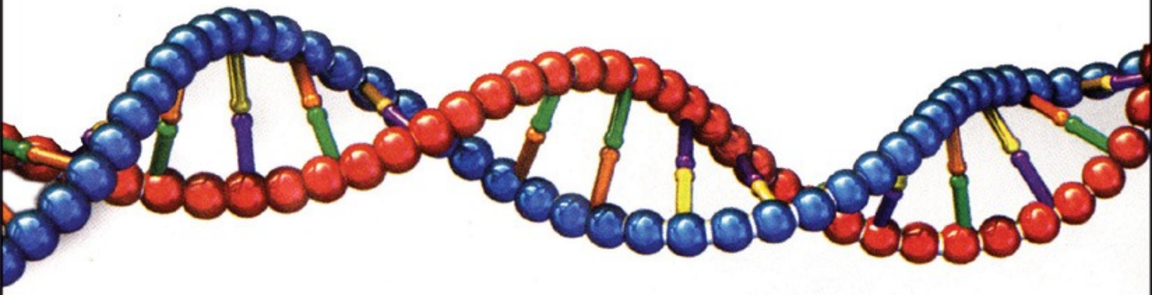

SIGNATURE IN THE CELL

DNA EVIDENCE FOR INTELLIGENT DESIGN

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Signature in the Cell

DNA and the Evidence for Intelligent Design

Stephen C. Meyer

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DNA, Darwin, and the Appearance of Design

When James Watson and Francis Crick elucidated the structure of DNA in 1953, they solved one mystery, but created another.

For almost a hundred years after the publication of *On the Origin of Species* by Charles Darwin in 1859, the science of biology rested secure in the knowledge that it had explained one of humankind's most enduring enigmas. From ancient times, observers of living organisms had noted that living things display organized structures that give the appearance of having been deliberately arranged or designed for a purpose, for example, the elegant form and protective covering of the coiled nautilus, the interdependent parts of the eye, the interlocking bones, muscles, and feathers of a bird wing. For the most part, observers took these appearances of design as genuine. Observations of such structures led thinkers as diverse as Plato and Aristotle, Cicero and Maimonides, Boyle and Newton to conclude that behind the exquisite structures of the living world was a designing intelligence. As Newton wrote in his masterpiece *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…?"[1]

But with the advent of Darwin, modern science seemed able to explain this appearance of design as the product of a purely undirected process. In the *Origin,* Darwin argued that the striking appearance of design in living organisms—in particular, the way they are so well adapted to their environments—could be explained by natural selection working on random variations, a purely undirected process that nevertheless mimicked the powers of a designing intelligence. Since then the appearance of design in living things has been understood by most biologists to be an illusion—a powerfully suggestive illusion, but an illusion nonetheless. As Crick himself put it thirty-five years after he and Watson discerned the structure of DNA, biologists must "constantly keep in mind that what they see was not designed, but rather evolved."[2]

But due in large measure to Watson and Crick's own discovery of the information-bearing properties of DNA, scientists have become increasingly and, in some quarters, acutely aware that there is at least one appearance of design in biology that may not yet have been adequately explained by natural selection or any other purely natural mechanism. Indeed, when Watson and Crick discovered the structure of DNA, they also discovered that DNA stores information using a four-character chemical alphabet. 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.

Crick later developed this idea in his famous “sequence hypothesis,” according to which the chemical parts of DNA (the nucleotide bases) function like letters in a written language or symbols in a computer code. Just as letters in an English sentence or digital characters in a computer program may convey information depending on their arrangement, so too do certain sequences of chemical bases along the spine of the DNA molecule convey precise instructions for building proteins. Like the precisely arranged zeros and ones in a computer program, the chemical bases in DNA convey information in virtue of their “specificity.” As Richard Dawkins notes, “The machine code of the genes is uncannily computer-like.”[3] Software developer Bill Gates goes further: “DNA is like a computer program but far, far more advanced than any software ever created.”[4]

But if this is true, how did the information in DNA arise? Is this striking appearance of design the product of actual design or of a natural process that can mimic the powers of a designing intelligence? As it turns out, this question is related to a long-standing mystery in biology—the question of the origin of the first life. Indeed, since Watson and Crick’s discovery, scientists have increasingly come to understand the centrality of information to even the simplest living systems. DNA stores the assembly instructions for building the many crucial proteins and protein machines that service and maintain even the most primitive one-celled organisms. It follows that building a living cell in the first place requires assembly instructions stored in DNA or some equivalent molecule. As origin-of-life researcher Bernd-Olaf Küppers explains, “The problem of the origin of life is clearly basically equivalent to the problem of the origin of biological information.”[5]

Figure 1.1. James Watson and Francis Crick at the Cavendish Laboratory in Cambridge. *Courtesy of Barrington Brown/Photo Researchers, Inc.*

Much has been discovered in molecular and cell biology since Watson and Crick's revolutionary discovery more than fifty years ago, but these discoveries have deepened rather than mitigated the enigma of DNA. Indeed, the problem of the origin of life (and the origin of the information needed to produce it) remains so vexing that Harvard University recently announced a $100 million research program to address it.[6] When Watson and Crick discovered the structure and information-bearing properties of DNA, they did indeed solve one mystery, namely, the secret of how the cell stores and transmits hereditary information. But they uncovered another mystery that remains with us to this day. This is the DNA enigma—the mystery of the origin of the information needed to build the first living organism.

In one respect, of course, the growing awareness of the reality of information within living things makes life seem more comprehensible. We live in a technological culture familiar with the utility of information. We buy information; we sell it; and we send it down wires. We devise machines to store and retrieve it. We pay programmers and writers to create it. And we enact laws to protect the "intellectual property" of those who do. Our actions show that we not only value information, but that we regard it as a real entity, on par with matter and energy.

That living systems also contain information and depend on it for their existence makes it possible for us to understand the function of biological organisms by reference to our own familiar technology. Biologists have also come to understand the utility of information, in particular, for the operation of living systems. After the early 1960s advances in the field of molecular biology made clear that the digital information in DNA was only part of a complex information-processing system, an advanced form of nanotechnology that mirrors and exceeds our own in its complexity, storage density, and logic of design. Over the last fifty years, biology has advanced as scientists have come to understand more about how information in the cell is stored, transferred, edited, and used to construct sophisticated machines and circuits made of proteins.

The importance of information to the study of life is perhaps nowhere more obvious than in the emerging fields of genomics and bioinformatics. Over the last decade, scientists involved in these disciplines have begun to map—character by character—the complete sequence of the genetic instructions stored on the human genome and those of many other species. With the completion of the Human Genome Project in 2000, the emerging field of bioinformatics entered a new era of public interest. News organizations around the world carried President Clinton's announcement of the project's completion on the White House lawn as Francis Collins, scientific director of the project, described the genome as a "book," a repository of "instructions," and the "book of life."[7] The Human Genome Project, perhaps more than any discovery since the elucidation of the structure of DNA in 1953, has heightened public awareness of the importance of *information* to living things. If Watson and Crick's discovery showed that DNA stores a genetic text, Francis Collins and his team took a huge step toward deciphering its message. Biology has irrevocably entered an information age.

In another way, however, the reality of information within living things makes life seem more mysterious. For one thing, it is difficult to understand exactly what information *is*. When a personal assistant in New York types a dictation and then prints and sends the result via fax to Los Angeles, some *thing* will arrive in L.A. But that thing—the paper coming out of the fax machine—did not originate in New York. Only the information on the paper came from New York. No single physical substance—not the air that carried the boss's words to the dictaphone, or the recording tape in the tiny machine, or the paper that entered the fax in New York, or the ink on the paper coming out of the fax in Los Angeles—traveled all the way from sender to receiver. Yet something did.

The elusive character of information—whether biological or otherwise—has made it difficult to define by reference to standard scientific categories. As evolutionary biologist George Williams notes, "You can speak of galaxies and particles of dust in the same terms because they both have mass and charge and length and width. [But] you can't do that with information and matter."[8] A blank magnetic tape, for example, *weighs* just as much as one "loaded" with new software—or with the entire sequence of the human genome. Though these tapes differ in information content (and value), they do not do so because of differences in their material composition or mass. As Williams concludes, "Information doesn't have mass or charge or length in millimeters. Likewise matter doesn't have bytes…. This dearth of shared descriptors makes matter and information two separate domains."[9]

When scientists during the late 1940s began to define information, they did not make reference to physical parameters such as mass, charge, or watts. Instead, they defined information by reference to a psychological state—the reduction of uncertainty—which they proposed to measure using the mathematical concept of probability. The more improbable a sequence of characters or signals, the more uncertainty it reduces, and thus the more information it conveys.[10]

Not surprisingly, some writers have come close to equating information with thought itself. The information technology guru George Gilder, for example, notes that developments in fiber optics have allowed more and more information to travel down smaller and smaller (and lighter and lighter) wires. Thus, he notes that as technology advances, we convey ever more thought across ever less matter—where the numerator in that ratio, namely, thought, corresponds precisely to information.[11]

So should we think of information as thought—as a kind of mental chimera etched in stone or burned onto compact discs? Or can we define information less abstractly as, perhaps, just an improbable arrangement of matter?

Whatever information is—whether thought or an elaborate arrangement of matter—one thing seems clear. What humans recognize as information certainly *originates* from thought—from conscious or intelligent activity. A message received via fax by one person first arose as an idea in the mind of another. The software stored and sold on a compact disc resulted from the design of a software engineer. The great works of literature began first as ideas in the minds of writers—Tolstoy, Austen, or Donne. Our experience of the world shows that what we recognize as information invariably reflects the prior activity of conscious and intelligent persons.

What, then, should we make of the presence of information in living organisms? The Human Genome Project, among many other developments in modern biology, has pressed this question to the forefront of public awareness. We now know that we do not just create information in our own technology; we also find it in our biology—and, indeed, in the cells of every living organism on earth. But how did this information arise?

And what does the presence of information in even the simplest living cell imply about life and its origin? Who or what "wrote" the book of life?

The information age in biology officially began in the mid-1950s with the elucidation of the chemical structure and information-bearing properties of DNA (deoxyribonucleic acid)—the molecule of heredity. Beginning in 1953 with their now famous communication to the British scientific journal *Nature,* James Watson and Francis Crick identified DNA as the molecular repository of genetic information.[12] Subsequent developments in the field of molecular biology confirmed this idea and showed that the precisely sequenced bases attached to the helical backbone of DNA store the information for building proteins—the sophisticated enzymes and machines that service the cells in all living things.

Though the discovery of the information-bearing properties of DNA dates back over a half century, the recognition of the full significance of this discovery has been slow in coming. Many scientists have found it difficult to relinquish an exclusive reliance upon the more traditional scientific categories of matter and energy. As George Williams (himself an evolutionary biologist) notes, "Evolutionary biologists have failed to realize that they work with two more or less incommensurable domains: that of information and that of matter…. The gene is a package of information, not an object. The pattern of base pairs in a DNA molecule specifies the gene. But the DNA molecule is the medium, it's not the message."[13]

Yet this recognition begs deeper questions. What does it mean when we find information in natural objects—living cells—that we did not ourselves design or create? As the information theorist Hubert Yockey observes, the "genetic code is constructed to confront and solve the problems of communication and recording by the same principles found…in modern communication and computer codes." Yockey notes that "the technology of information theory and coding theory has been in place in biology for at least 3.85 billion years," or from the time that life first originated on earth.[14] What should we make of this fact? How did the information in life first arise?

Our commonsense reasoning might lead us to conclude that the information necessary to the first life, like the information in human technology or literature, arose from a designing intelligence. But modern evolutionary biology rejects this idea. Many evolutionary biologists admit, of course, that living organisms "appear to have been carefully and artfully designed," as Richard Lewontin puts it.[15] As Richard Dawkins states, "Biology is the study of complex things that appear to have been designed for a purpose."[16] Nevertheless, Lewontin and Dawkins, like evolutionary biologists generally, insist that the appearance of design in life is illusory. Life, they say, looks designed, but was not designed by an actual intelligent or purposive agent.

Darwin's Designer Substitute

Why do evolutionary biologists so confidently assert that the appearance of design in living organisms is illusory? Of course, the answer to this question is well known. Evolutionary biologists have a theory that can apparently explain, or explain away, the appearance of design without invoking an actual designer. According to classical Darwinism, and now modern neo-Darwinism, the mechanism of natural selection acting on random variations (or mutations) can mimic the effects of intelligence, even though the mechanism is, of course, entirely blind, impersonal, and undirected.[17]

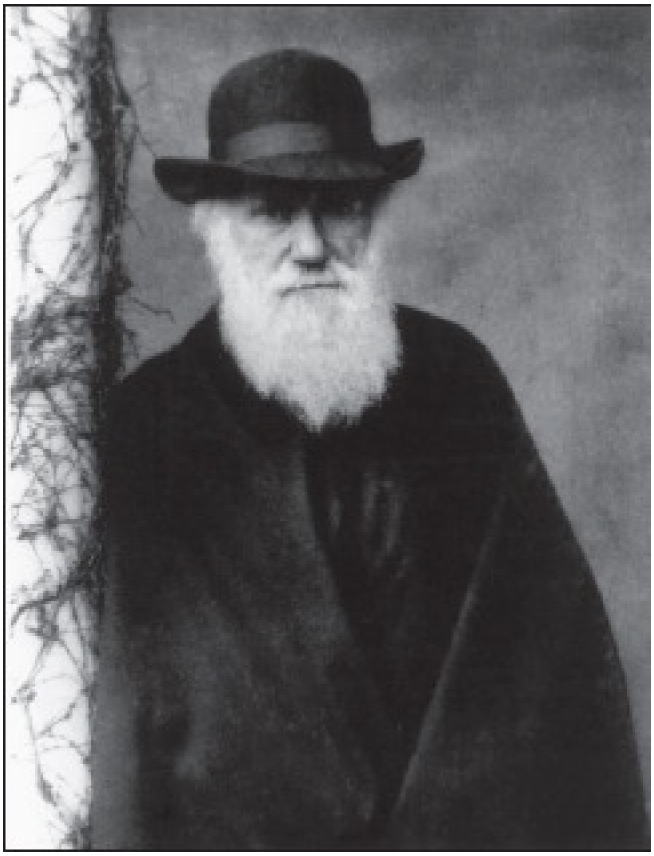

Figure 1.2. English naturalist Charles Robert Darwin (1809–82), age seventy-two. *Courtesy of SPL/Photo Researchers, Inc.*

Darwin developed his principle of natural selection by drawing on an analogy with artificial selection: the process of selective breeding to change the characteristics (whether anatomical, physiological, or behavioral) of a group of organisms. For example, a farmer might observe that some of his young stallions are faster than others. If he allows only the fastest of these to breed with the fastest mares, then, after several generations of selective breeding, he will own a small group of speedy "thoroughbreds" suitable for racing on the Downs.

Darwin realized that nature could imitate this process of selective breeding. The presence of unusually fast predatory wild cats would imperil all but the fastest horses in a wild herd. After several generations of such predatory challenge, the speed of the remaining herd might exhibit a discernable increase. Thus, environmental forces (predators, changes in weather, competition for food, etc.) could accomplish the work of a human breeder. By causing a population to adapt to its environment, blind forces of nature could come to mimic, over time, the action of a selecting or designing intelligence.

Yet if natural selection, as Darwin called this process, could improve the speed of a horse or an antelope, why couldn't it also produce those animals in the first place? "Reason," wrote Darwin "ought to conquer…imagination"[18]—namely, our incredulity about the possibility of such happenings and our impression that living things appear to have been designed. According to Darwin, if given enough time, nature's selective power might act on any variation perfecting any structure or function far beyond what any human could accomplish. Thus, the complex systems in life that we reflexively attribute to intelligence have wholly natural causes. As Darwin explained, "There seems to be no more design in the variability of organic beings, and in the action of natural selection, than in the course which the wind blows."[19] Or as evolutionary biologist Francisco Ayala explains, "The functional design of organisms and their features would…seem to argue for the existence of a designer. It was Darwin's greatest accomplishment [however] to show that the directive organization of living beings can be explained as the result of a natural process, natural selection, without any need to resort to a Creator or other external agent."[20] Thus, Ayala and other Darwinian biologists not only affirm that natural selection can produce "design without a designer," they also assert that it is "creative without being conscious."[21]

The Appearance of Design

To many outside evolutionary biology, the claim that design arises without a designer may seem inherently contradictory. Yet, in theory at least, the possibility that life is not what it seems represents nothing particularly unusual. Science often shows that our perceptions of nature do not match reality. A straight pencil appears bent when inserted in a glass of water; the sun appears to circle the earth; and the continents appear immobile. Perhaps, living organisms only appear to be designed.

Even so, there is something curious about the scientific denial of our ordinary intuition about living things. For almost a hundred and fifty years, since its putative explanation by Darwinian theory, this impression of design persists as incorrigibly as ever. Public opinion polls suggest that nearly 90 percent of the American public does not accept the full-fledged neo-Darwinian account of evolution with its denial of any role for a purposeful creator.[22] Though many of these people accept some form of evolutionary change and have a high view of science generally, they apparently cannot bring themselves to repudiate their deepest intuitions and convictions about the design of the living world. In every generation since the 1860s, scientific critics of Darwinism and neo-Darwinism have arisen marshaling serious evidential objections to the theory. Since the 1980s a growing number of scientists and scholars have expressed deep reservations about both biological and chemical evolutionary theory, each with their implicit denial of design. And even orthodox evolutionary biologists admit the overwhelming *impression* of design in modern organisms. To quote Francis Crick again, "Biologists *must constantly keep in mind* that what they see was not designed, but rather evolved."[23]

Perhaps more curiously, modern biologists can scarcely describe living organisms without resorting to language that seems to imply the very thing they explicitly deny: intentional and purposive design. As philosopher of science Michael Ruse notes, biologists ask about "the *purpose* of the fins on the back of the stegosaurus" or "the *function* of the bird's feathers" and discuss whether "the Irish elk's antlers did or did not exist *in order* to intimidate rivals." "It is true," Ruse continues, "that during the nineteenth century [some physicists] suggested that the moon exists in order to light the way home of lonely travelers, but no physicist would use such language today. In biology, however, especially evolutionary biology, this kind of talk is commonplace." He concludes, "The world of the evolutionist is drenched in the anthropomorphism of intention." And yet "paradoxically, even the severest critics" of such intentional language slip into it "for the sake of convenience."[24]

In theory, at least, the use of such metaphor in science derives from ignorance. Physicists talk about gravitational "attraction," because they don't really know what causes action at a distance. Metaphors reign where mystery resides. Yet, on these grounds, we might have expected that as biology advanced, as new discoveries explicated the molecular basis of biological functions, biology's reliance upon the language of purpose, upon teleological metaphor, might have diminished. Yet the very opposite has taken place. The advent of the most reductionistic subdiscipline of modern biology—molecular biology—has only deepened our dependence on teleological language.

In fact, molecular biologists have introduced a new "high-tech" teleology, taking expressions, often self-consciously, from communication theory, electrical engineering, and computer science. The vocabulary of modern molecular and cell biology includes apparently accurate descriptive terms that nevertheless seem laden with a "meta-physics of intention": "genetic code," "genetic information," "transcription," "translation," "editing enzymes," "signal-transduction circuitry," "feedback loop," and "information-processing system." As Richard Dawkins notes, "Apart from differences in jargon, the pages of a molecular-biology journal might be interchanged with those of a computer-engineering journal."[25] As if to underscore the point, University of Chicago cell biologist James Shapiro describes the integrated system of proteins that constitutes the mammalian blood-clotting system "as a powerful real-time distributed computing system." In the same context he notes that many biochemical systems within the cell resemble "the wiring diagram for an electronic circuit."[26] As the historian of biology Timothy Lenoir observes, "Teleological thinking has been steadfastly resisted by modern biology. And yet in nearly every area of research, biologists are hard pressed to find language that does not impute purposiveness to living forms."[27]

Thus, it seems that an acquaintance with biological organisms, to say nothing of the molecular biology of the cell, leads even those who repudiate design to use language that seems incompatible with their own reductionistic and Darwinian perspective—with their official denial of actual design. Although this may ultimately signify nothing, it does at least raise a question. Does the persistence of our perception of design, and the use of incorrigibly teleological language, indicate anything about the origin of life or the adequacy of scientific theories that deny (actual) design in the origin of living systems?

As always, in science the answer to such questions depends entirely on the justification that scientists can provide for their theories. Intuitions and perceptions can be right or wrong. It might well be, as many in biology assure us, that public and even scientific doubts about evolutionary theory derive solely from ignorance or religious prejudice, and that teleological language reflects nothing more than a metaphor of convenience, like saying the sun has set behind the horizon. Yet the persistence of dissenting scientific opinion and the inability of biologists to avoid the language of purpose raise a pardonable curiosity. Have evolutionary biologists discovered the true cause of the appearance of design in living systems, or should we look for another? Should we trust our intuitions about living organisms or accept the standard evolutionary account of biological origins?

The Origin of Biological Information

Consider the following sequence of letters:

AGTCTGGGACGCGCCGCCGCCATGATCATCCCTGTACGCTGCTTCACTTGT
GGCAAGATCGTCGGCAACAAGTGGGAGGCTTACCTGGGGCTGCTGCAGGC
CGAGTACACCGAGGGGTGAGGCGCGGGCCGGGGCTAGGGGCTGAGTCCGC
CGTGGGGCGCGGGCCGGGGCTGGGGGCTGAGTCCGCCCTGGGGTGCGCGC
CGGGGCGGGAGGCGCAGCGCTGCCTGAGGCCAGCGCCCCATGAGCAGCT
TCAGGCCCGGCTTCTCCAGCCCCGCTCTGTGATCTGCTTTCGGGAGAACC

This string of alphabetic characters looks as if it could be a block of encoded information, perhaps a section of text or machine code. That impression is entirely correct, for this string of characters is not just a random assortment of the four letters A, T, G, and C, but a representation of part of the sequence of genetic assembly instructions for building a protein machine—an RNA polymerase[28]—critical to gene expression (or information processing) in a living cell.

Now consider the following string of characters:

01010111011010000110010101101110001000000110100101
10111000100000001110100011010000110010100100000010
00011011011110111010101110010011100110110010100100
00000110111101100110001000000011010000111010101101
01011000010110111000100000001100101011101100110010
10110111001110100011100110010000001101001011101000

This sequence also appears to be an information-rich sequence, albeit written in binary code. As it happens, this sequence is also not just a random array of characters, but the first words of the Declaration of Independence ("When in the course of human events…")[29] written in the *binary conversion* of the American Standard Code for Information Interchange (ASCII). In the ASCII code, short specified sequences of zeros and ones correspond to specific alphabetic letters, numerals, or punctuation marks.

Though these two blocks of encoded information employ different conventions (one uses the ASCII code, the other the genetic code), both are complex, nonrepeating sequences that are highly specified relative to the functional or communication requirements that they perform. This similarity explains, in part, Dawkins's observation that, "The machine code of the genes is uncannily computer-like." Fair enough. But what should we make of this similarity between informational software—the undisputed product of conscious intelligence—and the informational sequences found in DNA and other important biomolecules?

Introduction to an Enigma

I first encountered the DNA enigma as a young scientist in Dallas, Texas, in 1985. At the time, I was working for one of the big multinational oil companies. I had been hired as an exploration geophysicist several years earlier just as the price of oil had spiked and just as I was graduating from college with degrees in physics and geology. My job, as the Texas oilmen put it, was to "look for *awl* out in the *guff*."

Though I had been a physics and geology student, I had enough exposure to biology to know what DNA did. I knew that it stored the instruction set, the information, for building proteins in the cell and that it transmitted hereditary traits in living things using its four-character chemical alphabet. Even so, like many scientists I had never really thought about where DNA—or the information it contained—came from in the first place. If asked, I would have said it had something to do with evolution, but I couldn't have explained the process in any detail.

On February 10, 1985, I learned that I wasn't the only one. On that day I found myself sitting in front of several world-class scientists who were discussing a vexing scientific and philosophical question: How did the first life on earth arise? As recently as the evening before, I had known nothing about the conference where this discussion was now taking place. I had been attending another event in town, a lecture at the Southern Methodist University by a Harvard astronomer discussing the big-bang theory. There I learned of a conference taking place the following day that would tackle three big scientific questions—the origin of the universe, the origin of life, and the nature of human consciousness. The conference would bring together scientists from competing philosophical perspectives to grapple with each of these issues. The next morning I walked into the downtown Hilton where the conference was being held and heard an arresting discussion of what scientists knew they didn't know.

I was surprised to learn—contrary to what I had read in many text-books—that the leading scientific experts on the origin of life had no satisfactory explanation for how life had first arisen. These experts, many of whom were present that weekend in Dallas, openly acknowledged that they did not have an adequate theory of what they called “chemical evolution,” that is, a theory of how the first living cell arose from simpler chemicals in the primordial ocean. And from their discussions it was clear that DNA—with its mysterious arrangements of chemical characters—was a key reason for this impasse.

The discussion changed the course of my professional life. By the end of that year, I was preparing to move to the University of Cambridge in England, in part to investigate questions I first encountered on that day in February.

On its face, my change of course looked like a radical departure from my previous interests, and that’s certainly how my friends and family took it. Oil-company geophysics was a highly practical, commercially relevant form of applied science. A successful study of the subsurface of the earth could net the company millions of dollars of revenue from the resulting discovery of oil and gas. The origin of life, however, was a seemingly intractable—even arcane—theoretical question, with little or no direct commercial or practical import.

Nevertheless, at the time, the transition seemed entirely natural to me. Perhaps it was because I had long been interested in scientific questions and discoveries that raised larger philosophical issues. In college, I had taken many philosophy courses while pursuing my scientific training. But perhaps it was what I was doing at the oil company itself. By the 1980s looking for oil required the use of sophisticated computer-assisted seismic-imaging techniques, at the time a cutting-edge form of information technology. After sending artificial seismic waves down into the earth, geophysicists would time the resulting echoes as they traveled back to the surface and then use the information from these signals to reconstruct a picture of the subsurface of the earth. Of course, at every stage along the way we depended heavily on computers and computer programs to help us process and analyze the information we received. Perhaps what I was learning about how digital information could be stored and processed in machines and about how digital code could direct machines to accomplish specific tasks made life itself—and the digital code stored in its DNA—seem less mysterious. Perhaps this made the problem of the origin of life seem more scientifically tractable and interesting. In any case, when I learned of the enigma confronting origin-of-life researchers and why DNA was central to it, I was hooked.

A controversy that erupted at the conference added to my sense of intrigue. During a session on the origin of life, the scientists were discussing where the information in DNA had come from. How do chemicals arrange themselves to produce code? What introduced drama into what might have otherwise been a dry academic discussion was the reaction of some of the scientists to a new idea. Three of the scientists on the panel had just published a controversial book called *The Mystery of Life’s Origin* with a prominent New

York publisher of scientific monographs. Their book provided a comprehensive critique of the attempts that had been made to explain how the first life had arisen from the primordial ocean, the so-called prebiotic soup. These scientists, Charles Thaxton, Walter Bradley, and Roger Olsen, had come to the conclusion that all such theories had failed to explain the origin of the first life. Surprisingly, the other scientists on the panel—all experts in the field—did not dispute this critique.

What the other scientists did dispute was a controversial new hypothesis that Thaxton and his colleagues had floated in the epilogue of their book in an attempt to explain the DNA enigma. They had suggested that the information in DNA might have originated from an intelligent source or, as they put it, an "intelligent cause." Since, in our experience, information arises from an intelligent source, and since the information in DNA was, in their words, "mathematically identical" to the information in a written language or computer code, they suggested that the presence of information in DNA pointed to an intelligent cause. The code, in other words, pointed to a programmer.

That was where the fireworks started. Other scientists on the panel became uncharacteristically defensive and hostile. Dr. Russell Doolittle, of the University of California at San Diego, suggested that if the three authors were not satisfied with the progress of origin-of-life experiments, then they should "do them." Never mind that another scientist on the panel who had favored Thaxton's hypothesis, Professor Dean Kenyon, of San Francisco State University, was a leading origin-of-life researcher who had himself performed many such experiments. It was clear that Doolittle regarded the three scientists, despite their strong credentials, as upstarts who had violated some unspoken convention. Yet it was also clear, to me at least, that the authors of the new book had seized the intellectual initiative. They had offered a bold new idea that seemed at least intuitively plausible, while those defending the status quo offered no plausible alternative to this new explanation. Instead, the defenders of the status quo were forced to accept the validity of the new critique. All they could do was accuse the upstarts of giving up too soon and plead for more time.

I left deeply intrigued. If my sense of the scientific status of the problem was accurate—if there was no accepted or satisfactory theory of the origin of the first life—then a mystery was at hand. And if it was the case that evolutionary theory could not explain the origin of the first life *because it could not explain the origin of the genetic information in DNA,* then something that we take for granted was quite possibly an important clue in a mystery story. DNA with its characteristic double-helix shape is a cultural icon. We see the helix in everything from music videos and modern art to science documentaries and news stories about criminal proceedings. We know that DNA testing can establish guilt, innocence, paternity, and distant genealogical connections. We know that DNA research holds the key to understanding many diseases and that manipulating DNA can alter the features of plants and animals and boost food production. Most of us know roughly what DNA is and what it does. But could it be that we do not know anything about where it came from or how it was first formed?

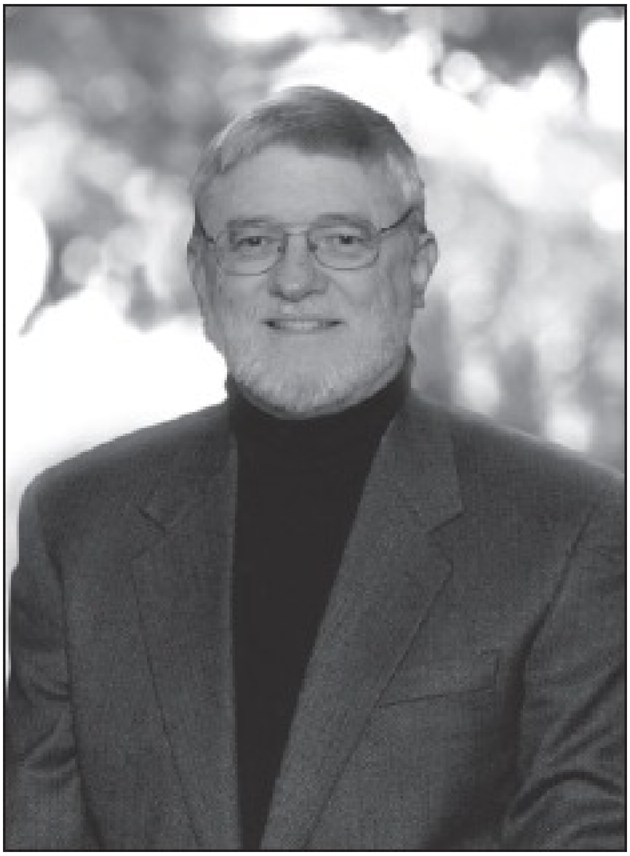

Figure 1.3. Charles Thaxton. *Printed by permission from Charles Thaxton.*

The controversy at the conference served to awaken me to the strange combination of familiarity and mystique that surrounds the double helix and the digital code it contains. In the wake of the conference, I learned that one of the scientists who participated in the origin-of-life discussion was living in Dallas. It was none other than Charles Thaxton, the chemist who with his coauthors had proposed the controversial idea about an intelligence playing a role in the origin of biological information. I called him, and he offered to meet with me. We began to meet regularly and talk, often long after work hours. As I learned more about his critique of "origin-of-life studies" and his ideas about DNA, my interest in the DNA enigma grew.

These were heady and exciting days for me as I first encountered and grappled with these new ideas. If Thaxton was right, then the classical design argument that had been dismissed first by Enlightenment philosophers such as David Hume in the eighteenth century and then later by evolutionary biologists in the wake of the Darwinian revolution might have legitimacy after all. On a visit back home to Seattle, I described what I had been learning to one of my earlier college mentors whose critical faculties I greatly respected, a philosophy professor named Norman Krebbs. He surprised me when he told me that the scientific idea I was describing was potentially one of the most significant *philosophical* developments in three hundred years of Western thought. Could the design argument be resuscitated based upon discoveries in modern science? And was DNA the key?

As intriguing as this new line of thinking was for me, I had a growing list of questions. I wondered, what exactly is information in a biological context? When biologists referred to the sequences of chemicals in the DNA molecule as “information,” were they using the term as a metaphor? Or did these sequences of chemicals really function in the same way as “code” or “text” that humans use? If biologists were using the term merely as a metaphor, then I wondered whether the genetic information designated anything real and, if not, whether the “information” in DNA could be said to point to anything, much less an “intelligent cause.”

But even if the information in DNA was in some important sense similar to the information that human agents devise, it didn’t necessarily follow that a prior intelligent cause was the only explanation of such information. Were there causes for information that had not yet been considered at the conference that day? Maybe some other cause of information would be discovered that could provide a better explanation for the information necessary for the origin of life. In short, I wondered, is there really evidence for the intelligent design of life, and if so, just how strong is that evidence? Was it, perhaps, scientifically premature or inappropriate to consider such a radical possibility, as Thaxton’s critics had suggested?

My concerns about this were heightened because of some of the things that Thaxton and his colleagues had written to justify their conclusion. *The Mystery of Life’s Origin* had made the radical claim that an intelligent cause could be considered a legitimate *scientific* hypothesis for the origin of life. To justify this claim Thaxton and colleagues argued that a mode of scientific inquiry they called *origins science* allowed for the postulation of singular acts of intelligence to explain certain phenomena. Thaxton and his colleagues distinguished what they called “origins sciences” from “operation sciences.” Operation sciences, in their view, focus on the ongoing operation of the universe. These sciences describe recurring phenomena like the motions of the planets and chemical reactions that can be described by general laws of physics and chemistry. Origins sciences, on the other hand, deal with unique historical events and the causes of those events—events such as the origin of the universe, the formation of the Grand Canyon, and the invention of ancient tools and agriculture. Thaxton and his colleagues argued that inferring an intelligent cause was legitimate in *origins science,* because such sciences deal with singular events, and the actions of intelligent agents are usually unique occurrences. On the other hand, they argued that it was not legitimate to invoke intelligent causes in operations sciences, because such sciences only deal with regular and repeating phenomena. Intelligent agents don’t act in rigidly regular or lawlike ways and, therefore, cannot be described mathematically by laws of nature.

Though their terminology was admittedly cumbersome, it did seem to capture an intuitively obvious distinction. But still I had questions. Thaxton had argued that theories in the operation sciences are readily testable against the repeating phenomena they describe. Regularity enables prediction. If a theory describing a repeating phenomenon was correct, then it should be able to predict future occurrences of that phenomenon at a specific time or under controlled laboratory conditions. Origins theories, however, do not make such predictions, because they deal with unique events. For this reason, Thaxton thought that such theories could not be tested. Theories about the past can produce plausible, but never decisive conclusions. As a geophysicist, I knew that earth scientists often formed hypotheses about past events, but I wasn't sure that such hypotheses were never testable or decisive. We have very good scientific reasons for thinking that dinosaurs existed before humans and that agriculture arose after the last ice age. But if Thaxton was right, then such conclusions about the past were merely plausible—no more than possibly true—and completely untestable.

Yet I wondered if a hypothesis about the past couldn't be tested—if there is no way to judge its strength or compare it against that of competing hypotheses—then why regard the claims of historical or "origins" theories as significant? It is provocative to claim that the evidence from DNA and our best scientific reasoning points strongly to an intelligent cause of life. It is not very interesting to claim that it is possibly true ("plausible") that DNA owes its origin to such cause. Many statements are merely plausible or possibly true. But that doesn't mean we have any reason to think them likely to be true. Rigorous scientific testing usually provides evidence-based reasons for making such claims or for preferring one hypothesis over another. Absent such testability, I wasn't sure how significant, or *scientific,* Thaxton's argument really was.

Even so, I was deeply fascinated with the whole issue. In September 1985, I learned that I was to be laid off from my oil-company job, as the price of oil had dropped from $32 to $8 per barrel. I was strangely relieved. I used the rather generous severance the company provided to begin supporting myself as a freelance science writer. But soon after I started, I also learned that I had received a Rotary scholarship to study in England. The following spring a thin airmail letter arrived informing me that I had been accepted to study the history and philosophy of science at the University of Cambridge. This course of study would enable me to explore many of the questions that had long fascinated me at the intersection of science and philosophy. It would also allow me to investigate the questions that had arisen in my discussions with Charles Thaxton.

What methods do scientists use to study biological origins? Is there a distinctive method of historical scientific inquiry? And what does the scientific evidence tell us about the origin of biological information and how life began? Is it possible to make a rigorous scientific argument for the intelligent design of life? I eventually completed a Ph.D. dissertation on the topic of origin-of-life biology. In it, I was able to investigate not only the history of scientific ideas about the origin of life, but also questions about the definition of science and about how scientists study and reason about the past.

The Current Controversy

I couldn’t have known as I was leaving for England, but the two main questions I had about Dr. Thaxton’s idea—“Is it scientific?” and “How strong is the evidence for it?”—would resurface with a vengeance twenty years later at the center of an international controversy, indeed, one that would engage the attention of the mainstream media, the courts, the scientific establishment, and the publishing and movie industries. In 2005, a federal judge would rule that public-school science students in Dover, Pennsylvania, could not learn about the idea that life pointed to an intelligent cause, because the idea was neither scientific nor testable. Mainstream scientific organizations—such as the National Academy of Sciences and American Association for the Advancement of Science—would issue similar pronouncements.

In 2006 and 2007, a spate of books with titles like *The God Delusion* and *God Is Not Great* would argue there is no evidence for design in biology and, therefore, no good evidence for the existence of God. According to Oxford evolutionary biologist Richard Dawkins and other New Atheists, the lack of evidence for design has made the idea of God tantamount to a “delusion.” In 2008, the controversy surrounding what is now known as the “theory of intelligent design” moved into movie theaters, video stores, and candidate press conferences. And this year, with the celebration of the 200th anniversary of Darwin’s birth and the 150th anniversary of the publication of *On the Origin of Species,* the main question that Darwin himself addressed—“Was life designed or does it merely *appear* designed?”—has reemerged as scientists, scholars, teachers, and media commentators evaluate his legacy.

Yet in all of this discussion—from Dover to Dawkins to Darwin’s big anniversary—there has been very little discussion of DNA. And yet for me and many other scientists and scholars, the question of whether science has refuted the design argument or resuscitated it depends critically upon the central mystery of the origin of biological information. This book examines the many successive attempts that have been made to resolve this enigma—*the DNA enigma*—and will itself propose a solution.