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DARWIN'S DOUBT AND THE CASE FOR INTELLIGENT DESIGN

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SYNOPSIS

Charles Darwin knew there was a significant event in the history of life that his theory did not explain. During this event, known today as the "Cambrian explosion," many animals suddenly appeared in the fossil record without apparent ancestors in earlier layers of rock. In recent years, the mystery of the Cambrian explosion has intensified, not only because the expected ancestors of these animals have not been found but also because scientists have learned more about what it takes to construct an animal—specifically, vast amounts of new biological information. This discovery suggests intelligent design, as opposed to an undirected process such as natural selection and random mutation, as the best explanation of the explosive origin of animal life.

When Charles Darwin completed *On the Origin of Species* in 1859, he was convinced that he had explained every clue but one. Like a great Gothic cathedral, his ambitious theory integrated many disparate elements into a grand synthesis, explaining phenomena in fields as diverse as comparative anatomy, paleontology, embryology, and biogeography.

Despite the scope of his synthesis, there was one set of facts that troubled Darwin—something he conceded his theory couldn't adequately explain. Darwin was puzzled by a pattern in the fossil record that seemed to document the geologically sudden appearance of animal life in a remote period of the earth's history, the Cambrian period. During this geological period, many new and anatomically complex creatures—such as trilobites with their compound eyes and articulated exoskeletons—appeared suddenly in the sedimentary layers without any evidence of simpler ancestral forms in the earlier layers below.

The sudden appearance of animals so early in the fossil record did not easily accord with Darwin's picture of gradual evolutionary change. Indeed, Darwin had depicted the history of life as a *gradually* unfolding branching tree, with the trunk representing the first simple one-celled organisms and the branches representing all the

forms of life that had evolved from these simple forms. Thus, as Darwin envisioned the history of life, complex animals such as trilobites, for instance, would have arisen from a series of simpler precursors and intermediate forms over vast stretches of geologic time. As Darwin noted, "If my theory be true, it is indisputable that before the lowest . . . [Cambrian] stratum was deposited, long periods elapsed . . . and that during these vast, yet quite unknown, periods of time, the world swarmed with living creatures."[1] Yet Darwin knew that the Precambrian fossil record did not attest to such a rainbow of intermediate forms leading to the Cambrian animals.

As a result of these difficulties, Darwin frankly expressed his puzzlement in the *Origin of Species* about this mysterious event. "The difficulty of assigning any good reason for the absence of vast piles of strata rich in fossils beneath the Cambrian system is very great," he wrote. "The case at present must remain inexplicable; and may be truly urged as a valid argument against the views here entertained."[2]

Of course, Darwin hoped the mystery of the missing ancestral fossils would be solved by the eventual discovery of numerous transitional forms in the Precambrian fossil record. Since he anticipated that future discoveries would resolve the Cambrian mystery, he did not doubt the
ultimate truth of his theory, only its ability to explain all the evidence. Yet what Darwin saw as a minor anomaly has turned out to be the leading edge of two unresolved mysteries and a fundamental problem now affecting all of evolutionary biology.

THE MYSTERY OF THE MISSING FOSSILS

Darwin thought that the fossil record was woefully incomplete. Thus, he expected that future fossil discoveries would eliminate the problem posed by the abrupt appearance of animals in the Cambrian period. But the opposite happened. In the 150 years since the publication of *On the Origin of Species*, scientists have combed Precambrian strata worldwide for the alleged precursors to the Cambrian animals, but they haven't found the evolutionary ancestors that Darwin anticipated. Instead, they have made new discoveries that have shown that the Cambrian explosion was an even more explosive event than Darwin knew.

After Darwin's time, the first major Cambrian-era fossil discovery took place in 1909 when Charles Doolittle Walcott discovered a trove of Cambrian animals in the Burgess Shale in the Canadian Rockies. There Walcott found the fossilized remains of an astonishing array of novel, often bizarre marine invertebrates, each of which lacked discernible evolutionary ancestors in Precambrian strata. He also discovered soft- and hard-bodied animals preserved in exquisite detail. The discovery showed that the origin of new animal forms in the Cambrian was an even more explosive event than previously thought. Far from resolving Darwin's doubt, Walcott's discovery merely deepened the Cambrian mystery.

The Explosion Intensifies

Over the next decades, additional discoveries of Cambrian animals were made, but the most spectacular Cambrian find took place in 1984 near the town of Chengjiang, in

southern China. The fossils there beautifully preserved the structure of a variety of ancient Cambrian animals, including many animals such as fish that had never before been found in Cambrian-era rocks. As a result, paleontologists had to again reassess their understanding of the scope of the Cambrian explosion. Most paleontologists now believe that at least twenty new animal phyla with unique body plans first arose in the Cambrian. Moreover, after the discoveries in China, scientists concluded that the Cambrian explosion took place many times faster than had been previously believed, in a geological blink of the eye.

A DEEPER MYSTERY: HOW TO BUILD AN ANIMAL

There is a second, and arguably deeper, mystery associated with the Cambrian explosion: could the neo-Darwinian mechanism of natural selection and random mutation have built these animals and done so quickly enough to account for the pattern in the fossil record? That question became acute in the second half of the twentieth century as biologists learned more about what it takes to build an animal.

When I was a college professor, I used to ask my students, "If you want your computer to acquire a new function or capability, what do you have to give it?" Typical answers included: "code," "instructions," "software," "information." All these answers were correct. And we now know that something similar is true of life: to build a new form of animal life from a simpler preexisting form requires the generation of new biological information.

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. Strings of precisely sequenced chemicals called nucleotide bases store and transmit the assembly instructions—the information—for building the crucial protein molecules that 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 alphabetic letters in a written language or digital characters 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 DNA molecule carries the same kind of "specified" or "functional" information that characterizes written texts or computer codes. As Richard Dawkins acknowledged, "The machine code of the genes is uncannily computer-like."[3] Or as Bill Gates has noted, "DNA is like a computer program, but far, far more advanced than any software ever created."[4]

The Cambrian Information Explosion

The Cambrian period is marked by an explosion of new animal body plans. But building new body plans requires new organs, tissues, and cell types. And new cell types require many kinds of specialized or dedicated proteins. For example, animals with gut cells require new digestive enzymes (proteins). But building new proteins requires genetic information stored on the DNA molecule. Thus, building new animals

with distinctive new body plans requires, at the very least, vast amounts of new genetic information. Building a new animal body plan also requires another type of information, not stored in genes, called epigenetic information, which I have discussed elsewhere.[5]

During the Cambrian period, a veritable carnival of novel biological forms arose. But since new biological form requires new genetic information, the Cambrian explosion of animal life also required an information explosion unparalleled in the previous history of life. If the origin of the Cambrian animals required vast amounts of new functional information, what produced the explosion of information necessary to produce these new forms of life? Is it plausible to think that the neo-Darwinian mechanism of natural selection acting on random mutations in DNA could produce the highly *specific* arrangements of bases in DNA (the chemicals that function as alphabetic or digital characters) necessary to generate the protein building blocks of new cell types and novel forms of life? Definitely not.

THE COMBINATORIAL INFLATION PROBLEM

According to neo-Darwinian theory, new genetic information arises first as random mutations occur in the DNA of existing organisms. When mutations arise that confer a survival advantage on the organisms that possess them, the resulting genetic changes are passed on by natural selection to the next generation. As such changes accumulate, the features of a population change over time. Nevertheless, natural selection can only "select" what *random* mutations first generate. Thus, for natural selection to preserve any significant functional or anatomical innovation, random mutations must first produce new genetic information for building novel proteins.

Nevertheless, when it comes to producing new genetic information, the neo-Darwinian mechanism, with its reliance on random mutations, faces a kind of needle-in-the-haystack problem—or what mathematicians call a "combinatorial problem." "Combinatorial" refers to the number of possible ways that a set of objects can be arranged. Many simple bike locks, for example, have four dials with ten settings on each dial. A bike thief encountering one of these locks (and lacking bolt cutters) faces a combinatorial problem because there are 10 × 10 × 10 × 10 or 10,000 possible ways of combining the possible settings on the four dials and only one combination that will open the lock. A random search of possible combinations is unlikely to yield the correct combination.

Random Assembling?

What does this have to do with the origin of biological information? It turns out that it is extremely difficult to assemble a new information-bearing gene or protein by the natural selection/random mutation process because of the sheer number of possible sequences that must be searched in the available time. As the length of the required gene or protein grows, the number of possible base or amino-acid sequences of that length grows exponentially.

Imagine that we encounter a committed bike thief who is willing to search the "sequence space" of possible bike combinations at a rate of about one new combination per two seconds. If our hypothetical bike thief had three hours and took no breaks, he could generate more than half (about 5,400) of the 10,000 total combinations of a four-dial bike lock. In that case, the probability that he will stumble on the right combination *exceeds* the probability that he will fail and it becomes more likely than not that he will *succeed* in opening the lock by chance. Thus, the chance hypothesis—the hypothesis that he will succeed in opening the lock by chance—is also more likely to be *true* than false.

Consider another case. If that thief with the same limited three-hour time period available to him confronted a lock with ten dials and ten digits per dial (a lock with ten *billion* possible combinations), he would now have time only to explore a small fraction of the possible combinations—5,400 of 10,000,000,000—far, far fewer than half. In this case, it now becomes much more likely than not that he would *fail* to open the lock by chance. And the chance hypothesis would be much more likely to be false than true.

These examples suggest that the ultimate probability of the success of a random search—and the plausibility of any hypothesis that affirms the success of such a search—depends upon both the *size of the space* that needs to be searched and the *number of opportunities* available to search it.

In my new book *Darwin's Doubt*, I show that the number of possible DNA sequences (or amino acid sequences) that need to be searched by the evolutionary process dwarfs the time available for such a search—even taking into account evolutionary deep time. Molecular biologists have long understood that the size of the sequence space of possible nucleotide bases and amino acids is extremely large. Moreover, recent experiments in molecular biology and protein science have established that functional genes and proteins are extremely rare within these vast combinatorial spaces of possible arrangements. There are vastly (exponentially!) more ways of arranging nucleotide bases that result in nonfunctional sequences of DNA, and vastly more ways of arranging amino acids that result in nonfunctional amino-acid chains, than there are corresponding *functional* genes or proteins. One recent experimentally derived estimate places that ratio—the size of the haystack in relation to the needle—at 1077nonfunctional sequences for every functional gene or protein.[6] (There are only 1065 atoms in our galaxy!)

All this suggests that the mutation and selection mechanism would only have enough time in the entire multibillion year history of life on earth to generate or search but a small fraction (one ten trillion, trillion trillionth) of the total number of possible nucleotide base or amino-acid sequences corresponding to a single functional gene or protein. The number of trials available to the evolutionary process turns out to be incredibly small *in relation to* the number of *possible* sequences that need to be searched.

Thus, as with our bike thief who is confronted with many more combinations than he has time to explore, the mutation and selection mechanism is much *more likely to fail* than to succeed in generating even a single new gene or protein in the known history of life on earth. It follows that the neo- Darwinian mechanism—with its reliance on a random search—is not sufficient to generate the information necessary to produce

even a single new protein, let alone a completely new Cambrian animal, in the time available. Or to put the point differently, the neo-Darwinian explanation for the origin of genetic information is *overwhelmingly* more likely to be *false* than true.

THEORY OF INTELLIGENT DESIGN

We have seen that building a Cambrian (or any other) animal would require vast amounts of new, functional genetic information. We've also seen that the neo-Darwinism mechanism lacks the creative power to generate the new genetic information necessary to build new forms of animal life. (In *Darwin's Doubt*, I also show that *other* evolutionary mechanisms fail to account for the origin of the genetic information, the genetic circuitry and the epigenetic [beyond the gene] information necessary to build new animal body plans).

Could this unexplained—from a materialistic point of view—origin of information point instead to the activity of a different type of cause? Do we know of any other kind of entity that has the power to create large amounts of specified information?

We do. As information scientist Henry Quastler recognized, the "creation of new information is habitually associated with conscious activity."[7] Indeed, experience affirms that functionally specified information routinely arises from the activity of intelligent agents. For example, a computer user who traces the information on a screen back to its source invariably comes to a mind—that of a software engineer or programmer.

But could this intuitive connection between information and the prior activity of a designing intelligence justify a rigorous scientific argument for intelligent design? I first began to consider this possibility during my Ph.D. research at Cambridge University in the late 1980s. At that time, I was examining how scientists investigated origins events. Specifically, I examined the method of reasoning that historical scientists use to identify causes responsible for events in the remote past.

I discovered that historical scientists often use a method of reasoning called "the method of multiple working hypotheses" or "inference to the best explanation." That is, when trying to explain the origin of an event or structure from the past, scientists often compare various hypotheses to see which would, if true, best explain it. They then provisionally affirm the hypothesis that best explains the data as the one that is most likely to be true. But that raised an important question: exactly what makes an explanation best?

Historical scientists have developed criteria for deciding which cause provides the best explanation for some event in the remote past. The most important of these criteria is called "causal adequacy." This criterion requires that historical scientists, as a condition of a successful explanation, identify causes that are known to have the power to produce the kind of effect, feature, or event that requires explanation. For instance, a volcanic eruption provides 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.

In the words of the famed historical geologist Charles Lyell, historical scientists must cite "causes now in operation" or "presently acting causes."[8] This was the idea behind his uniformitarian dictum: "The present is the key to the past." According to Lyell, our *present* experience of cause and effect should guide our reasoning about the causes of *past* events. Darwin himself adopted this methodological principle and used it to develop his case in *Origin*.

Philosophers of science have emphasized causal adequacy as the key criterion by which competing hypotheses are adjudicated. But philosophers of science also have noted that assessments of explanatory power lead to conclusive inferences only when it can be shown that there is *only one known cause* for the effect or evidence in question. When scientists can infer a *uniquely* plausible cause, they can avoid the logical fallacy of affirming the consequent—the error of ignoring other possible causes with the power to produce the same effect.

What does all this have to do with the Cambrian explosion? My study of historical scientific reasoning suggested to me that it was possible to formulate a rigorous scientific case for intelligent design as an inference to the best explanation—specifically, the best explanation for the origin of biological information. The action of a conscious and intelligent agent clearly represents a known (presently acting) and adequate cause for the origin of specified or functional information. Uniform and repeated experience affirms that intelligent agents produce information-rich systems, whether software programs, ancient inscriptions, or Shakespearean sonnets.

Further, the origin of the functional information necessary to produce new forms of animal life in the Cambrian period also points to intelligent design as the best explanation for the origin of functional biological information. Why? Experience shows that large amounts of functional information invariably originate from an intelligent source— from a mind or a personal agent. Further, as my critiques of the creative power of various materialistic evolutionary mechanisms in *Darwin's Doubt* help to show, intelligent activity is the only known cause of large amounts of functionally specified information. Since intelligence is the only known cause of functional information, the origin of the new functional information necessary to produce novel forms of animal life in the Cambrian period points decisively to the past activity of a designing intelligence.

DNA contains information in digital form—information that functions much like a software program. We know from experience that software comes from programmers. We know that information in whatever form we find it—whether inscribed in hieroglyphics, written in a book, or encoded in radio signals—always arises from an intelligent source. So the realization that building the animals attested by the Cambrian fossil record required huge infusions of new functional information into the biosphere provides strong grounds for inferring that a designing intelligence played a role in this event in the history of life, even if we weren't there to observe the first animals coming into existence.

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He has authored *Signature in the Cell: DNA and the Evidence for Intelligent Design* (HarperOne, 2009) and *Darwin's Doubt: The Explosive Origin of Animal Life* (HarperOne 2013), upon which this article is based.

NOTES

1 Charles Darwin, *On the Origin of Species by Means of Natural Selection* (A facsimile of the first edition, published by John Murray, London, 1859. Reprint, Cambridge, MA: Harvard Univ. Press, 1964), 307.
2 Ibid., 308.
3 Richard Dawkins, *River Out of Eden: A Darwinian View of Life* (New York: Basic Books/Harper Collins, 995), 17.
4 Bill Gates, *The Road Ahead* (New York: Viking, Penguin Group, 1995), 188.
5 See Stephen C. Meyer, *Darwin's Doubt: The Explosive Origin of Animal Life* (San Francisco: HarperOne, 2013), chap. 14.
6 Douglas Axe, "Estimating the Prevalence of Protein Sequences Adopting Functional Enzyme Folds," *Journal of Molecular Biology* 341 (2004)): 1295–1315.
7 Henry Quastler, *The Emergence of Biological Organization* (New Haven, CT: Yale University Press, 1964), 16.
8 Charles Lyell, *Principles of Geology: Being an Attempt to Explain the Former Changes of the Earth's Surface, by Reference to Causes Now in Operation* (London: Murray, 1830–33), 75–91.