifting methodological canons in science, it also gradually emptied it of any distinctive empirical content, leaving it vulnerable to charges of subjectivism and vacuousness. By locating design more in natural law and less in complex contrivances that could be understood by direct comparison to human creativity, later British natural theologians ultimately made their research program indistinguishable from the positivistic and fully naturalistic science of the Darwinians (*Dembski* 1996). As a result, the notion of design, to the extent it maintained any intellectual currency, soon became relegated to a matter of subjective belief. One could still believe that a mind superintended over the regular law-like workings of nature, but one might just as well assert that

dom, power, etc., of the Author of the world, but can take us no further" (*Kant* 1963: 523).

[4] The effort to explain biological organisms was reinforced by a trend in science to provide fully naturalistic accounts for other phenomena such as the precise configuration of the planets in the solar system (Laplace) and the origin of geological features (Lyell and Hutton). It was also reinforced (and in large part made possible) by an emerging positivistic tradition in science that increasingly sought to exclude appeals to supernatural or intelligent causes from science *by definition* (see *Gillespie* 1987: 1-49).

nature and its laws existed on their own. Thus, by the end of the nineteenth century, natural theologians could no longer point to any specific artifact of nature that required intelligence as a necessary explanation. As a result, intelligent design became undetectable except "through the eyes of faith."

Though the design argument in biology went into retreat after the publication of *The Origin*, it never quite disappeared. Darwin was challenged by several leading scientists of his day, most forcefully by the great Harvard naturalist Louis Agassiz, who argued that the sudden appearance of the first complex animal forms in the Cambrian fossil record pointed to "an intellectual power" and attested to "acts of mind." Similarly, the co-founder of the theory of evolution by natural selection, *Alfred Russel Wallace* (1991: 33-34), argued that some things in biology were better explained by reference to the work of a "Higher intelligence" than by reference to Darwinian evolution. There seemed to him "to be evidence of a Power" guiding the laws of organic development "in definite directions and for special ends." As he put it, "[S]o far from this view being out of harmony with the teachings of science, it has a striking analogy with what is now taking place in the world." And in 1897, Oxford scholar F.C.S. Schiller argued that "it will not be possible to rule out the supposition that the process of Evolution may be guided by an intelligent design" (*Schiller* 1903: 141).

This continued interest in the design hypothesis was made possible in part because the mechanism of natural selection had a mixed reception in the immediate post-Darwinian period. As the historian of biology *Peter Bowler* (1986: 44-50) has noted, classical Darwinism entered a period of eclipse during the late 19th and early 20th centuries mainly because Darwin lacked an adequate theory for the origin and transmission of new heritable variation. Natural selection, as Darwin well understood, could accomplish nothing without a steady supply of genetic variation, the ultimate source of new biological structure. Nevertheless, both the blending theory of inheritance that Darwin had assumed and the classical Mendelian genetics that soon replaced it, implied limitations on the amount of genetic variability available to natural selection. This in turn implied limits on the amount of novel structure that natural selection could produce.

By the late 1930s and 1940s, however, natural selection was revived as the main engine of evolutionary change as developments in a number of fields helped to clarify the nature of genetic variation. The resuscitation of the variation / natural selection mechanism by modern genetics and population genetics became known as the neo-Darwinian synthesis. According to the new synthetic theory of evolution, the mechanism of natural selection acting upon random variations (especially including small-scale mutations) sufficed to account for the origin of novel biological forms and structures. Small-scale "microevolutionary" changes could be extrapolated indefinitely to account for large-scale "macroevolutionary" development. With the revival of natural selection, the neo-Darwinists would assert, like Darwinists before them, that they had found a "designer substitute" that could explain the appearance of design in biology as the result of an entirely undirected natural process.[5] As Harvard evolutionary biologist *Ernst Mayr* (1982: xi-xii) has explained, "[T]he real core of Darwinism [...] is the theory of natural selection. This theory is so important for the Darwinian because it permits the explanation of adaptation, the 'design' of the natural theologian, by natural means." By the centennial celebration of Darwin's *Origin of Species* in 1959, it was assumed by many scientists that natural selection could fully explain the appearance of design and that, consequently, the design argument in biology was dead.

[5] "[T]he fact of evolution was not generally accepted until a theory had been put forward to suggest how evolution had occurred, and in particular how organisms could become adapted to their environment; in the absence of such a theory, adaptation suggested design, and so implied a creator. It was this need which Darwin's theory of natural selection satisfied" (*Smith*, 1975: 30).

Problems with the Neo-Darwinian Synthesis

Since the late 1960s, however, the modern synthesis that emerged during the 1930s, 1940s and 1950s has begun to unravel in the face of new developments in paleontology, systematics, molecular biology, genetics and developmental biology. Since then a series of technical articles and books – including such recent titles as *Evolution: a Theory in Crisis* (1986) by Michael Denton, *Darwinism: The Refutation of a Myth* (1987) by Soren Lovtrup, *The Origins of Order* (1993) by Stuart A. Kauffman, *How The Leopard Changed Its Spots* (1994) by Brian C. Goodwin, *Reinventing Darwin* (1995) by Niles Eldredge, *The Shape of Life* (1996) by Rudolf A. Raff, *Darwin's Black Box* (1996) by Michael Behe, *The Origin of Animal Body Plans* (1997) by Wallace Arthur, *Sudden Origins: Fossils, Genes, and the Emergence of Species* (1999) by Jeffrey H. Schwartz – have cast doubt on the creative power of neo-Darwinism's mutation/selection mechanism. As a result, a search for alternative naturalistic mechanisms of innovation has ensued with, as yet, no apparent success or consensus. So common are doubts about the creative capacity of the selection / mutation mechanism, neo-Darwinism's "designer substitute," that prominent spokesmen for evolutionary theory must now periodically assure the public that "just because we don't know *how* evolution occurred, does not justify doubt about *whether* it occurred."[6] As *Niles Eldredge* (1982: 508-9) wrote, "Most observers see the current situation in evolutionary theory – where the object is to explain how, not if, life evolves – as bordering on total chaos." Or as *Stephen Gould* (1980: 119-20) wrote, "The neo-Darwinism synthesis is effectively dead, despite its continued presence as textbook orthodoxy." (See also *Müller and Newman* 2003: 3-12.)

Soon after Gould and Eldredge acknowledged these difficulties, the first important books (*Thaxton, et al.* 1984; *Denton* 1985) advocating the idea of intelligent design as an alternative to neo-Darwinism began to appear in the United States and Britain.[7] But the scientific antecedents of the modern theory of intelligent design can be traced back to the beginning of the molecular biological revolution. In 1953 when Watson and Crick elucidated the structure of the DNA molecule, they made a startling discovery. The structure of DNA allows it to store information in the form of a four-character digital code. (See Figure 1). Strings of precisely sequenced chemicals called nucleotide bases store and transmit the assembly instructions – the information – for building the crucial protein molecules and machines the cell needs to survive.

Francis Crick later developed this idea with his famous "sequence hypothesis" according to which the chemical constituents in DNA function like letters in a written language or symbols in a computer code. Just as English letters may convey a particular message depending on their arrangement, so too do certain sequences of chemical bases along the spine of a DNA molecule convey precise instructions for building proteins. The arrangement of the chemical characters determines the function of the sequence as a whole. Thus, the DNA molecule has the same property of "sequence specificity" or "specified complexity" that characterizes codes and language. As Richard Dawkins has acknowledged, "the machine code of the genes is uncannily computer-like" (*Dawkins* 1995: 11). As Bill Gates has noted, "DNA is like a computer program but far, far more advanced than any software ever created" (*Gates* 1995:188). After

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[6] "There is absolutely no disagreement among professional biologists on the fact that evolution has occurred. [...] But the *theory* of how evolution occurs is quite another matter, and is the subject of intense dispute" (*Futuyma* 1985: 3-13). Of course, to admit that natural selection cannot explain the appearance of design is in effect to admit that it has failed to perform the role that is claimed for it as a "designer substitute."

[7] Note that similar developments were already taking place in Germany, starting with W.-E. Lönnig's *Auge – widerlegt Zufalls-Evolution* [=*The Eye Disproves Accidental Evolution*] (Stuttgart: Selbstverlag, 1976) and Henning Kahle's book, *Evolution – Irrweg moderner Wissenschaft?* [=*Evolution – Error of Modern Science?*] (Bielefeld: Moderner Buch Service, 1980).

the early 1960s, further discoveries made clear that the digital information in DNA and RNA is only part of a complex information processing system – an advanced form of nanotechnology that both mirrors and exceeds our own in its complexity, design logic and information storage density.

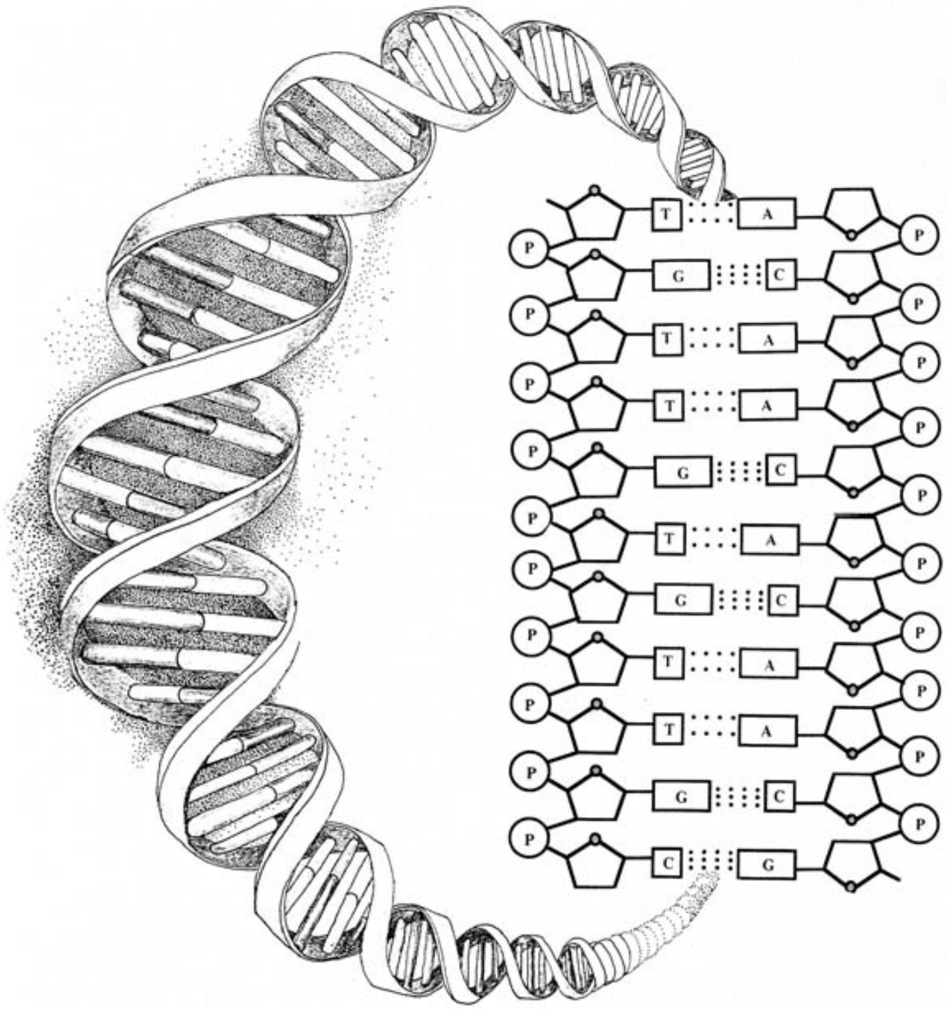

Figure 1

Thus, even as the design argument was being declared dead at the Darwinian centennial at the close of the 1950s, evidence that many scientists would later see as pointing to design was being uncovered in the nascent discipline of molecular biology. In any case, discoveries in this field would soon generate a growing rumble of voices dissenting from neo-Darwinism. In *By Design*, a history of the current design controversy, journalist *Larry Witham* (2003) traces the immediate roots of the theory of intelligent design in biology to the 1960s, at which time developments in molecular biology were generating new problems for the neo-Darwinian synthesis. At this time, mathematicians, engineers and physicists were beginning to express doubts that random mutations could generate the genetic information needed to produce crucial evolutionary transitions in the time available to the evolutionary process. Among the most prominent of these skeptical scientists were several from the Massachusetts Institute of Technology.

These researchers might have gone on talking among themselves about their doubts but for an informal gathering of mathematicians and biologists in Geneva in the mid-1960s at the home of MIT physicist Victor Weisskopf. During a picnic lunch the discussion turned to evolution, and the mathematicians expressed surprise at the biologists' confidence in the power of mutations to assemble the genetic information necessary to evolutionary innovation. Nothing was resolved during the argument that ensued, but those present found the discussion stimulating enough that they set about organizing a conference to probe the issue further. This gathering occurred at the Wistar Institute in Philadelphia in the spring of 1966 and was chaired by Sir Peter Medawar, Nobel Laureate and director of North London's Medical Research Council's laboratories. In his opening remarks at the meeting, he said that the "immediate cause of this conference is a pretty widespread sense of dissatisfaction about what has come to be thought of as the accepted evolutionary theory in the English-speaking world, the so-called neo-Darwinian theory" (*Taylor* 1983: 4).

The mathematicians were now in the spotlight and they took the opportunity to argue that neo-Darwinism faced a formidable combinatorial problem (see *Moorhead and Kaplan* 1967 for the seminar proceedings).[8] In their view, the ratio of the number of functional genes and proteins, on the one hand, to the enormous number of possible sequences corresponding to a gene or protein of a given length, on the other, seemed so small as to preclude the origin of genetic information by a random mutational search. A protein one hundred amino acids in length represents an extremely unlikely occurrence. There are roughly 10^{130} possible amino acid sequences of this length, if one considers only the 20 protein-forming acids as possibilities. The vast majority of these sequences – it was (correctly) assumed – perform no biological function (see *Axe* 2004: 1295-1314 for a rigorous experimental evaluation of the rarity of functional proteins within the "sequence space" of possible combinations). Would an undirected search through this enormous space of possible sequences have a realistic chance of finding a functional sequence in the time allotted for crucial evolutionary transitions? To many of the Wistar mathematicians and physicists, the answer seemed clearly 'no.' Distinguished French mathematician *M. P. Schützenberger* (1967: 73-5) noted that in human codes, randomness is never the friend of function, much less of progress. When we make changes randomly to computer programs, "we find that we have no chance (i.e. less than $1/10^{1000}$) even to see what the modified program would compute: it just jams." MIT's Murray Eden illustrated with reference to an imaginary library evolving by random changes to a single phrase: "Begin with a meaningful phrase, retype it with a few mistakes, make it longer by adding letters, and rearrange subsequences in the string of letters; then examine the result to see if the new phrase is meaningful. Repeat until the library is complete" (*Eden* 1967: 110). Would such an exercise have a realistic chance of succeeding, even granting it billions of years? At Wistar, the mathematicians, physicists and engineers argued that it would not. And they insisted that a similar problem confronts any mechanism that relies on random mutations to search large combinatorial spaces for sequences capable of performing novel function – even if, as is the case in biology, some mechanism of selection can act after the fact to preserve functional sequences once they have arisen.

Just as the mathematicians at Wistar were casting doubt on the idea that chance (i.e., random mutations) could generate genetic information, another leading scientist was raising questions about the role of law-like necessity. In 1967 and 1968, the Hungarian chemist and philosopher of science Michael Polanyi published two articles suggesting that the information in

[8] Commenting on events at this symposium, mathematician David Berlinski writes, "However it may operate in life, randomness in language is the enemy of order, a way of annihilating meaning. And not only in language, but in any language-like system—computer programs, for example. The alien influence of randomness in such systems was first noted by the distinguished French mathematician M. P. Schützenberger, who also marked the significance of this circumstance for evolutionary theory.

DNA was "irreducible" to the laws of physics and chemistry (*Polanyi* 1967: 21; *Polanyi* 1968: 1308-12). In these papers, Polanyi noted that the DNA conveys information in virtue of very specific arrangements of the nucleotide bases (that is, the chemicals that function as alphabetic or digital characters) in the genetic text. Yet, Polanyi also noted the laws of physics and chemistry allow for a vast number of other possible arrangements of these same chemical constituents. Since chemical laws allow a vast number of possible arrangements of nucleotide bases, Polanyi reasoned that no specific arrangement was dictated or determined by those laws. Indeed, the chemical properties of the nucleotide bases allow them to attach themselves interchangeably at any site on the (sugar-phosphate) backbone of the DNA molecule. (See Figure 1). Thus, as *Polanyi* (1968: 1309) noted, "As the arrangement of a printed page is extraneous to the chemistry of the printed page, so is the base sequence in a DNA molecule extraneous to the chemical forces at work in the DNA molecule." Polanyi argued that it is precisely this chemical indeterminacy that allows DNA to store information and which also shows the irreducibility of that information to physical-chemical laws or forces. As he explained:

> Suppose that the actual structure of a DNA molecule were due to the fact that the bindings of its bases were much stronger than the bindings would be for any other distribution of bases, then such a DNA molecule would have no information content. Its code-like character would be effaced by an overwhelming redundancy. […] Whatever may be the origin of a DNA configuration, it can function as a code only if its order is not due to the forces of potential energy. It *must be* as physically indeterminate as the sequence of words is on a printed page (*Polanyi* 1968:1309).

The Mystery of Life's Origin

As more scientists began to express doubts about the ability of undirected processes to produce the genetic information necessary to living systems, some began to consider an alternative approach to the problem of the origin of biological form and information. In 1984, after seven years of writing and research, chemist Charles Thaxton, polymer scientist Walter Bradley and geochemist Roger Olsen published a book proposing "an intelligent cause" as an explanation for the origin of biological information. The book was titled *The Mystery of Life's Origin* and was published by The Philosophical Library, then a prestigious New York scientific publisher that had previously published more than twenty Nobel laureates.

Thaxton, Bradley and Olsen's work directly challenged reigning chemical evolutionary explanations of the origin-of-life, and old scientific paradigms do not, to borrow from a Dylan Thomas poem, "go gently into that good night." Aware of the potential opposition to their ideas, Thaxton flew to California to meet with one of the world's top chemical evolutionary theorists, San Francisco State University biophysicist Dean Kenyon, co-author of a leading monograph on the subject, *Biochemical Predestination*. Thaxton wanted to talk with Kenyon to ensure that *Mystery*'s critiques of leading origin-of-life theories (including Kenyon's), were fair and accurate. But Thaxton also had a second and more audacious motive: he planned to ask Kenyon to write the foreword to the book, even though *Mystery* critiqued the very origin-of-life theory that had made Kenyon famous in his field.

One can imagine how such a meeting might have unfolded, with Thaxton's bold plan quietly dying in a corner of Kenyon's office as the two men came to loggerheads over their competing theories. But fortunately for Thaxton, things went better than expected. Before he had worked his way around to making his request, Kenyon volunteered for the job, explaining that he had been moving toward Thaxton's position for some time (Charles Thaxton, interview by Jonathan Witt, August 16, 2005; Jon Buell, interview by Jonathan Witt, September 21, 2005).

Kenyon's bestselling origin-of-life text, *Biochemical Predestination*, had outlined what was then arguably the most plausible evolutionary account of how a living cell might have organized itself from chemicals in the "primordial soup." Already by the 1970s, however, Kenyon was questioning his own hypothesis. Experiments (some performed by Kenyon himself) increasingly suggested that simple chemicals do not arrange themselves into complex information-bearing molecules such as proteins and DNA without guidance from human investigators. Thaxton, Bradley and Olsen appealed to this fact in constructing their argument, and Kenyon found their case both well-reasoned and well-researched. In the foreword he went on to pen, he described *The Mystery of Life's Origin* as "an extraordinary new analysis of an age-old question" (*Kenyon* 1984: v).

The book eventually became the best-selling advanced college-level work on chemical evolution, with sales fueled by endorsements from leading scientists such as Kenyon, Robert Shapiro and Robert Jastrow and by favorable reviews in prestigious journals such as the *Yale Journal of Biology and Medicine*.[9] Others dismissed the work as going beyond science.

What was their idea, and why did it generate interest among leading scientists? First, *Mystery* critiqued all of the current, purely materialistic explanations for the origin of life. In the process, they showed that the famous Miller-Urey experiment did not simulate early Earth conditions, that the existence of an early Earth pre-biotic soup was a myth, that important chemical evolutionary transitions were subject to destructive interfering cross-reactions, and that neither chance nor energy-flow could account for the information in biopolymers such as proteins and DNA. But it was in the book's epilogue that the three scientists proposed a radically new hypothesis. There they suggested that the information-bearing properties of DNA might point to an intelligent cause. Drawing on the work of Polanyi and others, they argued that chemistry and physics alone couldn't produce information any more than ink and paper could produce the information in a book. Instead, they argued that our uniform experience suggests that information is the product of an intelligent cause:

> We have observational evidence in the present that intelligent investigators can (and do) build contrivances to channel energy down nonrandom chemical pathways to bring about some complex chemical synthesis, even gene building. May not the principle of uniformity then be used in a broader frame of consideration to suggest that DNA had an intelligent cause at the beginning? (*Thaxton et al.* 1984: 211.)

Mystery also made the radical claim that intelligent causes could be legitimately considered as scientific hypotheses within the historical sciences, a mode of inquiry they called *origins science*.

Their book marked the beginning of interest in the theory of intelligent design in the United States, inspiring a generation of younger scholars (see *Denton* 1985; *Denton* 1986; *Kenyon and Mills* 1996: 9-16; *Behe* 2004: 352-370; *Dembski* 2002; *Dembski* 2004: 311-330; *Morris* 2000: 1-11; *Morris* 2003a: 13-32; *Morris* 2003b: 505-515; *Lönnig* 2001; *Lönnig and Saedler* 2002: 389-410; *Nelson and Wells* 2003: 303-322; *Meyer* 2003a: 223-285; *Meyer* 2003b: 371-391; *Bradley* 2004: 331-351) to investigate the question of whether there is actual design in living organisms rather than, as neo-Darwinian biologists and chemical evolutionary theorists had long claimed, the mere appearance of design. At the time the book appeared, I was working as a geophysicist for the Atlantic Richfield Company in Dallas where Charles Thaxton happened to live. I later met him at a scientific conference and became intrigued with the radical idea he was developing about DNA. I began dropping by his office after work to discuss the arguments made in his book. Intrigued, but not yet fully convinced, the next year I left my job as a geophysicist to pursue a Ph.D. at The University of Cambridge in the history and philosophy of science. During my Ph.D. research, I investigated several questions that had emerged in my discussions with Thaxton. What methods do scientists use to study biological origins? Is there a distinctive method of historical scientific inquiry? After completing my

[9] For instance, it also received praise in the *Journal of College Science Teaching* and in a major review essay by Klaus Dose, "The Origin of Life: More Questions than Answers," *Interdisciplinary Science Reviews*, 13.4, 1988.

Ph.D., I would take up another question: Could the argument from DNA to design be formulated as a rigorous historical scientific argument?

Of Clues and Causes

During my Ph.D. research at Cambridge, I found that historical sciences (such as geology, paleontology and archeology) do employ a distinctive method of inquiry. Whereas many scientific fields involve an attempt to discover universal laws, historical scientists attempt to infer past causes from present effects. As *Stephen Gould* (1986: 61) put it, historical scientists are trying to "infer history from its results." Visit the Royal Tyrrell Museum in Alberta, Canada and you will find there a beautiful reconstruction of the Cambrian seafloor with its stunning assemblage of phyla. Or read the fourth chapter of Simon Conway Morris's book on the Burgess Shale and you will be taken on a vivid guided tour of that long-ago place. But what *Morris* (1998: 63-115) and the museum scientists did in both cases was to imaginatively reconstruct the ancient Cambrian site from an assemblage of present-day fossils. In other words, paleontologists infer a past situation or cause from present clues.

A key figure in elucidating the special nature of this mode of reasoning was a contemporary of Darwin, polymath William Whewell, master of Trinity College, Cambridge and best known for two books about the nature of science, *History of the Inductive Sciences* (1837) and *The Philosophy of the Inductive Sciences* (1840). Whewell distinguished inductive sciences like mechanics (physics) from what he called palaetiology – historical sciences that are defined by three distinguishing features. First, the palaetiological or historical sciences have a distinctive *object*: to determine "ancient condition[s]" (*Whewell* 1857, vol. 3: 397) or past causal events. Second, palaetiological sciences *explain* present events ("manifest effects") by reference to past (causal) events rather than by reference to general laws (though laws sometimes play a subsidiary role). And third, in identifying a "more ancient condition," Whewell believed palaetiology utilized a distinctive mode of reasoning in which past conditions were *inferred* from "manifest effects" using generalizations linking present clues with past causes (*Whewell* 1840, vol. 2: 121-22, 101-103).

Inference to the Best Explanation

This type of inference is called abductive reasoning. It was first described by the American philosopher and logician C.S. Peirce. He noted that, unlike inductive reasoning, in which a universal law or principle is established from repeated observations of the same phenomena, and unlike deductive reasoning, in which a particular fact is deduced by applying a general law or rule to another particular fact or case, abductive reasoning infers unseen facts, events or causes in the past from clues or facts in the present.

As Peirce himself showed, however, there is a problem with abductive reasoning. Consider the following syllogism:

> If it rains, the streets will get wet.
> *The streets are wet.*
> Therefore, it rained.

This syllogism infers a past condition (i.e., that it rained) but it commits a logical fallacy known as *affirming the consequent*. Given that the street is wet (and without additional evidence to decide the matter), one can only conclude that *perhaps* it rained. Why? Because there are many other possible ways by which the street may have gotten wet. Rain may have caused the streets to get wet; a street cleaning machine might have caused them to get wet; or an uncapped fire hydrant might have done so. It can be difficult to infer the past from the present because there are many possible causes of a given effect.

Peirce's question was this: how is it that, despite the logical problem of affirming the consequent, we nevertheless frequently make reliable abductive inferences about the past? He noted, for example, that no one doubts the existence of Napoleon. Yet we use abductive reasoning to infer Napoleon's existence. That is, we must infer his past existence from present effects. But despite our dependence on abductive reasoning to make this inference, no sane or educated person would doubt that Napoleon Bonaparte actually lived. How could this be if the problem of affirming the consequent bedevils our attempts to reason abductively? Peirce's answer was revealing: "Though we have not seen the man [Napoleon], yet we cannot explain what we have seen without" the hypothesis of his existence (*Peirce*, 1932, vol. 2: 375). Peirce's words imply that a particular abductive hypothesis can be strengthened if it can be shown to explain a result in a way that other hypotheses do not, and that it can be reasonably believed (in practice) if it explains in a way that no other hypotheses do. In other words, an abductive inference can be enhanced if it can be shown that it represents the best or the only adequate explanation of the "manifest effects" (to use Whewell's term).

As Peirce pointed out, the problem with abductive reasoning is that there is often more than one cause that can explain the same effect. To address this problem, pioneering geologist *Thomas Chamberlain* (1965: 754-59) delineated a method of reasoning that he called "the method of multiple working hypotheses." Geologists and other historical scientists use this method when there is more than one possible cause or hypothesis to explain the same evidence. In such cases, historical scientists carefully weigh the evidence and what they know about various possible causes to determine which best explains the clues before them. In modern times, contemporary philosophers of science have called this the method of *inference to the best explanation*. That is, when trying to explain the origin of an event or structure in the past, historical scientists compare various hypotheses to see which would, if true, best explain it. They then provisionally affirm that hypothesis that best explains the data as the most likely to be true.

Causes Now in Operation

But what constitutes the best explanation for the historical scientist? My research showed that among historical scientists it's generally agreed that *best* doesn't mean *ideologically satisfying* or *mainstream*; instead, *best* generally has been taken to mean, first and foremost, most *causally adequate*. In other words, historical scientists try to identify causes that are known to produce the effect in question. In making such determinations, historical scientists evaluate hypotheses against their present knowledge of cause and effect; causes that are known to produce the effect in question are judged to be better causes than those that are not. For instance, a volcanic eruption is a better explanation for an ash layer in the earth than an earthquake because eruptions have been observed to produce ash layers, whereas earthquakes have not.

This brings us to the great geologist Charles Lyell, a figure who exerted a tremendous influence on 19th century historical science generally and on Charles Darwin specifically. Darwin read Lyell's magnum opus, *The Principles of Geology,* on the voyage of the Beagle and later appealed to its uniformitarian principles to argue that observed micro-evolutionary processes of change could be used to explain the origin of new forms of life. The subtitle of Lyell's *Principles* summarized the geologist's central methodological principle: "*Being an Attempt to Explain the Former Changes of the Earth's Surface,* by Reference to Causes now in Operation." Lyell argued that when historical scientists are seeking to explain events in the past, they should not invoke unknown or exotic causes, the effects of which we do not know, but instead they should cite causes that are known from our uniform experience to have the power to produce the effect in question (i.e., "causes now in operation").

Darwin subscribed to this methodological principle. His term for a "presently acting cause" was a *vera causa*, that is, a true or actual cause. In other words, when explaining the past, historical scientists should seek to identify established causes – causes known to produce the effect in question. For example, Darwin tried to show that the process of descent with modification was the *vera causa* of certain kinds of patterns found among living organisms. He noted that diverse organisms share many common features. He called these *homologies* and noted that we know from experience that descendents, although they differ from their ancestors, also resemble them in many ways, usually more closely than others who are more distantly related. So he proposed descent with modification as a *vera causa* for homologous structures. That is, he argued that our uniform experience shows that the process of descent with modification from a common ancestor is "causally adequate" or capable of producing homologous features.

And Then There Was One

Contemporary philosophers agree that causal adequacy is the key criteria by which competing hypotheses are adjudicated, but they also show that this process leads to secure inferences only where it can be shown that there is just one known cause for the evidence in question. Philosophers of science Michael Scriven and Elliot Sober, for example, point out that historical scientists can make inferences about the past with confidence when they discover evidence or artifacts for which there is only one cause known to be capable of producing them. When historical scientists infer to a *uniquely* plausible cause, they avoid the fallacy of affirming the consequent and the error of ignoring other possible causes with the power to produce the same effect. It follows that the process of determining the best explanation often involves generating a list of possible hypotheses, comparing their known or theoretically plausible causal powers with respect to the relevant data, and then like a detective attempting to identify the murderer, progressively eliminating potential but inadequate explanations until, finally, one remaining causally adequate explanation can be identified as the best. As *Scriven* (1966: 250) explains, such abductive reasoning (or what he calls "Reconstructive causal analysis") "proceeds by the elimination of possible causes," a process that is essential if historical scientists are to overcome the logical limitations of abductive reasoning.

The matter can be framed in terms of formal logic. As C.S. Peirce noted, arguments of the form:

if X, then Y
Y
therefore X

commit the fallacy of affirming the consequent. Nevertheless, as *Michael Scriven* (1959: 480), *Elliot Sober* (1988: 1-5), *W.P. Alston* (1971: 23) and *W.B. Gallie* (1959: 392) have observed, such arguments can be restated in a logically acceptable form if it can be shown that Y has only one known cause (i.e., X) or that X is a necessary condition (or cause) of Y. Thus, arguments of the form:

X is antecedently necessary to Y,
Y exists,
Therefore, X existed

are accepted as logically valid by philosophers and persuasive by historical and forensic scientists. Scriven especially emphasized this point: if scientists can discover an effect for which there is only one plausible cause, they can infer the presence or action of that cause in the past with great confidence. For instance, the archaeologist who knows that human scribes are the only known cause of linguistic inscriptions will infer scribal activity upon discovering tablets containing ancient writing.

In many cases, of course, the investigator will have to work his way to a unique cause one painstaking step at a time. For instance, both wind shear and compressor blade failure could explain an airline crash, but the forensic investigator will want to know which one did, or if the true cause lies elsewhere. Ideally, the investigator will be able to discover some crucial piece of evidence or suite of evidences for which there is only one known cause, allowing him to distinguish between competing explanations and eliminate every explanation but the correct one.

In my study of the methods of the historical sciences, I found that historical scientists, like detectives and forensic experts, routinely employ this type of abductive and eliminative reasoning in their attempts to infer the best explanation.[10] In fact, Darwin himself employed this method in *The Origin of Species*. There he argued for his theory of Universal Common Descent, not because it could predict future outcomes under controlled experimental conditions, but because it could explain already known facts better than rival hypotheses. As he explained in a letter to Asa Gray:

> I [...] test this hypothesis [Universal Common Descent] by comparison with as many general and pretty well-established propositions as I can find – in geographical distribution, geological history, affinities &c., &c. And it seems to me that, supposing that such a hypothesis were to explain such general propositions, we ought, in accordance with the common way of following all sciences, to admit it till some better hypothesis be found out. (*Darwin* 1896, vol. 1: 437.)

DNA by Design: Developing the Argument from Information

What does this investigation into the nature of historical scientific reasoning have to do with intelligent design, the origin of biological information and the mystery of life's origin? For me, it was critically important to deciding whether the design hypothesis could be formulated as a rigorous scientific explanation as opposed to just an intriguing intuition. I knew from my study of origin-of-life research that the central question facing scientists trying to explain the origin of the first life was this: how did the sequence-specific digital information (stored in DNA and RNA) necessary to building the first cell arise? As *Bernd-Olaf Küppers* (1990: 170-172) put it, "the problem of the origin of life is clearly basically the equivalent to the problem of the origin of biological information." My study of the methodology of the historical sciences then led me to ask a series of questions: What is the presently acting cause of the origin of digital information? What is the *vera causa* of such information? Or: what is the "only known cause" of this effect? Whether I used Lyell's, Darwin's or Scriven's terminology, the question was the same: what type of cause has demonstrated the power to generate information? Based upon both common experience and my knowledge of the many failed attempts to solve the problem with "unguided" pre-biotic simulation experiments and computer simulations, I concluded that there is only one sufficient or "presently acting" cause of the origin of such functionally-specified information. And that cause is intelligence. In other words, I concluded, based on our experience-based understanding of the cause-and-effect structure of the world, that intelligent design is the best explanation for the origin of the information necessary to build the first cell. Ironically, I discovered that if one applies Lyell's uniformitarian method – a practice much maligned by young earth creationists – to the question of the origin of biological information, the evidence from molecular biology supports a new and rigorous scientific argument to design.

What is Information?

In order to develop this argument and avoid equivocation, it was necessary to carefully define what type of information was present in the cell (and what type of information might,

[10] *Gian Capretti* (1983: 143) has developed the implications of Peircian abduction. Capretti and others explore the use of abductive reasoning by Sherlock Holmes in detective fiction of Sir Arthur Conan Doyle. Capretti attributes the success of Holmesian abductive "reconstructions" to a willingness to employ a method of "progressively eliminating hypotheses."

based upon our uniform experience, indicate the prior action of a designing intelligence). Indeed, part of the historical scientific method of reasoning involves first defining what philosophers of science call the *explanandum* – the entity that needs to be explained. As the historian of biology *Harmke Kamminga* (1986: 1) has observed, "At the heart of the problem of the origin of life lies a fundamental question: What is it exactly that we are trying to explain the origin of?" Contemporary biology had shown that the cell was, among other things, a repository of information. For this reason, origin-of-life studies had focused increasingly on trying to explain the origin of that information. But what kind of information is present in the cell? This was an important question to answer because the term "information" can be used to denote several theoretically distinct concepts.

In developing a case for design from the information-bearing properties of DNA, it was necessary to distinguish two key notions of information from one another: mere information carrying capacity, on the one hand, and functionally-specified information, on the other. It was important to make this distinction because the kind of information that is present in DNA (like the information present in machine code or written language) has a feature that the well-known Shannon theory of information does not encompass or describe.

During the 1940s, Claude Shannon at Bell Laboratories developed a mathematical theory of information (1948: 379–423, 623–56) that equated the amount of information transmitted with the amount of uncertainty reduced or eliminated by a series of symbols or characters (*Dretske*, 1981: 6–10). In Shannon's theory, the more improbable an event the more uncertainty it eliminates, and thus, the more information it conveys. Shannon generalized this relationship by stating that the amount of information conveyed by an event is inversely proportional to the prior probability of its occurrence. The greater the number of possibilities, the greater the improbability of any one being actualized, and thus the more information is transmitted when a particular possibility occurs.[11]

Shannon's theory applies easily to sequences of alphabetic symbols or characters that function as such. Within a given alphabet of x possible characters, the occurrence or placement of a specific character eliminates x-1 other possibilities and thus a corresponding amount of uncertainty. Or put differently, within any given alphabet or ensemble of x possible characters (where each character has an equi-probable chance of occurring), the probability of any one character occurring is 1/x. In systems where the value of x can be known (or estimated), as in a code or language, mathematicians can easily generate quantitative estimates of information-carrying capacity. The greater the number of possible characters at each site, and the longer the sequence of characters, the greater is the information-carrying capacity – or Shannon information – associated with the sequence.

The way that nucleotide bases in DNA function as alphabetic or digital characters enabled molecular biologists to calculate the information-carrying capacity of those molecules using the new formalism of Shannon's theory. Since at any given site along the DNA backbone any one of four nucleotide bases may occur with equal probability (*Küppers*, 1987: 355-369), the probability of the occurrence of a specific nucleotide at that site equals 1/4 or .25. The information-carrying capacity of a sequence of a specific length n can then be calculated using

[11] Moreover, information increases as improbabilities multiply. The probability of getting four heads in a row when flipping a fair coin is 1/2 X 1/2 X 1/2 X 1/2 or $(1/2)^4$. Thus, the probability of attaining a specific sequence of heads and/or tails decreases exponentially as the number of trials increases. The quantity of information increases correspondingly. Even so, information theorists found it convenient to measure information additively rather than multiplicatively. Thus, the common mathematical expression ($I = -\log_2 p$) for calculating information converts probability values into informational measures through a negative logarithmic function, where the negative sign expresses an inverse relationship between information and probability.

Shannon's familiar expression ($I = -\log_2 p$) once one computes a probability value (p) for the occurrence of a particular sequence n nucleotides long where $p = (1/4)^n$. The probability value thus yields a corresponding measure of information-carrying capacity for a sequence of n nucleotide bases (*Schneider* 1997: 427-441; *Yockey* 1992: 246-258).

Though Shannon's theory and equations provided a powerful way to measure the amount of information that could be transmitted across a communication channel, it had important limits. In particular, it did not and could not distinguish merely improbable (or complex) sequences of symbols from those that conveyed a message or performed a function. As Warren Weaver made clear in 1949, "The word *information* in this theory is used in a special mathematical sense that must not be confused with its ordinary usage. In particular, information must not be confused with meaning." (*Shannon* and *Weaver* 1949: 8.) Information theory could measure the information-carrying capacity of a given sequence of symbols, but it could not distinguish the presence of a meaningful or functional arrangement of symbols from a random sequence.

As scientists applied Shannon information theory to biology it enabled them to render rough quantitative measures of the information-carrying capacity (or brute complexity or improbability) of DNA sequences and their corresponding proteins. As such, information theory did help to refine biologists' understanding of one important feature of the crucial biomolecular components on which life depends: DNA and proteins are highly complex, and quantifiably so. Nevertheless, the ease with which information theory applied to molecular biology (to measure information-carrying capacity) created confusion about the sense in which DNA and proteins contain "information."

Information theory strongly suggested that DNA and proteins possess vast information-carrying capacities, as defined by Shannon's theory. When molecular biologists have described DNA as the carrier of hereditary information, however, they have meant much more than that technically limited term *information.* Instead, leading molecular biologists defined biological information so as to incorporate the notion of specificity of function (as well as complexity) as early as 1958 (*Crick*, 1958: 144, 153). Molecular biologists such as Monod and Crick understood biological information – the information stored in DNA and proteins – as something more than mere complexity (or improbability). Crick and Monod also recognized that sequences of nucleotides and amino acids in functioning bio-macromolecules possessed a high degree of *specificity* relative to the maintenance of cellular function. As Crick explained in 1958, "By information I mean the specification of the amino acid sequence in protein [...] Information means here the *precise* determination of sequence, either of bases in the nucleic acid or on amino acid residues in the protein (1958: 144, 153)."

Since the late 1950s, biologists have equated the "*precise* determination of sequence" with the extra-information-theoretic property of "specificity" or "specification." Biologists have defined specificity tacitly as 'necessary to achieving or maintaining function.' They have determined that DNA base sequences are specified, not by applying information theory, but by making experimental assessments of the function of those sequences within the overall apparatus of gene expression (*Judson,*1979: 470-487). Similar experimental considerations established the functional specificity of proteins.

In developing an argument for intelligent design based upon the information present in DNA and other bio-macromolecules, I emphasized that the information in these molecules was functionally-specified *and* complex, not *just* complex. Indeed, to avoid equivocation, it was necessary to distinguish:

"information content" from *mere* "information carrying capacity,"
"specified information" from *mere* "Shannon information"
"specified complexity" from *mere* "complexity."

The first of the two terms in each of these couplets refer to sequences in which the function of the sequence depends upon the precise sequential arrangements of the constituent characters or parts, whereas second terms refer to sequences that do not necessarily perform functions or convey meaning at all. The second terms refer to sequences that may be merely improbable or complex; the first terms refer to sequences that are both complex and functionally-specified.

In developing an argument for intelligent design from the information-bearing properties of DNA, I acknowledged that merely complex or improbable phenomena or sequences might arise by undirected natural processes. Nevertheless, I argued – based upon our uniform experience – that sequences that are both complex and functionally-specified (rich in information *content* or *specified* information) invariably arise only from the activity of intelligent agents. Thus, I argued that the presence of specified information provides a hallmark or signature of a designing intelligence. In making these analytical distinctions in order to apply them to an analysis of biological systems, I was greatly assisted in my conversations and collaboration with William Dembski who was at the same time (1992-1997) developing a general theory of design detection which I discuss in detail below.

In the years that followed, I published a series of papers (see *Meyer* 1998a: 519-56; *Meyer* 1998b, 117-143; *Meyer* 2000a: 30-38; *Meyer* 2003a: 225-285) arguing that intelligent design provides a better explanation than competing chemical evolutionary models for the origin of the biological information. To make this argument, I followed the standard method of historical scientific reasoning that I had studied in doctoral work. In particular, I evaluated the causal adequacy of various naturalistic explanations for the origin of biological information including those based on chance, law-like necessities and the combination of the two. In each case, I showed (or the scientific literature showed) that such naturalistic models failed to explain the origin of specified information (or specified complexity or information content) starting from purely physical / chemical antecedents. Instead, I argued, based on our experience, that there is a cause – namely, intelligence – that is known to be capable of producing such information. As the pioneering information theorist *Henry Quastler* (1964: 16) pointed out, “Information habitually arises from conscious activity.” Moreover, based upon our experience (and the findings of contemporary origin-of-life research) it is clear that intelligent design or agency is the *only* type of cause known to produce large amounts of specified information. Therefore, I argued that the theory of intelligent design provides the best explanation for the information necessary to build the first life.[12]

Darwin on Trial and Philip Johnson

While I was still studying historical scientific reasoning in Cambridge in 1987, I had a fateful meeting with a prominent University of California, Berkeley law professor named Phillip

[12] I later extended this information argument to an analysis of the geologically-sudden appearance of animal body plans that occurred in the Cambrian period. In a peer-reviewed article published in 2004 with the *Proceedings of the Biological Society of Washington*, a journal published out of the Smithsonian Institution, I argued that intelligent design provided the best explanation of the quantum increase in biological information that was necessary to build the Cambrian animals. In constructing this case, I again self-consciously followed the method of multiple competing hypotheses by showing that neither neo-Darwinian mechanism, nor structuralism, nor self-organizational models nor other materialistic models offered an adequate causal explanation for the origin of the Cambrian explosion in biological form and information (see *Meyer* 2004: 213-239; *Meyer et al.* 2003). Instead, I argued that, based upon our uniform and repeated experience, only intelligent agency (mind, not a material process) has demonstrated the power to produce the large amounts of specified information such as that which arose with the Cambrian animals.

Johnson, whose growing interest in the subject of biological origins would transform the contours of the debate over evolution. Johnson and I met at a small Greek restaurant on Free School Lane next to the Old Cavendish Laboratory in Cambridge. The meeting had been arranged by a fellow graduate student who knew Johnson from Berkeley. My friend had told me only that Johnson was "a quirky but brilliant law professor" who "was on sabbatical studying torts," and he "had become obsessed with evolution." "Would you talk to him?" he asked. His description and the tone of his request led me to expect a very different figure than the one I encountered. Though my own skepticism about Darwinism had been well cemented by this time, I knew enough of the stereotypical evolution-basher to be skeptical that a late-in-career nonscientist could have stumbled onto an original critique of contemporary Darwinian theory.

Only later did I learn of Johnson's intellectual pedigree: Harvard B.A., top of his class University of Chicago law-school graduate, law clerk for Supreme Court Chief Justice Earl Warren, leading constitutional scholar, occupant of a distinguished chair at University of California, Berkeley. In Johnson, I encountered a man of supple and prodigious intellect who seemed in short order to have found the pulse of the origins issue. Johnson told me that his doubts about Darwinism had started with a visit to the British Natural History Museum, where he learned about the controversy that had raged there earlier in the 1980s. At that time, the museum paleontologists presented a display describing Darwin's theory as "one possible explanation" of origins. A furor ensued, resulting in the removal of the display when the editors of the prestigious journal *Nature* and others in the scientific establishment denounced the museum for its ambivalence about accepted fact. Intrigued by the response to such an apparently innocuous exhibit, Johnson decided to investigate further.

Soon thereafter, as Johnson was still casting about for a research topic early in his sabbatical year in London, he stepped off the bus and followed his usual route to his visiting faculty office. Along the way, he passed by a large science bookstore and, glancing in, noticed a pair of books about evolution, *The Blind Watchmaker* by Richard Dawkins and *Evolution: A Theory in Crisis* by Michael Denton. Historian of science Thomas Woodward recounts the episode:

> His curiosity aroused, he entered the store, picked up copies of both books from a table near the door, and studied the dust jacket blurbs. The two biologists were apparently driving toward diametrically opposite conclusions. Sensing a delicious scientific dialectic, he bought both books and tucked them under his arm as he continued on to his office. (*Woodward* 2003: 69.)

The rest, as they say, is history. Johnson began to read whatever he could find on the issue: Gould, Ruse, Ridley, Dawkins, Denton and many others. What he read made him even more suspicious of evolutionary orthodoxy. "Something about the Darwinists' rhetorical style," he told me later, "made me think they had something to hide."

An extensive examination of evolutionary literature confirmed this suspicion. Darwinist polemic revealed a surprising reliance upon arguments that seemed to assume rather than demonstrate the central claim of neo-Darwinism, namely, that life had evolved via a strictly undirected natural process. Johnson also observed an interesting contrast between biologists' technical papers and their popular defenses of evolutionary theory. He discovered that biologists acknowledged many significant difficulties with both standard and newer evolutionary models when writing in scientific journals. Yet, when defending basic Darwinist commitments (such as the common ancestry of all life and the creative power of the natural selection / mutation mechanism) in popular books or textbooks, Darwinists employed an evasive and moralizing rhetorical style to minimize problems and belittle critics. Johnson began to wonder why, given mounting difficulties, Darwinists remained so confident that all organisms had evolved naturally from simpler forms.

In the book *Darwin on Trial, Johnson* (1991) argued that evolutionary biologists remain confident about neo-Darwinism, not because empirical evidence generally supports the theory, but instead because their perception of the rules of scientific procedure virtually prevent them from considering any alternative view. Johnson cited, among other things, a communiqué from the National Academy of Sciences (NAS) issued to the Supreme Court during the Louisiana "creation science" trial. The NAS insisted that "the most basic characteristic of science" is a "reliance upon naturalistic explanations."

While Johnson accepted this convention, called "methodological naturalism," as an accurate description of how much of science operates, he argued that treating it as a normative rule when seeking to establish *that* natural processes alone produced life assumes the very point that neo-Darwinists are trying to establish. Johnson reminded readers that Darwinism does not just claim that evolution (in the sense of change over time) has occurred. Instead, it purports to establish that the major innovations in the history of life arose by purely *natural* mechanisms – that is, without any intelligent direction or design. Thus, Johnson distinguished the various meanings of the term "evolution" (such as change over time or common ancestry) from the central claim of Darwinism, namely, the claim that a purely undirected and unguided process had produced the appearance of design in living organisms. Following Richards Dawkins, the staunch modern defender of Darwinism, Johnson called this latter idea "the Blind Watchmaker thesis" to make clear that Darwinism as a theory is incompatible with the design hypothesis. In any case, he argued, modern Darwinists refuse to consider the possibility of design because they think the rules of science forbid it.

Yet if the design hypothesis must be denied consideration from the outset, and if, as the U.S. National Academy of Sciences also asserted, exclusively negative argumentation against evolutionary theory is "unscientific," then *Johnson* (1991: 8) observed that "the rules of argument. [...] make it impossible to question whether what we are being told about evolution is really true." Defining opposing positions out of existence "may be one way to win an argument," but, said Johnson, it scarcely suffices to demonstrate the superiority of a protected theory.

When I first met Johnson at the aforementioned Greek restaurant it was not long after he had started his investigation of Darwinism. Nevertheless, we came to an immediate meeting of minds, albeit from different starting points. Johnson saw that, as matter of logic, the convention of methodological naturalism forced scientists into a question-begging affirmation of the proposition that life and humankind had arisen "by a purposeless and natural process that did not have him in mind," as the neo-Darwinist *George Gaylord Simpson* (1967: 45) had phrased it. For my part, I had come to question methodological naturalism because it seemed to prevent historical scientists from considering all the possible hypotheses that might explain the evidence – despite a clear methodological *desideratum* to do otherwise. How could an historical scientist claim that he or she had inferred the *best* explanation if the causal adequacy of some hypotheses were arbitrarily excluded from consideration? For the method of multiple competing hypotheses to work, hypotheses must be allowed to compete without artificial restrictions on the competition.

In any case, when *Darwin on Trial* was published in 1991 it created a minor media sensation with magazines and newspapers all over America either reviewing the book or profiling the eccentric Berkeley professor who had dared to take on Darwin. Major science journals including *Nature*, *Science* and *Scientific American* also reviewed *Darwin on Trial.* The reviews, including one by Stephen J. Gould, were uniformly critical and even hostile. Yet these reviews helped publicize Johnson's critique and attracted many scientists who shared Johnson's skepticism about neo-Darwinism. This allowed Johnson to do something that, until that time, hadn't been done: to bring together dissenting scientists from around the world.

Darwin's Black Box and Michael Behe

One of those scientists, a tenured biochemist at Lehigh University, Michael Behe, had come to doubt Darwinian evolution in the same way that Johnson had – by reading Denton's *Evolution: A Theory in Crisis*. Behe was a Roman Catholic and had been raised to accept Darwinism as the way God chose to create life. Thus, he had no theological objections to Darwinian evolution. For years he had accepted it without questioning. When he finished Denton's book, he still had no theological objections to evolution, but he did have serious scientific doubts. He soon began to investigate what the evidence from his own field of biochemistry had to say about the plausibility of the neo-Darwinian mechanism. Although he saw no reason to doubt that natural selection could produce relatively minor biological changes, he became extremely skeptical that the Darwinian mechanism could produce the kind of functionally integrated complexity that characterizes the inner workings of the cell. Intelligent design, he concluded, must also have played a role.

As his interest grew, he began teaching a freshman course on the evolution controversy. Later in 1992, he wrote a letter to *Science* defending Johnson's new book after it had been panned in the review that appeared there. When Johnson saw the letter in *Science*, he contacted Behe and eventually invited him to a symposium at Southern Methodist University in Texas, where Johnson debated the Darwinist philosopher of science Michael Ruse. The meeting was significant for two reasons. First, as *Behe* (2006: 37-47) explained, the scientists skeptical of Darwin who were present at the debate were able to experience what they already believed intellectually – they had strong arguments that could withstand high-level scrutiny from their peers. Second, at SMU, many of the leaders of the intelligent design research community would meet together for the first time in one place. Before, we had each been solitary skeptics, unsure of how to proceed against an entrenched scientific paradigm. Now we understood that we were part of an interdisciplinary intellectual community. After the symposium, Johnson arranged a larger meeting the following year for a core group of dissidents at Pajaro Dunes, California (shown in the film *Unlocking the Mystery of Life*). There we talked science and strategy and, at Johnson's prompting, joined an e-mail listserv so that we would remain in contact and hone our ideas. At Pajaro Dunes, "the movement" congealed.

Behe, in particular, used the new listserv to test and refine the various arguments for a book he was working on. Within three years, *Darwin's Black Box* appeared with The Free Press, a major New York trade publisher. The book went on to sell a quarter million copies.

In *Darwin's Black Box*, Behe pointed out that over the last 30 years, biologists have discovered an exquisite world of nanotechnology within living cells – complex circuits, molecular motors and other miniature machines. For example, bacterial cells are propelled by tiny rotary engines called flagellar motors that rotate at speeds up to 100,000 rpm. These engines look as if they were designed by the Mazda corporation, with many distinct mechanical parts (made of proteins) including rotors, stators, O-rings, bushings, U-joints and drive shafts. (See Figure 2). Behe noted that the flagellar motor depends on the coordinated function of 30 protein parts. Remove one of these necessary proteins and the rotary motor simply doesn't work. The motor is, in Behe's terminology, "irreducibly complex."

This, he argued, creates a problem for the Darwinian mechanism. Natural selection preserves or "selects" functional advantages. If a random mutation helps an organism survive, it can be preserved and passed on to the next generation. Yet the flagellar motor does not function unless all of its thirty parts are present. Thus, natural selection can "select" or preserve the motor once it has arisen as a functioning whole, but it can't produce the motor in a step-by-step Darwinian fashion.

Natural selection purportedly builds complex systems from simpler structures by preserving a series of intermediate structures, each of which must perform some function. In the case of the flagellar motor, most of the critical intermediate stages – like the 29- or 28-part version of the flagellar motor – perform no function for natural selection to preserve. This leaves the origin of the flagellar motor, and many complex cellular machines, unexplained by the mechanism – natural selection – that Darwin specifically proposed to replace the design hypothesis.

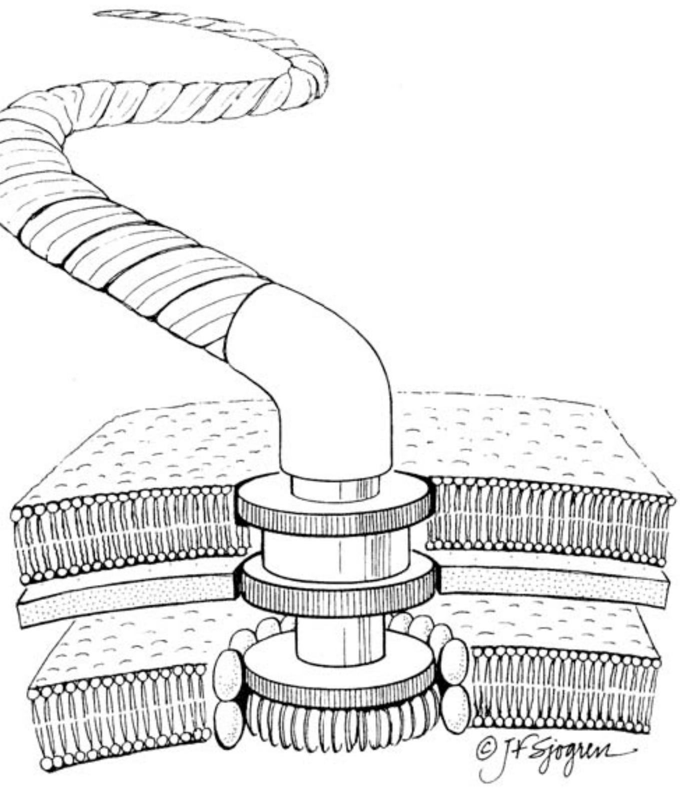

Figure 2

Is there a better explanation? Based upon our uniform experience, we know of only one type of cause that produces irreducibly complex systems – namely, intelligence. Indeed, whenever we encounter such complex systems – whether integrated circuits or internal combustion engines – and we know how they arose, invariably a designing intelligence played a role.

The strength of Behe's argument can be judged in part by the responses of his critics. The neo-Darwinists have had ten years to respond and have so far mustered only vague stories about natural selection building irreducibly complex systems (like the flagellar motor) by “co-opting” simpler functional parts from other systems. For example, some of Behe’s critics, such as Kenneth Miller of Brown University, have suggested that the flagellar motor might have arisen from the functional parts of other simpler systems or from simpler subsystems of the motor. He and others have pointed to a tiny molecular syringe called a type III secretory system (or TTSS) – that is sometimes found in bacteria without the other parts of the flagellar motor present – to illustrate this possibility. Since the type III secretory system is made of ten or so proteins that are also found in the thirty-protein motor, and since this tiny pump does perform a function, Professor *Miller* (2004: 81-97) has intimated[13] that the bacterial flagellar motor might have arisen from this smaller pump.

While it's true that the type III secretory system can function separately from the other parts of the flagellar motor, attempts to explain the origin of the flagellar motor by co-option of the TTSS face at least three key difficulties. First, the other twenty or so proteins in the flagellar motor are unique to it and are not found in any other bacterium. This raises the question: from where were these other protein parts co-opted? Second, as microbiologist Scott Minnich (*Minnich* and *Meyer* 2004: 295-304) of the University of Idaho points out, even if all the genes and protein parts were somehow available to make a flagellar motor during the evolution of life, the parts would need to be assembled in a specific temporal sequence similar to the way an automobile is assembled in factory. Yet, in order to choreograph the assembly of the flagellar motor, present-day bacteria need an elaborate system of genetic instructions as well as many other protein machines to regulate the timing of the expression of these assembly instructions. Arguably, this system is itself irreducibly complex. Thus, advocates of co-option tacitly presuppose the need for the very thing that the co-option hypotheses seek to explain: a functionally interdependent system of proteins (and genes). Co-option only explains irreducible complexity by presupposing irreducible complexity. Third, analyses of the gene sequences of the two systems (*Saier* 2004: 113-115) suggest that the flagellar motor arose first and the pump came later. In other words, if anything, the syringe evolved from the motor, not the motor from the syringe. (See *Behe* 2006b: 255-272 for Behe's response to his critics.)

An Institutional Home

In the same year, 1996, that Behe's book appeared, the Center for Science and Culture was launched as part of the Seattle-based Discovery Institute. The Center began with a research fellowship program to support the research of scientists and scholars such as Michael Behe, Jonathan Wells and David Berlinski who were challenging neo-Darwinism or developing the alternative theory of intelligent design. The Center has now become the institutional hub for an international groups of scientists and scholars who are challenging scientific materialism or developing the theory of intelligent design.

[13] Kenneth Miller carefully avoids saying that the bacterial flagellar motor actually *did* evolve from the type III secretory system. Instead, he insists that the TTSS simply refutes Behe's claim that the flagellar motor is irreducibly complex. But as Behe has made clear his definition of "irreducible complexity" (IC) does not entail the claim that the parts of an irreducibly complex system perform no other function, only that the loss of parts from an irreducibly complex system destroys the function of *that* system. Systems that are IC even by this less restrictive definition still pose formidable obstacles to co-option scenarios, even granting that some of their parts may have had some other selectable function in the past. For co-option scenarios to be plausible, natural selection must build complex systems from simpler structures by preserving *a series* of intermediate structures, each of which must perform some function. For this reason, it is not enough for advocates of co-option to point to a single possible ancestral structure, but instead they must show that a plausible series of such structures existed and could have maintained function at each stage. In the case of the flagellar motor, co-option scenarios lack such plausibility in part because experimental research has shown that the presumptively precedent stages to a fully functional flagellar motor (for example, the 29, 28 and 27—part versions of the flagellar motor) have no motor function. If the last stages in a hypothetical series of functional intermediates are not functional, then it follows that the series as a whole is not. For this and other reasons, co-option does not presently provide either an adequate explanation of the origin of the flagellar motor or a better explanation than Behe's design hypothesis.

William Dembski and *The Design Inference*

One of the first Center-supported research projects was completed two years later when mathematician and probability theorist *William Dembski* (1998) completed a monograph for Cambridge University Press titled *The Design Inference*. In this book, Dembski argued that rational agents often infer or detect the prior activity of other designing minds by the character of the effects they leave behind. Archaeologists assume, for example, that rational agents produced the inscriptions on the Rosetta Stone. Insurance fraud investigators detect certain "cheating patterns" that suggest intentional manipulation of circumstances rather than natural disasters. Cryptographers distinguish between random signals and those that carry encoded messages. Dembski's work showed that recognizing the activity of intelligent agents constitutes a common and fully rational mode of inference.

More importantly, Dembski's work explicated criteria by which rational agents recognize the effects of other rational agents, and distinguish them from the effects of natural causes. He argued that systems or sequences that have the joint properties of "high complexity" (or low probability) and "specification" invariably result from intelligent causes, not chance or physical-chemical laws (see *Dembski* 1998: 36-66). Dembski noted that complex sequences are those that exhibit an irregular and improbable arrangement that defies expression by a simple rule or algorithm. According to Dembski, a specification, on the other hand, is a match or correspondence between a physical system or sequence and a set of independent functional requirements or constraints. To illustrate these concepts (of complexity and specification), consider the following three sets of symbols:

"inetehnsdysk]idfawqnz,mfdifhsnmcpew,ms.s/a"
"Time and tide waits for no man."
"ABABABABABABABABABABABABAB"

Both the first and second sequences shown above are complex because both defy reduction to a simple rule. Each represents a highly irregular, aperiodic and improbable sequence of symbols. The third sequence is not complex, but is instead highly ordered and repetitive. Of the two complex sequences, only one exemplifies a set of independent functional requirements – i.e., is specified. English has a number of such functional requirements. For example, to convey meaning in English one must employ existing conventions of vocabulary (associations of symbol sequences with particular objects, concepts or ideas) and existing conventions of syntax and grammar (such as "every sentence requires a subject and a verb"). When arrangements of symbols "match" or utilize existing vocabulary and grammatical conventions (i.e., functional requirements), communication can occur. Such arrangements exhibit "specification." The second sequence ("Time and tide waits for no man") clearly exhibits such a match between itself and the preexisting requirements of vocabulary and grammar. It has employed these conventions to express a meaningful idea.

Of the three sequences above only the second ("Time and tide waits for no man") manifests both the jointly necessary indicators of a designed system. The third sequence lacks complexity, though it does exhibit a simple periodic pattern, a specification of sorts. The first sequence is complex, but not specified as we have seen. Only the second sequence exhibits both complexity and specification. Thus, according to Dembski's theory, only the second sequence, but not the first and third, implicates an intelligent cause – as indeed our intuition tells us. (See *Dembski* 1998).

As it turns out, these criteria are equivalent (or "isomorphic") to the notion of specified complexity or information content. Thus, Dembski's work suggested that "high information content" or "specified information" or "specified complexity" indicates prior intelligent activity. This theoretical insight comported with common, as well as scientific, experience. Few rational people would, for example, attribute hieroglyphic inscriptions to natural forces such as wind or erosion; instead, they would immediately recognize the activity of intelligent agents. Dembski's work shows why: Our reasoning involves a comparative evaluation process that he represents with a device he calls "the explanatory filter." The filter outlines a formal method by which scientists (as well as ordinary people) decide among three different types of explanations: chance, necessity and design. (See Figure 3). His "explanatory filter" constituted, in effect, a scientific method for detecting the effects of intelligence.

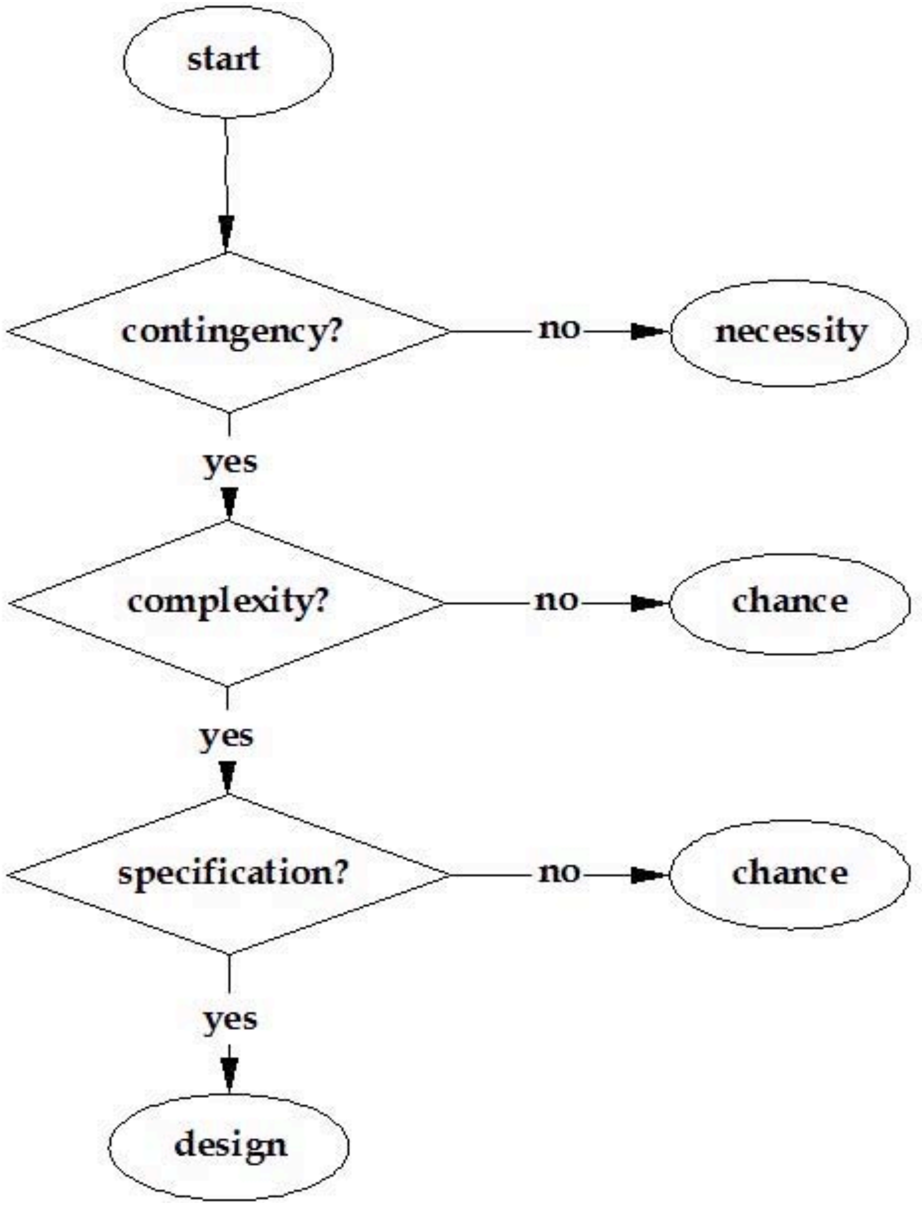

Figure 3

Dembski's academic credentials were impeccable, and since the book had been published after a rigorous peer review process as part of the prestigious Cambridge University Press monograph series, his argument was difficult to ignore. Dembski's formal method also reinforced the argument that I was making simultaneously, namely, that the specified information in DNA is best explained by reference to an intelligent cause rather than by reference to chance, necessity or a combination of the two (*Meyer* 1998a; Meyer 1998b; *Meyer* 2003a; *Meyer et al.*, 2003.) Indeed, the coding regions of the nucleotide base sequences in DNA manifest both complexity and specification just as does the second of the three symbol strings in the preceding illustration.

Design Beyond Biology

Meanwhile, the fledgling Center for Science and Culture was working with scientists and scholars around the world to develop the case for intelligent design not only in biology but also in the physical sciences. Since then, its fellows have written more than sixty books and hundreds of articles (including many peer-reviewed scientific articles challenging Darwinian evolution or, in some cases, explicitly arguing for intelligent design [see *Meyer* 2004: 213-239; see http://www.discovery.org/csc for other peer-reviewed books and articles supporting intelligent design]), and have appeared on hundreds of television and radio broadcasts, many of them national or international. In addition, the center co-produced four science documentaries and helped improve science education policy in seven states and in the U.S. Congress. As a result of these efforts, the work of the center has generated an international discussion about the growing evidence for design in nature.

Since so much of the intelligent design debate concerns biology, many journalists covering the debate – particularly those guided by boilerplate of the 1925 Scopes Monkey Trial and its Hollywood embodiment, *Inherit the Wind* – fail to mention that the theory of intelligent design is larger than biology. In recent decades, molecular and cell biology have provided powerful evidence of design, but so too have chemistry, astronomy and physics.

Consider, for example, the role that physics has played in reviving the case for intelligent design. Since Fred Hoyle's prediction and discovery of the resonance levels of Carbon in 1954 (*Hoyle* 1954: 121-146), physicists have discovered that the existence of life in the universe depends upon a number of precisely balanced physical factors (see *Giberson* 1997: 63-90; *Yates,* 1997: 91-104). The constants of physics, the initial conditions of the universe and many other of its contingent features appear delicately balanced to allow for the possibility of life. Even very slight alterations in the values of many independent factors such as the expansion rate of the universe, the speed of light, the precise strength of gravitational or electromagnetic attraction, would render life impossible. Physicists now refer to these factors as "anthropic coincidences" and to the fortunate convergence of all these coincidences as the "fine-tuning of the universe." Many have noted that this fine-tuning strongly suggests design by a pre-existent intelligence. As physicist *Paul Davies* (1988: 203) has put it, "The impression of design is overwhelming."

To see why, consider the following illustration. Imagine a cosmic explorer has just stumbled into the control room for the whole universe. There he discovers an elaborate "universe creating machine," with rows and rows of dials each with many possible settings. As he investigates, he learns that each dial represents some particular parameter that has to be calibrated with a precise value in order to create a universe in which life can survive. One dial represents the possible settings for the strong nuclear force, one for the gravitational constant, one for Planck's constant, one for the speed of light, one for the ratio of the neutron mass to the proton mass, one for the strength of electromagnetic attraction and so on. As our cosmic explorer examines the dials, he finds that the dials can be easily spun to different settings – that they could have been set otherwise. Moreover, he determines by careful calculation (he is a physicist) that even slight alterations in any of the dial settings would alter the architecture of the universe such that life would cease to exist. Yet for some reason each dial sits with just the exact value necessary to keep the universe running – like an already-opened bank safe with multiple dials in which every dial is found with just the just the right value. What should one infer about how these dial settings came to be set?

Not surprisingly, many physicists have been asking the same question about the anthropic coincidences. And for many,[14] the design hypothesis seems the most obvious and intuitively plausible answer to this question. As *George Greenstein* (1988: 26-27) muses, "the thought insistently arises that some supernatural agency, or rather Agency, must be involved." As *Fred Hoyle* (1982: 16) commented, "a commonsense interpretation of the facts suggests that a superintellect has monkeyed with physics, as well as chemistry and biology, and that there are no blind forces worth speaking about in nature." Or as he put it in his book *The Intelligent Universe*, "A component has evidently been missing from cosmological studies. The origin of the Universe, like the solution of the Rubik cube, requires an intelligence" (*Hoyle* 1983: 189). Many physicists now concur. They would argue that – in effect – the dials in the cosmic control room appear finely-tuned because someone carefully set them that way.

In the 2004 book *The Privileged Planet*, astronomer Guillermo Gonzalez and philosopher Jay Richards extended this fine-tuning argument to planet earth (*Gonzalez and Richards* 2004). They showed first that the Earth's suitability as a habitable planet depends on a host of very improbable conditions – conditions so improbable in fact as to call into question the widespread assumption that habitable planets are common in our galaxy or even the universe. Further, by drawing on a host of recent astronomical discoveries, Gonzalez and Richards also showed that the set of improbable conditions that render the earth habitable also make it an optimal place for observing the cosmos and making various scientific discoveries. As they put it, habitability correlates with discoverability. They argued that the best explanation for this correlation is that the earth was intelligently designed to be a habitable planet and a platform for making scientific discovery. *The Privileged Planet* makes a nuanced and cumulative argument[15] – one that resists easy summation, but their groundbreaking advance of the fine-tuning argument for design was persuasive enough that such scientists as Cambridge's Simon Conway Morris and Harvard's Owen Gingerich endorsed the book, and *David Hughes* (2005: 113), a vice-president of the Royal Astronomical Society, gave it an enthusiastic review in the pages of *The Observatory*.

Three Philosophical Objections

On this and other fronts, advocates of the theory of intelligent design have stirred up debate at the highest levels of the scientific community. In response opponents have often responded with philosophical rather than evidential objections. The three of the most common are: (1) that the theory of intelligent design is an argument from ignorance, (2) that it repre-

[14] Greenstein himself does not favor the design hypothesis. Instead, he favors the so-called "participatory universe principle" or "PAP." PAP attributes the apparent design of the fine tuning of the physical constants to the universe's (alleged) need to be observed in order to exist. As he says, the universe "brought forth life in order to exist […] that the very Cosmos does not exist unless observed." See *Greenstein* 1988: 223.

[15] In arguing that our place in the cosmos is optimized for life and discovery, they introduce a concept from engineering, *constrained optimization*, offering the example of a notebook computer. Yes, a notebook computer's screen could be substantially bigger, but that would compromise its effectiveness as a lightweight, portable computer. The best notebook computer is the best compromise among a range of sometimes competing qualities. In the same way, Earth's situation in the cosmos might be improved in this or that way, but these improvements would involve tradeoffs. For instance, if we were near the center of our galaxy, we might be able to learn more about the black hole posited to rest there, but the bright galactic core would greatly compromise our ability to observe distant galaxies. Our actual viewing position, while perhaps not ideal in any one respect, possesses the same quality of *constrained optimization* that a well-designed notebook computer possesses.

sents the same kind of fallacious argument from analogy that David Hume criticized in the 18th century and (3) that the theory of intelligent design is not "scientific." Let us examine each of these arguments in turn.

An Argument from Knowledge

Opponents of intelligent design frequently characterize the theory as an argument from ignorance. According to this criticism anyone who makes a design inference from the presence of information or irreducible complexity in the biological world uses our present ignorance of an adequate materialistic cause of these phenomena as the sole basis for inferring an intelligent cause. Since, the objection goes, 'design advocates can't imagine a natural process that can produce biological information or irreducibly complex systems, they resort to invoking the mysterious notion of intelligent design.' In this view, intelligent design functions not as an explanation, but as a placeholder for ignorance.

On the contrary, the arguments for intelligent design described in this essay do not constitute fallacious arguments from ignorance. Arguments from ignorance occur when evidence against a proposition is offered as the sole grounds for accepting another, alternative proposition. The inferences and arguments to design made by contemporary design theorists don't commit this fallacy. True, the design arguments employed by contemporary advocates of intelligent design do depend in part upon negative assessments of the causal adequacy of competing materialistic hypotheses. And clearly, the lack of an adequate materialistic cause does provide part of the grounds for inferring design from information or irreducibly complex structures in the cell. Nevertheless, this lack is only part of the basis for inferring design. Advocates of the theory of intelligent design also infer design because we *know* that intelligent agents can and do produce information-rich and irreducibly complex systems. In other words, we have positive experience-based *knowledge* of an alternative cause that is sufficient to have produced such effects. That cause is intelligence. Thus, design theorists infer design not just because natural processes do not or cannot explain the origin of specified information or irreducible complexity in biological systems, but also because we *know* based upon our uniform experience that only intelligent agents produce these effects. In other words, biological systems manifest distinctive and positive hallmarks of intelligent design – ones that in any other realm of experience would trigger the recognition of an intelligent cause.

Thus, Michael Behe has inferred design not only because the mechanism of natural selection cannot (in his judgment) produce "irreducibly complex" systems, but also because in our experience "irreducible complexity" is a feature of systems known always to result from intelligent design. That is, whenever we see systems that have the feature of irreducible complexity and we know the causal story about how such systems originated, invariably "intelligent design" played a role in the origin of such systems. Thus, Behe infers intelligent design as the best explanation for the origin of irreducible complexity in cellular molecular motors and circuits based upon what we *know*, not what we do not know, about the causal powers of intelligent agents and natural processes, respectively.

Similarly, the "specified complexity" or "specified information" of DNA implicates a prior intelligent cause, not only because (as I have argued) materialistic scenarios based upon chance, necessity and the combination of the two fail to explain the origin of such information, but also because we know that intelligent agents can and do produce information of this kind. In other words, we have positive experience-based knowledge of an alternative cause that is sufficient to have produced such effects, namely, intelligence. To quote Henry Quastler again, "Information habitually arises from conscious activity" (*Quastler* 1964: 16). For this reason, specified information also constitutes a distinctive hallmark (or signature) of intelligence. Indeed, in all cases where we know the causal origin of such information, experience has shown that intelligent design played a causal role. Thus, when we encounter such information in the bio-macromolecules necessary to life, we may infer – based upon our *knowledge* of established cause-effect relationships (i.e., "presently acting causes") – that an intelligent cause operated in the past to produce the information necessary to the origin of life.

Thus, contemporary design advocates employ the standard uniformitarian method of reasoning used in all historical sciences. That contemporary arguments for design necessarily include critical evaluations of the causal adequacy of competing hypotheses is entirely appropriate. All historical scientists must compare causal adequacy of competing hypotheses in order to make a judgment as to which hypothesis is best. We would not say, for example, that an archeologist had committed a "scribe of the gaps" fallacy simply because – after rejecting the hypothesis that an ancient hieroglyphic inscription was caused by a sand storm – he went on to conclude that the inscription had been produced by a human scribe. Instead, we recognize that the archeologist has made an inference based upon his experience-based *knowledge* that information-rich inscriptions invariably arise from intelligent causes, not solely upon his judgment that there are no suitably efficacious natural causes that could explain the inscription.

Not Analogy but Identity

Nor does the design argument from biological information depend on the analogical reasoning that Hume critiqued since it does not depend upon assessments of degree of similarity. The argument does not depend upon the similarity of DNA to a computer program or human language but upon the presence of an identical feature ("information" defined as "complexity and specification") in both DNA and all other designed systems, languages or artifacts. For this reason, the design argument from biological information does not represent an argument from analogy of the sort that Hume criticized, but an "inference to the best explanation." Such arguments turn not on assessments of the degree of similarity between effects, but instead on an assessment of the adequacy of competing possible causes for the same effect. Because we know intelligent agents can (and do) produce complex and functionally specified sequences of symbols and arrangements of matter (information so defined), intelligent agency qualifies as a sufficient causal explanation for the origin of this effect. In addition, since naturalistic scenarios have proven universally inadequate for explaining the origin of such information, mind or creative intelligence now stands as the best explanation for the origin of this feature of living systems.

But Is It Science?

Of course, many simply refuse to consider the design hypothesis on grounds that it does not qualify as "scientific." Such critics (see *Ruse* 1988: 103) affirm the extra-evidential principle mentioned above known as methodological naturalism or methodological materialism. Methodological naturalism asserts that, as a matter of definition, for a hypothesis, theory or explanation to qualify as "scientific," it must invoke only materialistic entities. Thus, critics say, the theory of intelligent design does not qualify. Yet, even if one grants this definition, it does not follow that some nonscientific (as defined by methodological naturalism) or metaphysical hypothesis couldn't constitute a better, more causally adequate, explanation of some phenomena than competing materialistic hypotheses. Design theorists argue that, whatever its classification, the design hypothesis does constitute a better explanation than its materialistic rivals for the origin of biological information, irreducibly complex systems and the fine-tuning of the constants of physics. Surely, simply classifying an argument as "not scientific" does not refute it.

In any case, methodological materialism now lacks justification as a normative definition of science. First, attempts to justify methodological materialism by reference to metaphysically neutral (that is, non-question begging) demarcation criteria have failed (see *Meyer* 2000b; *Meyer* 2000c; *Laudan* 2000a: 337-50; *Laudan* 2000b: 351-355; *Plantinga* 1986a: 18-26; *Plantinga* 1986b: 22-34). Second, to assert methodological naturalism as a normative principle for all of science has a negative effect on the practice of certain scientific disciplines, especially those in the historical sciences. In origin-of-life research, for example, methodological materialism artificially restricts inquiry and prevents scientists from considering some hypotheses that might provide the best, most causally adequate explanations. To be a truth-seeking endeavor, the question that origin-of-life researchers must address is not "Which materialistic scenario seems most adequate?" but rather "What actually caused life to arise on Earth?" Clearly, it's at least logically possibly that the answer to the latter question is this: "Life was designed by an intelligent agent that existed before the advent of humans." If one accepts methodological naturalism as normative, however, scientists may never consider the design hypothesis as possibly true. Such an exclusionary logic diminishes the significance of any claim of theoretical superiority for any remaining hypothesis and raises the possibility that the best "scientific" explanation (as defined by methodological naturalism) may not be the best in fact.

As many historians and philosophers of science now recognize, scientific theory-evaluation is an inherently comparative enterprise. Theories that gain acceptance in artificially constrained competitions can claim to be neither 'most probably true' nor 'most empirically adequate.' At best, such theories can be considered the 'most probably true or adequate among an artificially limited set of options.' Thus, an openness to the design hypothesis would seem necessary to any fully rational historical science – that is, to one that seeks the truth, "no holds barred" (*Bridgman* 1955: 535). An historical science committed to following the evidence wherever it leads will not exclude hypotheses *a priori* on metaphysical grounds. Instead, it will employ only metaphysically neutral criteria – such as explanatory power and causal adequacy – to evaluate competing hypotheses. This more open (and seemingly rational) approach to scientific theory evaluation suggests the theory of intelligent design as the best, most causally adequate explanation for the origin of certain features of the natural world, especially including the origin of the specified information necessary to build the first living organism.

Conclusion

Of course, many continue to dismiss intelligent design as nothing but "religion masquerading as science." They point to the theory's obviously friendly implications for theistic belief as a justification for classifying and dismissing the theory as "religion." But such critics confuse the implications of the theory of intelligent design with its evidential basis. The theory of intelligent design may well have theistic implications. But that is not grounds for dismissing it. Scientific theories must be judged by their ability to explain evidence, not by whether they have undesirable implications. Those who say otherwise flout logic and overlook the clear testimony of the history of science. For example, many scientists initially rejected the Big Bang theory because it seemed to challenge the idea of an eternally self-existent universe and pointed to the need for a transcendent cause of matter, space and time. But scientists eventually accepted the theory despite such apparently unpleasant implications because the evidence strongly supported it. Today a similar metaphysical prejudice confronts the theory of intelligent design. Nevertheless, it too must be evaluated on the basis of the evidence, not our philosophical preferences or concerns about its possible religious implications. As Professor Flew, the long-time atheistic philosopher who has come to accept the case for design, advises: we must "follow the evidence wherever it leads."

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